Visualisation of Interactions in Online Collaborative Learning Environments

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Abstract

Much research in recent years has focused on the introduction of 'Virtual Learning Environments' (VLE's) to universities, documenting practice and sharing experience. Communicative tools are the means by which VLE's have the potential to transform learning with computers from being passive and transmissive in nature, to being active and constructivist. Attention has been directed towards the importance of online dialogue as a defining feature of the VLE. However, practical methods of reviewing and analysing online communication to encode and trace cycles of real dialogue (and learning) have proved somewhat elusive. Qualitative methods are under-used for VLE discussions, since they demand new sets of research skills for those unfamiliar with those methods. Additionally, it can be time-intensive to learn them.

This thesis aims to build an improved and simple-to-use analytical tool for Moodle that will aid and support teachers and administrators to understand and analyse interaction patterns and knowledge construction of the participants involved in ongoing online interactions. After reviewing the strengths and shortcomings of the existing visualisation models, a new visualisation tool called the Virtual Interaction Mapping System (VIMS) is proposed which is based on a framework proposed by Schrire (2004) to graphically represent social presence and manage the online communication patterns of the learners using Moodle. VIMS produces multiple possible views of interaction data so that it can be evaluated from many perspectives; it can be used to represent interaction data both qualitatively and quantitatively. The units of analysis can be represented graphically and numerically for more extensive evaluation. Specifically, these indicators are communication type, participative level, meaningful content of discussion, presence of lurkers, presence of moderators, and performance of participants individually and as a group. It thus enables assessment of the triangular relationship between conversation-content, online participation and learning.

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Abbreviations

API	Application Program Interface
CMC	Computer Mediated Communication
CSCL	Computer-Supported Collaborative Learning
DBAT	Discussion Board Analysis Tool
DIAS	Discussion Interaction Analysis System
DOM	Document Object Model
DTW	Dynamic Time Warping
GISMO	Graphical Interactive Student Monitoring Tool
ICT	Information and Communication Technology
LMS	Learning Management System
LSA	Latent Semantic Analysis
MAMP	Macintosh, Apache, MySQL, PHP
MOODLE	Modular Object-Oriented Dynamic Learning Environment
MTRDS	Mapping Temporal Relations of Discussions Software
PHP	Hypertext Processor
SOLO	Structure of Observed Learning Outcome
SQL	Structured Query Language
SSO	Single Sign-On
SVG	Scalar Vector Graphics
TrAVis	Tracking Data Analysis and Visualisation
UML	Unified Modeling Language
VIMS	Virtual Interaction Mapping System
VLE	Virtual Learning Environment
W3C	World Wide Web Consortium

Definitions and Terminology Used in Thesis

The usage of the following terms differs in the general use, in computer science and education research. The following definitions describe the use of these terms and meaning as used in this thesis.

Active Participants: All the participants who take part in the ongoing discussions by starting a discussion and/or replying to the previous posts.

Asynchronous discussion: Also termed as online discussions, online conversation, online forum or online conference. It is defined as a text based conversation on the internet that takes place over a period of time without all participants logging in at the same time.

Computer Mediated Communication: Communication using online tools such as email, forums or conferencing.

Inactive Participants: All the participants who do not contribute at all to the online discussion. They are registered for the course but they neither post nor read the posts.

Lurkers: The participants who only read the post but don't intend to contribute to the ongoing discussion by posting.

Online Interaction: Different from online participation. Participants engage in the online discussions by posting a thread and/or replying to a previous post. This is in many places often termed as online discussion or online conversation or online dialogue.

Online Participation: Engaging in online conversation or discussion either by posting and/or replying to the previous posts or by just reading the posts that are posted.

Participants: All those registered for a course and who participates in the online discussion. This includes the active participants and lurkers. Learners and students (terms often used interchangeably) are the participants in this research.

Teachers: They are often interchangeably termed as moderators or instructors.

Threads: Threads are headings of a subtopic in a discussion forum. The threads build up as the conversation continues.

1. Introduction

This chapter presents a general understanding of Computer Mediated Communication (CMC) and gives an overview of the environment in a Learning Management System (LMS), the experience of online learning through interactions and the importance of visualisation of the online activity. It features an overview of our research purpose followed by the research questions and then concludes with the significance and objectives of our research.

CMC refers to the area of human-computer interaction (HCI) which in the field of education promotes collaborative online learning. Online learning is a learning experience where the learning content is delivered through technology either through online course materials or online interactions. The rapid growth of online learning has created a drive to study and analyse online participation, which fosters cross-cultural learning communities. Online participation can be seen very clearly through forum-based interactions. To promote and develop children's intercultural education through CMC, an analysis of their interactions is needed. In particular, Gunawardena et al. (1997) emphasised that asynchronous discussions are widely used in educational contexts as are principles of constructivism. Asynchronous discussions promote social interaction in learning activities. Schellens & Valcke (2005) also point out that intensive discussion and social interaction may lead to multiple knowledge construction phases.

The dynamic nature of online interaction where new topics are often introduced and new threads and posts are formed to perpetuate the online activity is difficult to assess. To deliver a clear understanding of the nature of online discussions, there is a strong need to study the qualitative and quantitative nature of online interactions. The higher the number of interactions, the unclear could be the analysis of those interaction patterns. It seems reasonable to accept that participation and interaction are the enablers of learning and knowledge construction in Virtual Learning Environments (VLE). Communication on a

CMC has to be more interactive in order to assess the learning capabilities of an individual. However, sometimes this interaction could be just the formation of a social network. According to Sing and Khine (2006), successful co-construction of knowledge requires active and broad participation, which requires substantially more posted messages. They also state that this data can be used as important background information, to prompt further analysis to assess the quality of interaction.

There are many factors that contribute the purpose of our research. The characteristic of an LMS proposed to enhance a collaborative learning environment, is to assess the quality of participation and interaction (King & Doerfert, 1996; Sims, 1997; Geer & Campus, 2000; Jonassen et al., 2007). The quality of interaction relates to structured threads where the messages should be very concise and relate to the subject. The forum should be provocative and a comparatively high number of interactions usually equates to a comparatively better collaborative community. The students should be prompt and timely in replying to a message. 'Meaningful learning' is a relatively new term related to the quality of interaction and occurs when the discussion forum is active, constructive, intentional, authentic and cooperative (Jonassen et al., 2007).

The quality of interaction through the dialogue of discussion enables us to find out the attitudes and behaviour of the students interacting. This information will also help us to find out if there are any social barriers or negative behaviour among the students across boundaries during cross-border collaboration. In case there are any, then moderators or teachers can take the initiative to minimise these boundaries by facilitating a collaborative online communication. The role played by students and instructors in the online community, in the development of an online experience is another factor for successful cross-cultural collaborative learning (Berge, 1995). The role of an instructor is to monitor and facilitate interactions among the students (Stacey, 2002; Berge, 1995). The student's should play the role of active participants to form a collaborative community.

According to Waters & Gasson (2005), the student could be a message initiator, contributor, knowledge-elicitor, vicarious-acknowledger and/or a passive-learner. Research into online collaborative learning interactions highlighted the development of skills such as critical thinking, problem solving, higher retention capacity, goal setting, interpretation, analysis and evaluation process (Buck 2003; Burbach et al. 2004; Chen 2005; Risher & Stopper, 2002). Intervention of the instructor is needed, to monitor and help the student, if these skills are still at a low-level after a brief period of time.

There is a need for the teachers to monitor online interactions for more effective use of the online environment. To assist teachers to monitor the online conversations, there is a need for good and effective tools. Visualisation tools can always be more efficient than numerical and textual display to view online conversations and assess, review and analyse the flow of conversation at a glance. An expanded toolkit for the analysis of online discussion forums would enable researchers to address the wider research question of whether and how people learn from asynchronous discussion forums, such as those provided in virtual learning environments/learning management systems (VLE's/LMS's).

Not all the current tools give a clear, interesting and easy understanding of the conversation flow. They are either depicted in terms of a chart or they do not show the conversation flow in full. Interactions are not identified, monitored and analysed due to the lack of support of good visualisation tools for the teachers. This thesis proposes research on using a visual technique to interpret the data gathered by an LMS and intends to propose appropriate visual representation taking teachers' needs into consideration. We argue that the visualisation software presented here is an innovative way that improves monitoring and promotes student interactions and supports more detailed and reliable analysis of forum messages It therefore represents a valuable addition to the available tools and methods. The rest of the thesis gives a clear understanding of the importance of a visualisation tool and how the current developed tool fits into achieving our goal.

1.1 Background to this work

Asynchronous CMC has been the subject of extensive and prominent research from different perspectives (Bratitsis & Dimitracopoulou, 2006; Gant, 2007) namely virtual education, communication and technology. Much of this research has focused on the use of online communication to foster social interaction (Scheuermann et al., 2003; Guan et al., 2008; Berlanga et al., 2009), to create a collaborative online environment (Scheuermann et al., 2003) and to support learning (Garrison et al., 2001; Scheuermann et al., 2003). CMC can offer opportunities to 'meet' online when face-to-face meetings are not possible, but can also have advantages over face-to-face meetings in providing extra space and time for people to contribute to a discussion. Some learners may be more comfortable with contributing to an online discussion than they are with speaking in a classroom.

Participants in CMC form a community where they engage in discussion and begin to share and learn more about a particular domain of interest. Such communities according to Weber (2004) are called 'episodic communities' unlike the 'communities of practice' defined by Lave and Wenger (2002). The participants meet online and learn and share information of interest. Others have dubbed them 'ad-hoc transient communities' in the context of networked learning (Sloep, 2008). In relation to VLE's and CMC, Laurillard's (1993, 2001) 'conversational framework' is frequently cited and informs course design for many practitioners building communication tools into their VLE spaces. CMC promotes a type of interaction that is often lacking in the traditional teacher-based classroom. It allows learners the freedom to explore alternative pathways, to find and develop their own style of learning (Berge & Collins 1995). CMC systems allow learners to interact with one another over time and promote collaborative learning. Thus, many educational institutions have sought to exploit opportunities for CMC within their VLE environments. Apart from accessing course materials, students can discuss their subject and course online through forums and share their views, ask questions and gather

information. Moodle (Moodle, 2011) is a popular learning environment used by the institutions for online teaching, learning and discussions. In Moodle, all interactions and exchanges between people and resources are recorded and available for constant review. A detailed description of Moodle along with its features is provided in section 3.2. Users can interact with the Moodle discussion forum to start, read or reply to a conversation. Users can be teachers, students or moderators. The model in Figure 1.1 gives a use-case scenario of the interaction in a discussion board.

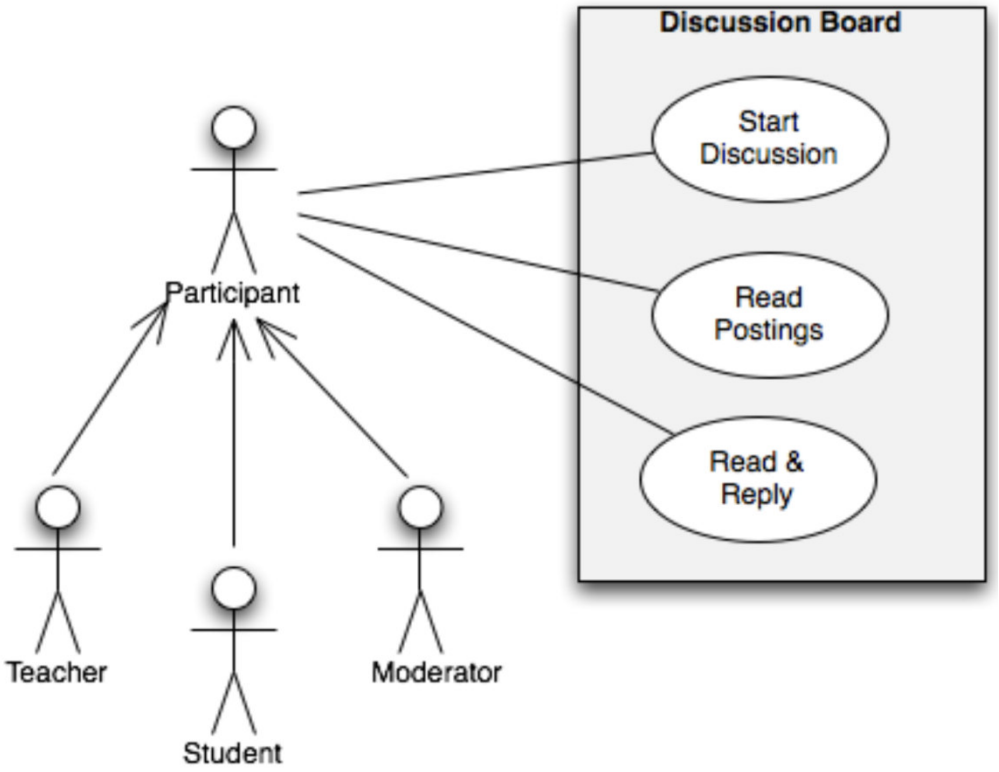


Figure 1.1 Use Case Scenario of Discussion Board

Given the importance ascribed to dialogue and CMC in educational theory, it follows that a means of reviewing and potentially analysing CMC interactions would therefore be useful to teachers and researchers, and research would benefit from an evidence base showing that online interactions had positive effects on students' learning. However, the best ways of analysing CMC are not clear. Studies that have analysed the content of the

online discussions are also limited. This may be due to the time required to perform such analyses (Hara et al., 2000) and the lack of a reliable instrument or an analytical framework to analyse the online discussions. As Goodyear (2001) notes:

> *Analysing the content of networked learning discussions is a troublesome research area and several commentators have remarked on the difficulty of connecting online texts to discourse learning. (Goodyear, cited Mehanna 2004: 283)*

Although there is existing research in Computer-Supported Collaborative Learning (CSCL) and CMC which references educational theory and analyses activities in online forums (Dillenbourg, 1999), it remains difficult for practitioners to review VLE forums easily and to conduct their own analyses. Forums are unwieldy to navigate and review, and there is no ready-made toolkit to analyse online communications. Therefore, there is an immediate practical problem of reviewing progress on a daily basis, and in research terms it is difficult to make links between theories about online interactions and real-world practice.

While teachers and researchers may have sound theoretical rationales for their use of CMC tools in the VLE, methods for analysing the communications are not always practical or clear. A methodological problem exists in making links between theory and practice when we come to analyse asynchronous dialogue in discussion forums for evidence of student learning.

Formal assessment offers one general indication of whether online dialogue has supported learning but gives no indication of where, how and to what extent this may have happened. Course feedback and evaluation mechanisms, similarly, may highlight the use of discussion forums as a useful supplement or yield examples of how students have used them. Again, however, there are few specific or reliable measures about the nature of the learning in this kind of feedback. Researchers have instead proposed treating forum messages as qualitative data and thereby draw on qualitative methods for analysis. These could include broad thematic analyses or extend to 'Grounded Theory' (Alsop & Tompsett, 2002). Alternatively, forum messages might be treated as

'discourse', and discourse analysis or methods of linguistic analysis used (Brown & Yule, 1983, Smith & Oliver, 2001). Viewed from these perspectives, students' learning is related to the quantity and quality of postings in on-line discussions and to the value instructors place on them (Jiang & Ting, 2000). Henri (1992) proposes an analytical framework to categorise five dimensions of the learning process evident in electronic messages namely (1) *student participation (2) interaction patterns (3) social cues (4) cognitive skills and depth of processing* and (5) *meta-cognitive skills and knowledge*. Interactivity models, too, can be used to evaluate and interpret each of these areas individually in online learning environments.

However, analysis of each of these dimensions listed above (including the discourse and linguistic analysis) entails a range of tasks and processes, which may be difficult and time-consuming to undertake and complete. A broad thematic analysis of forum messages, perhaps undertaken quickly and looking for common areas of discussion, will reveal something of the nature of interactions in the dialogue but is unlikely to give sufficient evidence to a researcher to suggest that learning has taken place. It lacks rigour and is untriangulated; it is difficult to use such unstructured analysis to draw meaningful conclusions. Qualitative research is more likely to yield a much richer set of results. However, these methods may be unfamiliar to people outside certain subject disciplines. They require study in and of themselves, and subsequently entail extensive coding of data before analysis can take place. Coded material may well be extremely difficult to manage without dedicated software for qualitative data analysis. Even for people accustomed to using such methods as part of their research activities, they may be unwieldy and time-consuming to use in the context of evaluating learning in CMC. The methodological difficulties of analysing discussion forum data are therefore compounded by the practical constraints of time and resources. This has wider implications for the 'evidence base' in e-learning: it is difficult to build up case studies of appropriate and effective use of technology where practitioners lack the tools to make these studies.

1.2 Research Questions

From an educational perspective the following have been identified as being important:
1. Quality of Interaction and the level of participation among the participants.
2. Role played by the students and teachers in the online community in order to create a memorable online experience.
3. Examine the conversation content and find the ability of the participants to relate to the subject of the conversation.

A study of the interactions from the educational perspective led us to continue the research and hence formulated our research questions which would identify the above mentioned aspects. The main research questions examined in this study were:

1. Can teachers and administrators be made aware of the ongoing discussions on Moodle?
2. Can informative features be extracted from data gathered from online discussions and activities?
3. Can this information be presented in a better way to the teacher?
4. How best to implement a visualisation tool that will enhance the means by which asynchronous online communications in discussion forums can be analysed?
5. Choose evaluation procedures that can be integrated with the visualisation tool that will allow comparisons between groups participating in the online discussion environments?

The following section gives a brief explanation of the motivation behind the research questions.

Question 1: Can teachers and administrators be made aware of the ongoing discussions on Moodle?

Moodle discussion forums can be used in distance education to foster a sense of community. Moodle forums can be used for group activities where the individuals can express their thoughts and ideas on a particular subject (more about Moodle in Section 3.2). This online community could be big enough that it would be difficult for the teachers to keep track of what is happening in the discussion. To make the teachers aware of what's going on in the discussions was important and so the first question was raised.

Question 2: Can informative features be extracted from data gathered from online discussions and activities?

Moodle stores lots of information about the online activities in a table format, but not all that is important for a teacher to monitor the online discussions. So only the information relevant to the teachers should be extracted for visualisation. And so one of the goals of this research is to identify the important features and so came up with this question of how the relevant features should be identified and extracted.

Question 3: Can this information be presented in a better way to the teacher?

This information extracted is to be represented in a way that could be easily understandable to the end-users especially teachers and moderators. The study aims to develop a methodology that could help teachers and come up with a graphical representation tool which will enhance the extracted information into an automated, scalable, multi-browser real-time visualisation.

Question 4: How best to implement a visualisation tool that will enhance the means by which asynchronous online communications in discussion forums can be analysed?

Visualisation as stated earlier, always is much better than textual analysis of data as it exploits people's ability to process images quickly. We wanted to prove that the pattern of activity in the online discussions can be easily represented, explored and searched

through visualising the vast amount of data and hence wanted to build this tool using the best approach and software architecture possible and software can be open sourced for future researchers to modify and build on. In order to make the tool more reliable and widely used we raised the above question.

Question 5: Choose evaluation procedures that can be integrated with the visualisation tool that will allow comparisons between groups participating in the online discussion environments?

Once we had decided to use a visual representation, we then wanted to analyse group interactions which has not been done by any of the visualisation tools reviewed (see Chapter 2). Comparison between groups helps the teacher identify which individual in a group needs attention or which group on the whole needs assistance in order to make the online interactions more meaningful and collaborative. This last question has led us to the development of the VIMS tool taking all the visualisation aspects.

Once we had the graphic representation which could be easily understood, we wanted to test the representations to be able to justify the first three questions. We wanted to see if the representation could enhance the analysis of the asynchronous discussions on the Moodle forum and if this representation could be used as a tool which can be embedded into a learning environment like Moodle. To make a good visualisation tool we wanted to incorporate most of the approaches needed to convey the mapping of abstract information of the ongoing discussion in an innovative manner.

We intend to design tools to extract relevant features from the online forum that will help to answer not only these five questions but also intend to explain the earlier raised educational perspective features.

1.3 Purpose of Study

The purpose of this study is three-fold. Firstly, to develop an enhanced tool that visually presents the asynchronous discussions in online forums in order to solve the problem of existing visual tools that do not present the entire conversation flow. Visually representing the entire conversation structure of every forum should help us to form an overview of the discussion space and compare different discussions or the same discussion over time. Secondly, to monitor the performance of the developed visualisation tool for an online environment and identify its usefulness. Thirdly, to choose evaluation procedures that can be integrated with the visualisation tool that will allow comparisons between groups participating in the online discussion environments. The overall aim is to facilitate the moderation in online forums and to minimise social and intercultural boundaries among online learning communities with a modest intervention by the instructor and moderator.

Our idea is based on the contention that students interacting in a collaborative online learning environment should be monitored, supervised and guided by their teachers. In this research, we begin by identifying the communication patterns of the participants who form online communities and represent the pattern in an easily understandable graphical way. We then proceed with analysing their conversation content, which can help to identify if their responses to a particular thread are close to the subject of the discussion or if they are deviating from the topic. We can understand their individual attitudes towards other participants from different cultural backgrounds with the structure of the conversation pattern. Quantitative statistical analysis is used to determine the consistency of participation among different groups involved in the online conversation. The cross-cultural education in this research is focused between schools in the Northern Ireland and Republic of Ireland. This group of schools were chosen to see the interaction patterns and conversation flow of students coming from different schools belonging to different regions. The research is focused on children aged between 7 and 12 but the techniques

can be adapted to any age group which can be seen in the asynchronous discussion forums taken from the National University of Ireland.

The solution we propose is the Virtual Interaction Mapping System (VIMS). VIMS, as an enhanced visual aid, facilitates teachers' and moderators' understanding of the semantic relationships in and between conversations; evaluate various outcomes of the conversation; and intervene whenever needed thus transform the 'online environment' into an 'online collaborative learning environment'. Information visualisation techniques (Shneiderman, 1996; Tufte, 2001) are adopted to make the tool more meaningful and useful. An analysis of online interaction, participation and behaviour is first made more accessible by visualising the mapping of the interactions and participation of the students. This gives the instructor a visual overview of the online activity. VIMS is a medium to allow instructors to assess their students' participation levels and behaviour and fosters a collaborative online environment that allows participants to transcend physical or cultural borders. Corrective action by the instructor after they assess interactions can help develop this collaborative cross-border online environment.

In the process of monitoring the ongoing conversation and visualising it, we had come across various important attributes that characterise the online conversation, which can be represented visually. Most of the attributes have been ignored by the other visualisation tools.

1.4 Significance of the Study

Moodle has been one of the effective sources for promoting collaborative online learning. It is also being widely used for online asynchronous communication through forums where both teachers and students participate in the social interaction sharing their views and thoughts. The significance of this study is to give a clear understanding of the ongoing asynchronous interactions through forums in a learning environment like

Moodle. The details of the interaction are necessary to identify the importance of a particular forum. The amount of detail is enormous and need to be interpreted in such a way that the moderators and/or teachers can see the activities of the forums.

There have been many researchers working in this area to visually represent online interactions, but none of them have clearly answered the questions raised in this research and hence there was a need to develop a visual tool. This research deals with interpreting the details of the online activity in forums in a visual manner, such that they can be easily understood at a glance. The intention is to produce a set of visual cues or clues that will prompt the teacher's and the moderator's actions. This research provides analysis on building a collaborative online learning community and expanding the capabilities of Moodle environment by providing a simple, understandable visual tool to interpret online activities happening on Moodle forums and so this thesis also presents the integration of this visual tool into Moodle.

In the attempt to monitor the forum interactions, we intend to come up with different kinds of visual representations like the radial tree representation, tabular representation and graphical representation which convey the same interaction patterns in a different view and interpreting different information. We also wanted both statistical and qualitative analysis of the content to be performed and represent them as a measure of the interactions and the content of the interaction. We planned to measure the value of the tool in a real-time environment and with the help of case studies, a set of conclusions were drawn from them. Thus, it is intended that the outcomes of this research will be a useful contribution to all participants in online learning activities and research.

1.5 Organisation of the Thesis

CHAPTER 2 gives an introduction to the interactions and visualisation of interactions in LMS and begin to review the related work. It categorises the tools, assesses each approach along with their significance and shortcomings.

CHAPTER 3 emphasises how VIMS combines aspects from the categories mentioned in Chapter 2 and expands by including the key features not present in the current tools. It also gives an overview of the Moodle environment. This drives the plan of work for the later chapters.

CHAPTER 4 describes the implementation and design of VIMS, a '*Virtual Interaction Mapping System*' that can be used by teachers to explore and examine the different online interactions of the participants and explains in detail the procedure of how VIMS can be integrated into the Moodle environment. Testing is also carried out and illustrated to show that integration is successful. Initial testing of the tool to establishing the correctness of design, methodology and interpretation was done which is explained in this chapter. This correctness means progress can be made to test the tool in the real-time environment, which is described in the next chapter.

CHAPTER 5 highlights the approach and plan designed for the VIMS system. It gives examples through case studies of how the goals of this research have been achieved. The case studies explain the approach taken and verify and confirm again that the planning and methodology are sound.

CHAPTER 6 gives an in-depth analysis and obtains the results for the questions raised in this chapter. This chapter investigates the operation of the VIMS tool in a Moodle environment. It also elaborates on the data analysis procedures of the VIMS tool. Sample results are generated to show the effectiveness of the tool. Furthermore, the actual results

taken from live interactions will be given alongside subjective evaluations given by teachers.

CHAPTER 7 summarises the study and draws our conclusions. We suggest further improvements that can be made at a later stage to make the tool more efficient and more re-useable.

1.6 Summary

In this chapter we presented an overview of the background of online learning through interactions and importance of visualisation of these online discussions. Throughout our study, we have highlighted and focused on online interaction and participation in a learning environment and how to change an online community to a collaborative online learning community. The need to visualise this online community has been explained so that the teachers or moderators can monitor the level of interaction and, if needed, intervene in the discussions to provide clarifications.

The next chapter describes the various visualisation tools that have been developed, reviewing their advantages and disadvantages. It is a study of the limitations of existing tools that informs and prompts us to study in-depth online interaction and participation and develop a visualisation tool that will benefit not only the teachers and moderators but also the students, by showing their level of interaction.

2 Literature Review

2.1 Introduction

This chapter gives a brief introduction to the terms 'interaction', 'participation' and 'learning' and their relationship. It then focuses on the importance of visualising these three concepts and critically reviews the tools developed so far and highlights the importance of the visualising tool that we plan to develop.

Much research in recent years has been focused on the value and significance of online collaborative learning environments and the interaction and participation level of learners (Shale & Garrison, 1990; Moore, 1989). The engagement of learners in synchronous or asynchronous discussions leads to successful learning and building up a social community (Wenger, 1998; Gunawardena et al., 1997). Hence, to encourage participation in interaction, researchers have tried to introduce various tools and techniques.

In the 'Information Visualisation' field research has continued to suggest alternative approaches to present simple quantitative information more efficiently. Furthermore, ways of producing new perspectives on the existing activity data, focusing on more qualitative aspects of analysis (cognitive and metacognitive), should be researched. The importance of evaluating the quality of the messages posted in the online discussions is still an ongoing research area in the educational context. Thus, as stated by Bratitsis & Dimitracopoulou (2007), the research should be focusing on finding new ways of raw data analysis and visualisation in order to provide more insightful examination of the collaboration, in favour of the users involved and the overall activity.

This section gives a brief review of the importance of participation and interaction in an online collaborative learning environment and also reviews the importance of the use of a visual aid to facilitate the understanding of the structure, quality and flow of online

conversations. It also reviews and presents the various available visualisation tools developed to analyse the online behaviour of the participants involved in the discussions and suggests various conclusions and observations that could be drawn from those visual representations.

The review also explains briefly the importance of this research context and what it contributes to the current on-going study of collaborative online interaction and learning.

2.2 Interaction in Virtual Learning Environment (VLE)

Almost all educational institutions in the UK and Ireland have institutional VLE's (Browne & Jenkins 2003; Weller, 2007). Although definitions differ, VLE in this context is the label given to a system that can store teaching materials, readings, web-based resources and course information shared between staff and students in different courses of study. In addition, VLE's commonly provide tools to support online activities including quizzes, assessments, communication between students, and between students and lecturers, and some tools to support groupwork (e.g. virtual presentation spaces, collaborative writing spaces, wikis and blogs). Blackboard/WebCT (http://www.blackboard.com), Moodle (http://www.moodle.org/), and Sakai (http://sakaiproject.org/) are currently amongst the most widely used VLE's. VLE's provide the means to support learning in practical ways associated with information and content management, but also have the potential to offer transformative approaches to teaching and learning, facilitating synchronous and asynchronous dialogue between participants and their teachers. Much has been made of the potential for VLE's to facilitate online dialogue.

Wenger (1998) defines participation as "a process of taking part and also to the relations with others that reflect the process". He interprets that participation involves the

interaction with others in a community. For online discussion forums to function effectively there is a need for active participation. It has been demonstrated that participation and interaction in online discussion forums adds value to student learning outcomes (Garrison & Anderson, 2003). Interaction, using knowledge as a tool of mediation among a community of learners, becomes a social mode of thinking where students learn by engaging in dialogue (Van Boxtel, 2000).

Social communication is an essential component of educational activity. For a successful online learning experience, developing a sense of community has important socio-affective and cognitive benefits for learning activities (Palloff & Pratt, 1999). Researchers have examined online social interaction and learning from two perspectives. Early experimental studies examined the characteristics of interaction in learning environments and the use of particular social cues to see how they resemble what happens in face-to-face interaction. If the social cues were removed from the interactions then there was no socialization, no intimacy, and the communication was impersonal and isolated. More recent research (Garrison et al., 2001; Nichani, 2000) revealed that, if more time was given to exchange information and messages, inter-personal relationships would develop and hence participants would be able to form an online community gradually. At the same time this would allow more time for reflection and information flow (Garrison et al., 2001; Johnson, 2007) and hence would improve the quality of participation and increase cognitive ability. Hence we can state that the main purpose of online interaction is to foster:

- Social ties between different groups
- Support learning
- Extend real-world relationships

There are different types of interactions in online communication. Moore (1989) has classified them as (1) learner-instructor (2) learner-learner and (3) learner-content interaction. There are other types of interactions as well, which are termed “vicarious

interactions" (Devries, 1996; Sutton, 2001) and "learner-self interactions". Vicarious interactions happen when the learner is not a participant in exchanging dialogue. These are learners who would just observe, be silent and learn through other learners' interactions. Such learners are termed as 'lurkers' (Rafaeli et al, 2004; Beaudoin, 2002). Learner-self interactions emphasize the importance of self-talking. All these types of interactions develop the cognitive ability of the learners.

Forums in VLE are used for discussing a particular topic and the participants share their views, ideas and opinions through asynchronous dialogue. A participant starts a discussion related to particular topics that identify the subject. Any number of discussions can be added onto a discussion board. Discussions are usually divided into different threads identified by their topic. The participants responding to those starting discussions are grouped together and form threads of a discussions.

2.2.1 Online Participation and Interaction

Participation, which plays a central role in online discussion, enhances one's learning experience. Interaction through online participation builds the online learning community. Participation and interaction adds significance to online communication. Participation and interaction can never be interchanged. Participation in online communication, according to a review by Hrastinski (2008), can be in terms of accessing e-learning environments, writing, quality writing, writing and reading, actual and perceived writing, and taking part and joining in a dialogue. Participants who participate could be both participants involved in reading and replying to posts as well as lurkers who just read the posts but do not contribute. Interaction involves contributing to the learning community. Motivation needs to be given to those participants who do not contribute their views. Although the participants, both the active and the lurkers, read the posts and build up their critical thinking, motivation needs to be given to the lurkers so that the online community can be more interactive and more meaningful. Fostering each

student's participation in any discussion in the online environment is a key requirement for building up a proper collaborative online learning environment.

Online asynchronous interactions break the social and cultural barrier (Hew & Cheung, 2003). The participants can narrow down all the difficulties faced during a face-face interaction. Online communication allows people to interact with others of different backgrounds and places. Interaction helps teachers and end-users to understand the behaviour and the learning abilities of the students involved in the discussion. Interaction could also help the students in their course. Participation of students by just reading the posts would not help the teacher understand the process of knowledge development in those students (Rutherford, 2010).

2.2.2 Socialising and Learning through Online Interaction

Communication through virtual interaction builds a virtual community. People tend to share their thoughts and ideas and establish connections with one another in this community. This process of sharing thoughts, ideas and goals establishes a tendency to learn more and communicate more (Nichani, 2000). Sustained engagement and collaboration leads to knowledge development and also removes a gap between the participants building a virtual relationship and refines their existing skills (Tan et al., 2010). One aspect that characterizes communities is the nature of the social interactions between members of the community. Through these social interactions they develop their communication skills and experience learning by discussing on a topic and hence form not just a community but a community of learners (Nichani, 2000). Online discussions enhances learning as the focus changes from an interaction with just one person, such as a teacher, as in a face-to-face meeting, to an interaction between people who have diverse views. Practical and meaningful human-computer interaction and human-human interaction leads to positive outcomes in terms of collaborative learning. Increased and meaningful participation which leads to greater reflection and enriched discussions can be

termed as learning. A significant correlation not only between students' perceived learner-learner interactions and students' satisfaction with their course but also a significant correlation between students' perceived learner-learner interactions and their learning was found by some researchers (Swan et al.,2000; Jiang & Ting, 2000).

2.3 Visualisation of Interaction

For exploratory analysis of how systems are being used, and for identifying patterns of use, information visualisation has proven to be a valuable aid. VLE's lack tools to facilitate quick and clean overviews of busy forums. Finding time to navigate and review large numbers of discussion threads in which there is frequent activity is a well-documented problem for teachers using VLE's (Fitzgibbon & Jones, 2004; Karasavvidis, 2009; Hamuy & Galaz, 2010). Where instructors may spend considerable amounts of time observing the asynchronous discussions to derive useful information, a visualisation tool could be always beneficial. The visualisation approach begins with exploring how online discussion might foster student social interaction and promote a virtual collaborative learning environment. A visual mapping of the messages (i.e., a conference activity graph with each message being sequentially numbered and the interaction between these indicated by the use of arrows) can be used in order to capture the interactive process in online discussion.

There is no specific standard for visualisation in order to achieve such a goal. Usually it depends on the nature of the information, the intended use of the visualisation and the inventiveness of the designer.

2.3.1 Exploration of models and tools implemented

Over the past decade, various CMC and collaboration systems have been researched to discover various aspects of the interactions. All of the researchers mentioned below state that the benefits of online discussion led them to explore student interactions and develop

tools and models that analyse the discussions. Visualisation tools (Gibbs et al., 2006; Smith & Fiore, 2001; Kurkowski, 2009) appear to offer potential in providing a practical overview of data quickly and easily. Visualisation allows us to generate initial analytical pictures of multiple forum threads quickly. This in turn facilitates investigation of different sections of dialogue and guides the selection of appropriate qualitative methods for further analysis. A suitable visual tool is the best approach for moderators and teachers to view the interaction and gauge the participation level of the learners involved. However, finding a suitable tool is somewhat challenging. Although a number of visualisation systems have been designed for use, not all follow the same approach or share the same goal.

Research in the field of representation or visualisation of interaction started by representing the participants and/or posts involved using various shapes and interpretations (Donath, 1995; Viegas & Donath, 1999; Erickson et al., 2002). Then research progressed to representing the conversations taking place online (Sack, 2000; Smith & Fiore, 2001; Mark & Andrew, 2001). Researchers then felt the need of analysing the participation, discussion and the participants involved in the ongoing online discussion through visualisation (Mark & Andrew, 2001; Wong, 2005; Bratitsis & Dimitracopoulou, 2006; Howard et al., 2007; May et al., 2007; Mazza & Botturi, 2007; Mazza & Dimitrova, 2007) and hence, this curiosity to know 'what is happening' in the online discussions lead to the development of various tools and visual representations.

The tools developed (and those, in the process of development) so far could be categorised according to the seven categories proposed by Shneiderman (1996). He categorised the information representation methods as: one-dimensional, two-dimensional, three-dimensional, multi-dimensional, tree, network and temporal approaches. Shneiderman has also proposed seven categories which are defined as:

1-D representation is a linear representation giving just the abstract information.

2-D analysis focuses attention on the connections without providing the flavour of those connections. The location of an item is identified by its placement on the x and y-axis. It usually displays the width and height of the object.

3-D representation not only gives the position of the object placed but also its orientation. This view represents the volume along with the width and height.

Multi-dimensional representation is used to represent more than 3 attributes.

Tree or Hierarchical representation produces a structure where each node has a single parent node and the parent and children are connected.

Network structure represents structures that cannot be represented by the tree-structure. Every node will potentially have a relationship with every other node in this representation.

Temporal representation gives importance to the timeline. Historical presentation is depicted in this representation.

i. TOOL NAME – *TrAVis (Tracking Data Analysis and Visualisation)*
CATEGORY - *2D Temporal*

May et al. (2007) (2008) has visualised the user communication activities through a web-based Tracking System named TrAVis. This is a reflective tool for the learners, guiding and assisting tool for the users to track their activity progress. The tool concentrates on only three main issues: trace collection, trace structuring and trace visualisation.

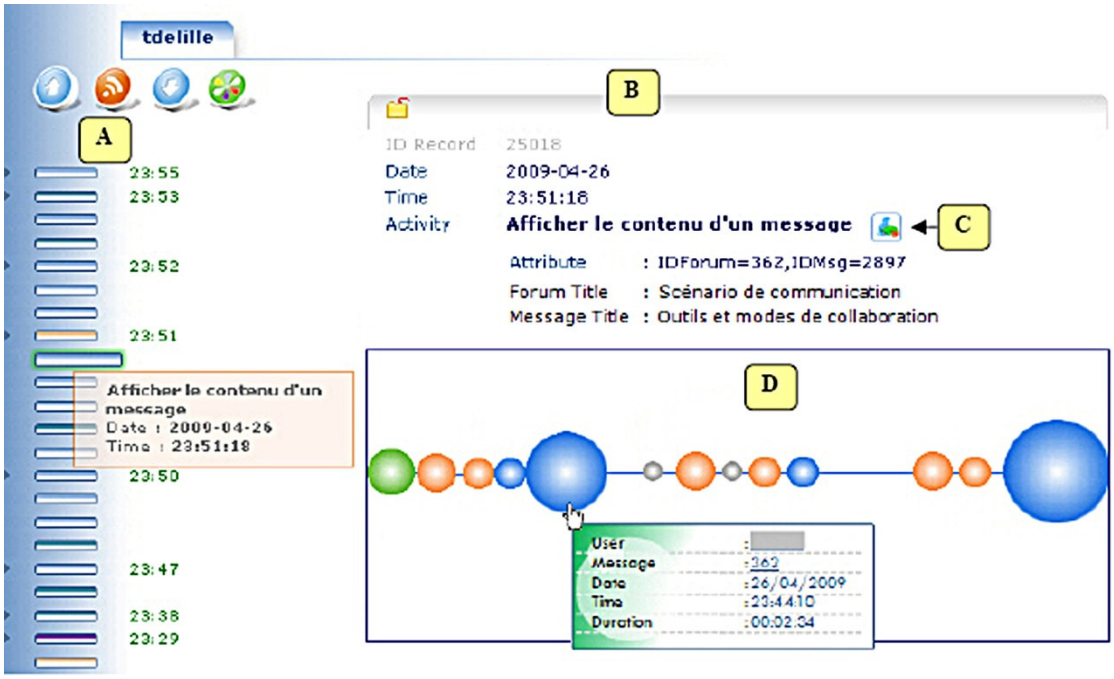


Figure 2.1: List of Student's Activities on View Screen of TrAVis
(May et al., 2007 & 2008)

Figure 2.1 displays the list of the activities of a user on view screen of TrAVis. This view displays the activity list (Figure 2.1A) which gives the most recent activities performed by the user. When an activity is selected, the detail information about the selected activity is displayed at the right of the screen (Figure 2.1B). The other activities that are related to the current activity (which can be identified by the same activity

name) as described by the author (forum_id with forum title, message_id with message title) are seen in Figure 2.1C. Figure 2.1D displays all the users who have read the displayed message along with the user whose details are highlighted. Each sphere shown in portion Figure 2.1D represents an activity of displaying a message and the diameter of the sphere is proportional to the time spent by each user reading the message. The distance between two spheres represents the time gap between two different readings. The colour of the sphere indicates if a message has been displayed, read partially or entirely.

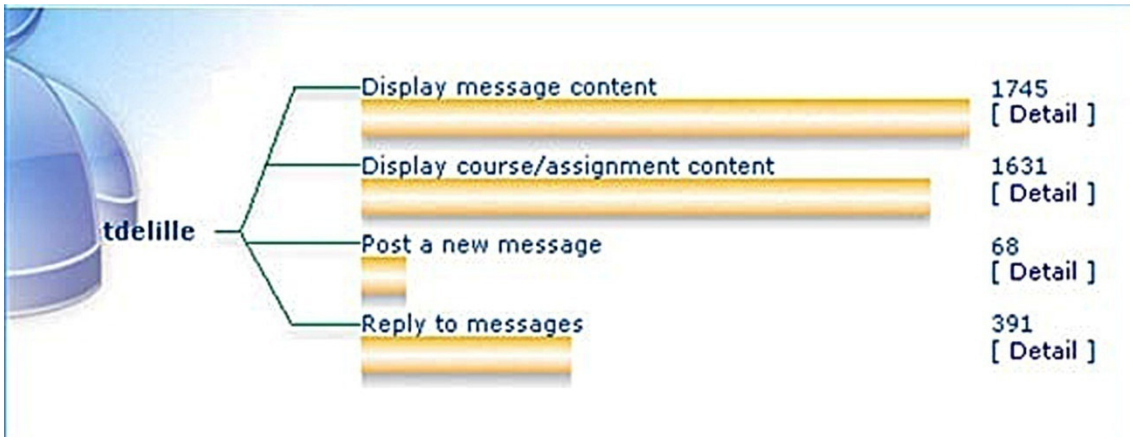


Figure 2.2: Overview of Learning and Communication Activities of a Student (TrAVis) (May et al., 2007 & 2008)

Figure 2.2 gives the statistical data summarising the quantitative information of four other activities of a student. It's a tracking system to observe the communication activities among the participants throughout the learning process. The collected data will be later exploited to assist the tutors in student monitoring and evaluation and learners in self-monitoring and in making self-assessment.

Even though trace visualisation was one of their main ideas, the tool does not visualise the message flow. It is hard to find the communication pattern from the visual representation. It is also impossible to deduce that the time spent 'reading' a message actually relates to 'reading'. Instead it could be a page left open.

ii. TOOL NAME – *Authorline Visualisation*
CATEGORY - *2D Temporal*

Howard et al. (2007) in their work describe visual strategies that illustrate patterns of contributions that they propose are a proxy for indicators of social roles (patterned characteristics of communication). They propose that the key behavioural signature of an answer person (individuals whose dominant behavior is to respond to questions posed by other users*)* is seen in the tendency to reply to discussion threads initiated by others, e.g. the presence of blue circles and the absence of red circles indicating thread initiation. The second attribute is a tendency towards brevity — represented by the absence or relative rarity of large circles in the authorline. Combined, it can be said that an authorline characterised by numerous small blue circles (and corresponding absence of large or red circles) is likely for actors who are primarily playing the role of answer person. An authorline represents the volume of contributions for a single actor across all the weeks of a given year.

Authorline identifies structural signatures of social roles. The distinctive structural features associated with a social role are defined as “structural signatures” (Howard et al., 2007). Authorlines can be viewed in this light as a kind of reputation system, making it faster to get a sense of the sum total of an individual's contributions.

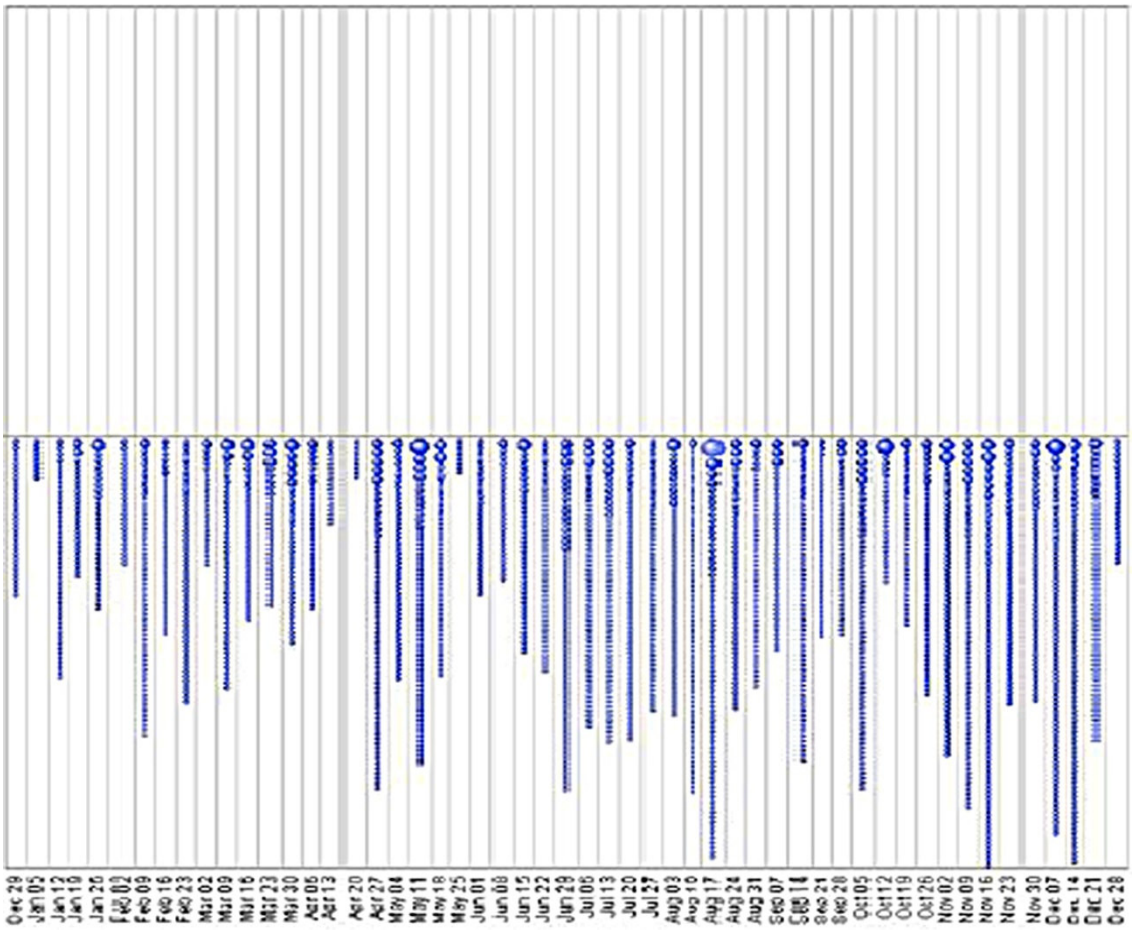


Figure 2.3: Authorline for an Answer Person (Howard et al., 2007)

The authorline visualisation in Figure 2.3 shows only one colour, which is an indication of all the thread initiators.

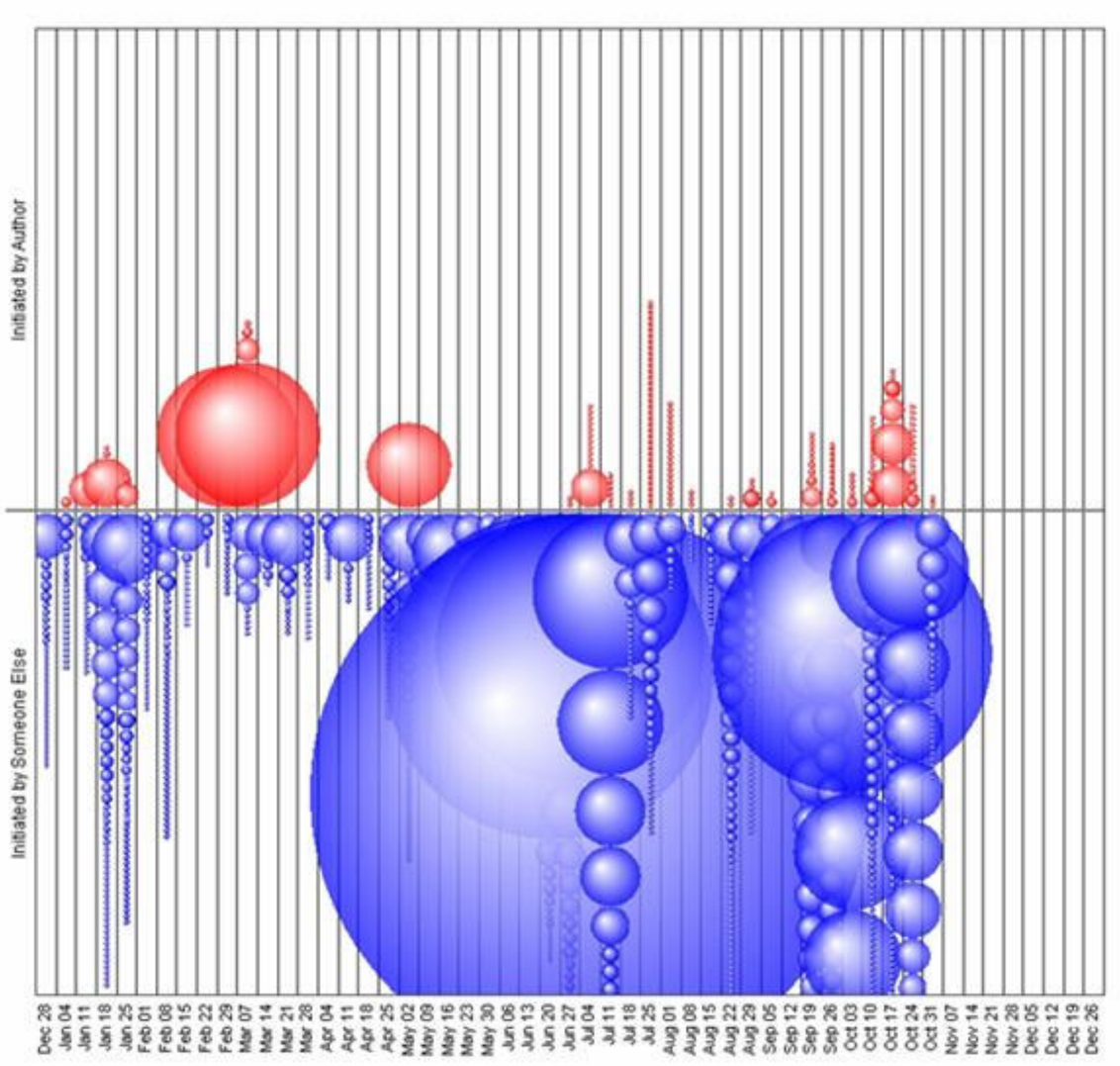


Figure 2.4: Authorline for a Discussion Person (Howard et al., 2007)

Figure 2.4 shows all the threads initiated by a person on the other side of the separator with a different colour indication. These participants both initiate (red) and reply to (blue) threads and contributes greatly to some threads while posting just one or two messages to others.

Although the tool helped to view the dynamics of the interactions at a glance, screen cluttering becomes a problem if the number of authors and the number of posts increase. There would be an overlap of different sized-circles. The inability to read individual messages within the visualisation was one of their issues.

iii. TOOL NAME – *GISMO (Graphical Interactive Student Monitoring Tool)*
CATEGORY - *2D Temporal*

GISMO is a graphical student monitoring and tracking tool designed and developed by Mazza & Botturi (2007). It is designed to be a practical tool, easily integrated into Moodle that can be visible and used by the instructor in realistic settings. GISMO uses the students' tracking data from Moodle, and generates graphical representations that can be explored and manipulated by course instructors to examine social, cognitive and behavioural aspects of distance students. It enables instructors to identify tendencies in their classes, or to quickly discover individuals who need special attention. Their objective was to help the teachers to evaluate the participation of the students in the ongoing discussion.

GISMO has proven to be a powerful tool for at least three activities according to Mazza & Botturi (2007): (a) monitoring class and individual behavior, (b) assessing participation in discussion forums, and (c) redesigning the course according to students' needs.

It fails to represent many of the important indicators like participant details and post details. This representation also lacks the ability to display the conversation flow and the interaction path. There is no way of identifying if the contribution is relevant, useful, and appropriate.

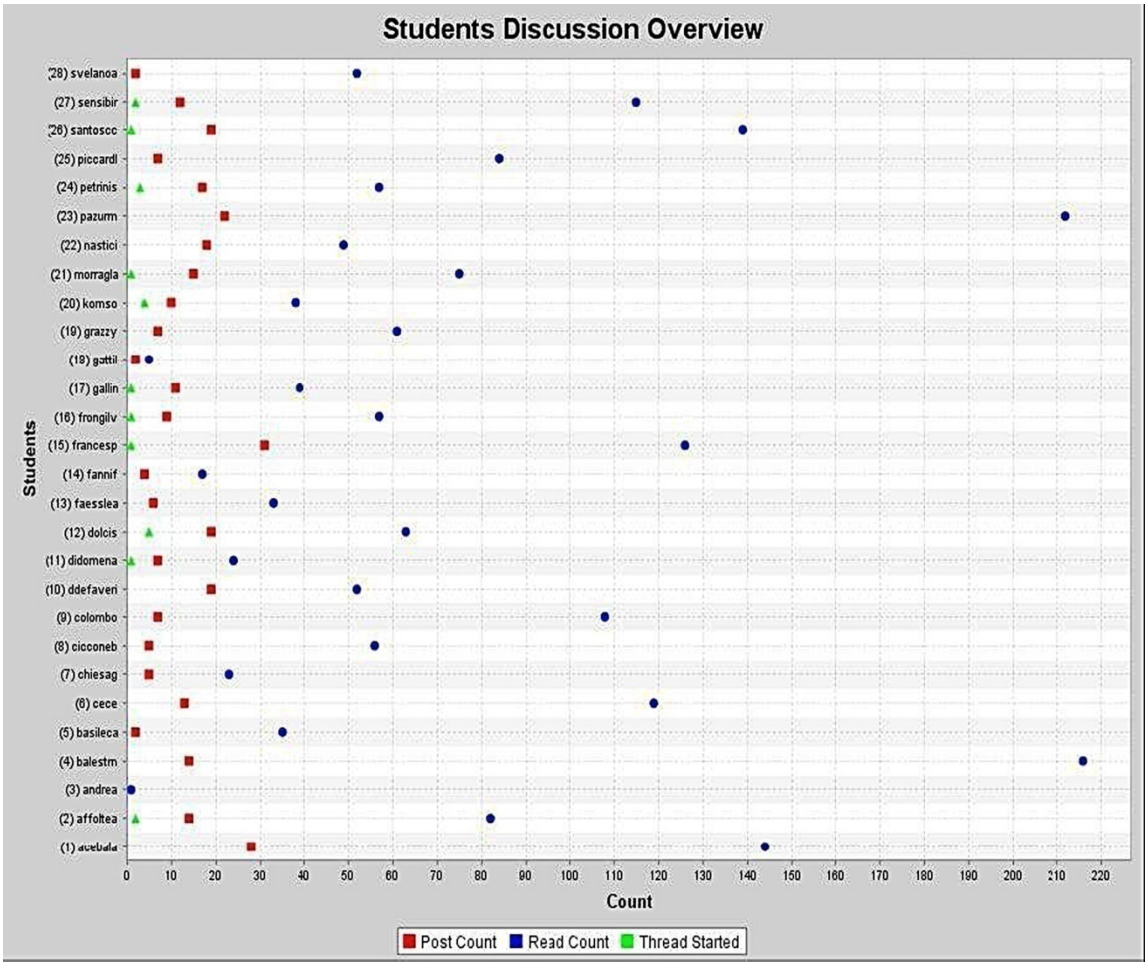


Figure 2.5: Representation of the Discussion on GISMO (Mazza & Botturi, 2007)

Figure 2.5 shows a chart which gives an overview of all the discussions in which students participated. For each student of the course it gives indications on the number of messages posted (with a square), number of messages read (with the circle) and the number of threads started by the student in the discussions (with the triangle). This representation can assist the teacher to grade the student based on their contributions.

iv. TOOL NAME – *CourseViz*
CATEGORY - *3D Temporal*

The use of information visualisation to facilitate instructors in distance learning lead to the development of CourseViz. (Mazza & Dimitrova, 2007). The representation gives information about the active and inactive participants. The cognitive aspect of learners is produced using representations of cognitive matrix and cognitive plot. The behavioural aspect is represented using a behavioural graph.

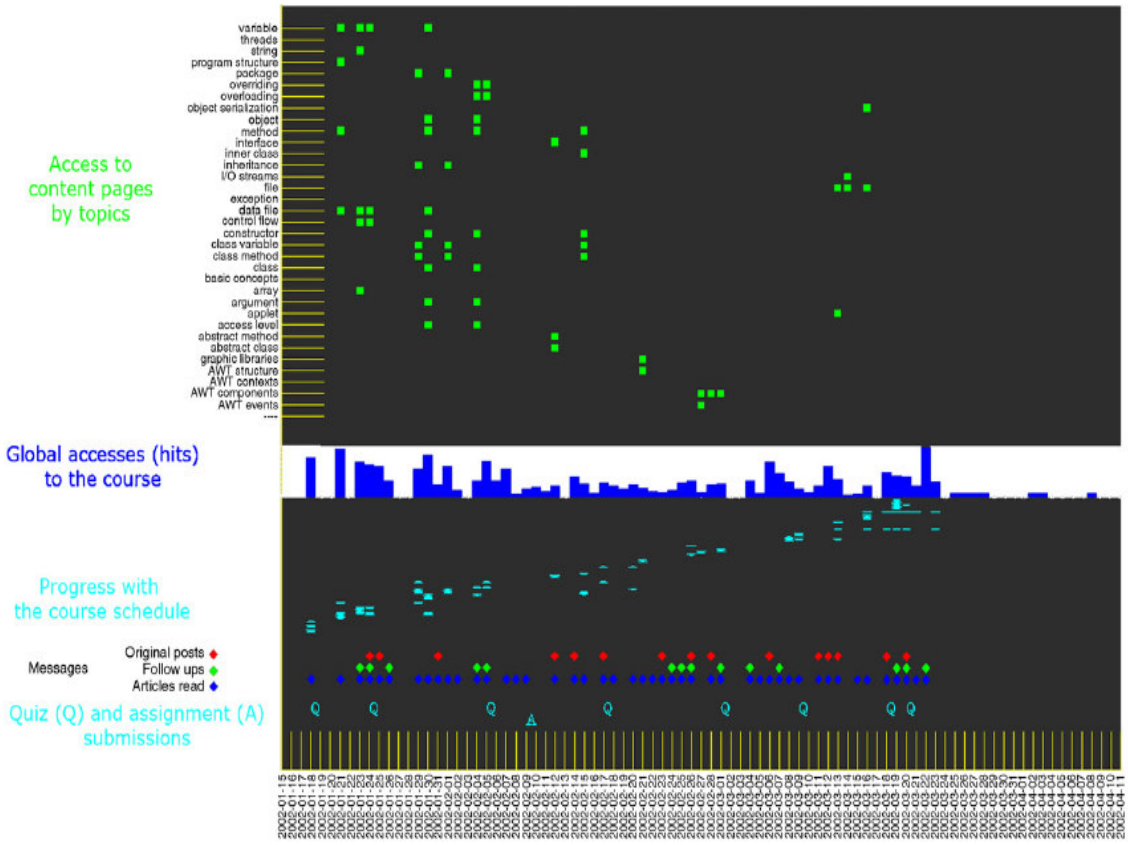


Figure 2.6: Representation of Student's Behavior Graph on CourseViz
(Mazza & Dimitrova, 2007)

The representation shown in Figure 2.6 includes dense information about a single student using the composition layout: access to the content pages, global accesses to the course, with the timeline, messages read, posted and replied to discussions represented by a diamond in different colours, and submission of quizzes and assignments.

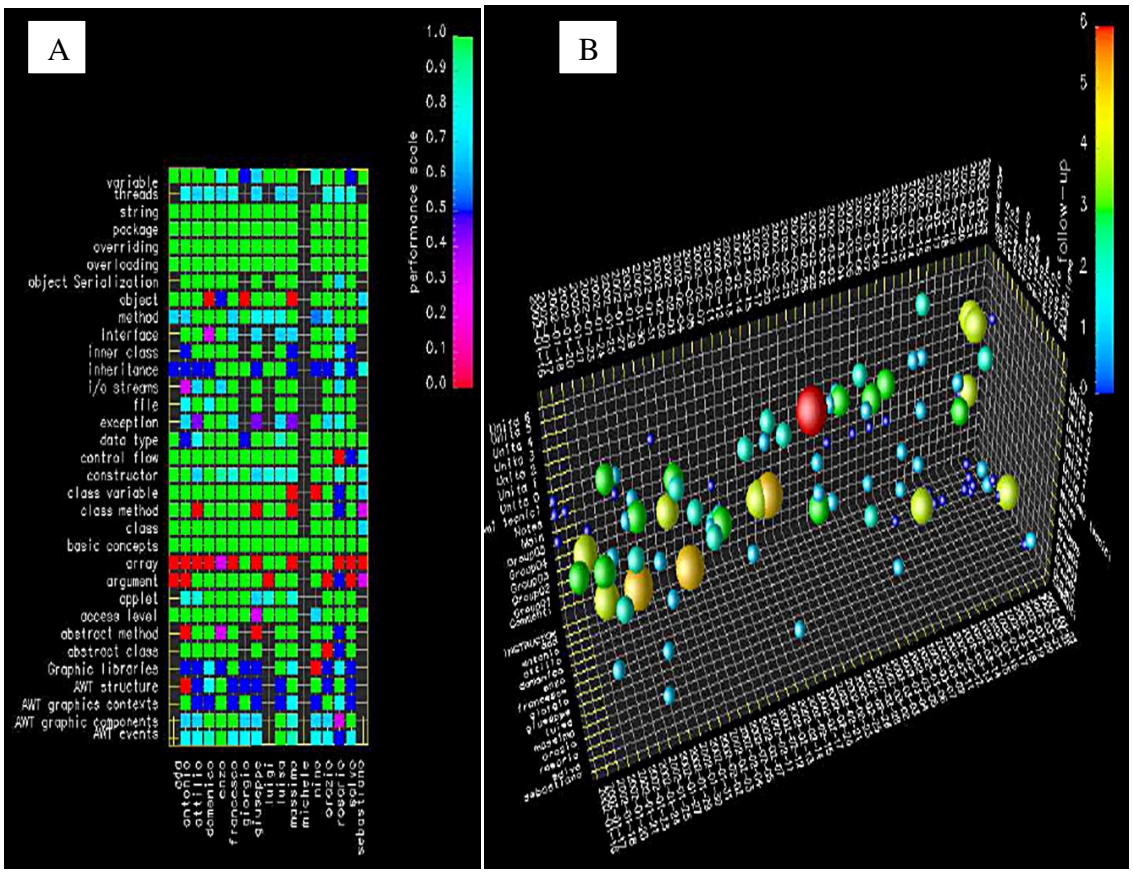


Figure 2.7: Representation of the Discussion on CourseViz
(Mazza & Dimitrova, 2007)

Figure 2.7A shows the cognitive matrix with a coloured cell meaning performance level of a student on a specific concept and a blank cell meaning that student has not done the relevant quizzes yet. Figure 2.7B presents the 3D plot displaying the discussion posts in conjunction with the 'topics', 'participants' and 'date of post' in different axes. The length of the discussion is indicated by the size and colour of the circle, which represents the post.

The evaluation of CourseVis carried out by Mazza & Dimitrova (2007) has shown that the representations it employs help instructors to quickly and more accurately grasp information about social, cognitive, and behavioural aspects of students.

This representation lacks the ability to visualise the conversation flow. It is difficult to view the 3rd dimension of the graph. The behavioural graph gives too much information making the graph look cumbersome.

v. TOOL NAME – *PieSpy*
CATEGORY - *2D Network*

Don & Stephan (2007) explain how a visualising application, when applied to the database of a Learning Management System (LMS), can provide a quick and accurate details of the discussion. PieSpy, an open source application, is used for gauging the effectiveness of online discussions. The visualisation reveals the structure of the social network, highlighting connectivity, clustering and strengths of relationships between users. The representation is simple, with different coloured nodes representing students and teachers and the lines connecting them representing the flow of messages. As more replies pass between two people, the "social bond" between them strengthens and they are drawn closer together. The strength of the bond is indicated by the weight of the line.

PieSpy produces a very simple illustration of the social network using a very simple algorithm. PieSpy can be referred to as a social network diagnosis tool only and doesn't give any details of the ongoing interaction.

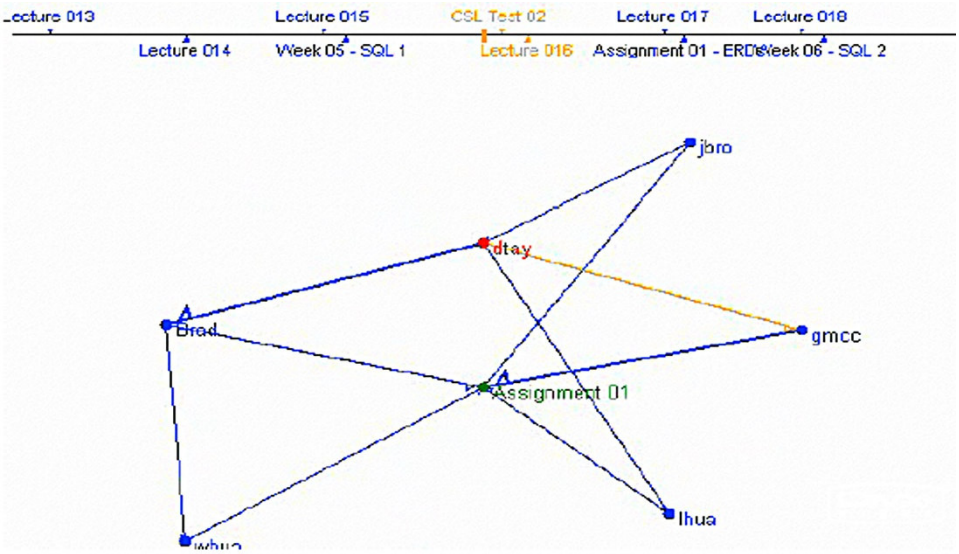


Figure 2.8: Central Thread with light Student Discussions on PieSpy (Don & Stephan, 2007)

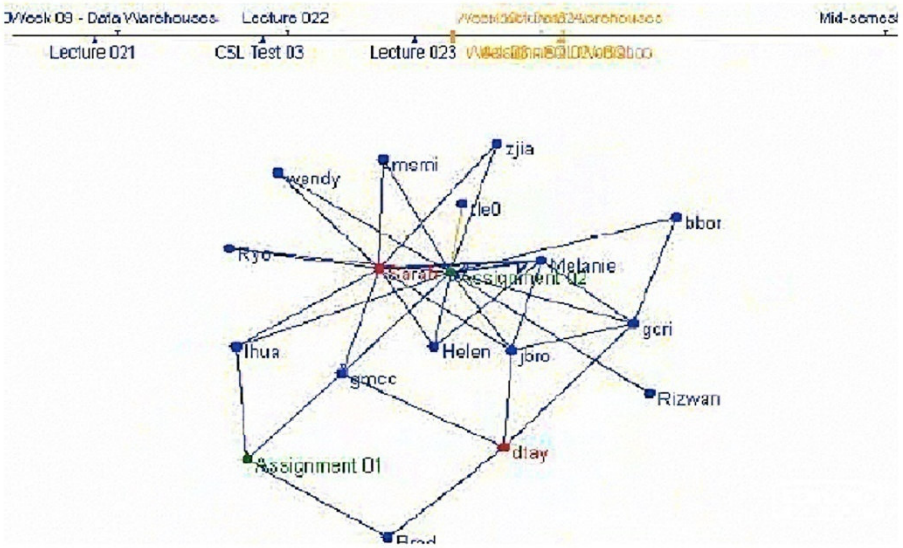


Figure 2.9: Diffused Discussion on PieSpy (Don & Stephan, 2007)

Figures 2.8 and 2.9 show the network of interactions. The timeline on the top gives when non-assessed activities start (lectures) or where assessed activities are due. The orange colour represents that the activity is within two days.

vi. TOOL NAME – *Representation through iGraph*
CATEGORY - *2D Network*

iGraph which is a graphical representation of interactions to obtain a descriptive image of forum participation, is another example of a visual tool, this time developed by Alvaro & Joanne (2007). They introduced a method based on numeric indicators and graph representation to interpret the behaviour of the participants. This graph consists of vertices representing actors and arcs representing the flow of information. The starter of the thread is placed at the centre and all the respondents are placed around. The 'Centrality Degree' which is defined as a count of the number of connections that an actor maintains with other actors is divided into input (the number of actors that respond to an actor) and output (the number of actors to which an actor replies) cases. The extent to which some actors contribute to the centralisation of a network, termed as 'Centralisation Index' is also divided into input and output cases, and expressed in percentage.

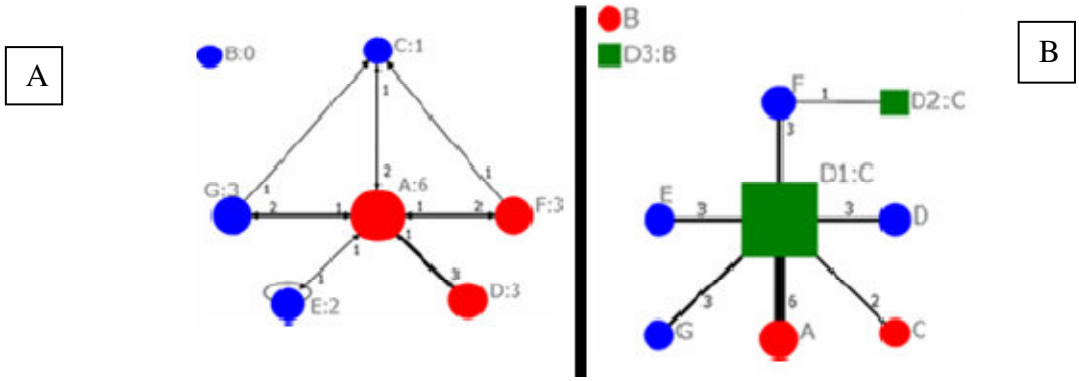


Figure 2.10: Interaction and Participation Graph in iGraph Interface
(Alvaro & Joanne, 2007)

Figure 2.10A illustrates the interactions between actors in a discussion forum and Figure 2.10B shows how actors participate in each discussion thread. In the interaction graph,

vertices are labelled with the corresponding actor; distinguished by colour, red for women and blue for men; the larger the vertex, the more replies sent by the actor.

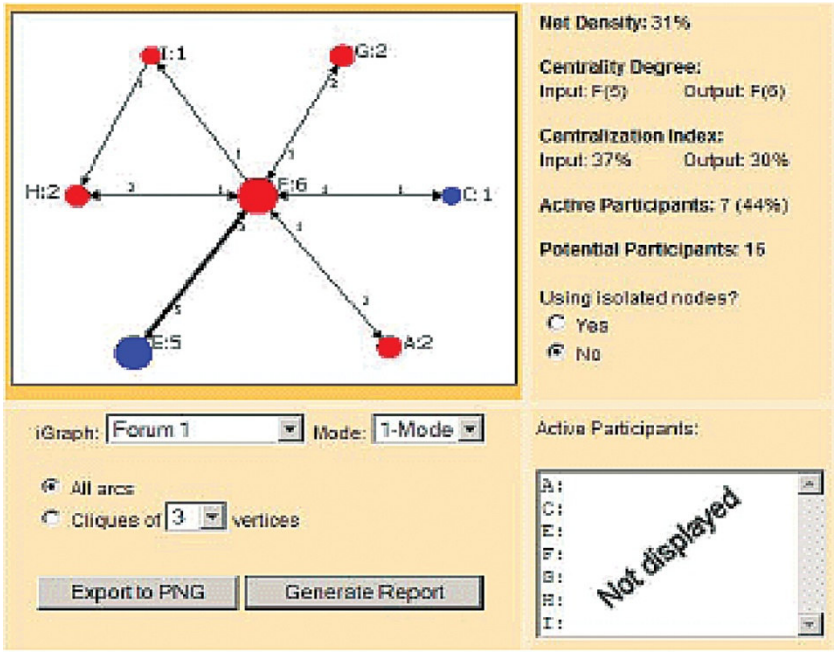


Figure 2.11: Interaction Graph as seen in the iGraph Interface
(Alvaro & Joanne, 2007)

Figure 2.11 displays the interaction graph as in the visualisation tool. It displays the intensity of the circulating information (net density), the incoming and the outgoing message percentage (centrality degree), centralisation index, total number of participants and the number of active participants.

The algorithm develops from a set of basic principles to improve readability and ease of understanding. The principles are:

- avoid overlapping

- information hubs placed at the centre
- minimise the crossing of edges and vertices
- equally spread dense net (vertices equally spaced in clockwise manner)

No further research has been done on iGraphs and hence the usability of this tool is not clearly defined. There are no indicators of lurkers and post quality.

vii. TOOL NAME – *MTRDS (Mapping Temporal Relations of Discussions Software)*
CATEGORY - *2D Temporal*

Gibbs (2006) produced his software MTRDS to assist analysis of the temporal aspects of online discussions. He represented the interaction in a way that could provide greater awareness of the communication dynamics. MTRDS generates a visual representation of discussions based on time and date.

Figure 2.12 represents the rendering of MTRDS map of a discussion, where the x and y axes denote the date and time respectively. The discussion posts are represented as a coded circles joined by arrows indicating the direction of the message flow. Such representations help in assessing the degree of participation in a particular time frame.

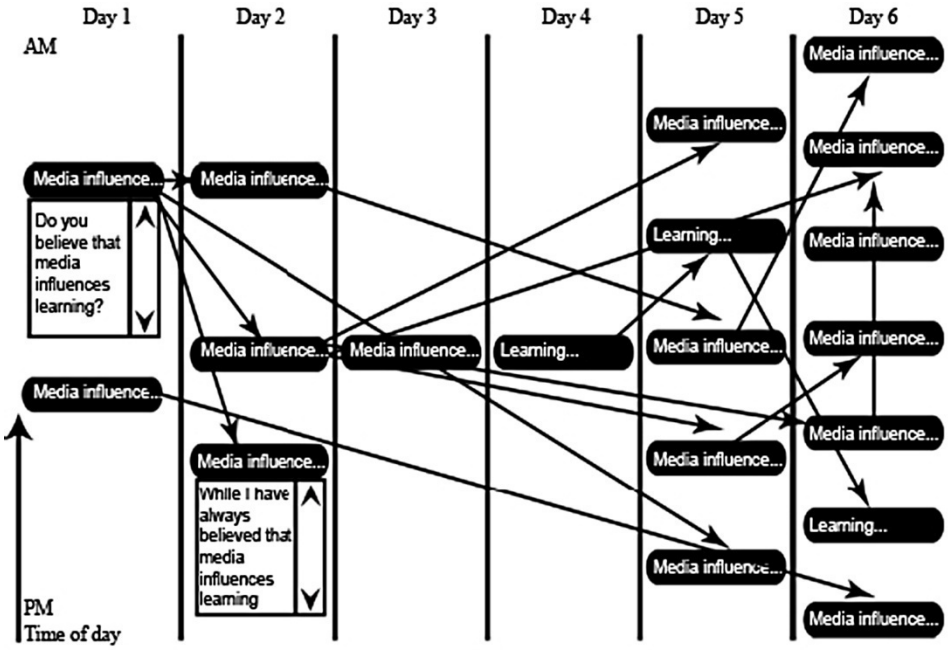


Figure 2.12: Rendering of MTRDS' map of Discussion (Gibbs, 2006)

MTRDS represents information spatial-temporal. It readily conveys information about interactivity (through node-links); thread dominance and development was indicated through colour-coding and structure of the visualisation; message continuity, sequencing, and ancestry can be identified through the map of the discussion; links between messages are identified by single arrow; and isolated messages represents disjoint communication indicated by colour-coding.

Only one week's (seven days) worth of messages display at a time. This number can be increased but the clarity of the map may be affected.

viii. TOOL NAME – *DBAT (Discussion Board Analysis Tool)*
CATEGORY – *2D Hierarchical/tree*

A formative assessment process of mapping discussions, to analyse group interaction, is done by Frey et al. (2006). A tree structure of interpretation was prototyped using simple Microsoft power point and Microsoft word documents. Each node represents a posting, identified by the initials of the student. Expanding the node gives the detailed posting of that student. Content analysis of the postings using Bloom's taxonomy (1956) was performed, to find the cognitive aspect of a particular learner. This research adds to the body of literature analysing online asynchronous discussions, particularly dealing with formative evaluation and analysis tools.

The results of the tests done using DBAT enabled the instructor to modify the questions and facilitation techniques, to engage students in higher level thinking skills.

No further study has been done on this representation. The analysis done ascertains that the results were not generalisable to a larger teaching population. Content analysis coding was not automated

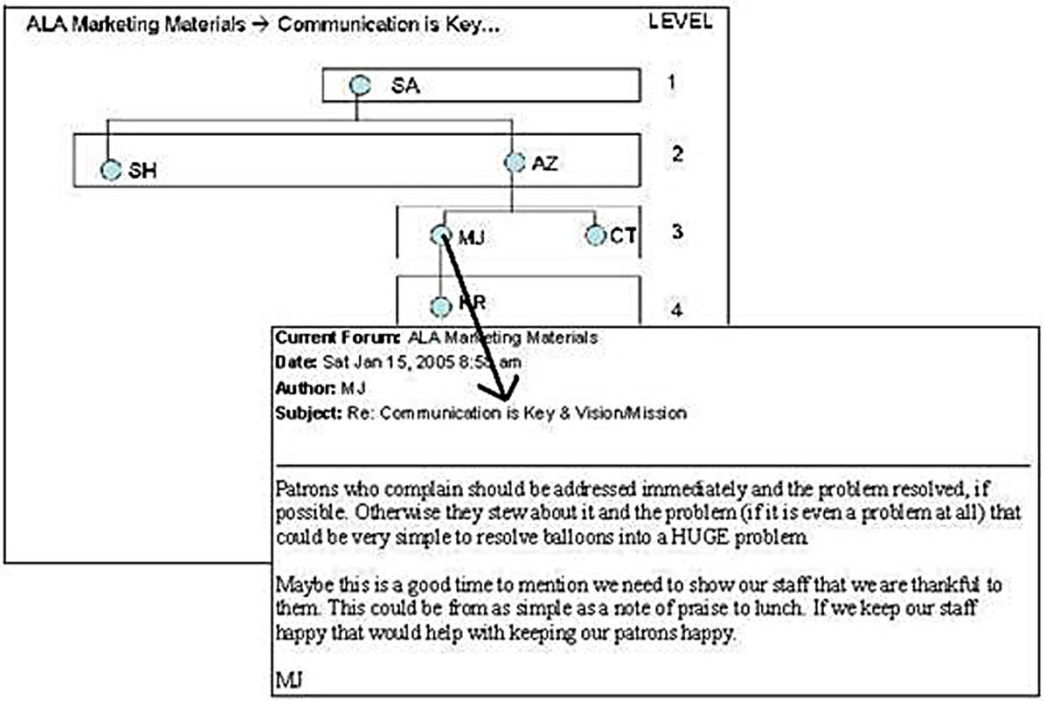


Figure 2.13: Levels within the Discussion Structure (DBAT)
(Frey et al., 2006)

Figure 2.13 shows the tree structure representation of the discussions. It also displays a message posted by one of the participants in the discussion along with the message details.

ix. TOOL NAME – *DIAS (Discussion Interaction Analysis System)*
CATEGORY - *2D Hierarchical/tree Network*

DIAS (Discussion Interaction Analysis System) is another software application for monitoring and analysing the interaction developed by Bratitsis & Dimitracopoulou (2006). The indicators in DIAS along with appropriate interpretation schema helps in drawing various conclusions related to the interactions among the learners. The main purpose of DIAS is to provide a range of indicators for analysis.

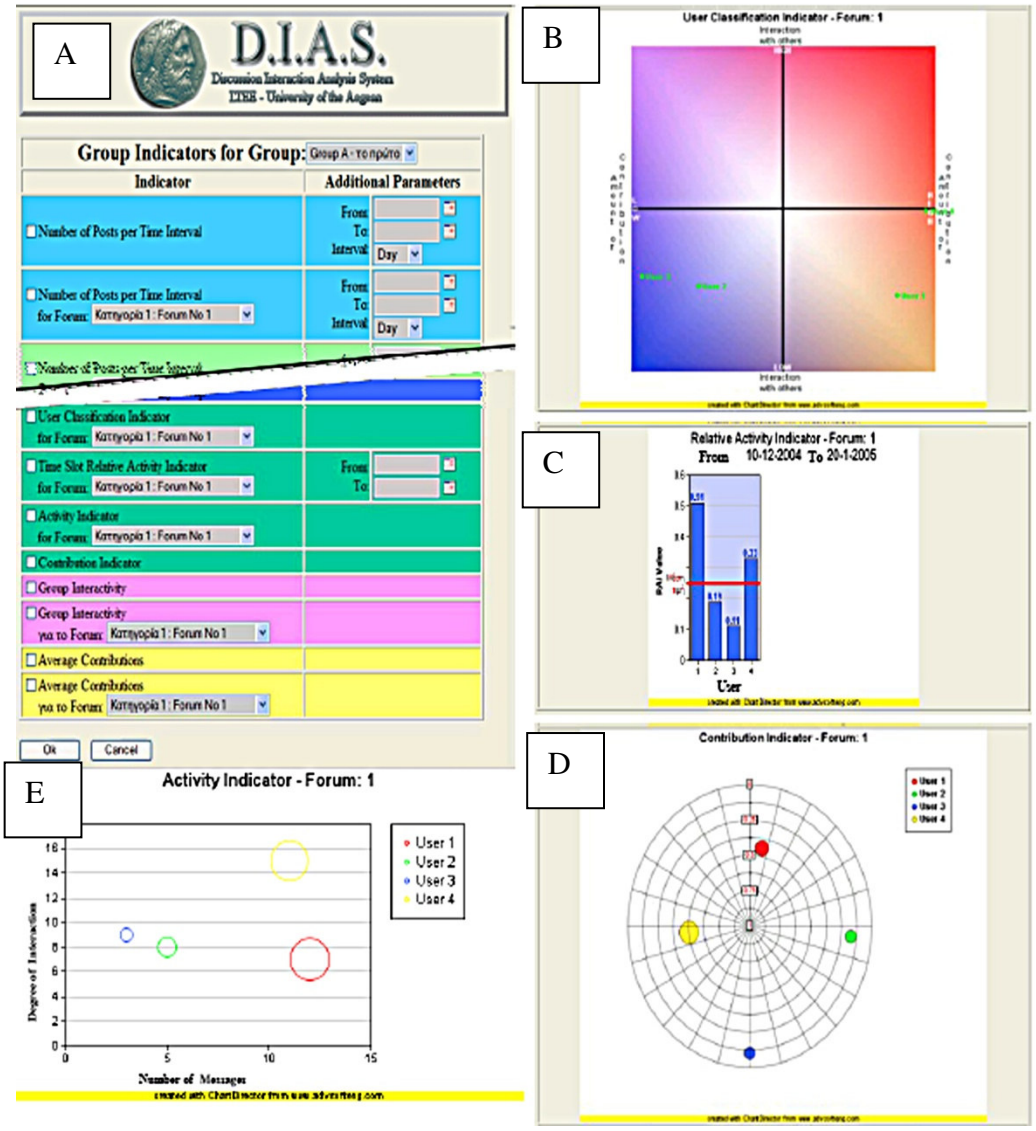


Figure 2.14: Interaction Analysis Indicators Visualised by DIAS (Bratitsis & Dimitracopoulou, 2006)

Figure 2.14 gives an idea of the overall display of information in different forms of a particular discussion visualised by DIAS tool. A detailed snapshot of all the individual elements of this image is displayed in Figure 2.15.

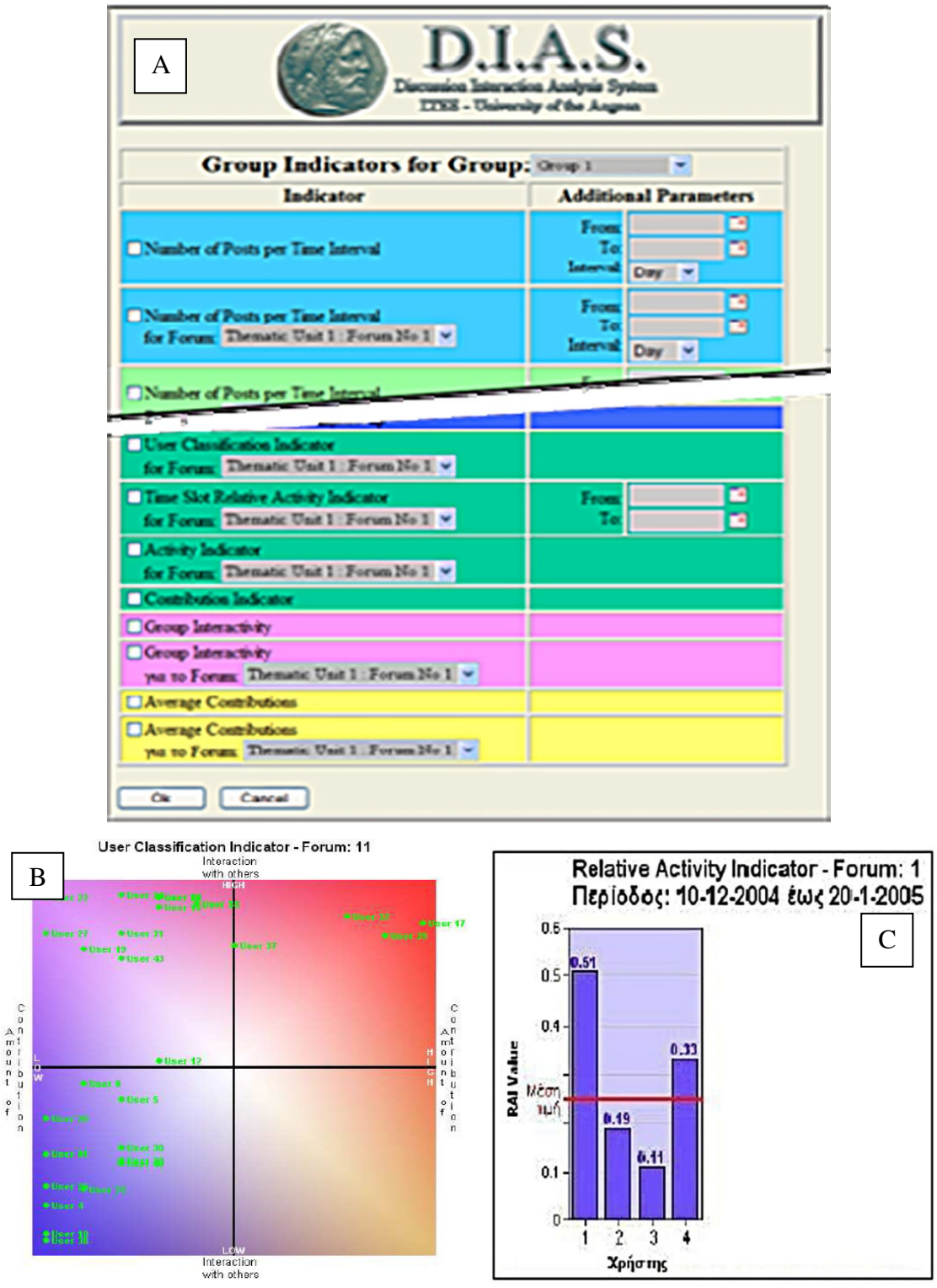


Figure 2.15 [A][B][C]: A Close-up View of all the Interaction Analysis Indicators (Bratitsis & Dimitracopoulou, 2006)

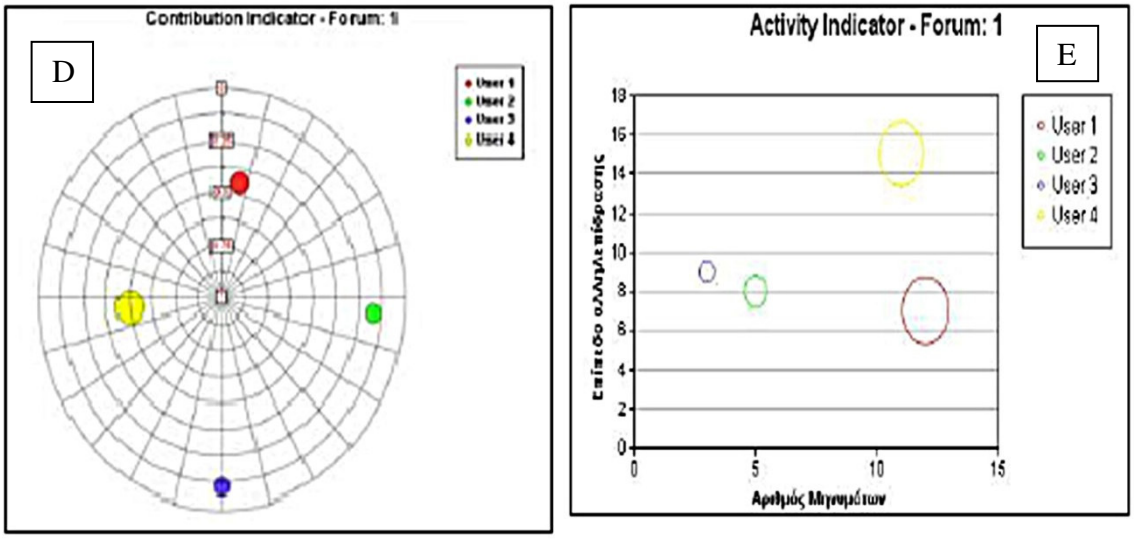


Figure 2.15 [D][E]: A Close-up View of all the Interaction Analysis Indicators (Bratitsis & Dimitracopoulou, 2006)

A 'user classification indicator' (Figure 2.14B) is an XY scatter plot representing the amount of contributions on the x-axis and the amount of interaction by the users on the y-axis. Relative Activity Indicator (Figure 2.14C) is a bar chart showing the activity of the users for the selected time duration as a percentage of the total activity. The contribution indicator (Figure 2.14D) is a polar chart containing bullets representing the various users. Activity Indicator (Figure 2.14E) is also an XY scatter chart showing the amount of contributions and the amount of messages read by other users. Figure 2.15[A][B][C][D][E] show the close up images of the indicators which gives analysis of four users.

The IA indicators of the discussion activity evolution focus on students' behaviour. It incorporates different views and detailed analysis.

A lot of quantitative analysis is done, but there is no indicator indicating the analysis of learning. There is no representation of the conversation flow.

x. TOOL NAME – *BulB (Bulletin Board Visualisation Tool)*
CATEGORY – *2D Network*

Mohamed et al. (2004) designed an architecture which visualises and examines the development of conversations within a bulletin board. The visualisation enables users to assess current levels of activity across threads and observes the growth of conversation. There are three separate visualisations within BulB:

- Temporal thread development (Figure 2.16A)
- User thread participation (Figure 2.16B)
- Timeline (Figure 2.16C)

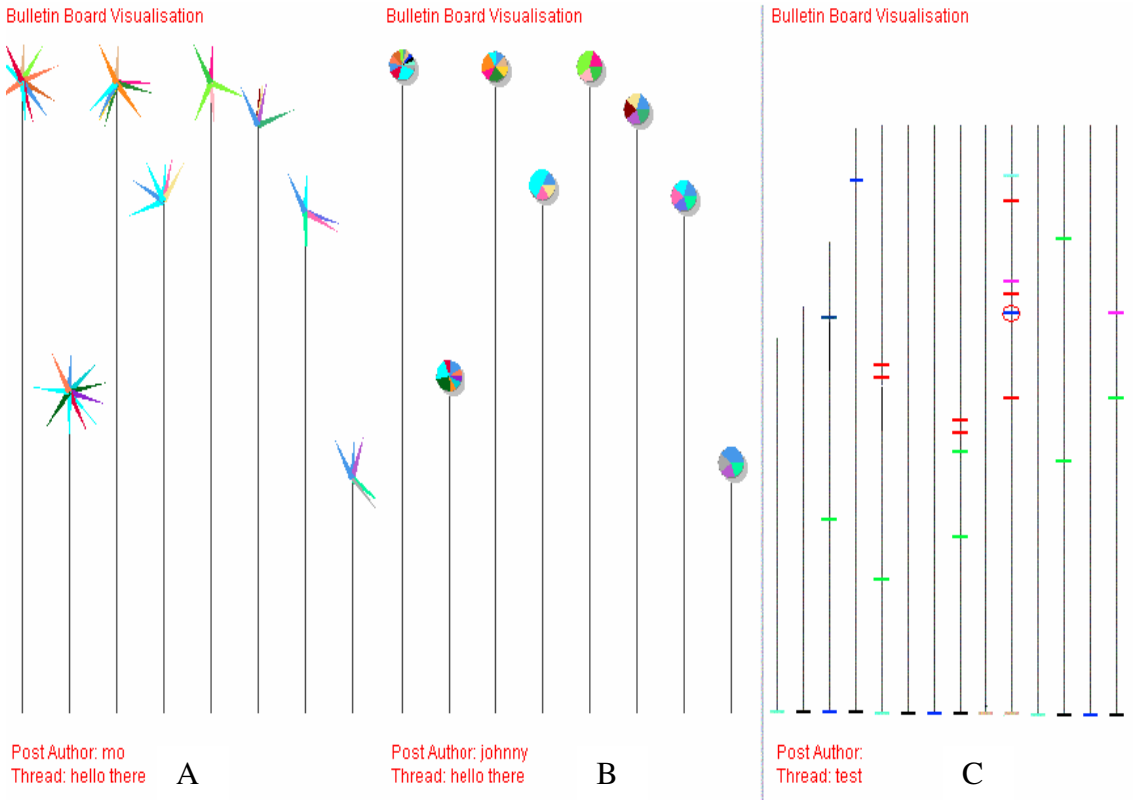


Figure 2.16: Sample BulB Visualisations (Mohamed et al., 2004)

BulB visualisations give an easy way to see which threads have been active longest by the length of each stalk. The visualisation also easily identifies the distribution of individual posting and the frequent contributors across multiple threads within the visualisations

The conversation flow is not visualised with this tool. No further research was done on this tool so it is difficult to draw significant conclusions as to its effectiveness.

xi. TOOL NAME – *Babble*
CATEGORY – *2D Temporal*

Babble, introduced by Erickson et al. (2002) is an online conversation area that enables visual feedback of the usage patterns of the online participants and their activities. People are shown as dots within a circle. The position of the dots changes according to the activity level of the person engaged in the conversation.

Visualisation called a social proxy uses a large circle to represent the conversation, and coloured dots to represent individuals. A dot inside the circle represents a user who is "in" the displayed conversation indicating the user's presence; a dot outside the circle is in some other conversation. The rapid movement of the dot towards and away from the hub represents active and inactive interactions of the user. In the Figure 2.17, five participants have recently "spoken" or "listened," two have been idle, and one is in a different conversation.

Babble on the whole visualises only the online activity of an asynchronous discussion. It does not indicate any details of the conversation.

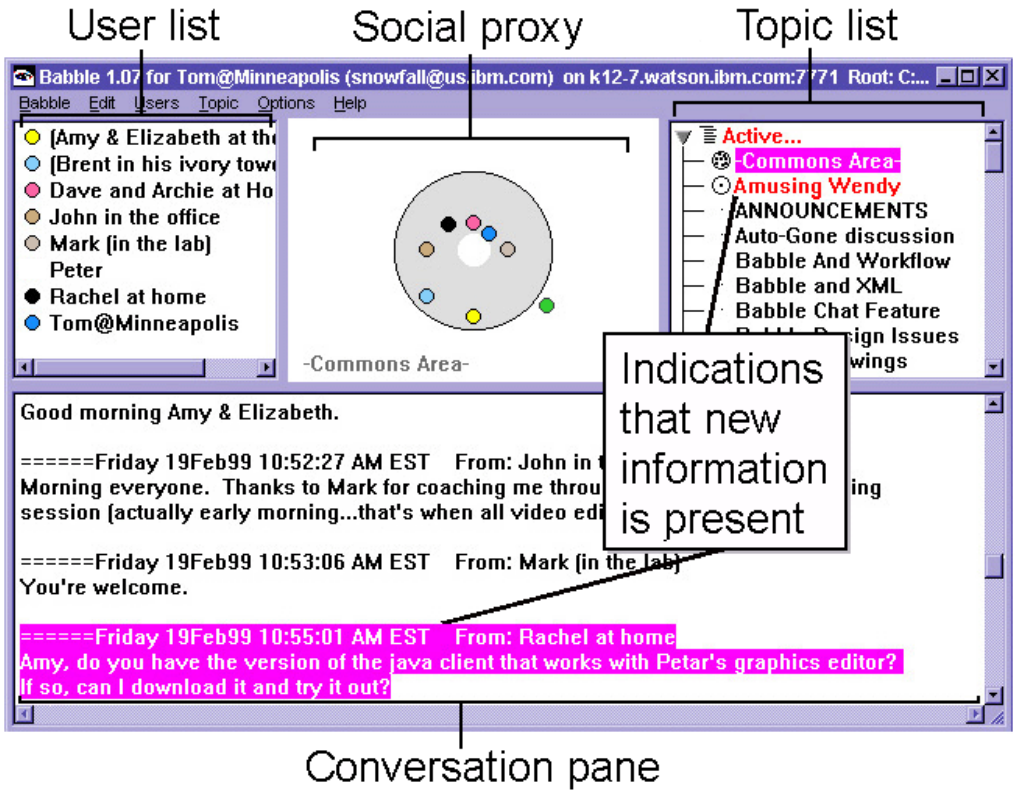


Figure 2.17: Visualisation in Babble (Erickson et al., 2002)

xii. TOOL NAME – *Seascape and Volcano*
CATEGORY – *2D Temporal*

Seascape and Volcano was proposed to explore large-scale discussion visualisation by Lam and Donath (2005).

Seascape (Figure 2.18) visualises a newsgroup as a sea of threads, where each is a square particle varying in size which propagates in the path of a sine wave. How fast the particle moves along the wave (velocity) shows how active the thread is.

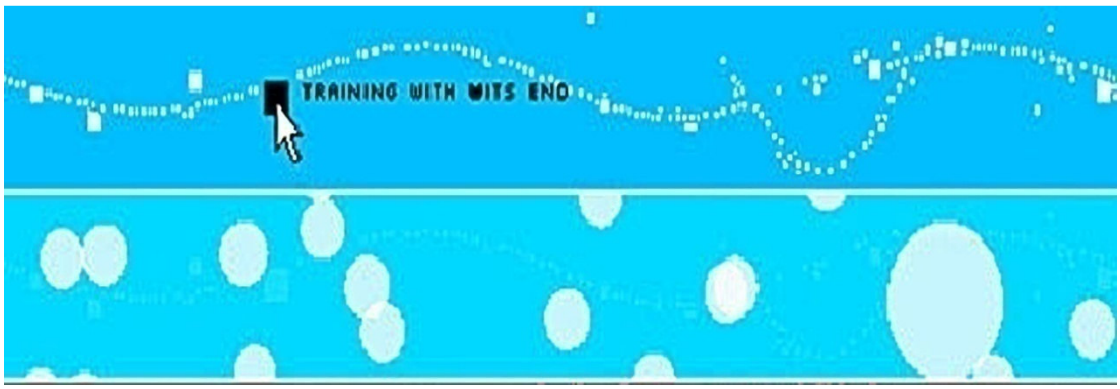


Figure 2.18: Seascape Representation of an Animated Group
(Lam & Donath, 2005)

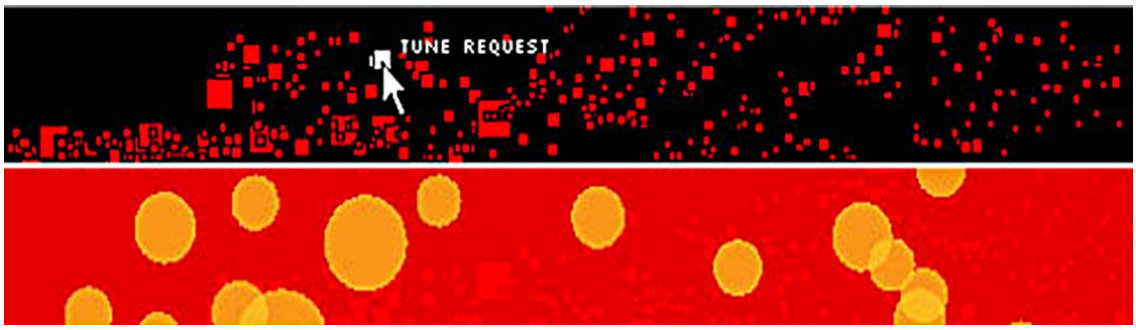


Figure 2.19: Volcanic Representation of an Animated Group
(Lam & Donath, 2005)

Volcano (Figure 2.19) employs motion loops only in the vertical axis. A newsgroup is represented by a collection of square particles ejected from the ground. Similar to the former interface, they represent threads. The speed of the bouncing particles denotes the activeness of the group while the vertical height shows the recentness of the group.

The study showed that most users thought that the interface is fairly easy to use. They could navigate well between the group and the thread views.

This innovative approach lacks a representation of the conversation flow and does not detail the pattern of interaction The visualisation provides the user only a sense of social structures and quantitative characteristics of the group.

xiii. TOOL NAME –*Netscan*

CATEGORY - *2D Hierarchical/tree Network*

Mark & Andrew (2001), describe a collection of visualisation components that illustrate patterns of activity and conversational structure (Figure 2.19). Netscan illustrates the structure of the message threads, temporal activity of the author and the roles of the author within the thread.

This tool has several additional graphic indicators and interactive behaviours that enhance the basic tree. A tree map approach reveals the dense, detailed hierarchical structure of Usenet.

A problem associated with this visualisation is that the number of gray bands that represent calendar days on which messages are posted during the thread's lifetime will increase whenever a message posted on a date that is not included in the current visualisation. As a result of these new bands the shape of the presentation of the thread tree may be different in different runs. It gives the structure of just one thread at a time, with the message that begins the thread, placed at the top.

The visualisation dashboard uses a tree map approach as a first component to present the structure and history of the selected thread and maximum depth and breadth of the thread (Figure 2.20A). The piano roll component (Figure 2.20B), displays a list of all the posters in the selected thread. The third component, the interpersonal connection component (Figure 2.20C) displays a sociogram of the interaction. This also includes a textual pane that identifies the selected newsgroup and reports the thread's subject line, start - end dates and number of active days within that period, total number of messages and authors (Figure 2.20D).

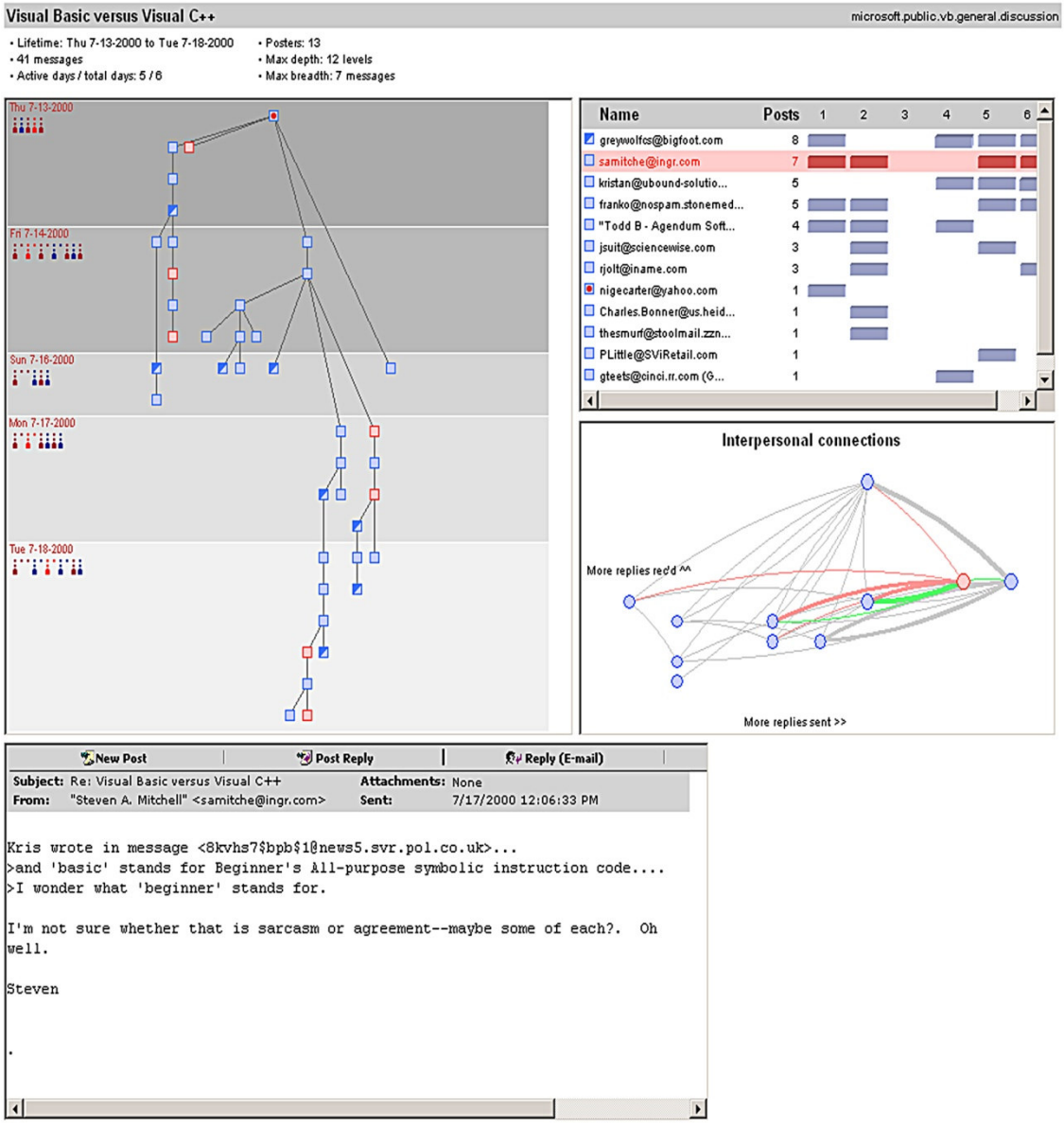
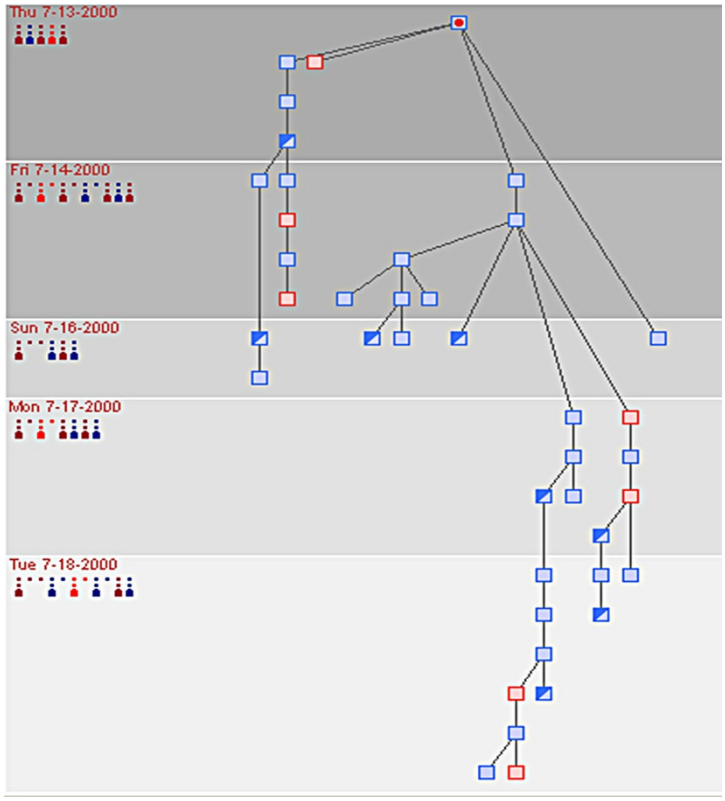


Figure 2.20: The Netscan with the Thread tree, Piano roll, Sociogram views, Message display (Mark & Andrew, 2001)

A



B

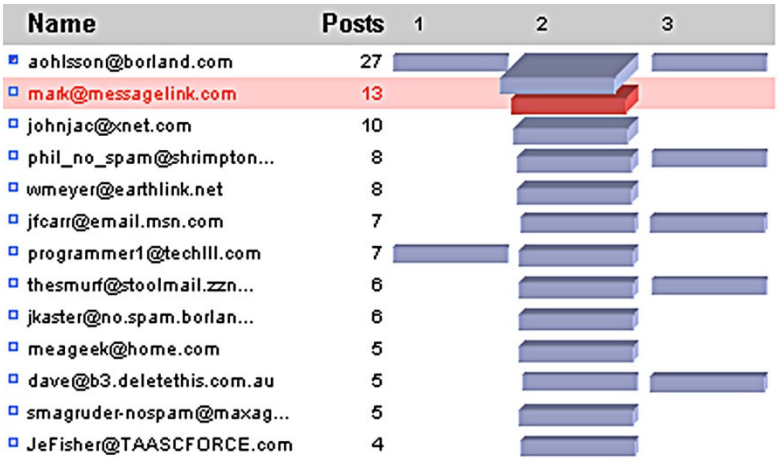


Figure 2.21[A][B]: Representations of the Close-up Views of Netscan (Mark & Andrew, 2001)

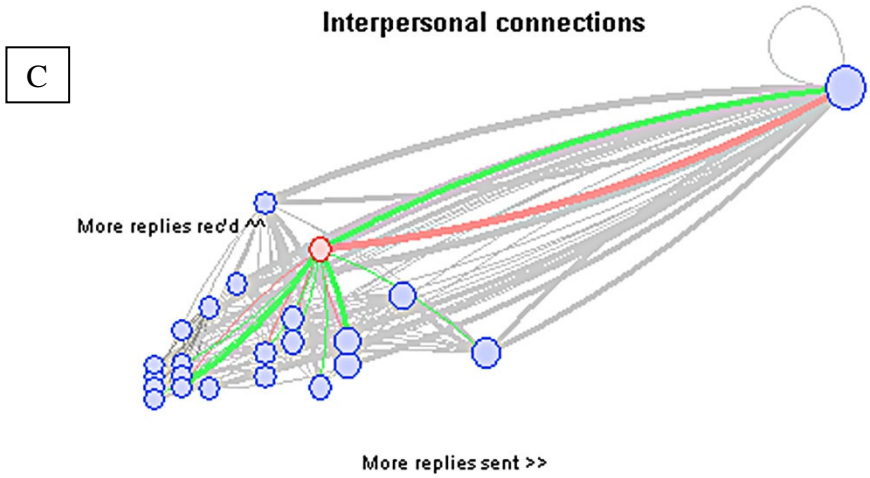


Figure 2.21[C]: Representations of the Close-up Views of Netscan
(Mark & Andrew, 2001)

Figure 2.21 gives a clearer view of all the representations of Netscan. Figure 2.21A reveals the Netscan thread tree. The gray bands represent the calendar days on which the messages are posted. The representation also gives information of the number of posts posted by a poster, with the number of posters each day at the left corner of the tree structure (1). It also gives information of the post quantity (2). Figure 2.21B gives the ranked list of the authors by their total activity. Figure 2.21C displays the authors in the thread and an indication of the quantity of the posts replied to and posted by the author.

2.4 Discussion

The list of visualisation tools is almost unlimited. There are PeopleGarden (Donath, 2002), Loom (Boyd et. al, 2002), WebFan (Xiong & Brittain, 1999) and many more innovative representations of online asynchronous discussions. All of these tools mentioned in this chapter are different and have their own advantages and disadvantages. Almost all of them will generate visualisations of a single discussion thread or a single participant interaction. However, when generated to show chains of messages, they become unclear and cluttered. Most visualisation tools depict crosslink (cluttering) when

describing the message chains. There would either be an overlap in the nodes representing the participants or there would be arcs denoting the flow of messages, crossing one over the other. Crosslink and/or cluttering usually occur as the data to represent the ongoing interaction increases. One of the important challenges of the concept of visualisation is to present as much information as possible in a given display area without overloading it. Having reviewed thoroughly the existing tools, we argue that this challenge has not yet been met with any of those tools developed so far.

A further issue with visualisation tools is their inconsistency in their tool in terms of the criteria or 'indicators' they use in order to produce visual representations of data. The next section details important indicators, many of which were overlooked by the above researchers, to be visualised by an interaction mapping visual tool to help the moderators/teachers draw conclusions about online discussions.

2.5 Important Indicators (attributes/units of analysis) for Analysis

In one paper May (2007) states that the traces of the learners' activities are meant to be a source of information that reveals not only their activities but also various results of those activities that the learners carried through. Donath et. al (1999) revealed that the information derived from these interactions helps learners and moderators review their own behaviour and that of others. By analysing the traces in the collaborative learning environments, moderators could evaluate the social and cognitive aspects of the learners. Evidence of a similar approach can be found in research works of Riccardo & Dimitrova (2003), where the teachers/moderators could view the three main aspects of online learners: social, behavioural and cognitive.

Interaction can be synchronous, asynchronous or mixed. It is important to find the mode of communication as a study by Hrastinski (2008) discovers that each supports different

purposes. He concluded that asynchronous communication involves more cognitive participation since it gives time for reflection and synchronous communication involves more personal participation as it consists of intense interaction. For most researchers, (Price & Lapham, 2003; Bolloju & Davison, 2003) the asynchronous interactions in any online distance learning courses are original (Gunawardena et al., 1997), structured and commonly used environment for analysing, monitoring and understanding the nature of the interactions and then predicting students' behaviour. Asynchronous discussion offers the advantage that students can participate whenever is convenient for them (Frey et al., 2006; Garrison et al., 2001). This improves the quality of the discussions. Researchers list numerous benefits to asynchronous discussion (Baker, 1999; Bolloju & Davison, 2003; Hew et al., 2009): active student participation in their own time, shy students may be less intimidated to participate, no student dominance, improvement of student writing skills and an increase in the quality of student discussions through reflection. All these combine to improve the learning process. From a research perspective (Baker, 1999; Hew et al., 2009), asynchronous communication is ready-made for historical analysis. Many online courses use discussion boards for their communication and participation so they can have an archive of student interaction (Meyer, 2004). This collection of the ongoing online discussion can be used quickly, to find out if the discussions between the students were subject-related or just casual conversations that arose throughout the course. Furthermore, the archives serve as a historical record of the development of the online interaction between students (Baker, 1999; Hew et al., 2009).

Whatever kind of interaction, some attributes/units of analysis/indicators can be easily found which help in predicting the behaviour and quality of interactions. Henri (1991) proposed that electronic communication could be analysed through five dimensions: participative, social, interactive, cognitive & depth of processing and metacognitive & knowledge. The proposed dimensions of previous research on the whole are collaboration, participation, social, behavioural, interactive, cognitive and metacognitive aspects. The collaboration and behavioural aspects were not identified by Henri but were

identified later. These aspects, which the above researchers felt needed to be analysed in a visual tool, are described in the comparison in Table 2.1. Note that the VIMS system proposed in this thesis is designed specifically to also address all the aspects that prior researchers felt was important, but all in a single application, and with the added function of being able to represent when a moderator was involved in a conversation. This final aspect opens up all possibilities in terms of how a group of students evolve in a discussion both in the presence and absence of moderation.

Table 2.1 Classification of Indicators for Visualising Interactions for various Visualisation Tools

Indicators / Tools	Change in Subject title (Column-1)	Type of Interaction (Column-2)	Quantitative Method (Column-3)	Participation Level (Column-4)	Social Interaction (Column-5)	Qualitative Method (Content analysis) (Column-6)	Cognitive Presence (Critical Thinking) (Column-7)	Lurkers (Column-8)	Participant Details (Column-9)	Time Duration indication (Column-10)	Presence of a moderator (Column-11)
TrAVis (Tracking Data Analysis and Visualisation)			✓	✓				✓	✓	✓	
Authorline Visualisation			✓	✓	✓	✓					
GISMO			✓	✓	✓	✓	✓				
CourseViz			✓	✓	✓	✓	✓			✓	✓
PieSpy			✓	✓	✓						
Representation through iGraph			✓	✓	✓						
MTRDS (Mapping Temporal Relations of Discussions Software)			✓	✓	✓					✓	
DBAT (Discussion Board Analysis Tool)					✓	✓	✓		✓		
DIAS (Discussion Interaction Analysis System)			✓	✓	✓					✓	
BulB			✓		✓					✓	
Babble				✓							
Seascape and Valcano				✓	✓					✓	
The Netscan				✓	✓				✓		

- Prominently seen indicators - Other indicators - Important indicators ignored by current tools

2.5.1 Classification of Indicators for various visual tools

1. ***Change in the Subject title*** (Table 2.1, Column-1): Change in the title of the subject while responding to a message might mislead the respondents replying to the earlier posts. This might lead the conversation in some other direction and hence we would see the conversation going off-topic. Some of the participants might not be sure of what the discussion is all about because of the change in the subject line in the middle of the conversation flow and so can lessen the likelihood of more responses. Staying on topic and keeping the conversation focussed during a discussion is important as it discourages participants from posting irrelevant and unrelated messages and preserves the thread. This would make the online discussions more meaningful and increases the learner's interest and the quality of discussion (Cantor, 1992). Teachers should be made aware that the students responding to the claims and arguments should be relevant to the claims and arguments made by the starter. The quality of speech (in virtual interaction - a written one) is judged by the organisation of the relevant information.

2. ***Type of interaction*** (Table 2.1, Column-2): According to Henri's model (1992), contributions to online discussions can be classified as explicit, implicit, or independent. Explicit interactions can be a response to someone's message where the reply message would address it particularly to the poster by the mention of their name. Implicit interaction is a response to the prior message, but without specifically mentioning the connection (Hara et al., 2000). Explicit interactions are always a first step in bonding with the participants. It gives importance to the participant who is referred to in the message. The teacher, having knowledge of explicit and implicit interaction can advise the students to be more explicit when conversing, especially when there is a group discussion or discussion between students of different places.

3. ***Method of Analysis*** (Table 2.1, Column-3 & Column-6): Research has suggested that student participation is necessary and important in an online environment to foster a collaborative online community (Scheuermann et al., 2003; Morris et al., 2005). To facilitate and develop this collaborative online community a detailed analysis of the forum threads and postings, quantitatively and qualitatively, yield much better results (Gunawardena et al., 1997). This analysis helps an educationalist to evaluate the student involvement and nature of the interaction and later helps them to monitor and intervene in their online communication (Mazzolini & Maddison, 2003; Heo & Breuleux, 2009).

Quantitative analysis involves measurable aspects such as number of messages sent and by whom, number and time of logons, number of threads, number of replies, time of posting and word count of the message posted (Mazzolini & Maddison, 2003; Monroe, 2003; Frey et al., 2006). This analysis is done to provide indications and alerts to the teachers and moderators (Gerosa et al., 2005) in facilitating their tasks during the learning activity. It also helps to improve the quality of the interaction (Mazza & Milani, 2005). In their study, Dringus & Ellis (2009) used qualitative analysis to address three goals: to determine if momentum (vitality of the discussion) or wellness of a discussion (indicated by an index) is evident and when any topic discussion notably reaches a natural stopping point or conclusion, to determine notable spikes (i.e., peaks and valleys) in a discussion flow; to reveal any significant patterns in a discussion. Quantitative procedures include participation and interaction rates (Pena-Shaff, 2009).

Qualitative analysis involves detailed analysis of the messages posted and this gives a deeper understanding of the messages and the discussion (Meyer, 2004). Qualitative analysis usually implies content analysis which is used to assess the quality of the interaction and the quality of the learning experience (Gunawardena et al., 1997). Dringus & Ellis (2009) used qualitative examination of the transcripts to determine

when the spikes (i.e., peaks and valleys) occurred. According to Wozniak (2006), this analysis is used to consider student reflections both before and after participating in the discussions. Qualitative procedures analyse patterns of interaction and knowledge construction (Pena-Shaff, 2009).

4. ***Participation Level*** (Table 2.1, Column-4): In the case of a virtual community, participation, both social and academic, is integral (Misanchuk & Anderson, 2001). Without active participation in discussions and other class activities, the learner is not part of the community. The definition of participation level in the discussion forum is the number of 'student posted messages' or number of posts, number of participants, etc. (Gibbs, 2006; Yeo & Quek, 2008). The participation level is evaluated to find out:

   a) if the observed online discussions are interactive or monologue (Chen, 2005; Gibbs, 2006)

   b) the rate and length of each response (reflectiveness) (Chen, 2005).

5. ***Social Interaction*** (Table 2.1, Column-5): Social interactions create a sense of community. To find out if the interaction was a social conversation content analysis is needed. For online learners, social presence is the feeling of community experienced in their online environment. Thus social presence is a key interpreter for the effectiveness of an online community (Tu & McIsaac, 2002). The degree of social presence is dependent upon the communication technology and the individual learner's perception of CMC technology (Tu & McIsaac, 2002). Research has also explored whether social interaction leads to the building of a successful collaborative online learning community (Nichani, 2000; Jianfei et al., 2008). The benefits for learners through social interaction include: improved learning strategies, greater perseverance, and reduced need for help from the instructor (Shank, 2004).

6. ***Cognitive Presence / Learning (Critical Thinking)*** (Table 2.1, Column-7): The main objective of this area of research in online interaction is to change an online environment into a collaborative online learning environment. Researchers have studied the process of writing and discussing online, (Newman et al., 1997) and the quantity and quality of postings in online discussions along with the role the instructor plays (Jiang & Ting, 2000; Walker, 2005) in encouraging reflection and promoting a higher-level learning. Higher levels of interaction in asynchronous discussions are needed to encourage learners to think critically. Garrison et al. (2001) suggests that cognitive presence can be created and supported in an online environment with appropriate teaching and social presence. Walker (2005) supports the statement made by Garrison and concludes that, when learners are able to collaborate in a socially interactive constructivist environment, they will be able to develop their critical thinking skills. Bloom (1956) illustrated six levels for higher order of cognitive processing and suggested that engagement in higher levels would agree to greater transfer of learning.

7. ***Lurkers*** (Table 2.1, Column-8): When analysing online interactions, the researchers not only analyse the participants involved in the online community but also examine those members of the community who are silent and passive during the process of communication online. Such participants who contribute little to make the online community an active, collaborative online community are termed as “lurkers” (Chen, 2004). Chen has also stated that lurking behaviour implies a lack of responsibility and minimal participation. Lazar & Preece (2002), feel that lurking should be encouraged as it is a different form of communication and avoids wastage of bandwidth. While this may be a very minor consideration in the developed world, bandwidth issues are still of major concern in developing economies or in territories where geographical considerations limit connectivity. Wozniak (2006) also agrees and states that both active and passive participants contribute to the learning outcomes and suggests that lurking could have a positive impact on learning in online discussions. Conversely,

researchers who are focusing on and studying the fostering of a collaborative online community disagree on the importance given to lurkers and lurking and state that lack of posting diminishes online activity (Johnson, 2007; Schults & Beach, 2004). It has been shown that a student who is actively involved has a greater learning potential compared to a passive learner (Webb et al., 2004). A positive association between students' participation in discussion forums and learning outcomes has also been shown in recent studies (Johnson, 2007). These studies confirm to the educators their perception that activity on the discussion forum improved the students' learning.

8. ***Participant details*** (Table 2.1, Column-9): Participants are individuals involved in the online interactions. Participants in an educationalist's view are students or learners. The participants can include moderator or teacher or instructor if the interaction is instructor-centered. Thus participants may have one or more roles depending on the attributes that could be identified (Bharadwaj & Reddy, 2003). Participant details give the moderators and the teachers, information about the participants involved in the online community. Consequently, two types of profiles exist (Abik & Ajhoun, 2009): The learner profile that gathers information about the learner, such as learning style, preferences and knowledge, and the group profile that gathers information about the group of learners such as group preferences and the type of group interaction. The personal information of the learner such as age and gender and the information relating to the learner's socio-cultural contexts (culture, languages, etc.) constitute their individual details. Cognitive function in some way determines the individual differences including the social background (Abik & Ajhoun, 2009).

9. ***Time Duration Indication*** (Table 2.1, Column-10): Time duration or time gap refers to the difference in the time of two successive postings in an online interaction. This gives the time duration between two successive conversations (May et al., 2007). Meyer (2003) noted the use of time as an important element in understanding the effectiveness of threaded discussions. The progress of a discussion over a period of

time in asynchronous discussions (Dringus & Ellis, 2005) is a concern as the interaction and participation happens irrespective of time and place (Frey et al., 2006). According to Dringus & Ellis (2009), there are transitions in the interaction patterns, due to the dynamic flow of interaction over time and the time indicators actually reveal these transitions (intensity and latency) in duration patterns and irregularities of the postings.

10. ***Presence of a Moderator*** (Table 2.1, Column-11): The role of a moderator plays a vital role in the asynchronous collaborative online community by encouraging, responding, starting discussions without any delay and assessing the efficiency of the online activity. Presence of a moderator indicates if the interaction was an instructor-centered interaction. It was suggested by Schrire (2004) that synergistic-instructor-centered interactions revealed a higher percentage of critical thinking (cognition). Some practical intervention enhances an online environment to become a collaborative learning community. It was also shown by Pawan et al. (2003) that the presence and participation of the instructor in the interaction centralizes the interaction pattern. It meant that the students would immediately reply to the posts and would not deviate from the subject. It would also mean that off-topic or other non-useful posts would be minimized if posters knew there was a moderator who might see them. Research on one side claims that the instructor or moderator will help to lead and guide the discussions (Berge, 1995; Greenlaw & DeLoach, 2003) and on the other side claim that too much involvement of the instructor by responding quickly or extensively may shut down the conversation (Li & Akins, 2005; Mazzolini & Maddison, 2003). Research shows that high quantity of instructor's posts was correlated to low quantity of student's posts.

All of the tools discussed in this thesis are different and have their own advantages and disadvantages. Almost all of them will generate visualisations of a single discussion thread or a single participant interaction. However, when made to show chains of

messages, they become unclear and cluttered. Most visualisation tools depict crosslinks (cluttering) when describing the message chains. There would either be an overlap in the nodes, which represent the participants, or there would be arcs, which denote the flow of messages, crossing one over the other. Crosslinks and/or cluttering usually occur when the data to represent the ongoing interaction is vast. A further issue with visualisation tools is their lack of agreement in terms of the criteria or 'indicators' they use in order to produce visual representations of data.

The most commonly used indicators in the visual representation of any CMC are type of analysis, participation level, and presence of social interaction. Not many visual tools give importance to lurkers, participation details, time duration and cognitive presence. Although most of the literature refers to qualitative analysis, very few writers represent the cognitive presence in their tool. Similarly, many of researchers who developed visual tools for the analysis of online discussions talk about the importance of a moderator or instructor, but only one of them includes that indicator in the visualisation tool. Change of topic and type of interactions (explicit or implicit), though important are not indicated in any of the visual tools.

From the start of research in CMC, the above mentioned indicators were thought to be very important in estimating the effectiveness of online interactions. It was not until recently that Dringus & Ellis (2005) identified and emphasised the need to analyse interaction data to disclose the 'dynamics of online learning and interaction process' and listed the common participation indicators which they think are of prime importance to assess student progress in asynchronous interactions (forums). According to Dringus and Ellis, the common participation indicators can be listed as:

- Level of interaction in the forum
- Learner-learner interaction activity
- Degree of cognitive and social presence

- Timing and pace
- Staying on topic
- Transitions
- Extent of Instructor presence
- Instructor-learner activity
- Teaching presence
- Mandatory/non-mandatory participation
- Lurking
- Shared resources
- Accuracy of message content
- Message response accuracy
- Group size

As research in this area has expanded, new indicators (for example 'Message read') seem to be used in the visual representations to give more insight into the ongoing conversations. As research in this field is extensive and growing, it would not be surprising for us to see more and more indications derived in this field in the near future.

For our research purposes, we looked for a visualisation model that included not only the key indicators identified in previous research, but which had been designed with an informed approach from educational theory.

The interface component of visualisation systems should comprise the basic characteristics to improve its functionality. The *visual information seeking mantra* has been the reference model for interactive visualisation for a very long time. Many systems have been developed under this paradigm. These elements are once again proposed by Shneiderman (1996) as overview, zoom, filter, details-on-demand, relate and history which is shown in Table 2.2. We would definitely implement the concept of extraction referred by Shneiderman in the near future. Tufte (2001) has also recommended a few

points on the how a graphic image should present the data. According to him a successful visualisation should show the data, not get in the way of the messages, avoid distortion, present many numbers in a small space, make large data sets coherent, encourage comparison between data, supply both a broad overview and fine detail and should serve the purpose.

Although our VIMS shares some of the features of some of the models mentioned above, it differs in that it provides an automated dynamic visualisation tool embedded into the VLE. In other words, it is constantly updated depending on the arrival of new postings to the Forum. This gives the instructor a representation that attempts to convey a sense of the participants' identity and behaviour and gives an insight of the flow of conversation activity.

Table 2.2: Characteristics of a Visualisation Tool

Characteristics / Tools	Overview (Column-1)	Navigation and zooming (Column-2)	Filtering techniques (Column-3)	Details-on-demand (Column-4)	Relate (Column-5)	History (Column-6)
TrAVis (Tracking Data Analysis and Visualisation)			✓	✓		✓
Authorline Visualisation				✓		
GISMO	✓					
CourseViz	✓	✓				
PieSpy	✓				✓	
Representation through iGraph			✓	✓	✓	
MTRDS (Mapping Temporal Relations of Discussions Software)		✓			✓	✓
DBAT (Discussion Board Analysis Tool)					✓	
DIAS (Discussion Interaction Analysis System)	✓	✓				✓
BulB	✓			✓		
Babble	✓					
Seascape and Valcano	✓	✓				
The Netscan	✓	✓			✓	✓

2.6 Characteristics of a visualisation tool for online forum discussions

From the classification table, we see that not all the evaluated visualisation tools implement all indicators. The most commonly visualised indicators in the representation are Type of analysis, Participation level and Presence of social interaction. Not many visual tools give importance to Lurkers, Participation details, Time duration and Cognitive presence. Although most of the papers talk about qualitative analysis very few of them depict the result (cognitive presence) of that analysis in their tool. Similarly, many researchers who developed the above tools talk about the importance of a moderator or instructor but not all of them actually portray the importance of that indicator in their output. Importance to results when there is change in subject title and the type of interaction whether implicit or explicit interaction is not visually identified by the previous researchers.

As discussed in Section 2.4.1, it was only recently that Dringus & Ellis (2005) identified and emphasised the need to analyse interaction data to disclose the 'dynamics of online learning and interaction process' and listed the common participation indicators which they think are of prime importance to assess a student's progress in asynchronous interactions (forums).

The list of indicators as outlined in the classification table (Table 2.1) agree with the indicators that Dringus & Ellis (2005) propose as being the important estimators and should be visualised in any visualisation tool.

Searching for the appropriate means to evaluate online discussions is not restricted to research in the field of education. Different models, techniques and tools were proposed and used for effectively evaluating the quality of ongoing online interactions in general. In order to evaluate the effectiveness of the online discussions, certain aspects need to be considered, such as:

- Participant's details, with their posting history to estimate their role in the collaborative online environment.
- The postings of the moderator in the interactions which assess their role and involvement in the online discussions.
- The evolution of the interaction cycle over time which allows the moderators to understand the active time period of the interactions.

The existing visualisation tools mentioned in Section 2.3 do not involve all those aspects among the priority list mentioned by Dringus & Ellis (2005). Another problem in the existing interfaces is that they provide inadequate support to help users understand the discussions as a whole. In many cases, discussion threads can lead to a different subject of discussion that may or may not be interrelated. Such interactions are termed as explicit interactions (Schrire, 2004) or off-topic posts. However, such relationships between the threads are not displayed in the evaluated visualisation tools. The attitudes and behaviour of the participants are also not addressed or depicted in the previous tools. Content analysis even though performed by few of the researchers was a lengthy process where they had two or more people read through the conversation dialogue and had come up with a conclusion about the conversation.

The important aspect of any visualisation tool is its user-friendly graphical user interface and the ability to display as many indicators as possible visually which the teachers can identify visually in order to examine the online discussions. However, not all the visualisation tools visually display the indicators mentioned in this thesis. To improve upon the deficiency of these tools, we have designed Virtual Interaction Mapping System.

Not all the tools developed can be used for large data sets. For example if the interactions for every six months or a year needed to be visualised, not all the tools would assist in

doing so. There would either be cluttering (overlap) of nodes or conversation flow. This will reduce the clarity of the visual tool.

2.7 Summary

This chapter examined the concepts and various approaches that underlie research on the importance of online participation and the visualisation of participation/interaction. This review of the research has enabled me to identify the key issues that are needed for investigation of collaborative online learning environment. Many researchers have concluded that the visualisation of the interactions in a learning environment helps the instructors and moderators to derive conclusions regarding participation level and behaviour. This visual approach helps instructors to encourage learners to engage in the discussion. However, current tools provide only a static view of the ongoing discussion which differs from our purpose of providing an automated scalable, multi-browser, real-time visualisation software tool.

We intend to provide an appropriate and effective means of coding and managing discussion forum messages in a visual format which analyses the ongoing participation and interaction, and facilitates both decision-making and in-depth analysis. Complex dimensions of the participation, such as whether participants are engaged in a meaningful dialogue, are not generally revealed by the reviewed tools. The next chapter details the features included in VIMS and critically evaluates the strengths of VIMS. After a thorough literature review of asynchronous communication we identified the importance of visually analysing online discussions.

3 Presentational Design Features for VIMS

This chapter presents the design features of VIMS which helps distinguish this tool from the current tools that have been reviewed in the previous chapter. It details the benefits of VIMS by comparing it with the present tools available for visualising the online asynchronous interactions.

3.1 Features of VIMS

VIMS resolves this problem of cluttering of nodes as the nodes are placed at a particular position at each level depending on the total number of nodes present in a level using the algorithm.

The characteristics available in VIMS can be identified as:

1. Data indicators visualisation:
   The indicators used in VIMS cover most of them necessary to be visualised to indicate to teachers the important aspects of an asynchronous discussion and be aware of the ongoing asynchronous discussions. Not all these indicators are covered by all of the other tools. The visualisation of the indicators proves to be added benefits for VIMS.

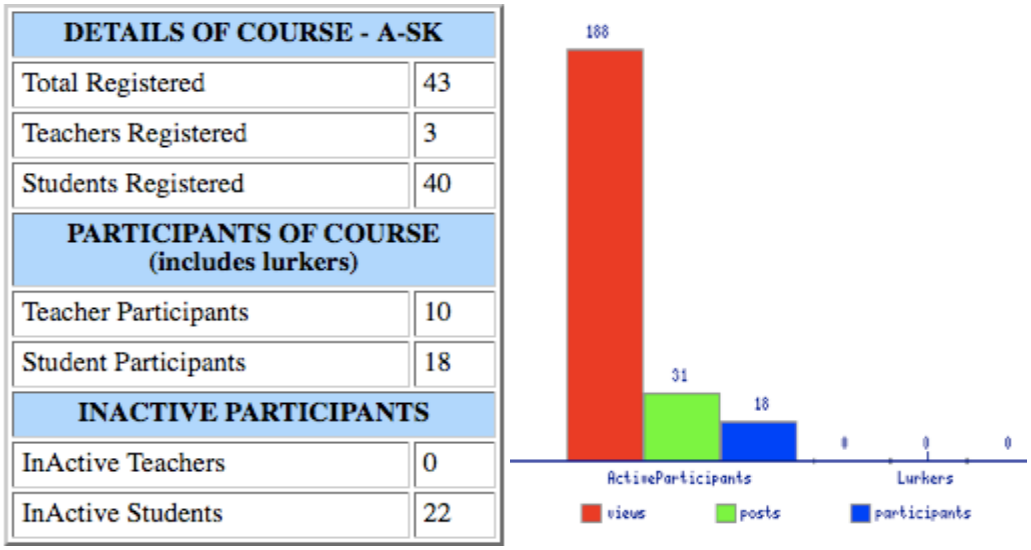
   a. *Change in Subject Title*: Figure 3.1 shows the change in the subject line which can be clearly seen in the visual map of VIMS. The original subject is indicated by a red dot and if the reply post has a different subject line the indication is changed to a blue square.

Figure 3.1: Change in Subject Title Indication by VIMS

b. *Type of Interaction*: Figure 3.2 shows the change in the type of interaction which again is clearly indicated in the visual map of VIMS. A message which does not specify is the name of the participant to whom the reply is sent to, is indicated by a black arrow, whereas a message which specifically is sent to a person with the person's name is denoted by a green arrow.

Figure 3.2: Implicit and Explicit Interaction Indicators

c. *Quantitative Method*: The quantitative analysis in VIMS is used to find the number of participants registered, participants active and participants inactive. Statistical analysis is done regarding the total number of posts, views and participants in a particular group and interpreted in the form of statistical charts.



DETAILS OF COURSE - A-SK	
Total Registered	43
Teachers Registered	3
Students Registered	40
PARTICIPANTS OF COURSE (includes lurkers)	
Teacher Participants	10
Student Participants	18
INACTIVE PARTICIPANTS	
InActive Teachers	0
InActive Students	22

Figure 3.3: Quantitative Analysis Indicators

d. *Participation Level & Social Interaction*: The participation level is clearly seen from the radial tree visualisation. From Figure 3.4, we see that the starters are placed at level1 and the conversation ends at level3. One of the conversations started by a teacher (on level1 indicated by red circle) leads to many replies at the next level which can tell us about the interest in discussing that topic. The social interaction is again seen through the connection of the replies.

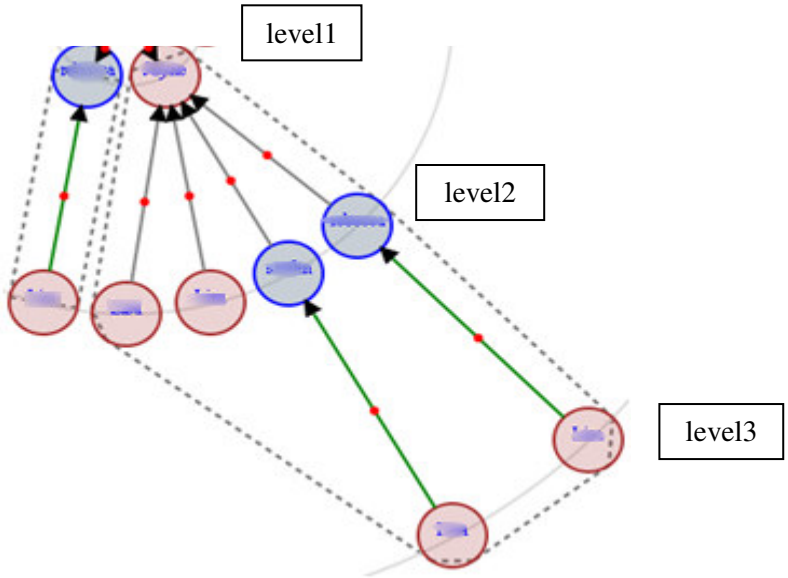


Figure 3.4: Participation Level & Social Interaction Indications

e. *Qualitative Method (Content analysis)*: The Latent Semantic Analysis (LSA) technique (Deerwester et al., 1990) used can identify the relevance of the message and give an indication if the message is related to the subject lines or if there is a deviation in the topic of discussion. More details of LSA can be found in section 6.3. From the figure we can state that the relevance to the subject is close to 90% and hence can state the discussion was going on track.

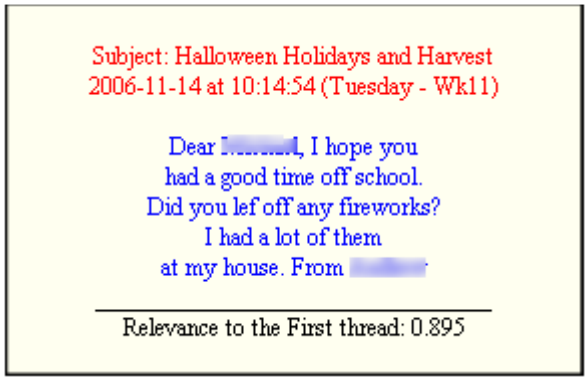


Figure 3.5: Qualitative Analysis Indication

f. *Lurkers*: Lurkers are equally important as the active participants and VIMS displays the lurkers list as well as indicates them in visuals. Hovering over the visuals gives their details. This helps the teachers to easily trace the participants who are just reading the posts.

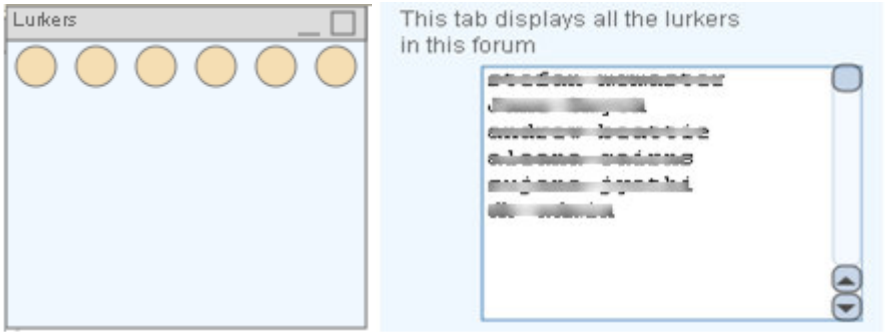


Figure 3.6: Indicators for Lurker's presence

g. *Participant Details*: A click on the circle which represents the participant's message gives details of the participant who posted that message and also indicates the other posts posted by that participant by highlighting those circles.

Figure 3.7: Indicators for Participant Details

h. *Time Duration indication*: By hovering over the boundary of the thread, the period of the discussion is indicated as a tool tip. The time-frame can also been seen through the selection-list display of the VIMS tool which indicates the duration of the conversation in weeks.

A

B

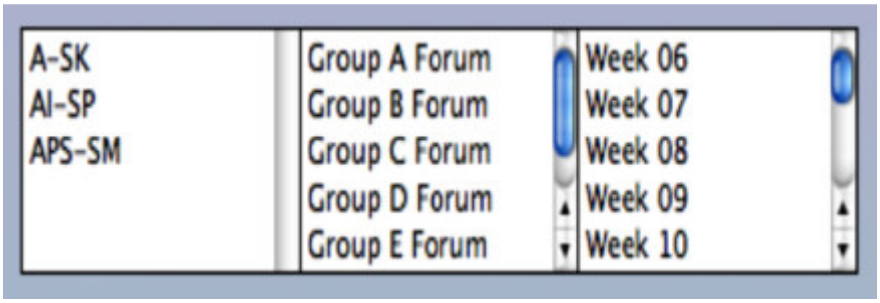


Figure 3.8 [A][B]: Time Duration Indicators

i. *Presence of a moderator*: The presence of the moderator is indicated on the radial tree with a change in colour. A red circle indicates a teacher's post.

Figure 3.9: Indicator for Moderator's presence

2. More Features of the Tool with Examples

VIMS can be a useful research tool for revealing the structure of online discussion in an asynchronous forum. The significant features of VIMS are:

- Chronology – The radial tree representation of the interaction depict the interaction in chronological order in terms of who replied to whom. The initiators of the threads are placed at the first level and the participants responding are placed are various other levels.

- Scalability - The main advantage of using scalar vector graphics is that it can produce an image scalable to any size and detail. The file size of vector data generating the image stays the same and the quality of the image is limited only by the resolution of the display (W3C, 2003). With dynamic data, the number of participants and the number of messages keeps increasing over time and hence the need arises to interpret enormous amounts of information in a manner that is clear and interpretable. VIMS exhibits this property. The interactive scalable features (e.g. zoom and pan) allow viewing the full structure of the conversation to fit the screen

and rolls across the screen in case the structure is too big with many conversations.

- Association – The radial tree visualisation illustrates clearly the message chain connections and hence reveals the connections between the participants. The table form of visualisation displays the number of posts and views of a participant with other participants in the group.

- Simple Interpretation and Clarity – The visual image shows, at a glance, the ongoing discussions in the Moodle forums. It clearly indicates who is interacting with whom and the interactive features like mouse clicks reveal details of the interactions. For example, a click on the node gives details of the participant and highlights the posts of that participant in that forum. This gives a clear indication how many times the participant has posted and the post to which he is responding. A click on the dot on the arc (arrow) reveals the message posted along with date, time and subject of the post. The convex hull separates the different discussions in a forum.

- History and Visits – The tool displays not only the participants posts but also the number of times they visited a particular discussion.

3. Uncluttered Visualisation: However large the data to be represented is, there is no cluttering of nodes or arrows in the radial tree representation. This overcomes a significant problem with other tools whose representation of conversation flow becomes easily cluttered. This non-overlapping of different indications gives clarity in the visualisation. Figure 3.10 and Figure 3.11 give examples of cluttered and uncluttered visualisations.

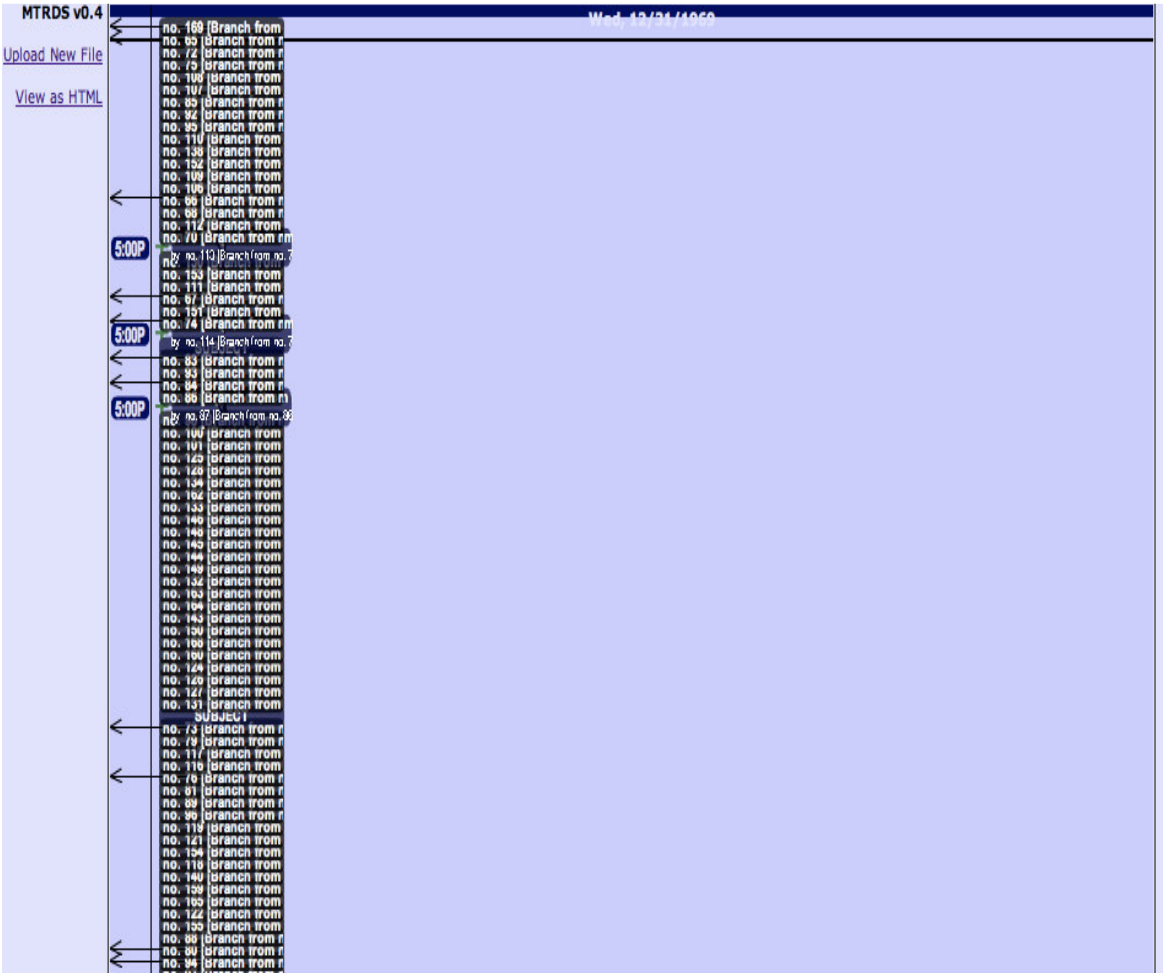


Figure 3.10: Example of Cluttered Visualisation (Gibbs, 2006)

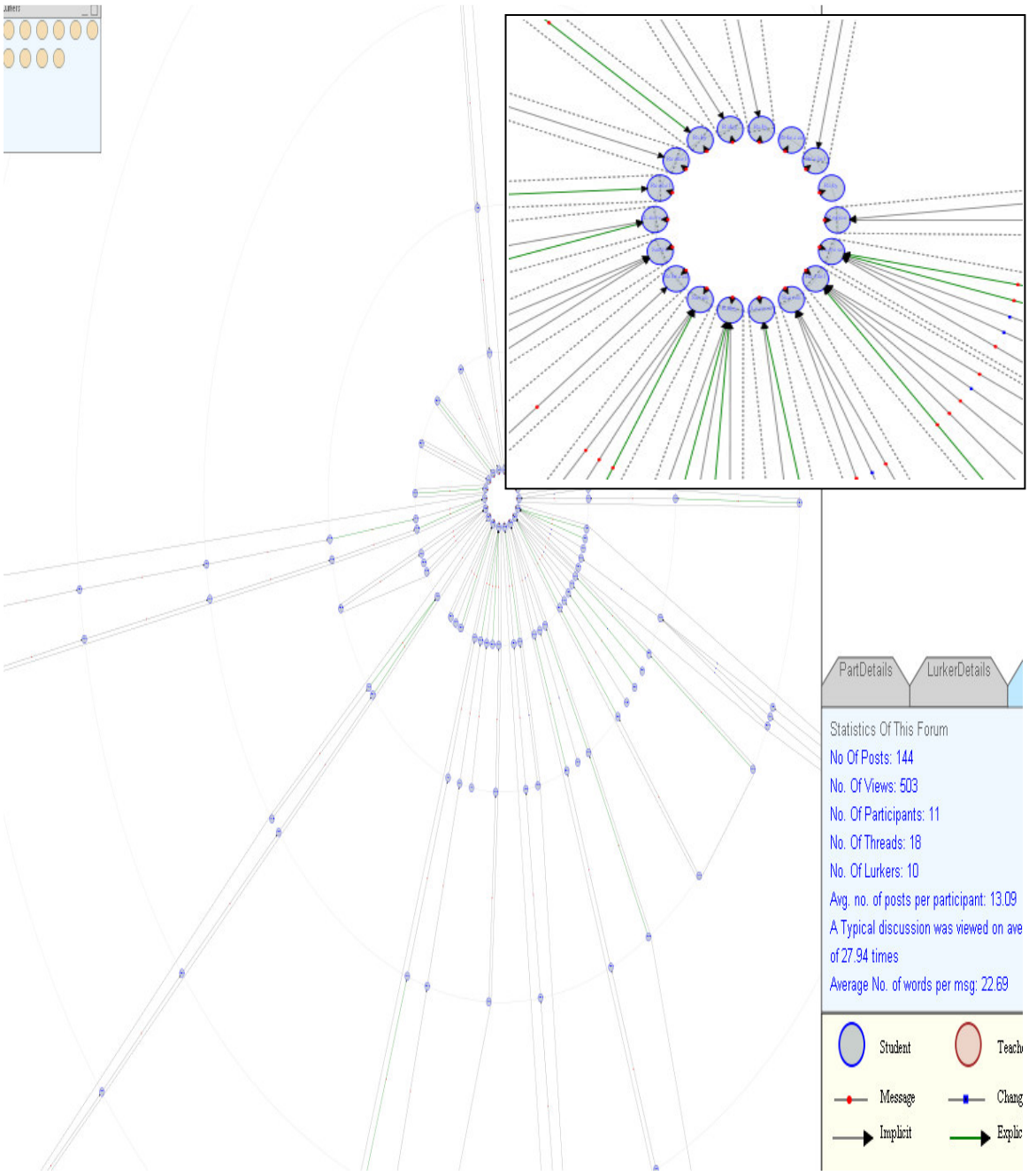


Figure 3.11: Example of Uncluttered Visualisation. A closer view of a part of the visualisation is shown in a smaller frame

Figure 3.10 is a representation of 104 messages taken from one of the visualisations that were reviewed. We see the overlapping of messages which is hard to identify. On the other side we have a visualisation image from VIMS (Figure 3.11) which represents 144 posts at a time. It is easy to identify the structure of the conversation as well. Although this is a zoomed image of an uncluttered representation, the users can zoom in only on a particular area and/or pan the region of display to find the details.

4. Group Comparisons: If the participants are divided into groups then VIMS compares the progress and consistency in and among the groups. This comparison between the groups has never been done in any of the visualisation tools. This indicates that VIMS can interpret interactions in a deeper way than other tools and can be very useful in any LMS to predict on the online discussion activity.

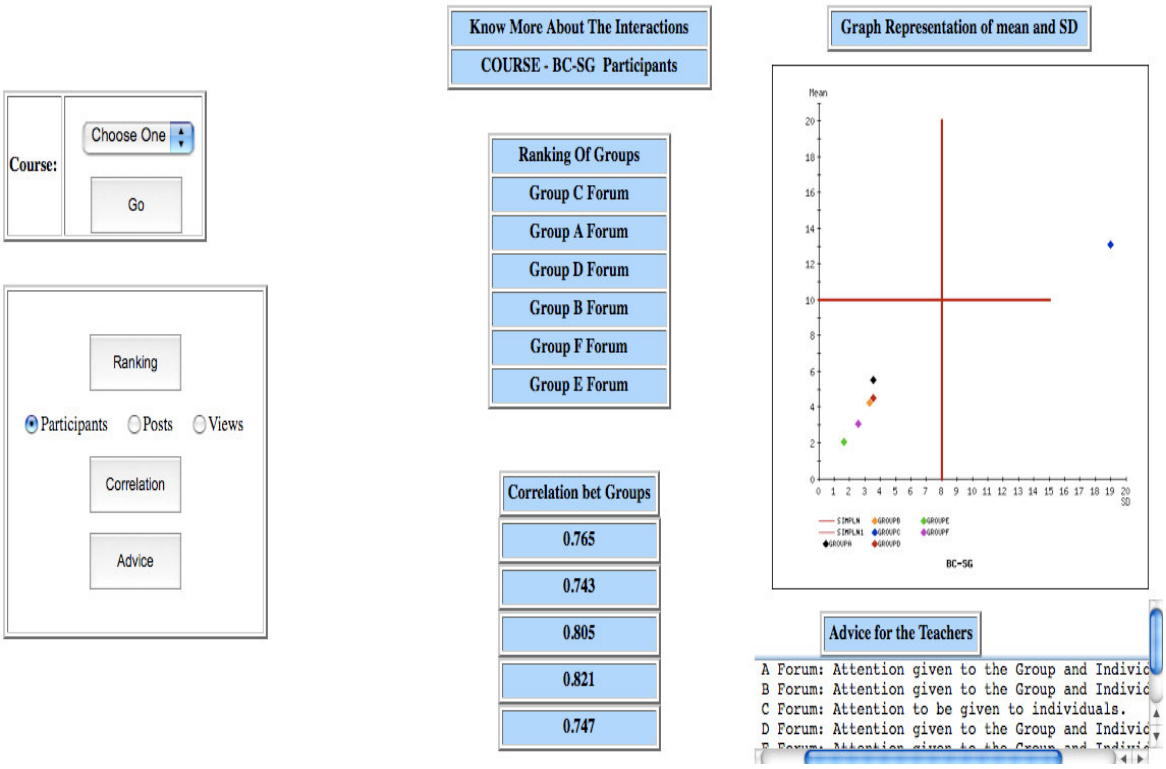


Figure 3.12: Group Comparisons on VIMS

5. Shneiderman's and Tufte's characteristics of a visualisation tool: VIMS has taken not only all the characteristics needed for a visualisation tool according to Shneiderman and Tufte but also considered the HCI elements needed for visualisation. The characteristics of a visualisation tool as listed in table 2.2. This helps the users to get a clear picture of the conversation map without any discrepancy in the process of viewing.

    i. Overview:

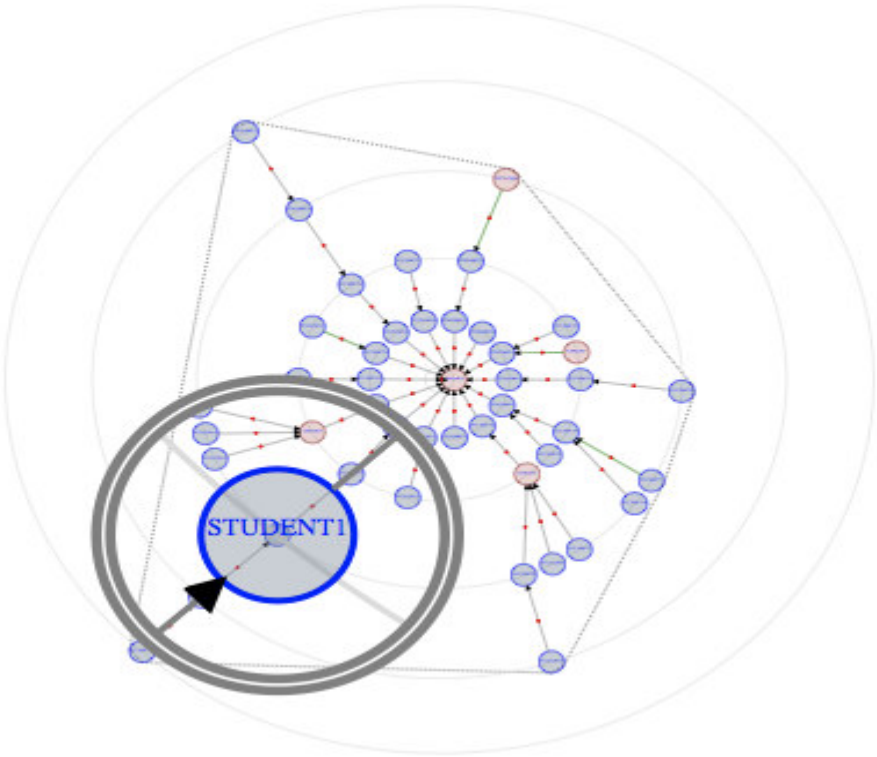


Figure 3.13: Overview on VIMS

The overview of the graphical image gives the user an idea of the pattern of the online interactions. It helps them to understand the structure and depth of the conversation. Especially when the data displayed goes off the screen, it would be difficult to view the entire structure at a glance.

Overview strategies according to Shneiderman should include a zoom-in view which gives the details of the visualised image according to user's area of interest. Figure 3.13 gives an overview of one of the conversations. This gives us information that this conversation took the structure of the web with teacher placed at the centre. There was only one discussion in the forum as it has only one starter. The overview image does not give a clear view of the participants involved in the interaction and hence a zoom circle gives a detailed view according to the user's navigation on the screen.

ii. Zoom: Apart from the facility to zoom only the details of interest, VIMS also provides a navigational tool to zoom, pan, centre and to get back the original full-sized image after zooming. The zoom-out and zoom-in facility helps to view the entire structure of the conversation or view the detailed two-dimensional structure according to the area of interest. The zooming facility in the overview gives only the participants involved but not the messages posted by them. The other zoom facility available allows smooth zooming of the entire graphic display. The panning allows smooth movement of the frame either up, down, left or right in case the image is of greater size and goes off the screen. Figure 3.14 gives the navigational tools.

Figure 3.14: Zoom and Pan on VIMS

iii. Filter: Filtering allows the user to choose only the visual that is intended for use thus reducing the number of elements on display. In the visualisation where there is a number of nodes in just one display related to the conversation on the whole, the user might want to view only the details necessary which could be achieved through filter. In VIMS, the filtering techniques are used to filter interactions on a weekly or a daily basis. There is also a facility for the user to choose the visualisation for a particular group and not for the entire course, when the participants of a course are divided into different groups. Figure 3.15 gives the VIMS selection which allows users to select the display they need.

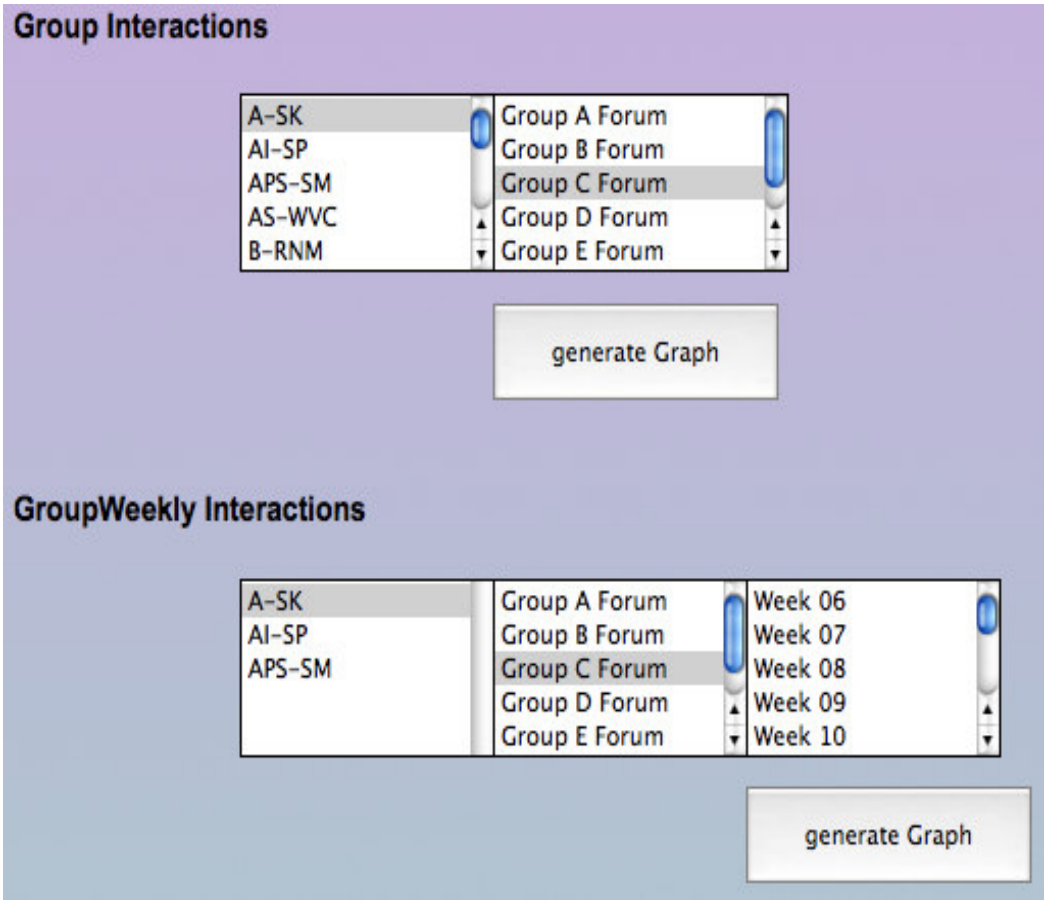


Figure 3.15: Filter on VIMS

iv. Details-on-demand: To explore further details from the visualisation, the users can click on the node which represents the message of the participant and this displays the details of the participant. It also indicates the position of the posts posted by that participant by highlighting those nodes. Hovering the mouse over the red dot on the arrow, which represents the flow of a message, displays the message along with the message details. Mouse over the dotted line, which represents the boundary of the discussion thread, reveals a tool-tip which details the thread name along with the time period, the thread was active. Figure 3.16 displays all the above mentioned features.

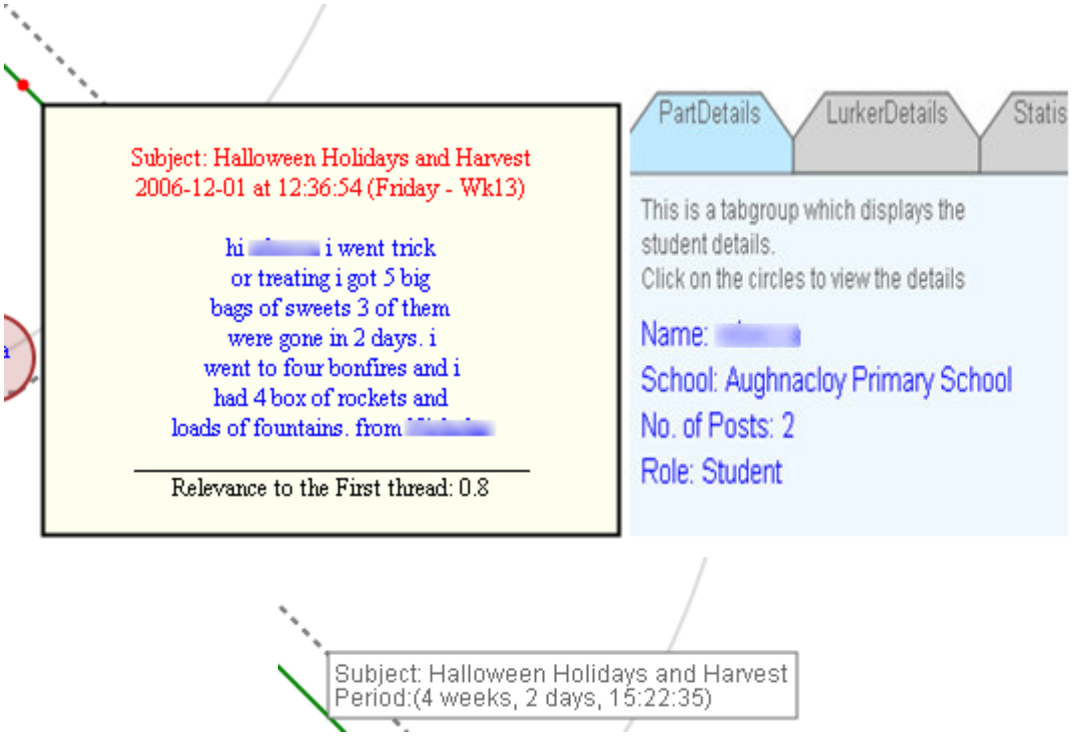


Figure 3.16: Details-on-demand on VIMS

v. Relate: VIMS has the ability to relate between and among the various groups involved in the online conversations. This helps the teacher to

understand the intensity and use of discussion forums by each group and the individuals involved (Figure 3.17B). The teacher would also be able to relate students' and teachers' activity and inactivity. A click on one of the nodes as mentioned in the explanation of details-on-demand highlights all the posts related to that participant (Figure 3.17A). The user can click on the statistics and see the related views, posts and participants of different groups. More detailed information on these relationships is explained in Chapter 5.

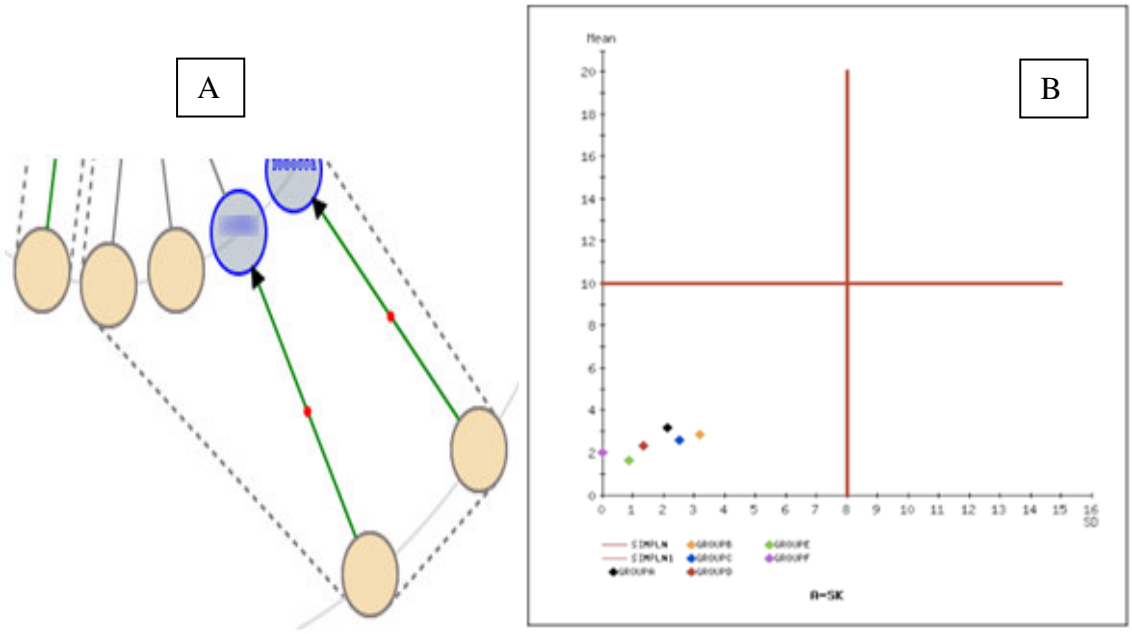


Figure 3.17: Relate on VIMS

vi. History: VIMS keeps a history of actions and stores them in the VIMS database. The navigational buttons on the VIMS tool helps the users to go back and forth through the visualisations. Moodle has its own internal database that also tracks and stores the student activities in the log database.

We have tried to display the data relevant to the teachers by incorporating Tufte's characteristics of information visualisation, which could help them understand the flow of conversation. Many of the visual tools have cluttering and/or overlapping of information like the one showed in Figure 3.18 and Figure 3.19. VIMS avoids distortion by its clarity in the visualisation and no element comes in the way. The tool also encourages comparison of different datasets and between data and serves a clear purpose for the teachers.

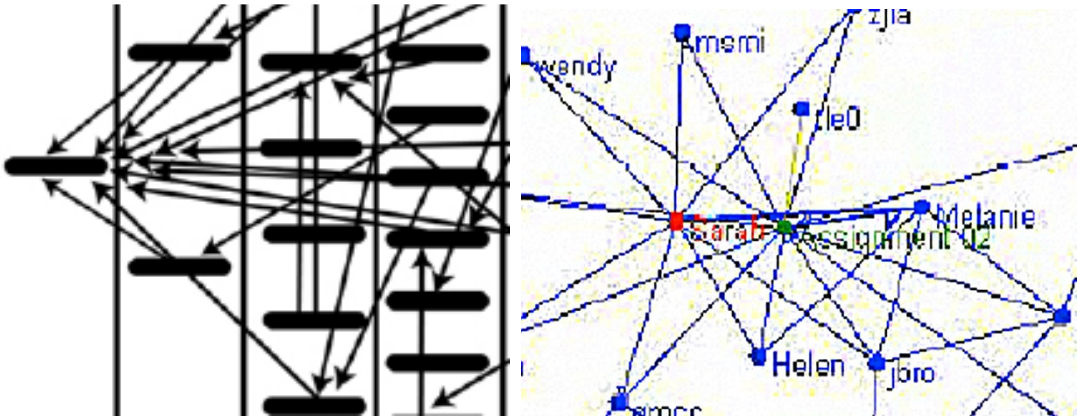


Figure 3.18: Example of Cluttering

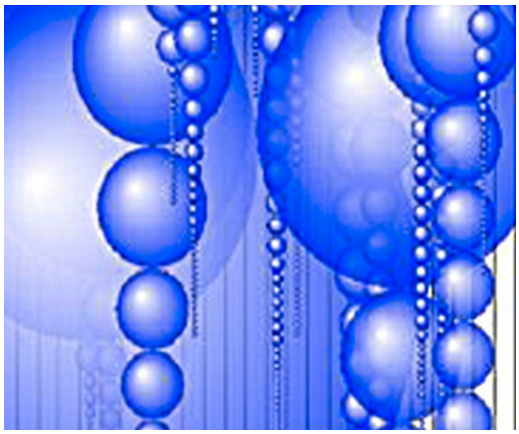


Figure 3.19: Example of Overlapping

6. Conversation Flow: The flow of the conversation is very important for any interaction. This clearly states the level and pattern of the ongoing discussion. Most of the tools like Babble, BulB, Flowergarden, chat circles, Seascape and Volcano, courseViz, traVis, authorlines, iGraph, piespy and DIAS do not represent these conversation flows in their visualisations. Some of them just visually represent the interactions and some of them represent the individuals participating in the discussions along with their online activity but ignore the conversation flow. VIMS apart from visualising the interactions and analysing the participant's details, also gives an idea of the conversation flow within a discussion. The other visualisations like MTRDS, DBAT and netscan show the conversation flow, but they restrict the visualisation to just one thread and not the discussion on the whole in one forum. VIMS places the starters of the thread in the first level and all those replying to those posts are placed at the next higher level and hence there is sequence of flow of the conversations shown in the forum as a whole.

Our research in this area is primarily focused on providing teachers and moderators with a better visual support addressing all the issues from the previous visualisation tools and assisting them to analyse the quality of the discussion.

Extensibility, scalability and future proofing are three important and needed features for any developed tool. VIMS can be easily extended by including more interaction attributes as they are developed. This tool allows educationalists or researchers to add additional indicators. This feature helps future-proof this system (VIMS).

3.2 Moodle in a Learning Environment

Moodle is an open source course management system (Moodle, 2011) designed for managing flexible communities of learners [Lengyel et.al, 2007] based on the principles

of social pedagogy (Moodle, 2011). It is a software tool, which creates communication and collaboration channels. Two attractive aspects of Moodle are: It is extensible and so a developer / researcher / educationalist can contribute to its development and add the modules they require. Secondly, Moodle is customisable. There are many options that can be adjusted to suit the needs of the user.

Moodle can be seen as a platform for learning and communication. Moodle is designed to help educators create online courses with opportunities for rich interaction (Moodle, 2011). There are seventeen tools in total available to course managers within Moodle which allow communication, individual and collaborative learning construction, such as forums, tasks, questionnaire, chat, collaborative writing wiki, blog, and so on. These allow different and efficient pedagogical online mediation procedures (Nonato & Sales, 2007). This research focuses on analysing communication in Moodle. This communication in turn leads to learning.

Moodle requires a web server with integrated PHP (which is the scripting language) and an underlying SQL database support (Lengyel et.al, 2007). An administrator manages the Moodle system during set-up. The administrator has the ability to customise the website and design it according to their needs. The required activity modules are then added on Moodle. The source code is easy to modify to suit the teacher's needs.

3.2.1 Blocks in Moodle

Blocks are "boxes" that appear on both sides of a Moodle page when displayed on a browser (Alier et.al, 2007). Moodle is highly adaptable, driven by the use of these blocks, which can be chosen and structured in a desired way. The Moodle community has created many different add-on blocks to choose from. All courses in Moodle contain blocks where the centre block displays course content. Blocks can be added or removed to customise the look and feel of the site.

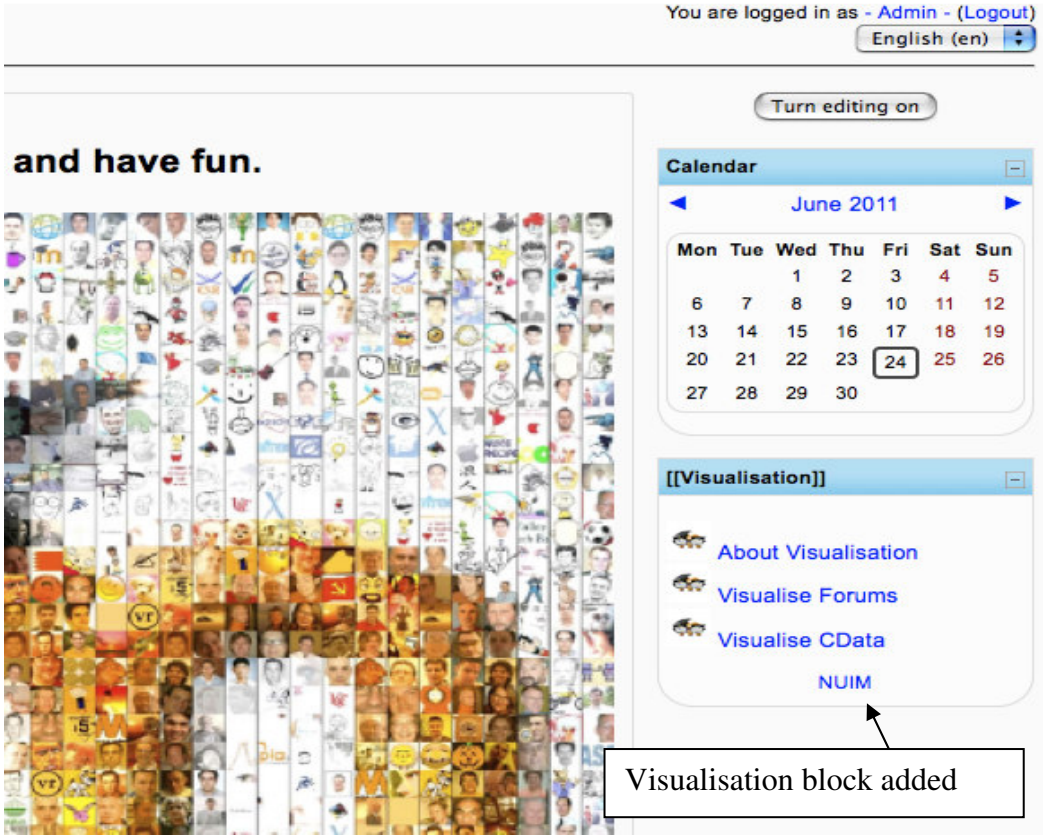


Figure 3.20: Part of the Moodle Page after adding VIMS block

3.2.2 Forum Module to build a collaborative online environment

Moodle is a tool that extends the classroom onto the web [Su, 2006]. It provides support for participants' interaction with a variety of online tools including discussion forums and wikis. It enables discussions relevant to teachers, courses and students. It is in this forum module that much of the interaction between students and teachers take place. Moodle forum, like other forums, supports asynchronous communication and hence leads to one of Moodle's principles of social constructivism. The module also supports images and also allows discussion threads to be moved from one forum to another.

VIMS can be embedded into any LMS. It is now tested on the most commonly used open sourced LMS, which is Moodle. Moodle has the ability to archive information for many years. Comparison of such information is almost difficult and cannot be done without a visualisation tool. VIMS can extract that information and interpret, compare and analyse the archived data of the participants through graphs and charts doing the current course. Comparisons of such information over a period of time reveal the behaviour of the participants over time.

3.3 Summary

This chapter presented the characteristic features that are incorporated in VIMS tool. The presence of these features distinguishes VIMS from the current tools available. After reviewing the other tools, we can say that VIMS integrates all the necessary indicators that are mentioned in Table 2.1 and characteristics of a visualisation tool mentioned in Table 2.2 which are not presented by the other visualisation tools currently available and usefulness of VIMS in a learning environment is much greater than the now existing tools. The chapter also gives a general description of Moodle.

The next chapter details the design and architecture of VIMS and gives instructions of how VIMS can be integrated to Virtual Learning Environment.

4 VIMS Design and Architecture

4.1 Introduction

Virtual Learning Environments have now become common means of learning and communication and are being applied in every educational sector (Harris, 2008; Galloway et.al, 2002). Exchange of information and expressing one's views, ideas and concepts through interaction has been proven to be an excellent way of Learning (Voigt & Swatman, 2006; Pawan et.al 2003). Some of the resources of these environments, like forums and wikis facilitate the sharing of information between participants and help build a collaborative online learning community mostly through asynchronous communication. One such learning environment, which is widely used and increasing in popularity in the educational world, is Moodle (http://moodle.org).

The chapter presents the technical aspects of the integration of Virtual Interaction Mapping System (VIMS) in the Moodle environment. The purpose of VIMS is to provide an effective means by which the enormous amount of information stored in Moodle databases can be visualised to obtain a greater understanding of any relationships that exists in the data. VIMS represents and visualises the interaction between participants and the involvement of lurkers during online discussions carried out through Moodle forums and forms a basic tool for teachers and moderators to analyse interactions and assess the discussion content. This can lead to prediction of the participation level and prompt intervention when needed. VIMS also provides a means to visualise certain features of forum activity via a statistical analysis, which can form the basis for comparative studies.

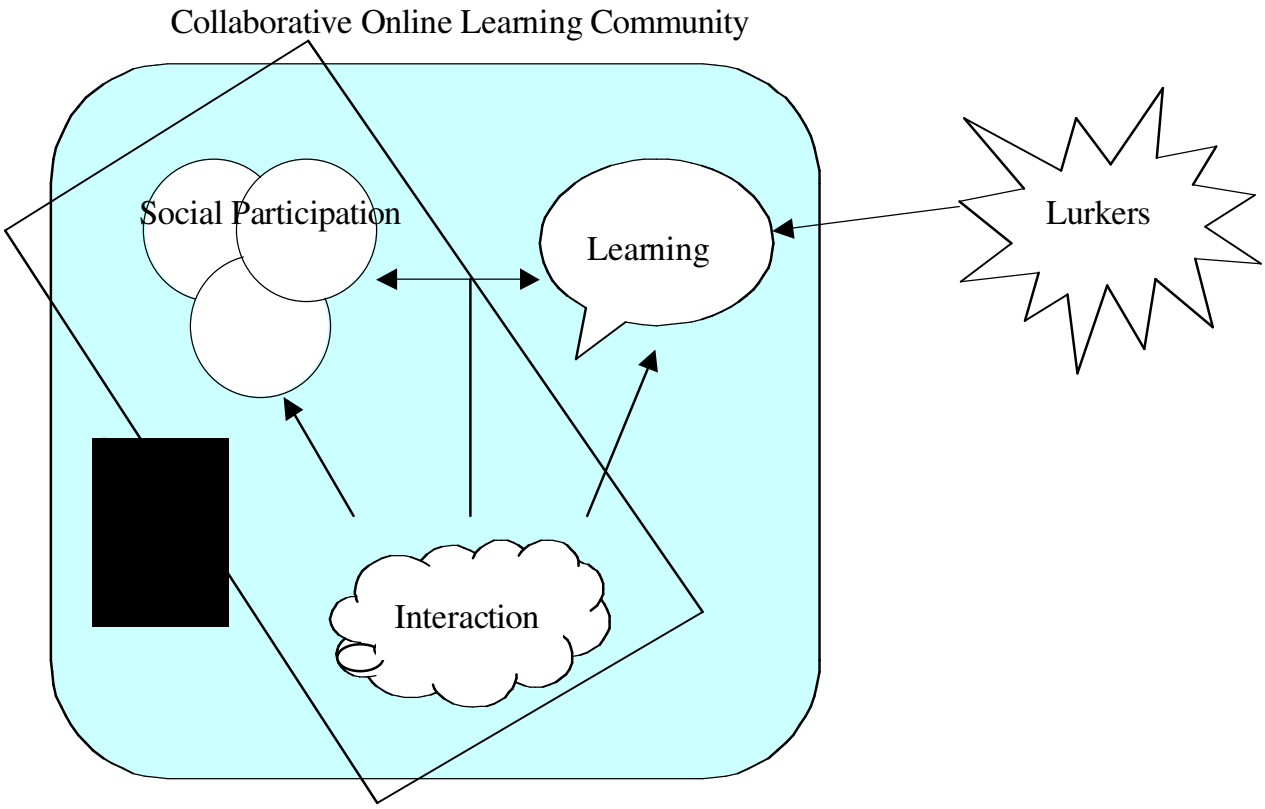


Figure 4.1: Representation of Concepts Studied in this Research

VIMS can be integrated into any learning environment. However, since Moodle is the most commonly used Open Source Learning Environment; we had tested the integration of this visual tool into Moodle.

Analysing the log information in a visual format has been an emerging area of research in the field of education (Romero et.al, 2008; Mazza & Dimitrova, 2004). Romero (2008) in his paper, also insists that a visual tool with good visualisation facilities is more intuitive and user-friendly. There have been many researchers developing tools to analyse the vast amount of raw data stored in the database and visualise them in different ways (Romero et.al, 2008; Mazza & Dimitrova, 2004). However, our approach to representing these dynamically-generated visual graphs is designed specifically to be different and much

simpler to understand even by a novice teacher, while at the same time providing extensive, and extensible, amounts and types of useful information.

Online interaction has become a part of most learning management systems. Interaction enables the learners to share information about their learning materials and to increase their knowledge about the subject. Research has proved that visualisation can help teachers and participants understand their level of participation in the ongoing discussions (May et.al, 2007; Gibbs et.al, 2006). The use of highly interactive visual tools can benefit the understanding of the interaction process in a collaborative learning environment.

Although visualisation of participation in the Learning Management System has been addressed for a long time (Donath, 1995), it still has not been integrated into any LMS environment and hence we propose the integration of VIMS in Moodle. Most aspects that make up the VIMS are not new and have been mentioned in related work [May et.al, 2007; Gibbs et.al, 2006].

Moodle, and related systems, lack the support for many aspects specific to evaluating participation level and analysing interactions. Moodle does not provide any tools for visually representing ongoing interactions. It is difficult and time consuming for the teachers and the educationalists to ascertain the number of participants, non-participants and lurkers in an ongoing discussion. VIMS is a visual tool which dynamically represents the interaction process in a graphical format using Scalar Vector Graphics (SVG) (W3C, 2003). The tool also examines the various aspects of the participants' behaviour and analyses if the participants' are forming a collaborative learning environment through various patterns of interaction. The tool can be used as a monitoring mechanism for the teachers to motivate the students to participate in ongoing discussions.

4.2 About Schrire's Model

Schrire analysed asynchronous discussions for evidence of 'interaction and cognition' (2004). Taking a case study design, Schrire developed a paper-based visual representation of asynchronous forums (computer conferences). We drew on this work to inform the development of our visualisation tool as a means of both mapping and analysing forum discussions. In tandem with a visual model using specific indicators, Schrire proposed a model of analysis, which looks for evidence of links between cognition and interaction, rather than focusing on the linguistic or thematic aspects of discussion messages. Drawing on a range of theoretical models, she asks three research questions:

1. What patterns of interaction can be found in asynchronous online computer conferences?
2. What kinds and levels of individual and socially distributed cognition characterise the learning process in asynchronous online computer conferences and their component threads?
3. How are interaction and cognition connected in asynchronous online computer conferences? (2004)

Her analysis is framed firstly by the visual representation of the discussion, and then by three theoretical approaches:

- Bloom's taxonomy (Bloom et al., 1956): focusing on the evidence for analysis, synthesis and evaluation associated with the upper levels of Bloom's taxonomy.
- The SOLO taxonomy (Biggs & Collis, 1982): Structure of Observed Learning Outcomes: analysing the discussions using taxonomy designed to show whether there had been in-depth or surface learning.

- The Practical Inquiry Model of Cognitive Presence (Garrison et al., 2001): identifying collaborative construction of knowledge in asynchronous forums, and looking for evidence of community amongst learners, rather than evidence of a more 'practical' focus in using asynchronous discussion (e.g. for course management or information).

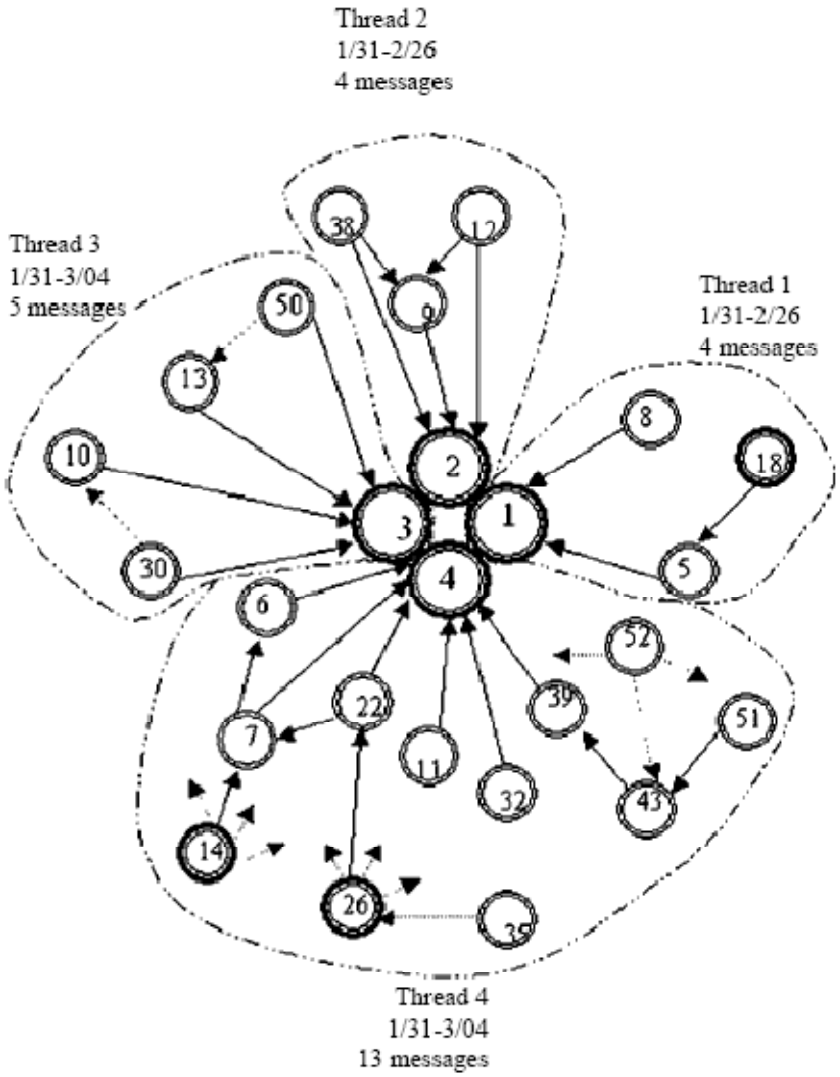


Figure 4.2: Interaction patterns as represented by Schrire (2004)

This 'interaction pattern mapping' as shown in Figure 4.2 gives a visual representation of the discussion threads making up the conference, the clusters of messages interacting with one another around sub-topics of the conference. The entire discussion is first read from beginning to end in order to get a general impression of the conversation. Each message is then visually depicted as a circle, and given a number based on its position in the chronology of the conference. Instructor messages are differentiated from students' messages by use of a double border. Message connections, showing the direction of the interaction, are represented by arrows. A dotted line is used when interaction is possibly present but could not be established definitively. Message clusters, that is, messages interacting around a subtopic of the discussion, are shown as such on the interaction pattern map.

Once constructed, the interaction pattern map can be scanned for important details, such as the intensity of activity in the component threads, the presence of distributed versus 'centralised' interaction, messages that have become nodes of interaction, and messages that are unanswered or that have remained isolated in the discussion space. Important or distinctive features become apparent from the interaction pattern map. It becomes very clear that threads are interactive to a greater or lesser extent, and also whether the interactions are one-way only or multi-directional. In Schrire's analysis, the interaction pattern maps allow her to categorise threads into five interaction pattern types:

1. Instructor-centered: responses initiated and triggered by the instructor message and responding mainly to the instructor message.
2. Synergistic: responses to the initiating message as well as follow-ups by conference participants from one message to another. They are interactions where every message is connected to another, either directly or indirectly.
3. Developing synergism: Mixed characteristics of Instructor-centered and Synergistic interactions.
4. Scattered: small separate message clusters around loosely related sub-topics.

5. Student-centered: responses initiated by a student message.

The work of Schrire, in organising and representing forum messages visually has provided a different perspective on the problems described earlier, and potentially connects the initial mapping provided by visualisation tools with further analysis of online interactions. We drew on this work to inform the development of our visualisation tool as a means of both mapping and analysing forum discussions.

4.3 VIMS: A new Intervention Tool for Moodle

We have developed a highly interactive VIMS, which uses interaction visualisation and statistical analysis to help monitor the participation and ongoing interaction in the Moodle discussion forums. VIMS involves three concepts:

- Information visualisation (In the form of radial tree and tabular representation) to improve understanding of ongoing discussions.
- High level of interactivity makes it easier to filter out the information needed to be visualised. For instance, if one wants to view the interaction of a particular forum, in a specific group for a specific period of weeks, this can easily be done using the filtering techniques.
- Statistical analysis, providing an in-depth analysis of participation in a graphical representation, to prompt further investigation by teachers where required.

The tool enables teachers to see the participation level of the participants along with their messages and their profiles. It also displays a list of lurkers along with their details and the amount of time spent viewing the posts. It serves the purpose of helping teachers intervene during the interaction process when the need arises.

4.4 Architecture of Virtual Interaction Management System (VIMS)

The W3C SVG (Scalable Vector Graphics) specification (W3C, 2003) is a standard tool to visualise 2D graphics in web browsers. The integration of SVG support into the Internet browser, along with browser support of the interaction between the SVG Document Object Model (DOM) and JavaScript, now provides the necessary foundation for rich, real-time, bi-directional client-server communication. The SVG-Client-Server triangle enables us to add interactive features like:

(i) Mouse events (ability to pick a part of the image and get detailed information about the focused part)

(ii) Zoom-and-pan

(iii) The possibility to connect the image to web services that will provide new data refreshing the image.

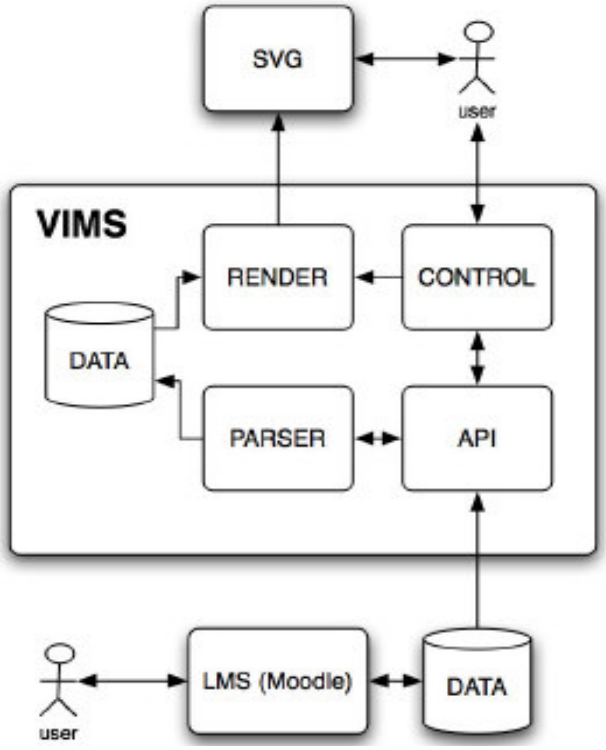


Figure 4.3: Architecture of VIMS

Figure 4.3 shows the basic structure of VIMS and the relationship with the LMS (for example Moodle). VIMS is composed of four distinct modules: (i) A Control module that handles all web-based user interactions including thread specification, authentication and data management, (ii) a Parser which parses thread and message content and prepares data for rendering in graphical format, (iii) a Rendering component that uses radial tree layout and convex hull algorithms to generate the Interaction Visualisation in SVG format and (iv) an API suite that facilitates deployment within different LMS (Jyothi et al., 2007). It is only necessary to provide a different API implementation to use VIMS with another LMS. A UML activity diagram for the rendering process is shown in Figure 4.4.

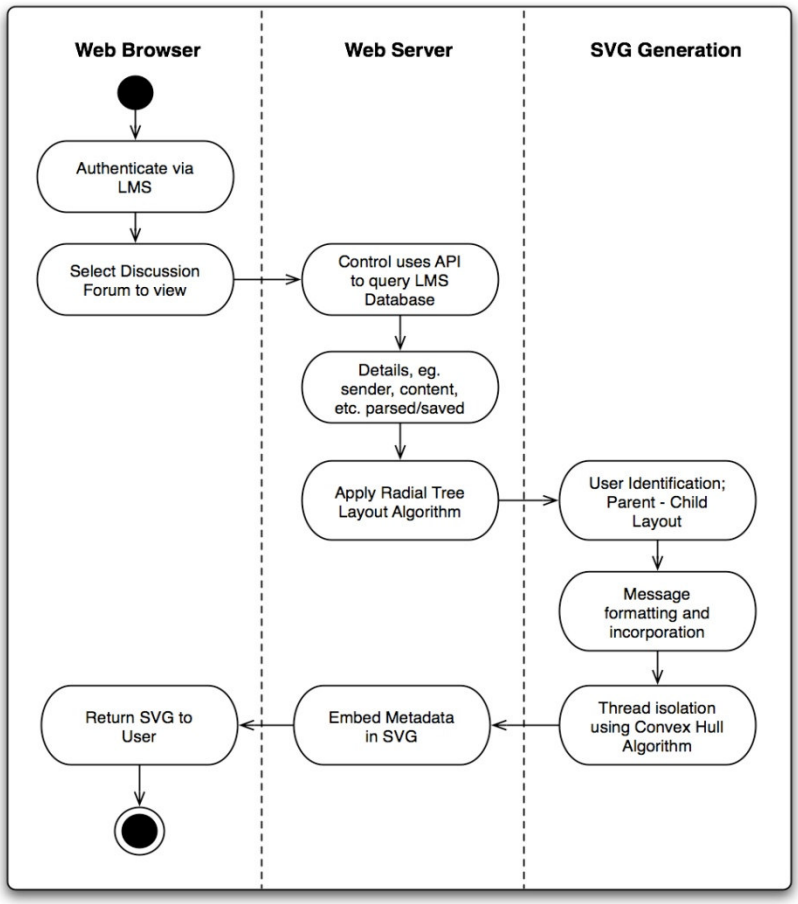


Figure 4.4: Activity Diagram (SVG Generation)

4.5 Structure and design of Radial-Visualisation Map

A tree structure representation is a graphical form of representing hierarchical structure of the data. We opted for a circular tree structure called the radial tree layout (Nihar & Qin Cai, 2003) to represent the asynchronous discussions in Moodle, as it is a fast and efficient way to achieve a visual display in terms of perceptual organisation with less cluttering of nodes. The circular arrangement of tree nodes represents the whole tree as a structure of nested circles, showing the degree of student participation. Furthermore, we can also evaluate the level of the child nodes and ascertain the depth or extent of the interaction. The automated tree layout structure uses the depth-first search recursively. It progresses by expanding the first child node and thus goes deeper and deeper until leaf node is found.

By examining message chains one can determine the active participants, interaction patterns, amount of time spent in the interaction and many more initial aspects, which are collectively used to evaluate social presence. It is also necessary to read the entire discussion to get a general impression of the conversation. The interacting participants are represented as small circles and the arrows connecting them represent the dialogue between those connected participants, flowing in the direction shown by the arrowhead. The circles are ordered chronologically and can be numbered based on the message timestamps.

As the visual representation is all nested circles, the concentric circles representing the levels of interaction are differentiated by the smaller circles representing the participants, using different colour codes. The initiators of the threads in every group are placed at the centre and the participants responding are placed at various levels depending on their hierarchical position (the post to which they have responded to). The presence of the node on the farthest circle indicates its level and depth in the structure. The more depth and width, the greater is the learning impact (Schrire, 2006). The depth (number of levels)

and the width (responses at a particular level) are explicitly clear from this structural layout. The learners interacting in one thread are separated from the other threads by drawing boundaries using the convex-hull algorithm (explained in the later part of this section). The learners are differentiated from one another using colour-codes.

By identifying the time of the interactions we will be able to say if the learners are interacting during school hours or at home. This tells us about their motivation to form a social network. The information exchanged by the participants can be viewed by placing the cursor on the message-flow arrow. Using a single mouse click it is possible to obtain statistics for a participant, highlight his/her overall contributions, and determine how many times he/she is involved in the interaction process.

Two important algorithms were implemented mainly to interpret the online discussions: The radial tree layout algorithm and the convex hull.

- ***Radial tree***:

In the last decade, the Information Visualisation research community has explored many display layout techniques for the visualisation of large hierarchical datasets. Radial tree layout [Nihar & Qin Cai, 2003] uses the focus + context (fisheye) technique for visualising and manipulating large hierarchies with non-hierarchical cross-links. In the radial tree layout a single node is placed at the centre of the display and all the other nodes are laid around it. The entire graph is like a tree rooted at the central node. The central node is referred to as the focus node and all the other nodes are arranged on concentric rings around it. Each node lies on the ring corresponding to its shortest network distance from the focus. Any two nodes joined by an edge in the graph are referred to as neighbours. Immediate neighbours of the focus lie on the smallest inner ring, their neighbours lie on the second smallest ring, and so on. This layout allows

getting a synthetic and compact view of a hierarchical network. Users can focus on particular parts of those trees without losing context.

- ***Convex-hull***:

In computational geometry, "convex hull" is defined as the boundary of the minimal convex set containing a given non-empty finite set of points in the plane [Gries & Stojmenovic, 1987]. Unless the points are collinear, the convex hull in this sense is a simple closed polygonal chain. Graham's scan is a straightforward implementation known with complexity of O(n*log(n)) and is the fastest known method of finding the convex hull of an arbitrary set of points.

4.6 Testing and Design Approach to the VIMS tool

We started the research by looking at the structure of the radial tree and wanted to make sure that the structure is easily understandable by any lay person. We built the structure by just using SVG without any algorithm. Once we were pleased with the structure we built up the radial structure using an algorithm with a few calculations for the placement for nodes on the concentric circles which identify the number of levels. We started building the tool using a simple radial-tree algorithm using perl and SVG. We wanted to distinguish every discussion thread in a forum with a boundary and so included the concept of convex-hull. Once the algorithm was built we wanted to test if the tool works with the data stored on Moodle forums. We intended to use a realistic test data only to provide a sense of the tool's functionality and not for analysis of the online discussion patterns. The Moodle database has around 200 tables and it was a time consuming activity to analyse how exactly data was stored within Moodle. We then identified the tables which stored the relevant information needed to build the tool (VIMS). With a set of SQL statements we parsed the information needed and stored them in the VIMS database.

Accessing the raw information from the database of real-time online interaction on Moodle forums was difficult in the beginning. There was no access to the Moodle database, but we had the html pages consisting of the real-time discussion forums. We parsed the relevant information needed about the discussion forums like the course code, school names, group, thread, subject, date, poster and message content and ignored the html content. We then tested the tool to analyse the structure of the discussion. It was difficult to even do a quantitative analysis because of the lack of information provided. A feedback from the moderators on the analysis and outputs from the software built so far helped us identify that our software can provide a useful means of mapping discussions in the first instance. The visualisation outputs identified the structure of threads and how the structure is related to moderation.

HCP School, Belfast and SBN School (Student1) OK! HC-SB::RC Group::LIVERPOOL::Re: LIVERPOOL by Student1 - Friday, 19 May 2006, 11:17 AM::Hay Student2 Student1 here. I was happy Liverpool won. The gaols were cool!!Got to go!!!!!BYE

Code: HC-SB
School1: HCP School, Belfast
School2: SBN School
Group: RC Group
Thread: LIVERPOOL
Subject: Re: LIVERPOOL
Date: Friday, 19 May 2006, 11:17 AM
Poster: Student1
Message: Hay Student2 Student1 here. I was happy Liverpool won. The gaols were cool!!Got to go!!!!!BYE

Figure 4.5: Unparsed Information at the top taken from the HTML Page and Parsed Information at the bottom

Our next step was to analyse large data sets with detailed information on the participant's interaction and automate the tool by automatically taking the values from the Moodle database. We then had access to the Dissolving Boundary Moodle database (Case study 2, Section 5.3 of Chapter 5). We tested the tool with this large data set to see if the structure of the radial tree needs any alteration when the number of nodes in each level and the number of levels in each thread increases. There were a few minor calculations needed to improve the structure of the radial tree. We also made sure that these minor changes to the algorithm should neither affect the placement of the nodes nor should there be any overlapping of the nodes or concentric circles. We had to make changes to the code from time-to-time to test the accuracy of the tool during the development process. There were many versions of VIMS built to enhance the tool with new functionalities.

The analysis with the second set of information paved the way for the analysis of the cross-border interaction among the students. We then automated the tool by embedding it into the Moodle environment. We were given the data for research purposes and hence all the names of the students and teachers involved in the Moodle discussion forums had to be anonymised. A detailed quantitative analysis of the discussion forums was done. We extended our research by analysing the discussion forums to find out the relevance to the subject, of the responses. We implemented the Latent Semantic Analysis (LSA) technique from http://LSA.colorado.edu/. A detailed description of LSA is found in Section 6.3

The project then shifted towards enhancing the statistical analysis capability of the tool as more feedback was received from the users of the discussion forums about the VIMS tool. There was more software development done with a lot of functionalities included in the VIMS tool. The structure of the VIMS changed with more improvements and modifications. We not only analysed the patterns of interaction with and without moderation but also compared the groups into which the participants were divided and

found the consistency of groups (explained in detail in 6.4.2) using the tool. We expanded the visualisation of discussion forums by the addition of important indicators needed to analyse the online discussions. We included more statistical concepts like mean, standard deviation, correlation and Dynamic Time Warping (DTW) (Saleemi, 2006; Senin, 2008) which are studied in detail in Chapter 6.

Initially tracing the data stored in the Moodle forums was time-consuming. Access to real-time data was the second problem we encountered. But as the tool started to develop there were teachers who wanted to use the tool with their forum information in order to track their students' participation. The identification and implementation of the actual needs of the user was a complex task. But since our main purpose caters the needs of the teachers, we considered most of their requirements and implemented them in VIMS.

We also encountered many technical issues relating to generating SVG's in perl to make it an automated tool. Most of the SVG's functionalities are applicable to be viewed only in the Opera web browser at the time of experimentation. We wanted the tool to be visualised in a multi-browser without any installation of extra plug-ins. This needed a through investigation of the software.

4.7 Different Representations of Interactions with VIMS

The VIMS tool has extended the teacher's ability to view various representations of the online activity. Each of the representations either presents the same information in a different format or present information that cannot be represented in the other format.

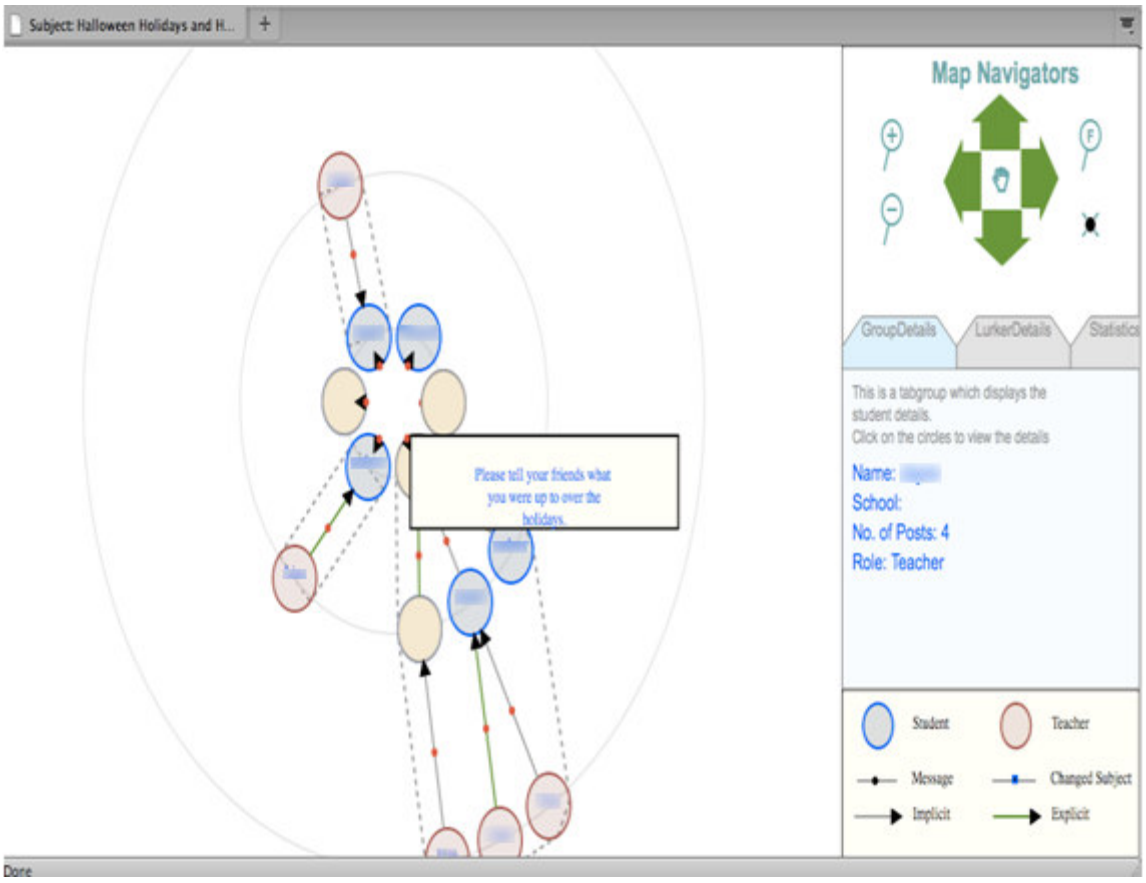


Figure 4.6: Radial Tree Representation

Figure 4.6 gives a snapshot of visual interactions in the form of Radial tree using Scalar Vector Graphics which has already been mentioned.

The VIMS has the ability to represent interaction maps in greyscale and colour. However, not all indicators would be the same in those two presentations.

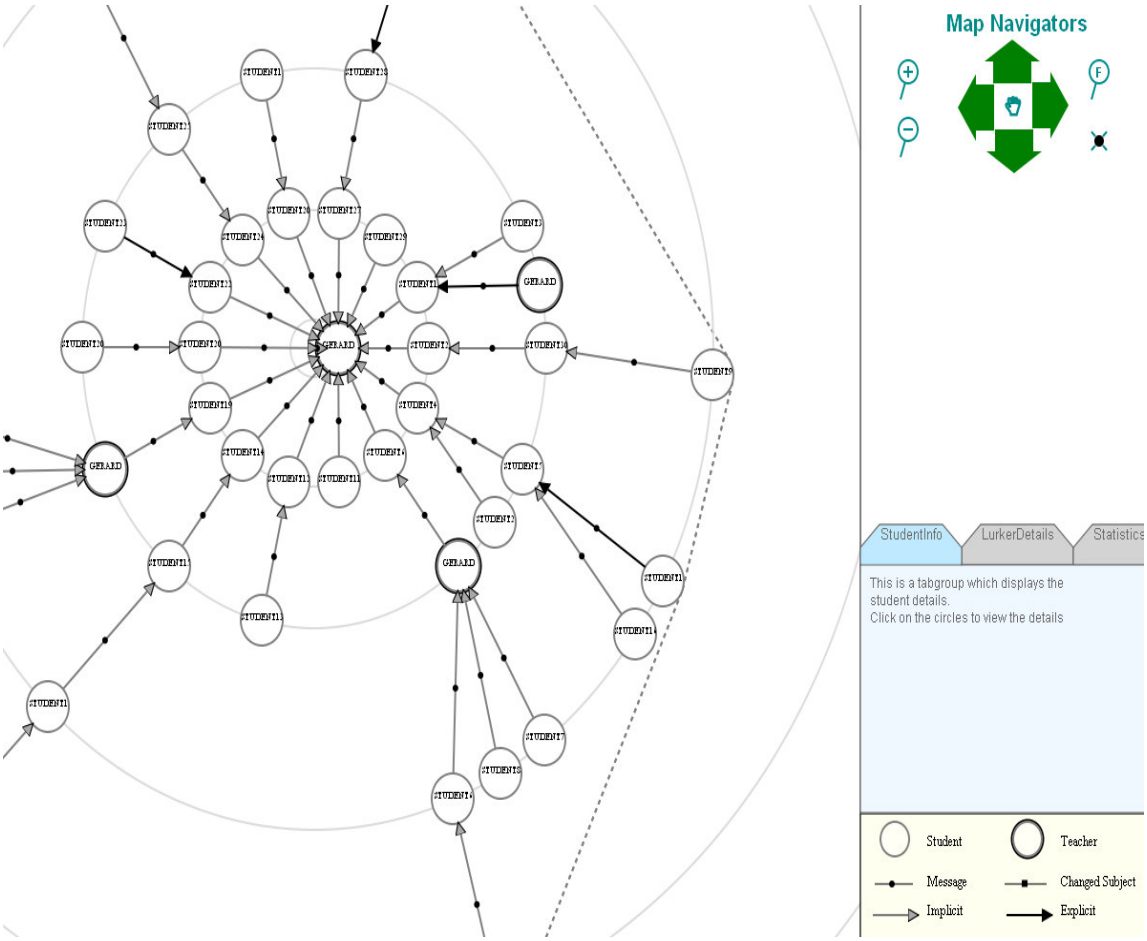


Figure 4.7: Radial Tree Representation in Greyscale

Viewing the conversations as a whole and also comparing the conversations from the day the conversation started to the day the conversation ended helps the teacher to visualise the flow of conversation over a period of time. We've intended to view the conversations on a weekly and daily basis, so that the teachers can find out the days on which the interactions were vibrant and the days on which it was silent. It also gives the structure of the conversation on a weekly basis and helps to see the participation level every week.

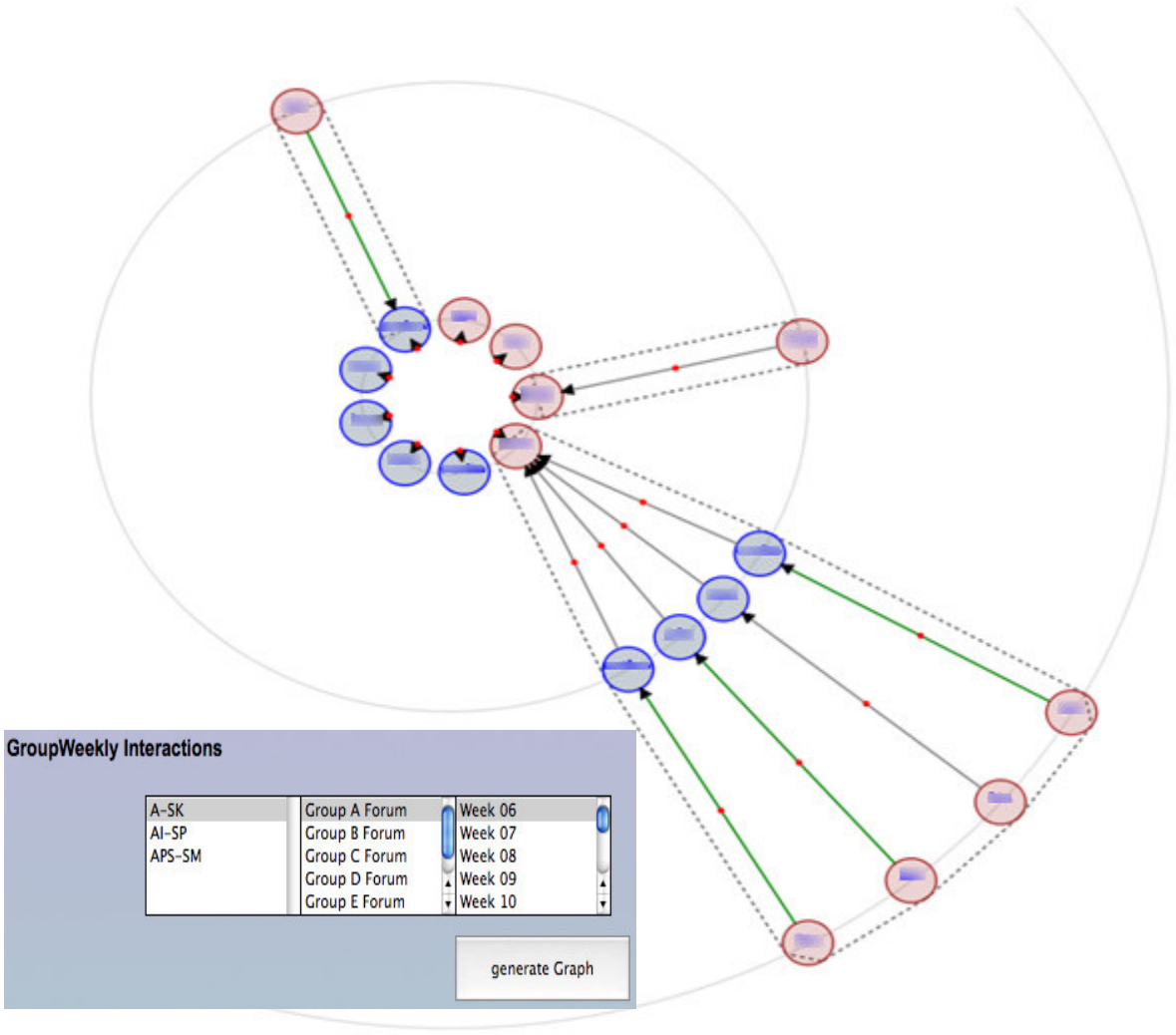


Figure 4.8: A Radial Tree Representation of a Forum along with the Selection list

Figure 4.8 shows a radial tree representation of one forum that has 9 discussion threads whose discussions happened over a period of 17 weeks, starting from the sixth week to the 22nd week. This gives the information of the delay of the start of discussions. While the discussions in other groups had already started this group (Group A) had started to interact with one another in the sixth week, with only one poster starting a thread and the other responding to it. The duration of the message flow in any asynchronous discussions is a concern as the interaction and participation happens irrespective of place and time.

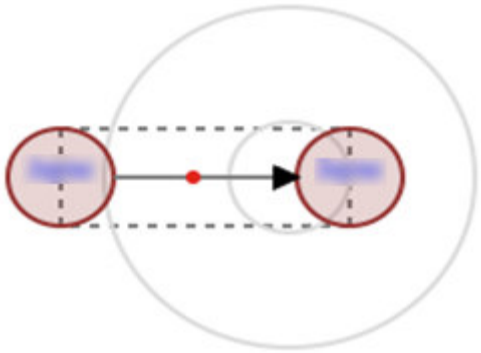


Figure 4.9: Representation of the Forum Interaction in Week 6

This structure (Figure 4.9) of the conversation lasted for about four weeks and then the structure tended to change with more discussions happening. By the 12th week there were a greater number of exchanged messages and the structure of the radial tree changed in response to the increased levels of participation, which can be clearly seen in Figure 4.10. The second discussion happened after week 6 and it was livelier than the conversation that had started at the very beginning. This could either be because of the participant who started the discussion or could be because of the topic of discussion. The teacher can intervene in this situation and make the other discussion as lively as the second one. The names of the participants are anonymised. From the visual display we see that the teacher involvement in this discussion was too rapid. Every alternate post in the discussion was a teacher's comment.

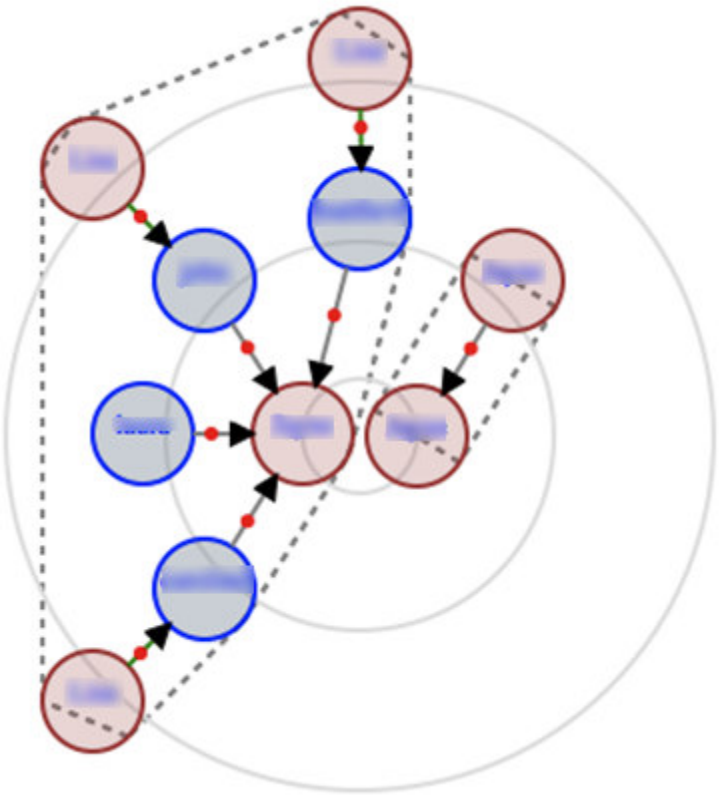


Figure 4.10: Representation of the Forum Interaction in Week 12

By week 21 as seen in Figure 4.11, there were many discussion threads started by different posters but none of them were responding to those discussions. Such threads seem to be isolated and needs motivation to carry on the discussion activity to make it more interactive.

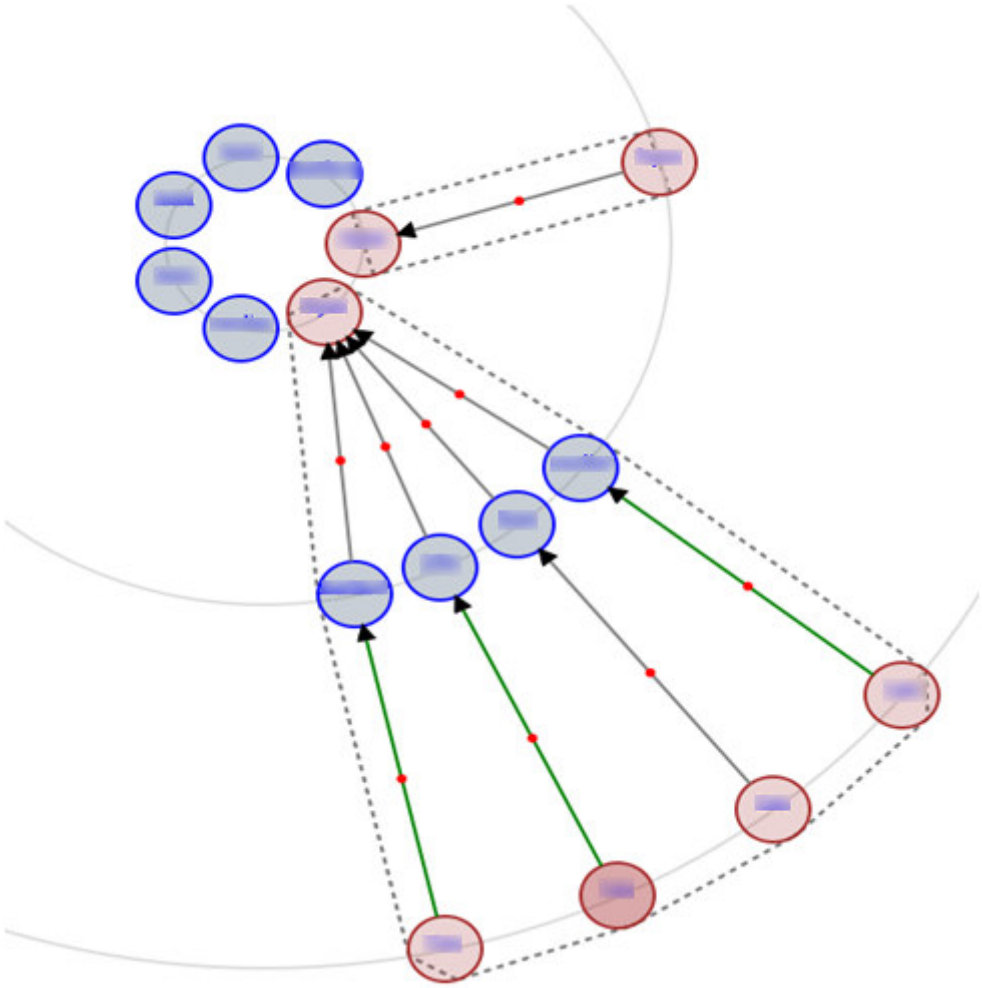


Figure 4.11: Representation of the Forum Interaction in Week 21

It was in Week 22 that there was one reply posted to an isolated thread and a start of two more discussion threads which can be seen in Figure 4.8.

Figure 4.12 gives another representation of the interaction process in a tabular form. This gives us an indication as to which participants replied to which other participants and gives a count of replies he has given to that participant. This reveals the information on the level of interactivity of a participant and also tells to which other participants they dialogue.

COURSE - A-SK → Replied to

Users	191	200	327	478	479	480	481	482	483	484	485	486	488	489	490	491	492	493	494	495	862	863	864	865	866	867	868	869	870	871	872
191	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
327	3	0	0	1	1	1	0	2	0	2	2	3	1	1	1	2	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0
478	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
479	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
480	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
481	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
482	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
483	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
484	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
485	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 4.12: Tabular representation of the Forum Interaction

From Figure 4.12 it can be said that the participant with user-id 191 has replied only once and has replied to his/her own post, whereas the participant whose user-id is 327, who is a teacher has replied not only to the teacher's posts but also replied to large number of the students. This shows that the participation level of that teacher is really high. One of the teachers (user-id 200) and one of the students (user-id 483) has never participated in the ongoing conversation. It could have been that the teacher was just observing the participant's communication which is not that major a concern, but a student not actively participating in the discussions is a concern which the teachers can now look into.

4.8 Detailed Architecture of VIMS

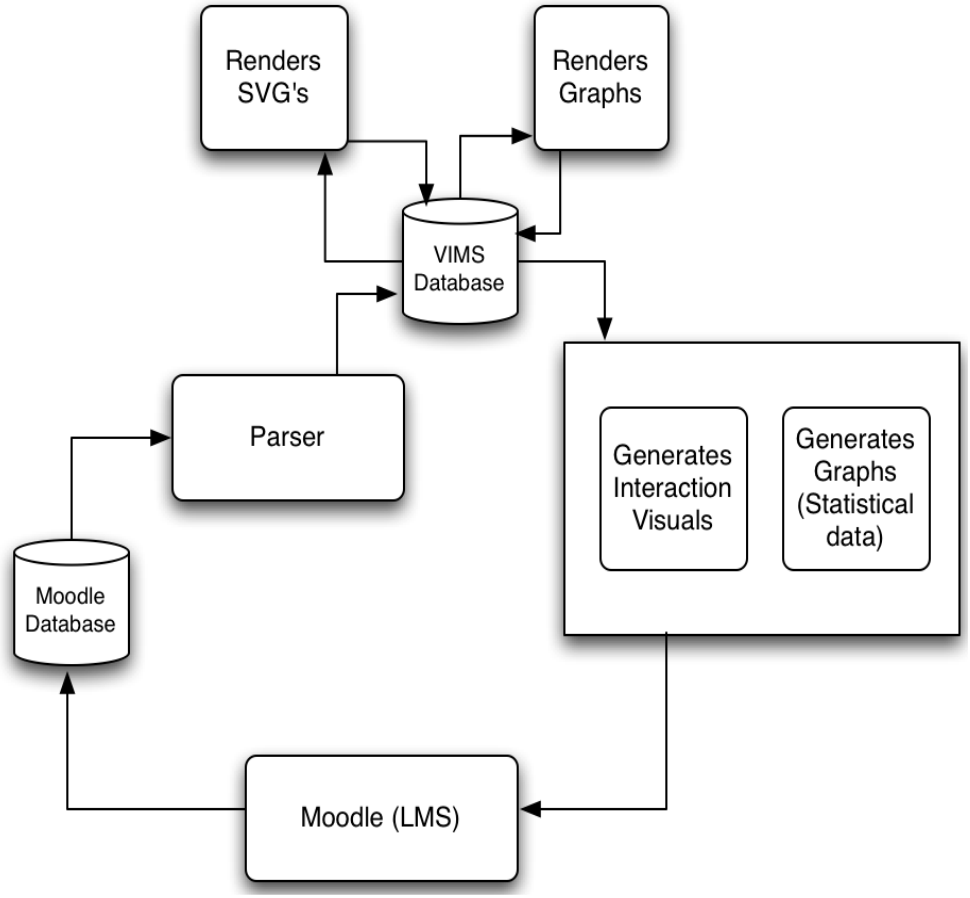


Figure 4.13: Detailed Architecture

VIMS is different from the other tools built so far in many aspects and can be seen in the Table 2.1. This system gets the required information necessary for the visual representation from the Moodle database. Analysis of the raw information from the log files has become more important because its details capture all the events occurring in the online virtual environment (Takada & Koike, 2002). The visualisation system parses the raw data into a simple understandable graphical representation in different steps. It should be noted that the Moodle database has around 200 tables. Our research is based on analysing only the Moodle forum discussions, participation level and the participants' details. These details are spread over several tables and hence we parsed only the

information needed from those tables through a series of customised SQL statements and exported them to the VIMS database. The radial tree module inputs the information from the VIMS database and generates the data required to render SVG representations and stores these back in VIMS database. The same is done for the generation of the statistical graphs. This stored information helps generate the visual images on the screen. VIMS is integrated into the Moodle environment and allows only the participants and the teachers to view the interaction graphs.

The two main components of VIMS as seen in Figure 4.13 are:

Parser Module: The Parser module collects all the necessary raw data from the Moodle database relating to all the participants interactions. It then uses a sequence of custom-written SQL statements and parses the information needed. This stage involves separating the pieces of SQL statements into data structures that can be processed by other routines. After parsing the useful information, it then adds them to the VIMS database. The tables used by the Parser are described in the section 3.6.2.3, 'Moodle Database & VIMS Database Tables'.

Renderer Module: The renderer module renders the visual images of the ongoing interactions by using Scalar Vector Graphics (SVG). Perl handles dynamic generation of these SVG's.

4.9 Embedding VIMS in Moodle

The visualisation aspect is added as a block in the Moodle environment. At the moment, only the teachers and administrators logged in would be able to view the visual representation of the forum interaction. We intend to improve it by adding functionality to teachers and administrators and the participants would also be able to view the visual interaction to see their own level of participation in ongoing online discussions. The usual

layout for Moodle is to have the main course content in the large central column and blocks (Alier et.al, 2007) to the left and right. A tutor can decide which blocks are to be displayed, and where, and would be set to default settings if no changes are made to the block. The block has a description of the visualisation details and a link to the VIMS, which displays the interactions and/or graphs according to the given criteria of selection.

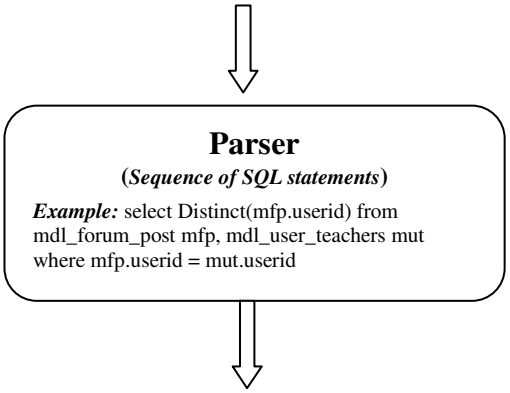
The main focus of this block is to embed a visual tool, which assists teachers to diagnose the interaction and participation of the students and through intervention motivate the lurkers and any students with low participation rate.

4.9.1 Moodle Database & VIMS Database Tables

The structure of the Moodle database is understandable and organised in tables with simple and short column names. The minimum fields contained in the main table are id, course and name. As stated, there are around 200 tables in the Moodle database. The main tables that are important for our visualisation are:

Table 4.1: Moodle Tables Used and Created for VIMS Tools

Table Name	Relevance to VIMS
mdl_user	Gather participants information
mdl_forum_posts	Get the forum and message details
mdl_forum_discussions	Get the details on the discussion threads
mdl_forum	Get the details of different groups in a course
mdl_course	Get the details of different courses
mdl_log	Get the logs of the participant's interaction
mdl_user_teachers	Get the teacher details and distinguish a student from a teacher



dbtable (21 fields)	Stores all parsed data form Moodle database
GroupInter (4 fields)	Stores details of Group Interactions
WeekInter (5 fields)	Stores details of Weekly Interactions

The tables mentioned in Table 4.1 after parsing information are automatically added to the Moodle database during the time of installation.

System Requirements:

Moodle is an existing system, written in PHP to run on Apache server. VIMS is written in Perl with SVG code integration. The combination of these two is an effective way to

visualise data in new and useful ways. A Perl program can easily generate SVG or an SVG-based application can call a server for updated information.

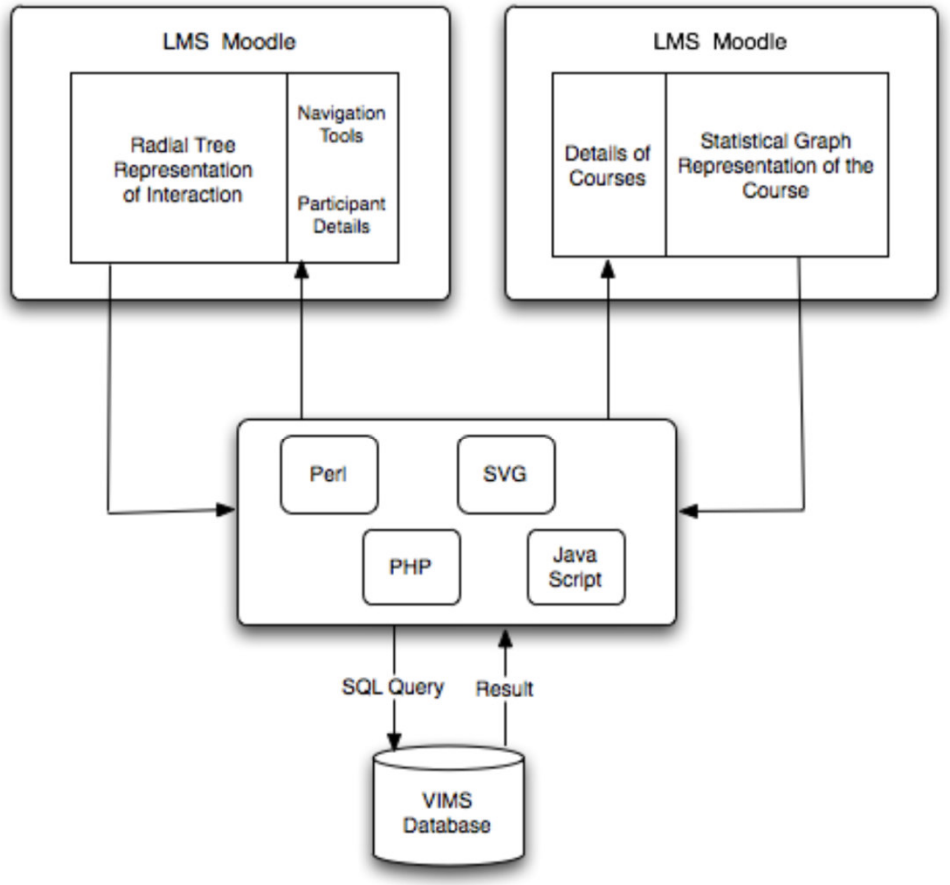


Figure 4.14: System Architecture of VIMS

Perl can be run with Apache (on windows) and MAMP (on Mac), using few SVG modules listed in Appendix F, so it should be possible to run Moodle and VIMS together on the same server. The tool has been tested on Firefox version 3.5 and above. The visualisations are SVG elements and hence it is required to log into Moodle using Firefox, chrome or opera browser. It can also be viewed using Internet Explorer version 6.0 or higher but with an installation of a plug-in called Abode SVG Viewer.

Authentication:

Moodle supports a range of authentication mechanisms through plug-in authentication modules, allowing easy integration with existing systems. Administrators can specify which fields to use. It maintains standard email method: students can create their own login accounts. Email addresses are verified by confirmation. If you are using email authentication, this is the period within which a response will be accepted from users. After this period, old unconfirmed accounts are deleted. Each person requires only one account for the whole server - each account can have different access. An administrator can configure variables that affect the general operation of the site: an administrator account controls the creation of courses and creates teachers by assigning users to courses; a course creator account is only allowed to create courses and teach in them; teachers may have editing privileges removed so that they cannot modify the course; students have the least privileges on Moodle.

VIMS does not need a separate authentication. It is a single sign-on by anybody using Moodle. Single sign-on (SSO) is a mechanism whereby a single action of user authentication and authorisation can permit a user to access all computers and systems where he has access permission, without the need to enter multiple passwords.

Virtual Interaction Mapping System (VIMS) is a robust web-based tool that dynamically generates scalable graphs to visualise and analyse the ongoing interaction in the forums. This section deals with the integration of our visualisation tool in the Moodle environment. One of the PHP modules will provide an API, which will integrate this tool in Moodle. The tool promises easier in-depth understanding of the interaction process.

The interaction between the instructor-student and student-student has been enhanced through the virtual environment by keeping track of the interaction patterns. VIMS supports real-time viewing of the ongoing discussions in the Moodle forum.

4.10 Methodology

The approach we used to collect subjective evaluations on the use of VIMS was a qualitative user study. This approach evaluates the usability of the visualisation and assesses the tool. By collecting the opinion from the moderators and teachers, we would evaluate the use of VIMS. Their questions, feedback and comments guided us in making improvements to VIMS. The study included gathering comments & feedback from the moderators regarding the understanding of the structure of the visualisation. This was done once we had the structure of the visualisation ready. A questionnaire to obtain qualitative reactions from teachers and moderators when the tool was ready to be used was our next approach.

First we explained the structure of the radial tree representation and then asked them their opinion regarding the representation. Our goal was to know if the moderators understood the structure of the representation and found the representation useful to understand the online activity. Through a number of meetings with the moderators and teachers we identified few indicators and graphical representations and improved the tool. Once the tool was ready to use we tested the tool with three teachers who already had knowledge of Moodle and frequently used the discussion forums on Moodle for their students. We wanted their opinion on the understanding of the VIMS tool itself and its navigability. Once we got their comments we framed a second questionnaire to get more feedback. This was done with the help of one of the teachers who tested the tool.

A final questionnaire was sent to a different set of teachers and few researchers electronically. The first part consists of a brief background and explanation about the VIMS to be tested. A brief description of the structure of the visual representation was also given. A questionnaire consisting of 3 questions which also included an open question allowing the teachers to write their comments on the tool and the representations of the tool was given to collect information about the usability of the visualisation tool.

Those comments play a central role for further improvement of the structure of the visualisation the tool presented and the tool itself. Full details on all materials for this survey along with 14 images of the interactive visualisations sent to the teachers are listed in Appendix G.

4.10.1 The First Questionnaire

1. Does the structure of the visualisation clearly explain the discussion space?

2. Is the radial tree structure clearly understandable?

3. What are the indicators that you (as teachers) feel should be included in the visualisation?

4. What are the other kinds of representations that you think could be included in the tool?

5. Do you suggest that the students also should be encouraged to view the online activity?

4.10.2 Final User Feedback Survey

The final survey was conducted once the tool was ready to be used. This survey was conduction to get a feedback on the understanding and the use of those interactive visualisations. The questionnaire for that survey is as follows:

1. In your opinion how useful is a visualisation tool with respect to monitoring the student's online discussions in a Learning Management System (LMS) like Moodle?

2. What other indicators like time difference between two posts, posts read ... do you think can be added to the visualisation in VIMS tool? (In other words what other important aspects of the forum details would you prefer to be viewed), If you can think of a few more indicators that could help the teachers through visualisation, please mention.

3. Can you suggest from your experience what needs to be improved in the tool? (Could be help information on the buttons or the graphs).

4.10.3 Feedback from the First Survey

About 10 teachers which included three moderators were asked to give their feedback and the first questionnaire was given to them during one of the meetings that I had with the teachers. All the teachers had a positive reply to the question asked and replied saying that the structure of the radial tree is clearly understandable to them and it also helps them understand the discussion space much better. The teachers gave valuable suggestions as to what other indicators would be useful to interpret through visualisation. Two of the teachers had also suggested the need of a greyscale visualisation of the same radial tree representation. There were few teachers who wanted statistical analysis to done and so could be another representation of the VIMS tool.

They also suggested an individual analysis of the students to be represented in an understandable form apart from the conversation flow. Although some of the teachers encouraged that students should be able to view their progress of the online activity, some of them didn't find the need of it for the students. And so explained that Moodle would have a feature for the teachers to choose if they wanted the visualisations to be viewed by their students or not. Although lurkers were not represented in earlier version of the visualisation, a need for the lurkers representation and their silent activity was proposed.

On the whole they responded saying that this tool once built would be valuable source for the teachers and the moderators to visually track the online participants. One of the moderators was very much interested to see the activities of students when divided into groups and compare the groups. The teachers who used the tool and navigated through it found it easy and understandable. However, one of them suggested having a dropdown menu in one of the pages rather than having a teacher to click through so many buttons.

4.10.4 Feedback from Final Survey

The final questionnaire also gave positive feedback from the teachers of NUIM. There were eight teachers and three researchers involved in this survey. This was conducted once the tool was built according to the requirements of the teachers who were involved in the first survey. The people involved in the final survey also expressed the need of a visual tool of online interactions on Moodle. The teachers felt that structure was clearly understandable and the indicators helped them view most of the necessary features of the online activity. The statistical analysis was useful to find the quantity of the contributions. Some of them suggested a few modifications to the current tool which they thought could make the tool much more useful. Some of them were, having some kind of marking scheme to be included based on their amount of participation, some way to represent the time difference between the two posts, the size of the textbox which displays the dialogue of the participants to be a small size with a scroll bar beside to scroll through the dialogue in case where the conversation dialogue is too long. Their suggestions are taken into consideration as future research and could be implemented in the visual representation.

4.11 Summary

In this chapter we presented the technical implementation of VIMS, highlighting the model used, the structure and architectural designs, our approach in building the tool and detailed instructions of embedding VIMS on Moodle. VIMS is graphical interactive

online discussions tracking and representation tool that examines the various aspects on the ongoing asynchronous discussions on Moodle environment. This tool can however be integrated into any LMS. VIMS in general can be assumed as a solution to our research questions. The chosen research methodology and architecture that we presented in this chapter is an outcome of the limitations of the other tools that we had discussed in Chapter 2. The feedback from the various sources gave evidence of the importance of VIMS in a learning environment. In the next chapter we present the visualisations comprising of two different data sets, which can detect the structures and patterns of the discussion threads.

5 VIMS Approach and Case Studies

5.1 Approach and Plan

In this chapter we present two case studies, taken from the forums of two different institutions. Using these case studies we illustrate the working and usefulness of VIMS and analyse the various types of interactions, producing an analysis of group interactions.

This research project is predicated on the belief that the understanding of discussion forums for future collaboration and online learning requires improvements in our understanding of the behaviour and patterns associated with the existing discussion threads. Through this research effort, we plan to develop visualisation techniques for correlating huge volumes of online discussion forums and various techniques aimed at enhancing the community's ability to model future discussions in a Moodle environment.

Two case studies were conducted with the following objectives:
Firstly, to assess the effectiveness of the visual tool which captures large information in one visualisation and, secondly, to identify the quality of the ongoing discussions. The case study information images reveal that the tool was indeed helpful for the moderators and teachers to identify the details of the activities happening online on discussion boards (forums) on Moodle, both in quantity and quality. VIMS provides visualisations of the participant’s social and behavioural patterns, allowing constant monitoring of their online activities and the role played, along with their contributions and meaningful interactions.

5.2 Case Study 1

5.2.1 Background of the participating organisation

The first study is based at NUI Maynooth in Ireland. The author is located at NUI Maynooth, and this research was prompted by our interest in exploring some of the effects of the introduction of an institution-wide VLE at the university. NUIM has three Faculties encompassing Humanities, Social Sciences, and Science and Engineering subjects. It has a student population of just over 8,000. Courses at undergraduate and postgraduate levels have been modularised. Teaching is predominantly face-to-face, through lectures, tutorials and practical sessions. Most students are full-time participants in undergraduate courses, which they attend on campus.

The dominant culture of the university is a traditional one, where attendance at timetabled teaching events is expected. However, there is increasing interest in blending this 'traditional' teaching model with other modes of teaching and learning: changes in the student body, with increasing numbers of part-time and international students, are leading more departments to explore the use of learning technologies within their courses. The university adopted Moodle as its institutional virtual learning environment in 2005. All taught modules automatically have a space created for them in Moodle, with students having access to these spaces automatically after registration.

The decision of whether or not to use the environment remains with lecturers, tutors and with their departments. Additional Moodle spaces have been created for staff in the Library and in offices undertaking learning support, career development and staff development activities. At the time of writing, approximately 900 people have edited spaces in Moodle. There are around 8,000 independent student logins each week, and in effect student use of the system is now pervasive. Patterns of VLE adoption are broadly similar to those of other institutions (Kirkup & Kirkwood 2005, Smith 2005), with the

initial drive being towards support for existing processes (in particular, the sharing of course materials) rather than radical changes to learning and teaching.

Evaluation of the use of Moodle in its first four years has been undertaken by NUIM, and prompted our interest in exploring the use of forums in this research. The evaluation data from students and staff had shown that the reported benefits to students of using Moodle were predominantly practical, and related to the availability of course materials online. However, the students' responses also indicated extensive use of the forums within their courses. One unexpected finding was the extent to which students used unmoderated forums in Moodle. News forum spaces (created by default in each course space in Moodle) have been used independently by students to discuss coursework, assessment and other issues. This unmoderated use of forums in Moodle predated the popularity of social networking sites such as Facebook (http://www.facebook.com). The evaluation data suggested that students valued both moderated and unmoderated discussions. The use of unmoderated forums, in particular, was interesting as a possible site for informal learning. Therefore, we decided to explore further the interactions taking place in both moderated and unmoderated forums, and to examine whether these forums were potential supports for learning.

5.2.2 Case Study

Figures 5.1 and 5.2 show the initial test visualisations that were produced. Two forums are shown, each having four threads. Figure 5.1 shows a moderated Forum, Figure 5.2 shows an unmoderated Forum. The entire discussion was first read to get a general impression of the conversation. The messages of students (posters) interacting are represented as circles and the arrows connecting them represent the dialogue between those connected students, flowing in the direction of the arrowhead. The message text can be viewed by placing the cursor over the message-flow arrow. The instructor can also

view the profile of the student with a click on the node that represents that student. This gives a detailed description and shows the involvement of the student.

The interactions are depicted in layers: the person starting the thread is placed at the centre (the first level), and the people responding to the thread are placed at different levels around it. The presence of the node on the farthest circle (of each thread) indicates its level and depth in the structure. The increase in layers and the movement of circles far away from the centre indicates conversation in progress. The depth and the number of levels represents the complexity of the discussion forums and is explicitly clear from this structural layout. The structure of the radial tree identifies the mostly discussed topic. The arrow between two nodes represents the flow of information (the message). For example, an arrow from one node in level2 connected to another node in level1 with the arrow head (always) facing to the lower node (level1) indicates that the participant at level2 is responding to the participant at level1. If the participant at level1 (starter of the thread) replies to the participant at level2, then that message is indicated at level3. If there are more than one nodes with arrows pointing to a node at a lower level, there are more respondents to that post. The arrow heads with a dot in the nodes at the first level are used to view the post of the initiators.

Since time and timing are implicitly part of Schrire's model, we looked for ways to make this more explicit in our interactive visualisations. Although asynchronous discussions are by definition taking place at different times and places, it is important to consider time and timing in the messages that result. Long gaps in discussion can indicate possible lack of understanding of material or, perhaps, difficulties communicating (whether these are due to linguistic or other barriers). Drawing on Gibbs et al. model (2006), we included a means for the viewer to see the hour and date of a message. A drop-down list allows the moderator to view the conversations on a weekly basis. They would then be able to identify the participation level in the discussion, and how long a particular discussion lasted.

Interaction maps produced by VIMS can be shown in greyscale or colour. Colour-coding supports quicker and more efficient reading of the visualisation. For example, a red node can be used to represent teacher/moderator, and a blue node can represent a student participant. Dotted lines and arrows can automatically show a deviation from the topic under discussion. A dot on the arrow used within the radial tree means that the message details are available on clicking. A change of subject heading in a message is shown by a blue square. The concentric circles show the levels of the discussion, with the number of levels indicating the depth of the discussion. The dotted outline surrounding a set of circles represents a boundary around a particular thread within the discussion. Tabs located to the right of the visualisation show the details of the participant, lurkers, and other statistics about the forum (like the total number of posts, views, participants, threads, lurkers; the average number of posts per participant, average number of views of a typical discussion and average number of words per message).

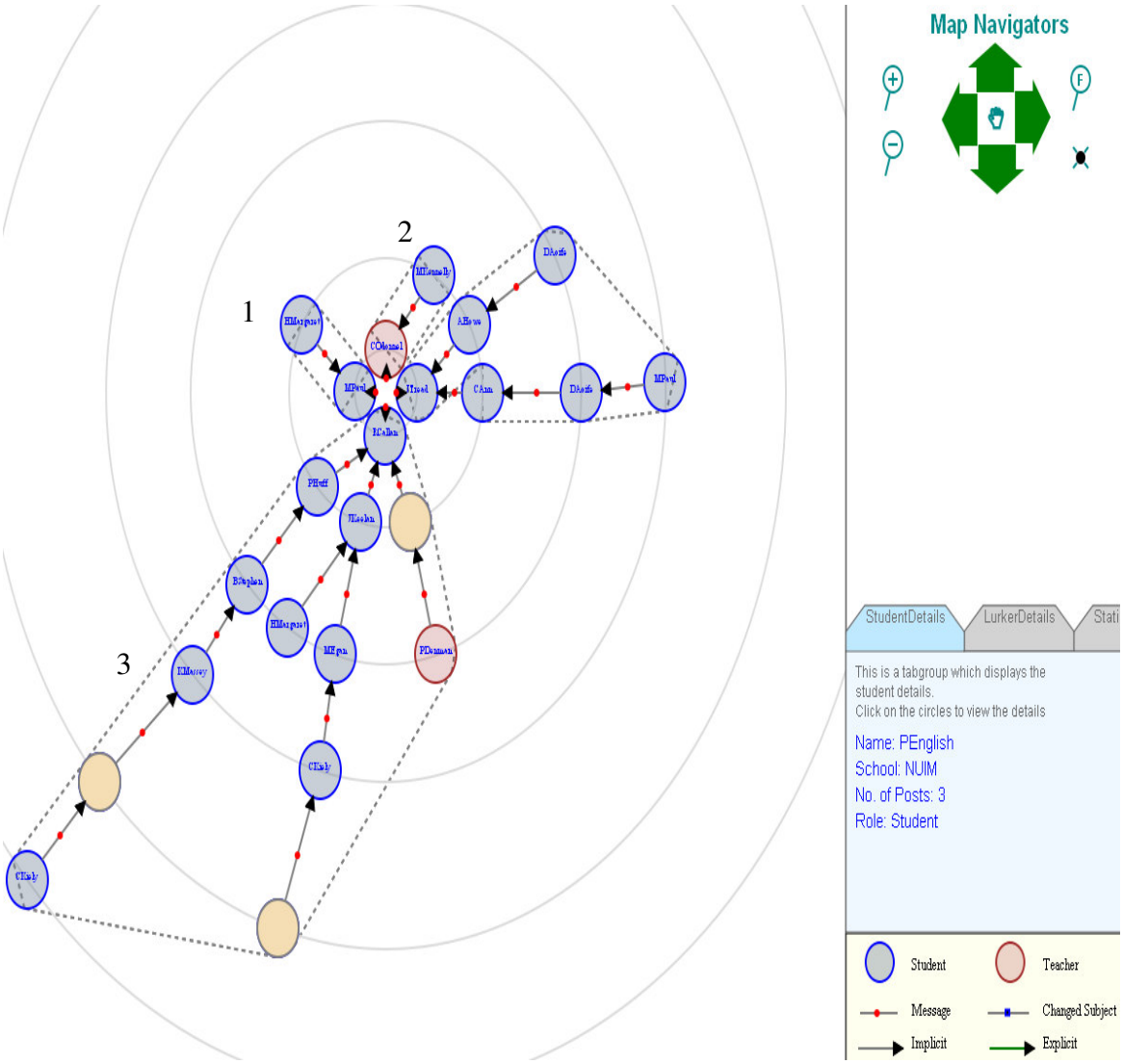


Figure 5.1: Initial Test - Threads from a Moderated Forum

In Figure 5.1, it can be clearly seen that the conversation involved responses by multiple posters, two of which went unanswered (1), (2) and one of which went on for some time (3). The depth of the conversation is clear to see. A click on the node highlights all the posts of that particular participant. Figure 5.2 shows the output of the test thread used to validate the output initially.

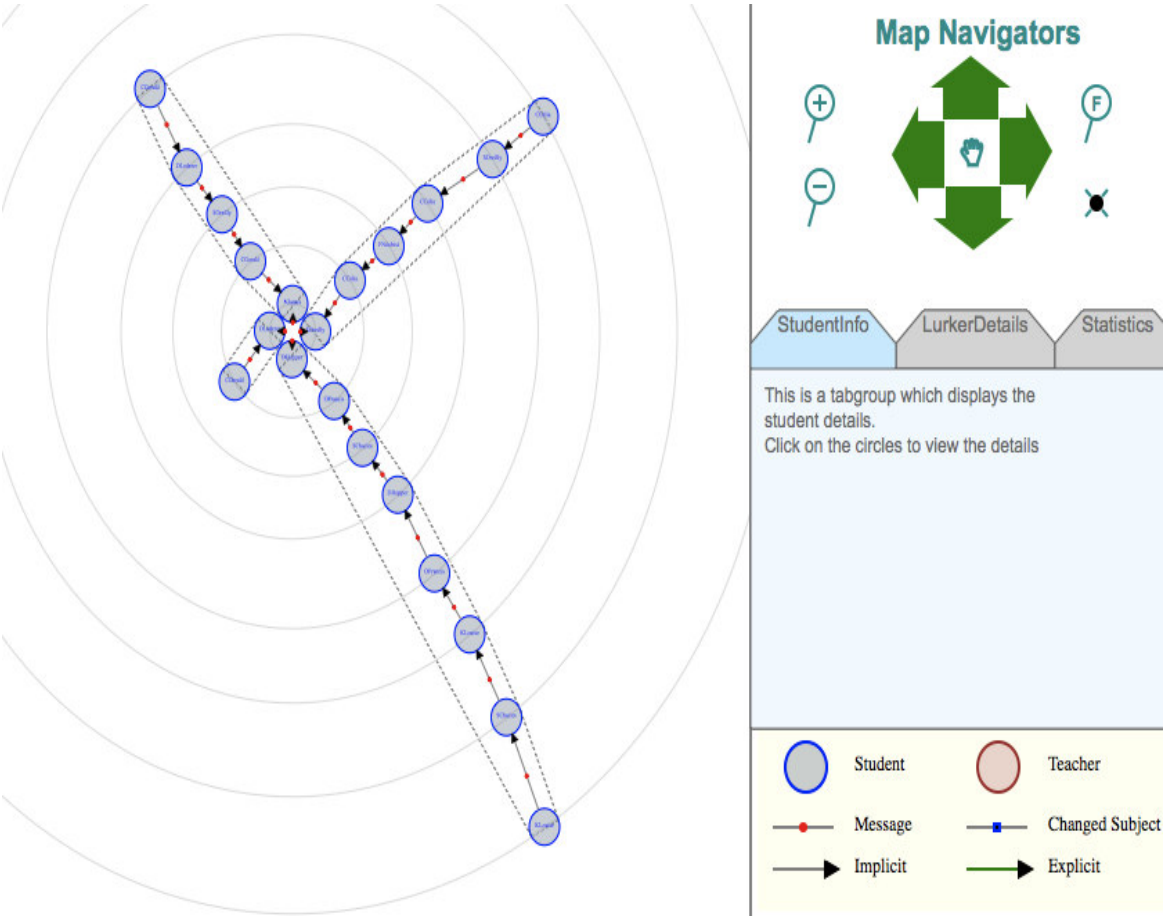


Figure 5.2: Initial Test - Threads from an Unmoderated Forum

Having completed the initial testing and confident that the tool was technically viable, we then carried out a more structured sampling of moderated Forums, selecting three threads for analysis:

1. Figure 5.3: A thread discussing whether or not a particular writer was racist, taken from a 1st year humanities course. There were 472 students registered on the course in total. Moodle had logged 2887 records for the overall discussion, which included two other threads. These other threads were barely used, and so the activity was

predominantly in the thread sampled. There were 44 replies to the original posting by the lecturer. 32 people participated in the thread, but the logs reveal that 235 people accessed and viewed the discussion from its launch date until mid-summer (when all examinations would have been completed). Therefore, there were 203 people 'lurking' in this discussion who viewed the thread at least once without posting to it. Some of these lurkers had returned several times at intervals during the discussion perhaps to read any further posts on the discussion and keep themselves informed.

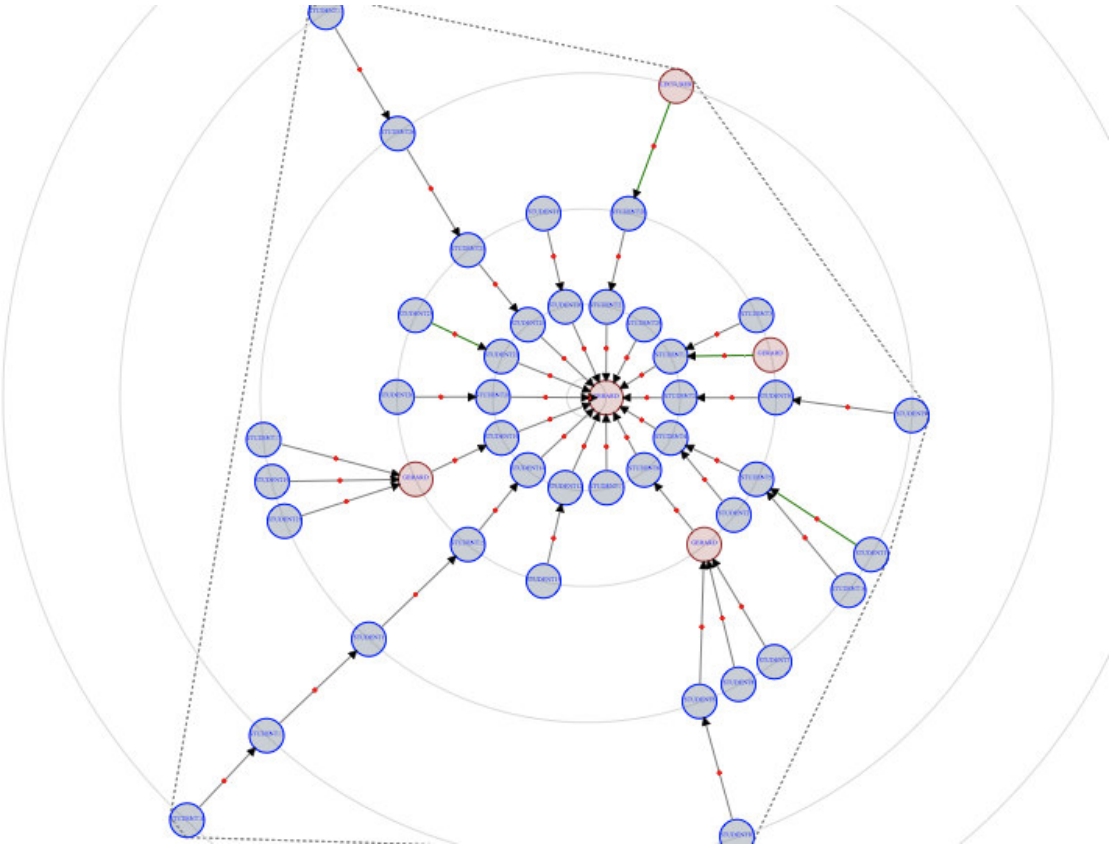


Figure 5.3: Discussion of Thread Concerning Whether Writer was Racist

2. Figure 5.4: This thread was again from a first year humanities course and addressed a specific theme in a poet's work. 473 students were registered to the course, which had a large number of Forums, one for each topic studied. There were 11 messages in the thread selected, and just four people were involved in the exchange of these

messages. However, the logs showed that 128 people viewed the discussion at intervals. This means that there were 124 ‘lurkers’ in this thread, viewing it at least once without posting any messages. However, in contrast to the first thread, there were few return visits by lurkers, and they tended to view the messages once only, suggesting that they were not interested in the subject or did not impact on course work or that they understood or agreed with it.

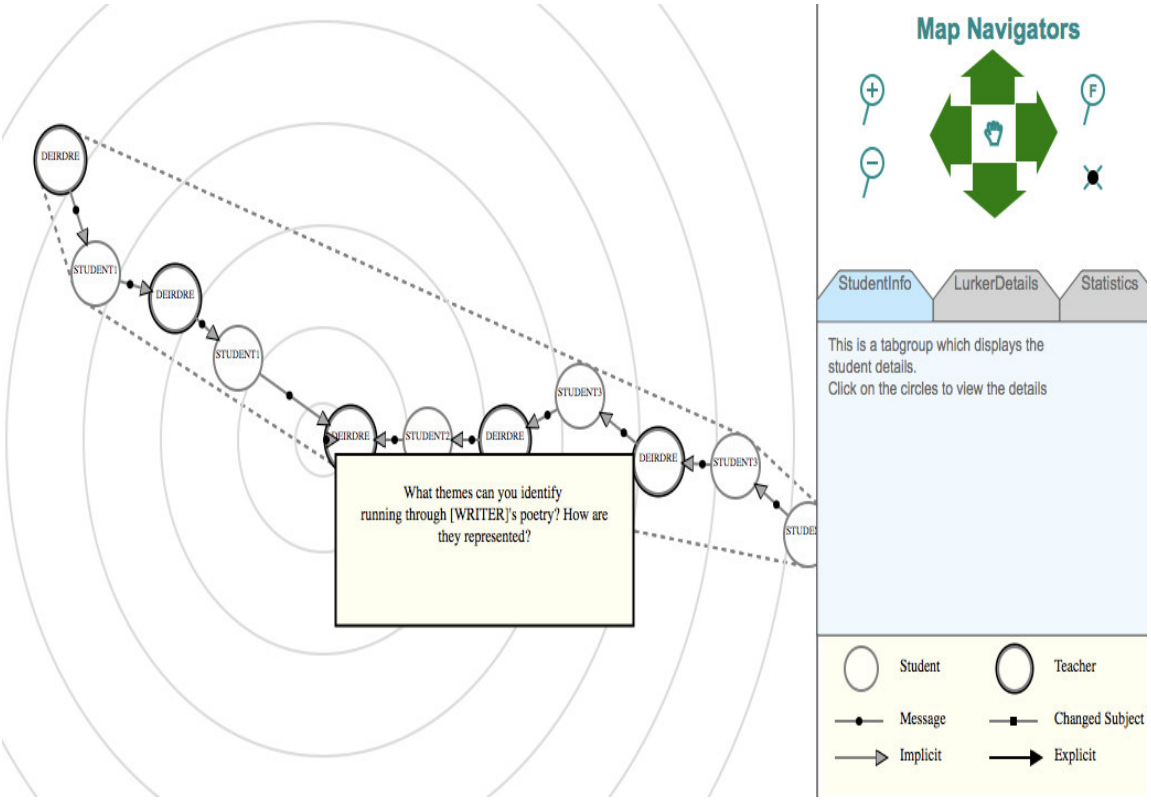


Figure 5.4: Discussion Thread on Themes in Poetry (In gray-scale view)

3. Figure 5.5: This thread came from an online course for teaching staff. The course was designed to help staff develop skills in forum moderation, and participants attended online only. There were nine registered participants on this course and the busiest thread was selected. It had 21 messages and all but two of the course participants had posted to the thread, with only one person never viewing it at all. This might suggest

a problem with the participant's involvement with the course overall, and prompt further investigation to identify any such issues.

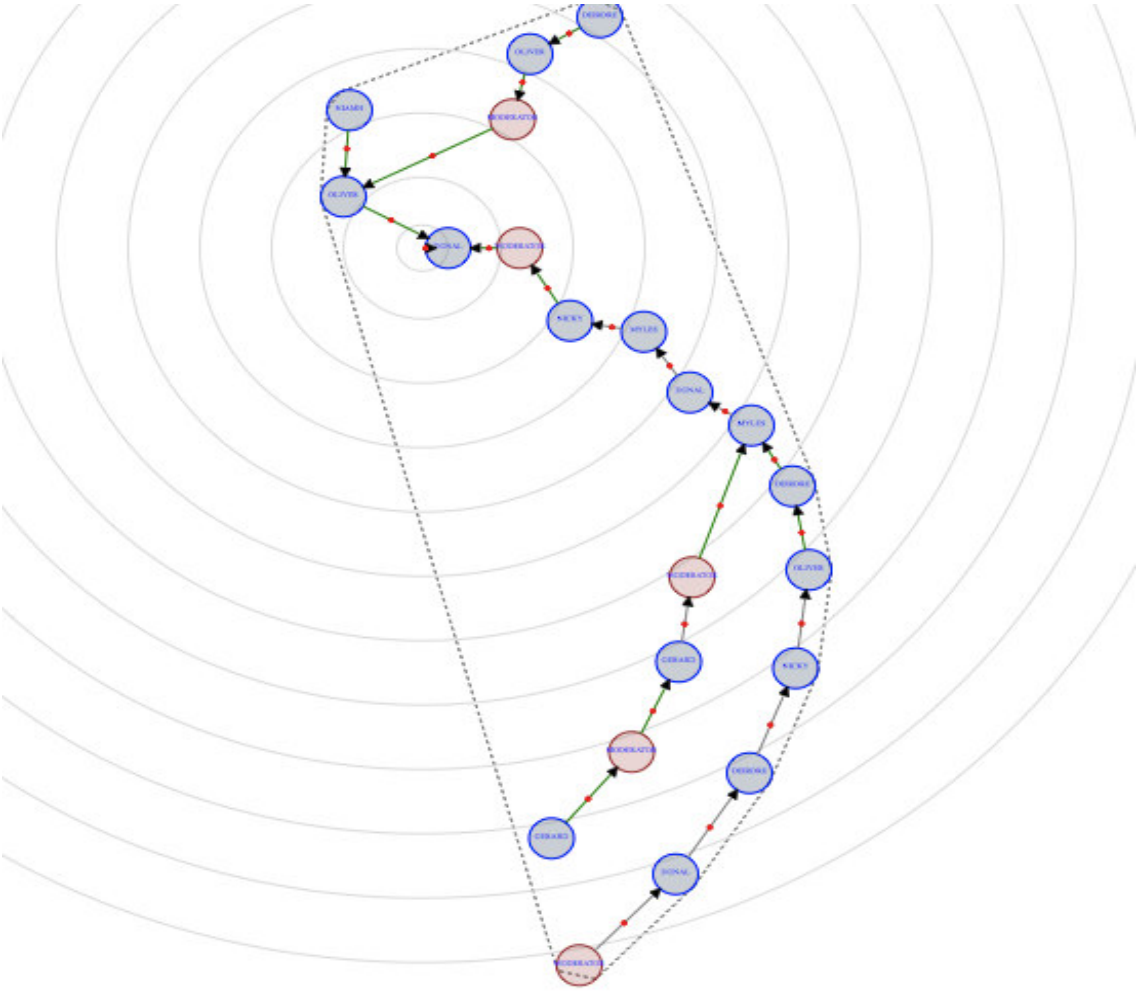


Figure 5.5: Thread from Online Staff Development Course on e-moderation

In this phase of our research, we aimed to select threads that showed a good degree of activity but also to include a thread, which would clearly show conscious and very deliberate efforts to moderate discussion in the case of the staff development course. This was to highlight the importance of the various types of interactions possible in an asynchronous environment and to represent the pattern of such interactions. However, the

limitations of our samples must be acknowledged: for practical reasons it was not possible to migrate large amounts of data from Moodle to the software at this stage. Our primary concern was to protect the personal data of staff and students, and therefore we selected and extracted small amounts of data, which could be easily anonymised. (However, it is important to note that VIMS can also be used with large amounts of data which can be proved in the other case study).

In our initial tests and subsequent analysis of three selected discussions, the threads were parsed by the software to produce interaction pattern maps. The final illustration, in Figure 5.6, shows how a message would appear to the viewer where he/she hovered over the arrow-head between two of the nodes shown. In this case, the message was from 'Shauna' to 'Cormac' and refers to a book Cormac is asking about.

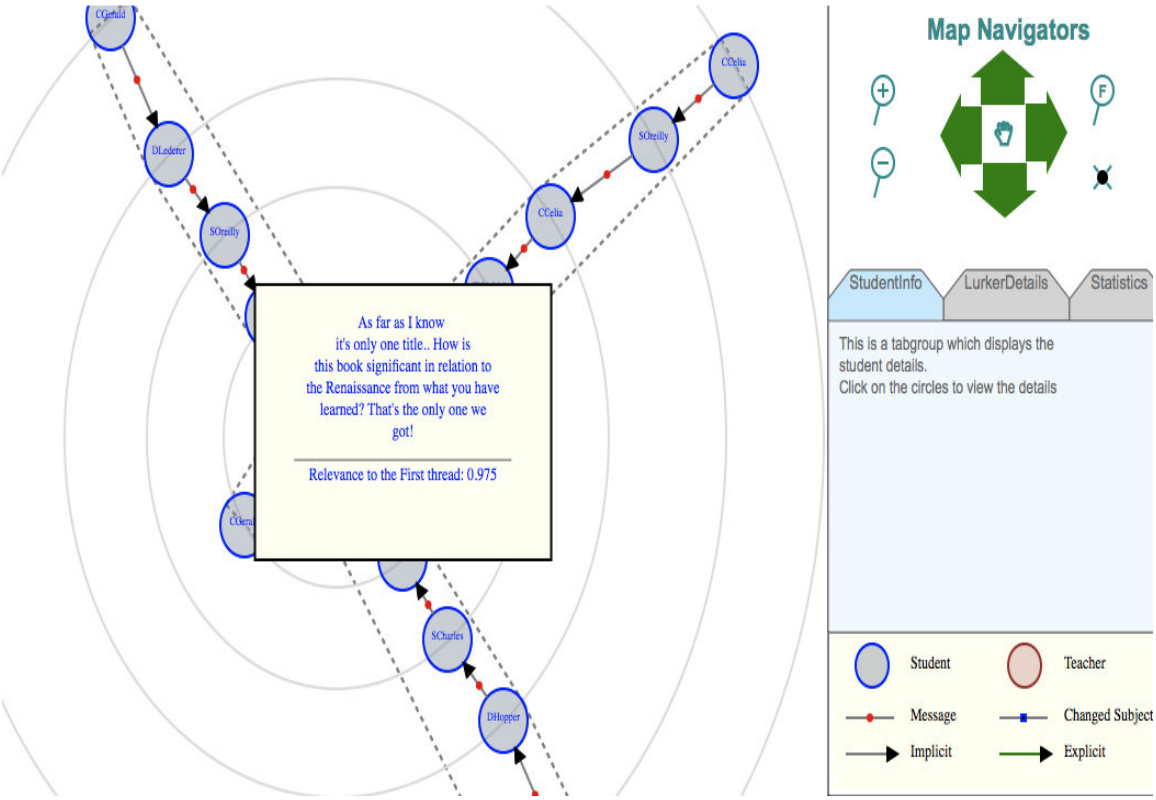


Figure 5.6: Example showing how Message Text can be Accessed from the Map

5.2.2.1 Findings

Following Schrire's (2004) model, we attempted to categorise the overall trend of the messages based on Schrire's scheme (from 'instructor-centred', 'synergistic' to 'studentcentred' and 'scattered'). As can be seen from the visualisations reproduced here, the visual representation not only differentiates a teacher from a student but also shows that there was no change in the subject title, and identifies an explicit and an implicit interaction which is explained in detail in the next chapter. We have enhanced Schrire's model by adding in additional important visual indicators. We will present further analysis in respect to the Figures 5.3, 5.4 and 5.5.

In Figure 5.3 we see that the thread had been initiated by a teacher, and as such it could be regarded as Instructor-centered. Most of the students tend to reply to the teacher's message. We also see that there are a lot of follow-up responses to the threads, and the thread shows a Synergistic pattern of interaction. The web like structure of this thread with a depth of five levels indicates collaborative learning and some social networking in this forum. The teacher has not just initiated the thread and kept silent but has responded to some of the messages which indicates that the teacher/moderator is performing his/her role by intervening and participating in the interaction process.

We see in Figure 5.4 an almost the opposite scenario to that shown in Figure 5.3. This thread is also initiated by a lecturer but the students did not participate in the thread to the same extent. The group size is the same as that for the thread in Figure 5.3, but more forums were used in this course. Only four people participated in this thread and the messaging is linear in nature. We see that the teacher had to keep posting her views and asked for more ideas and thoughts on the subject to motivate the students to post more. This thread is Instructor-centred and does not appear to move towards the Synergistic pattern.

Compared with the other two threads, we can say that the thread in Figure 5.5 is the busiest, because of the amount of activity among only nine registered participants. All but two of the course participants posted to this thread, and only one of these people never accessed the thread at all. One person viewed it on just one occasion. The visual representation of this thread shows developing synergism: the Instructor contributes at several points, but there are areas in which the discussion sub-divides and is not confined to the linear pattern.

The radial tree shown in Figure 5.2 indicates a linear pattern to messages, with no sub-division into discussion of the first posting. By contrast, the moderated threads represented in Figures 5.3 and 5.5 combined 'instructor centered' dialogue with 'synergistic' dialogue. The radial tree representation suggests that there were more connections between messages in these threads. However, it is interesting to note that there is more instructor presence in Figures 5.4 and 5.5 than in Figure 5.3, where the students appear to take the discussion and develop it in a number of directions independently.

Where there are more connections between messages, Schrire suggests there is more evidence of collaborative learning. The unmoderated forum shown in Figure 5.2 in our test example has what Schrire describes as the appearance of 'spokes on a wheel' with a linear messaging process rather than connections between parts of the dialogue. In the absence of synergistic dialogue, it becomes more difficult to argue that learning (or collaborative learning) is taking place. According to Schrire's classification, the unmoderated thread combines 'scattered' and 'student centered' messages. However, we also see a linear pattern in Figure 5.3, which is 'instructor-centred'. We see more evidence of wider dialogue in the moderated threads in Figures 5.1, 5.3 and 5.5, where the original message gives rise to two or three separate strands of discussion. The trend is towards a 'synergistic' pattern in these threads.

Thus we argue that the VIMS software can provide a useful means of mapping discussions in the first instance, but its development as an enhanced version of Schrire's (2004) model also provides an initial analysis of the interactions. This initial analysis, we argue, could support the development of a research design to undertake more detailed qualitative analysis of forum discussions. The interaction pattern maps shown earlier, and our initial findings described above, have indicated a number of areas for discussion at this stage.

In our local evaluations of VLE usage, the extent of the use of unmoderated forums by students was an unexpected finding. First reading of some of these unmoderated discussions suggested that they could be a potentially valuable site for learning. However, the interaction pattern map for four threads in an unmoderated Forum in which we had seen messages relating to coursework and course reading (Figure 5.2) suggested it was student-centred and even scattered in nature, with little evidence of synergistic dialogue. Having used the visualisation tool to examine this unmoderated discussion, we would now reconsider the focus of further research in this area: it seems less likely that unmoderated discussions are sites for collaborative learning. Therefore, the visualisation tool has had merit in helping us to refine and re-focus a research question arising.

We do also re-examine the role of the instructor/moderator in moderated forums. Figures 5.4 and 5.5 show patterns that might be described as *instructor-centred* (Figure 5.4) and *instructor-centred tending towards synergistic* (Figure 5.5). The most synergistic discussion is seen in Figures 5.1 and 5.3. Although an instructor is present in both examples, instructor postings are firmly in the minority compared with students' postings. In these cases, we might begin to examine why the discussions were more synergistic in nature and therefore had more potential for collaborative learning. Were the topics being discussed of greater interest or importance to students? In the case of Figure 5.3, we know that the discussion focused on a potentially controversial topic, whether or not a particular writer could be regarded as racist. This clearly generated debate amongst

students. However, in the case of Figure 5.1, we observed something different: the instructor/moderator also made extensive use of the 'Topic' spaces in the course homepage in Moodle. These spaces – although not forum spaces – referred to the discussions, and set particular tasks for students. Topic spaces are frequently used as 'notice boards' in Moodle, and are easily updated. However, they are static and the information shown in topic spaces is not copied to forums, nor is it visible within a forum. It may or may not be read by the student before viewing of forums messages. A topic space may therefore have a role – albeit limited – in influencing the discussions in a Moodle course. Here again, then, the visualisations have prompted us to reconsider and refocus possible research questions in the analysis of the online interactions. The role of the instructor/moderator has been shown to be nuanced, and potentially to be dependent on the topic under discussion, as well as the wider course space in Moodle.

Our goals in this research have been to produce dynamic interaction maps, and to begin the process of analysing these. It was outside the scope of this research to investigate further the discussions undertaken by the groups sampled here, and there were practical constraints on how much of their discussions we could draw on. However, the findings from our initial tests and our structured samples suggest that the discussions shown in Figures 5.1 and 5.3 would merit further analysis to examine the collaborative learning taking place. With further research, and a research design that also included interview or focus group work with students, it would be possible to investigate whether the discussions shown in Figures 5.4 and 5.5 would have benefited from an alternative choice of topic, or whether practical issues (such as timetabling and assessment deadlines) influenced the extent to which learners could participate in forums. In the case of staff learners (Figure 5.5), they may not have found moderator intervention useful, since they were already accustomed to working together within their academic department. Initial analysis, based on the interaction mapping, provided us with insights for further analysis, and the formulation of clearer research questions. The areas we wish to investigate

further could now be examined using other qualitative and quantitative methods, which is discussed in the second case study using more elaborate data from a different source.

5.3 Case Study 2

5.3.1 Background of the participating organisation

The "Dissolving Boundaries" program was initiated in 1999 and has been designed, developed and managed by educationalists based in National University of Ireland, Maynooth and University of Ulster at Coleraine, Northern Ireland. The "Dissolving Boundaries" program uses the integration of technology to facilitate cross-cultural education linkages between schools in the Northern Ireland and Republic of Ireland. Schools at primary, post-primary levels and the special schools' sector in two jurisdictions participate in this program.

The "Dissolving Boundaries" program aims to promote cultural awareness and develop valuable collaborative online learning experience by integrating Information and Communication Technology (ICT) in their curriculum (Nigel et al., 2008; Austin et al., 2007). The term 'dissolving boundaries', according to the program team (Abbortt et al., 2004), has multiple strands—that is, cross-national, inter-cultural and in terms of religion and gender. Associations also existed between contrasting education systems, between urban and rural communities, and between different school enrolment types (boys' and girls' schools and coeducational). Some cross-sector collaboration also took place, as two of the special schools had mainstream primary partners (Abbortt et al., 2004).

"Dissolving Boundaries" works with each school to set up and sustain a link with a compatible school on the other side of the Irish border (Austin et al., 2007). Every participating school is linked with a compatible school from across the border to form a partnership. Compatibility of the schools is judged according to their school sector, age

of pupils, and, in the post-primary sector, according to the subject specialization of the participating teacher. The partnered schools work collaboratively during the year on a joint project to promote cultural awareness and learning experience through technology. Throughout the year, students and teachers engage in various forms of on-line communication, one of which is asynchronous conversation through forums, with their partner schools across the border.

Every partnered school is identified by an acronym. These partner schools exchanged views and ideas through the Moodle forum. The students are divided into different groups namely Group A, Group B ... and so on, depending on the number of students in each school.

5.3.2 Case Study

In this case study there are approximately 140 schools involved, including both Northern Ireland (NI) and Republic of Ireland (RI). Every school participating in NI is linked with a RI school and so such schools become partner schools and the students and teachers of the partner schools are divided into different Groups, again depending on the number of participants. Each group had a corresponding partner group in the other school. The case study deals with the ongoing interactions between the participating groups of various participating schools. The discussion activity was for a period of 10 months. Not all the discussion groups began the activity at the same time.

The discussion topics were general and the activity was mainly to dissolve the intercultural barriers between the two nations and promote a friendly online environment. There were a large number of postings exchanging ideas, information and arguments. It was a challenge for the co-ordinating team to view all of these online activities. Studying activity behaviours and applying the indicators used for online activity was one of our intentions. The purpose of choosing this case study is to provide evidence that the

visualisation tool can assist a teacher to foster social ties between different groups and extend real-world relationships. The course is maintained by Moodle and the installation of VIMS tool on Moodle, proved very valuable to study a number of critical issues in collaborative online learning.

5.3.2.1 Viewing the Discussions of a group:

With so many schools involved and large numbers of posts it was hard for the teachers and moderators to identify the flow of posts, level of discussion and the participants involved in the discussions with their details. VIMS would firstly solve this problem by helping the teachers to view the online interactions. Teachers and moderators would first begin by selecting the criteria for which to view a discussion, as shown in Figure 5.7.

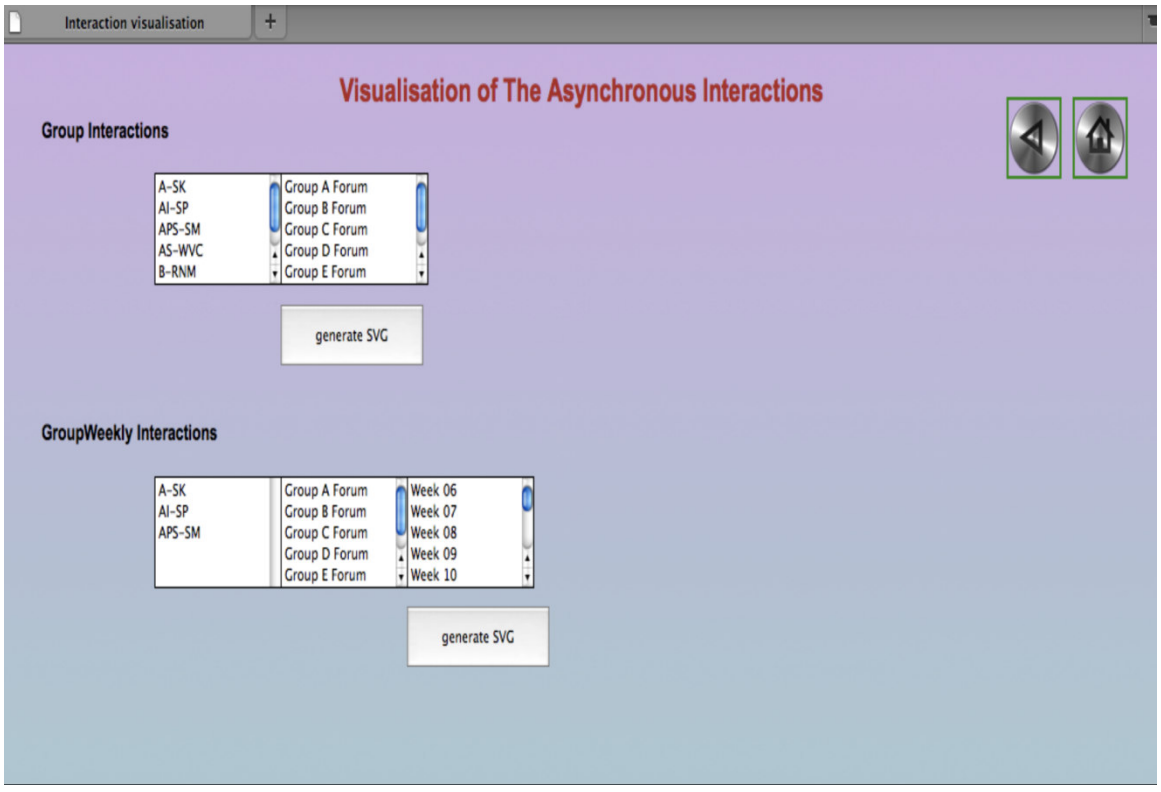


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Figure 5.7: Selection list consisting of Course, Groups and Weeks

Figure 5.7 gives a snapshot of the selection lists, which displays the radial-tree visualisation of the selected information. The first selection list displays the overall interactions in the group and the second selection list visualises the interactions weekly. The teacher would have to choose the Course and the Group in order to view the graphical representation of the interaction in that Group. Once selected visualisation is then produced, as shown by the example in Figure 5.8.

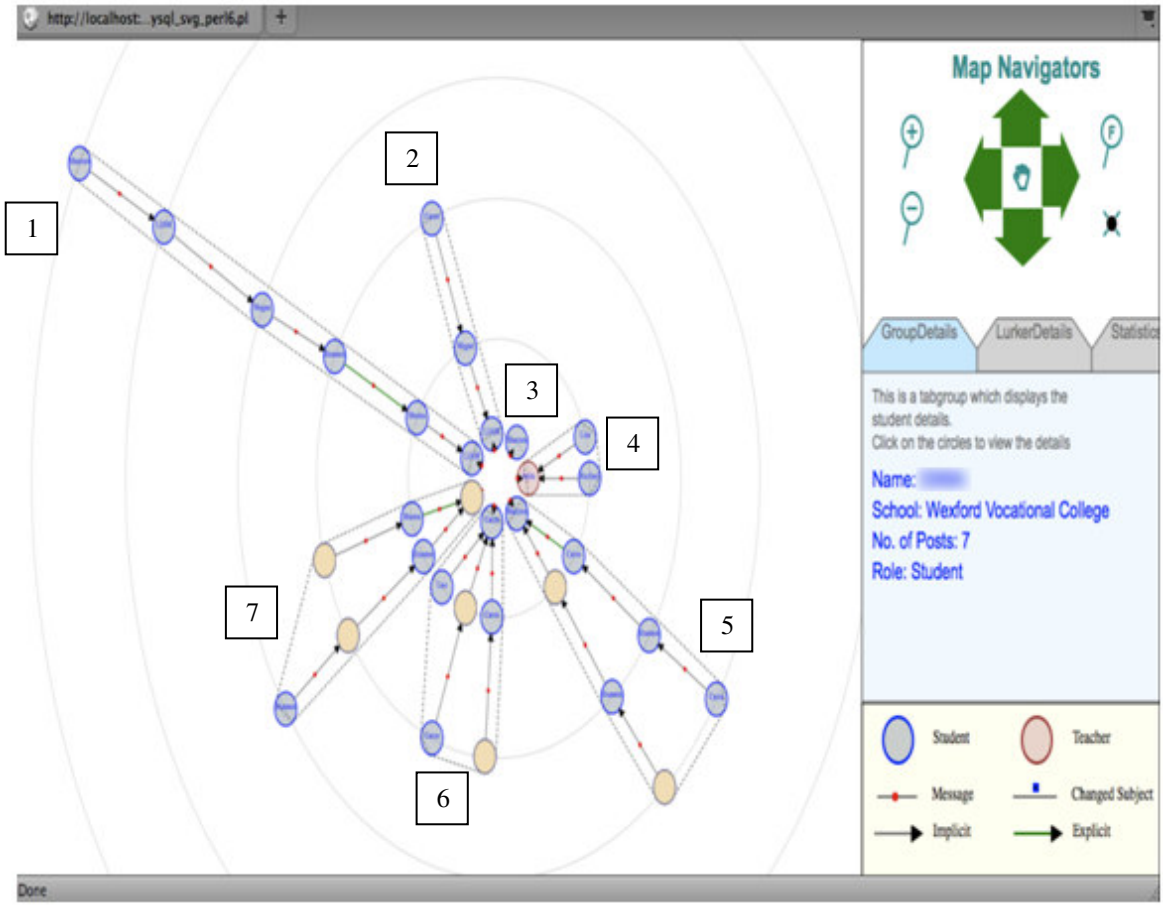


Figure 5.8: Details of a Participant shown alongside Discussion Visualisation

Figure 5.8 shows the radial tree representation of the interactions of one such group selected and also provides the details of one of the participant, when the mouse hovers and clicks on the circles. The circles represent the participants involved in the discussion. It simultaneously highlights the circles that represent the position of the selected

participant's posts. The radial view organises the participants according to their postings in an orderly manner in concentric circles. This representation gives the level of the interactions in this ongoing discussion. This conversation goes to six levels. Concentric circles represent the levels. When the 'lurker details' tab is selected, the participant details are replaced by a list of those participants who have viewed but not responded in this conversation, as shown in Figure 5.9.

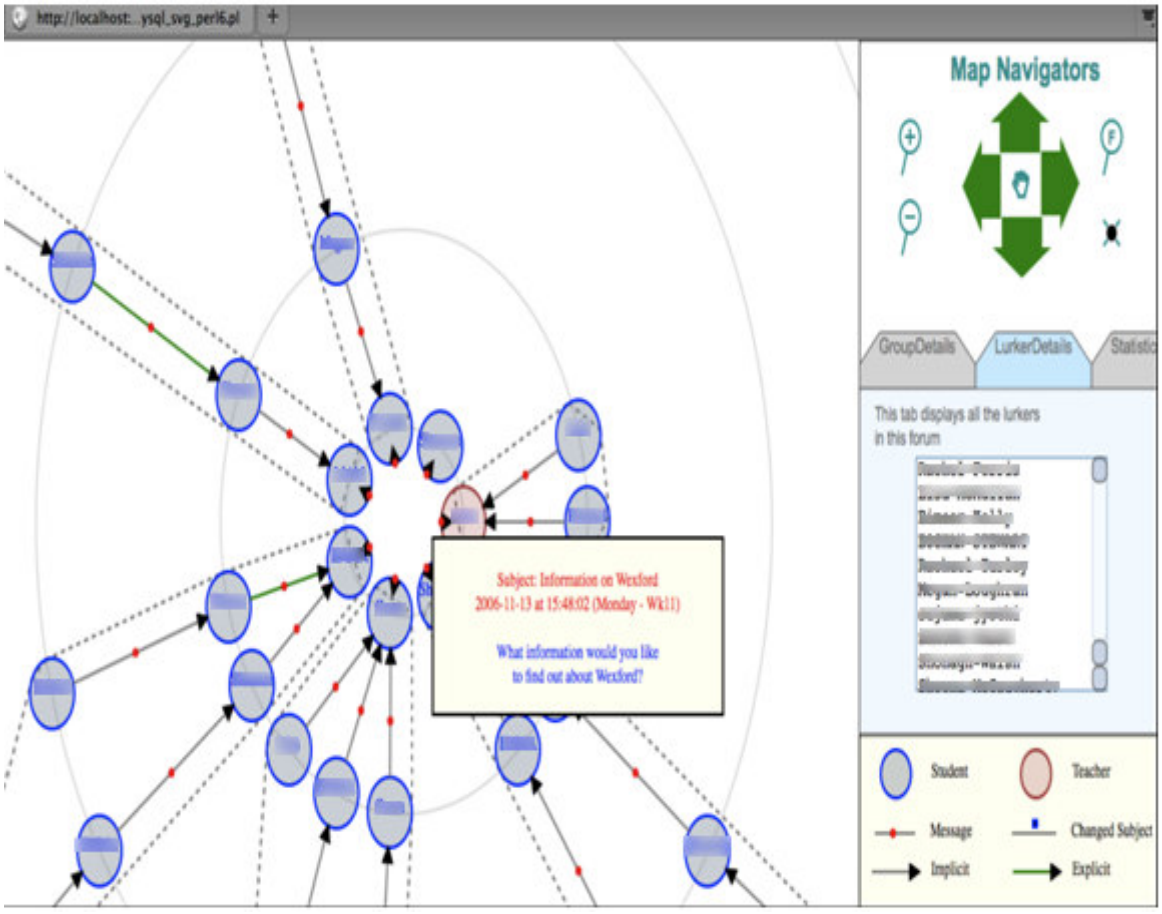


Figure 5.9: Lists the Lurkers of the Conversation and Displays a Post

Figure 5.9 displays a zoomed image showing a list of all the lurkers present in the discussion to the right side of the image. The lurkers could be students, teachers or administrators. The teachers can now play their role and intervene asking the lurkers to

participate in the ongoing discussions. This image also displays a post by one of the participants, along with its details. Since there is no reference to the relevance of the subject, the post displayed is the post of one of the starters. The posts are displayed by the mouse hover on the small red or blue dot displayed. This suggests that visual representation can indeed reveal a lot of information of the forums at a glance.

Interested parties, such as teachers, moderators or researchers, can then select the 'statistics' tab to get aggregate information about the discussions, as shown in Figure 5.10. It should be noted that this aggregated data could be expanded and extended as more (or different) statistics are required to be generated.

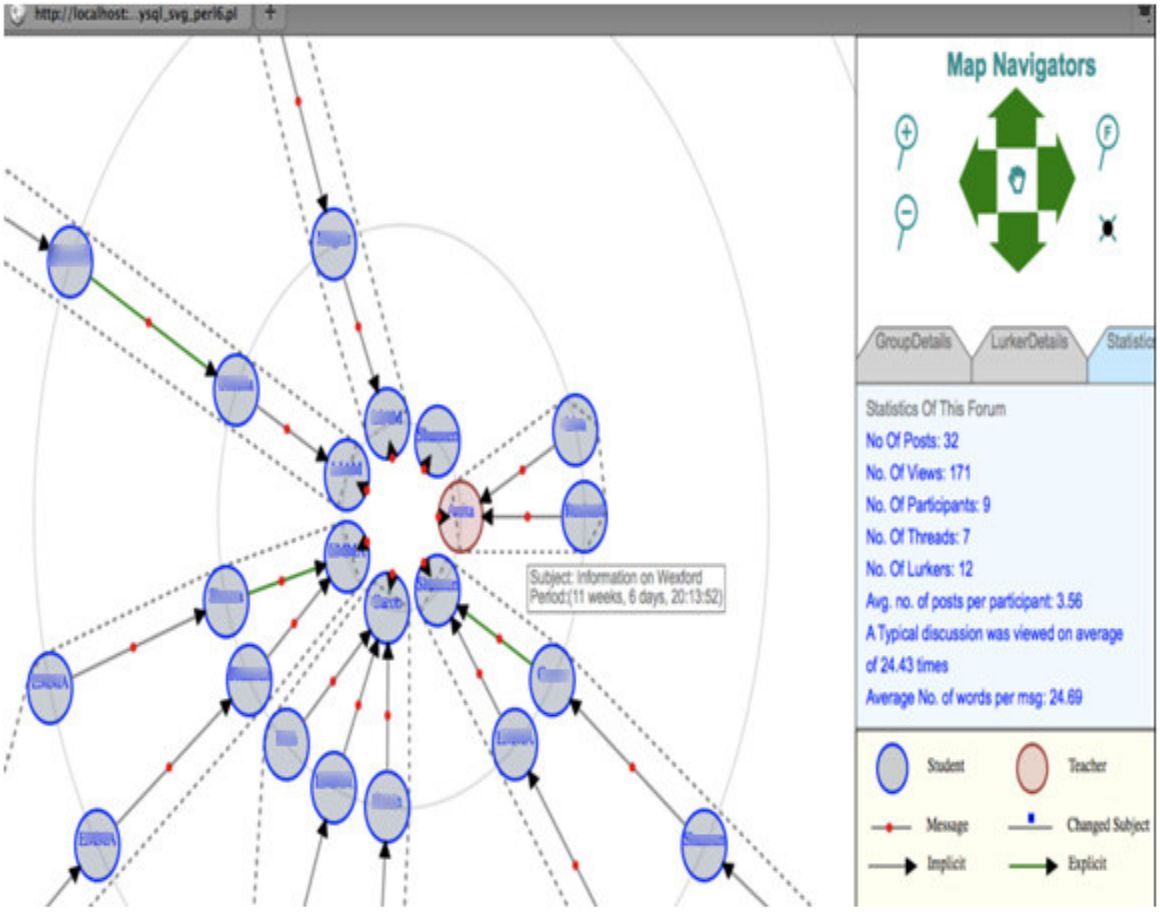


Figure 5.10: Quantitative Statistics of the Discussion

Figure 5.10, reveals the quantitative analysis of this particular ongoing discussion on Moodle to the right of the visualisation. It also reveals the display of a tool tip having details of the thread, with a click of a mouse on the boundary of the discussion. This image reveals information that this particular discussion lasted for 11 weeks and 6 days and the discussion was a generalised discussion on 'information on Wexford'.

There are 32 posts, viewed 171 times, contributed by nine participants, which 12 other people read but did not respond to (lurkers). It also shows that the conversations were, repeatedly read and re-read as the discussion was accessed 24 times per person (including lurkers). This information can be valuable, not least for identifying which discussions/subjects attract most/least attention and participation.

Figure 5.8, Figure 5.9 and Figure 5.10 show screenshots taken from one of the forums of a particular group belonging to particular course. From the visuals we can state that there were two discussions which occurred in a linear pattern (Figure 5.8 – threads labelled as 2 & 3) and in four other threads the discussions subdivided where two or more responded to one post posted (Figure 5.8 – threads labelled as 4, 5, 6 & 7). There was one thread that is isolated having no responses to it (Figure 5.8 – thread labelled as 3). The teacher would need to intervene to find out the reason for no responses to the thread. It could most probably be that nobody was interested to talk about that subject of discussion or could be that the discussion started late. It is definitely not because of the person who posted it as there were many replies to the same poster who initiated another post. Since this is a cross-border interaction care should be taken that the students are not neglected just because they do not belong to their place or school. Although there was teacher involvement in one of the discussions that discussion did not stay long. It is hard to make a conclusion on this regard.

The topics discussed in these threads are mainly general related to cross-border relationship, but there was always a need of more student involvement and also that the

students stay on the subject lines only. In most of the cases we had seen that the students might have changed the topic title but still maintained to be on subject lines. And hence they were relevant to the subject of discussion. However, there were some of them who slighted deviated from the topic of discussion. This could be firstly found out by reading their content and secondly by the percentage of relevance indicated at the bottom of the message. Relevance to the subject can be seen in more detail in the next chapter.

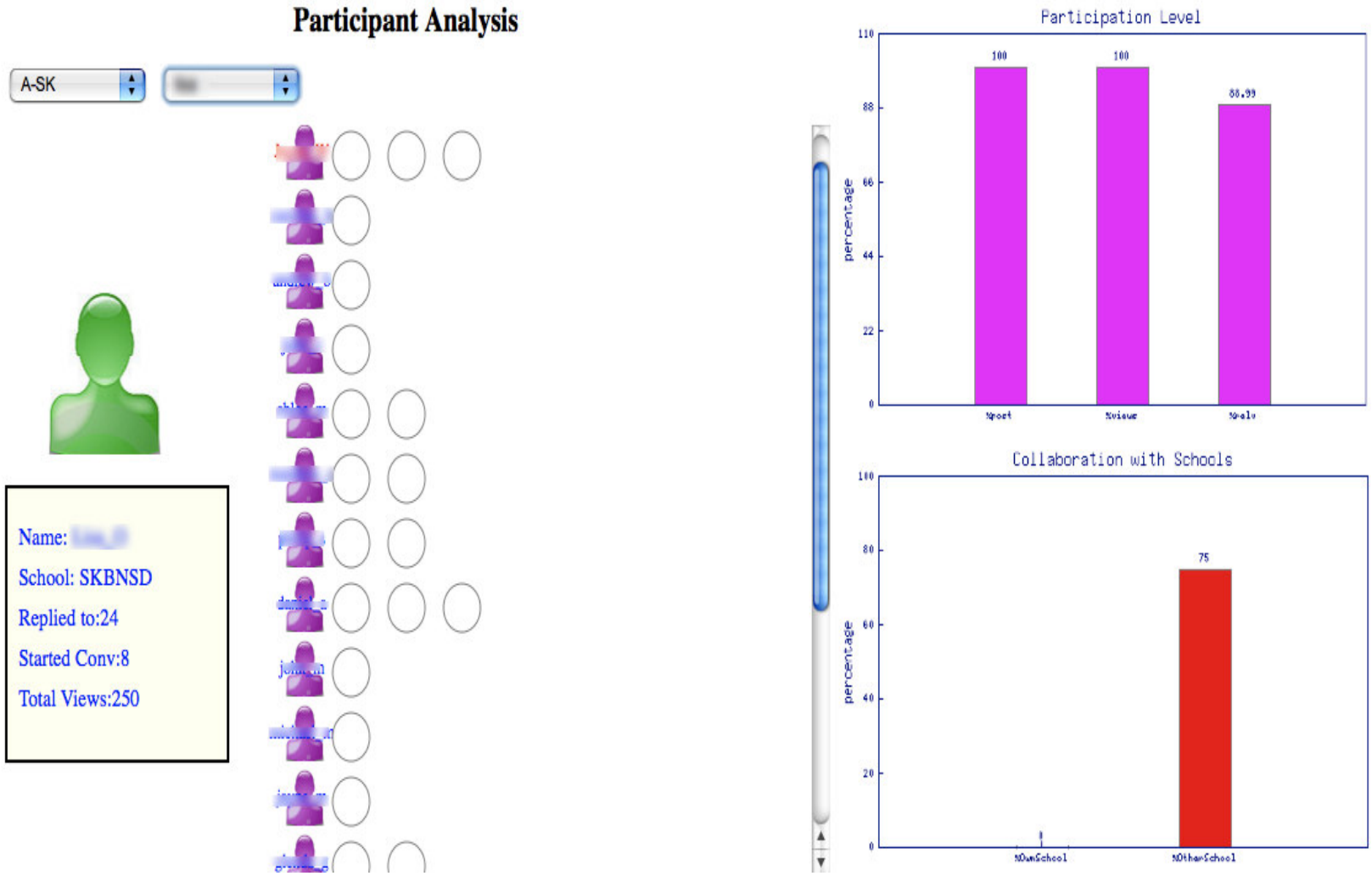


Figure 5.11: More Analysis on Individual Participant

Figure 5.11 features the visualisation of the statistical data of different activities of a particular participant. The objective of this visualisation is to provide an overview of the participant's collaboration in the online discussion. It details the participant's personal details along with the total number of messages the participants has replied to, total number of conversations started by the participant, and the total number of times the participant has viewed the conversations. In Moodle it is hard to find out the total number of posts reads, but can identify the number of discussions viewed by the participant. Figure 5.11 displays the activities of a participant, belonging to SKBNSD School. The numerical figures give an indication that the participant was very active during the discussions. It also displays the list of all the other participants to whom this participant has responded to. A change in colour of the image of the other participants, indicate a change in the school. This means that this particular participant whose analysis is done has been communicating online to only the participants of the other school and not to the participants of his/her own school. The change in colour on the display of names show if the participant was a teacher or a student. Red indicates teacher and blue indicates student. The number of circles represent the number of messages replied by this participant to a particular participant. From Figure 5.11 this participant has communicated three times to a teacher not belonging to his/her school and 21 times to the students not belonging to his/her own school. This can give a clear visualisation about the cross-cultural or cross-border online collaboration of a particular participant.

The graphs give the participation level and collaboration of the individual participant during the online activity. The participation level gives the quantity of the participant's postings, quantity of participant's views and the quality of the participant's postings. The other graph shows the collaboration of the participant with the participants of her school and the cross-border school. This graphical representation can give an impression of the participant's attitudes towards online collaborative environment and the interaction with the partner school (cross-border school). A detailed description of the analysis is explained in Chapter 6.

5.3.2.2 Findings

Some of the findings from this case study are:
Most of the postings were staying on topic. There was no change in the subject lines even though there was a change in subject title number of times, in most of the discussions. Although the replies were written in response to the previous message, the relevance of the message in terms of the first message kept decreasing as the level of the conversation was increasing. The claim made by some of the researchers (Li & Akins, 2005; Mazzolini & Maddison, 2003) in terms of the discussion not expanding due to too much involvement of the teacher is very clearly seen in most of the cross-border interaction case study. Through visual and statistical analysis, it was observed that most of the participants (almost 25%) did not participate in the ongoing discussions. Among them, there were quite a number of lurkers and only a few of them were inactive.

Apart from the above findings, the case study in Section 5.3.2 also explored that VIMS was used to examine the following:

- Continuity of the discussion: The continuity or flow of discussion is clearly visible through the visual radial tree representation. The length of the message chains is a clear indication of the student engagement in the discussion. From Figure 5.8 we see that the longest length of the message chain in this conversation was six.
- Isolated messages: Isolated messages are an indication for instructors' intervention. From Figure 5.8 we see one isolated thread [3] which was initiated by a student. An isolated thread receives no responses and is regarded to be a silent thread. Isolated threads do not indicate the conversation flow and hence this silence needs to be broken by the instructors.
- Message length: Message length is clearly indicated by the size of the rectangular box in which the message is displayed. Longer messages need not indicate a higher quality post, and attract more attention. Smaller messages also get the same

response as the longer ones. Longer message might indicate the enthusiasm of the student in discussing the topic.

- Thread development: The thread development provides an indication of the thread activity. Some of the threads develop in a linear fashion where the participants responded to the earlier message without any sub-division (Figure 5.8 [1][2]). The length of such threads would be much greater than the sub-divided thread if the number of postings in these threads is equal. The width of the sub-divided thread would be much wider than the linear pattern. Sub-division of threads indicates many replies to one post (Figure 5.8 [4][5][6][7]).
- Involvement of teacher: Teachers' presence is always important during an asynchronous discussion. From Figure 5.8, we see that there was one thread initiated by a teacher but the conversation did not last long. This is surely a rare case which some researchers has already identified and could not find the reason behind it.
- Participant's activity overview: Along with the visualisation of the online activity, a visualisation of the analysis of the individuals participating in the online discussion makes VIMS tool more interesting. This visualisation helps a teacher to predict the participation, collaboration and attitudes of their students.

5.4 Summary

Based on the large number of institutions using Moodle and the difficulty for teachers and moderators in trying to track the significant outcomes of the discussion forums, we have designed a graphical visualisation tool that monitors and represents participants' online activities making it a useful monitoring and intervention tool for teachers and moderators. These case studies have revealed the importance of VIMS on Moodle or any other LMS. Through these case studies we have identified the various patterns and structure of the discussion threads. The approach, analysis and the outcomes of the case

studies prove the importance and usefulness of VIMS as a monitoring tool for group and individual behaviour in the online discussion forums.

The next chapter gives insights to more detailed analysis using the VIMS tool. The results of those analyses can be useful for teachers to predict the group and individual online activities.

6 VIMS Analysis, Observations and Results

This chapter explains in detail some of the important outcomes of this research. It presents a few statistical analyses using the Virtual Interaction Mapping System (VIMS).

6.1 Types of Interactions

The online community is a group of people who share their views, ideas and interests with a common objective to learn and build their online presence. But not all participants are active participants and hence the online community becomes very sparse. One of our aims is to build a tool to aid the teachers analyse the online discussions and indicate their intervention to encourage the students to participate in the online communication.

The relationship among the message postings reveals the extent to which the learners and teachers are responding to one another. Message categories depicting the dimensions of interactivity between the online messages according to Henri (1992) are explicit, implicit or independent. Explicit and implicit interactions are represented as a three-step process where one writes a message, a second person replies to it followed by a comment by the first person to the reply of the second (Hara et.al, 2000).

According to Henri (1992), explicit interactions are messages that are either in response to a question posted, or a comment on someone's message. In explicit interaction, the person to whom the communication is directed is indicated in the message. Implicit interactions are messages that include a response or a comment on the previous message but there is no reference to the previous message. Independent statements are messages that contain new ideas, which have not been mentioned in the previous messages and are not connected to the others. A pattern or relationship of communication can be observed by differentiating the interactions into these three categories.

In Figure 6.1 the explicit-implicit interactions are indicated by a different colour scheme. Student23 has agreed with the statement made by Student22 and gives her statement in reply.

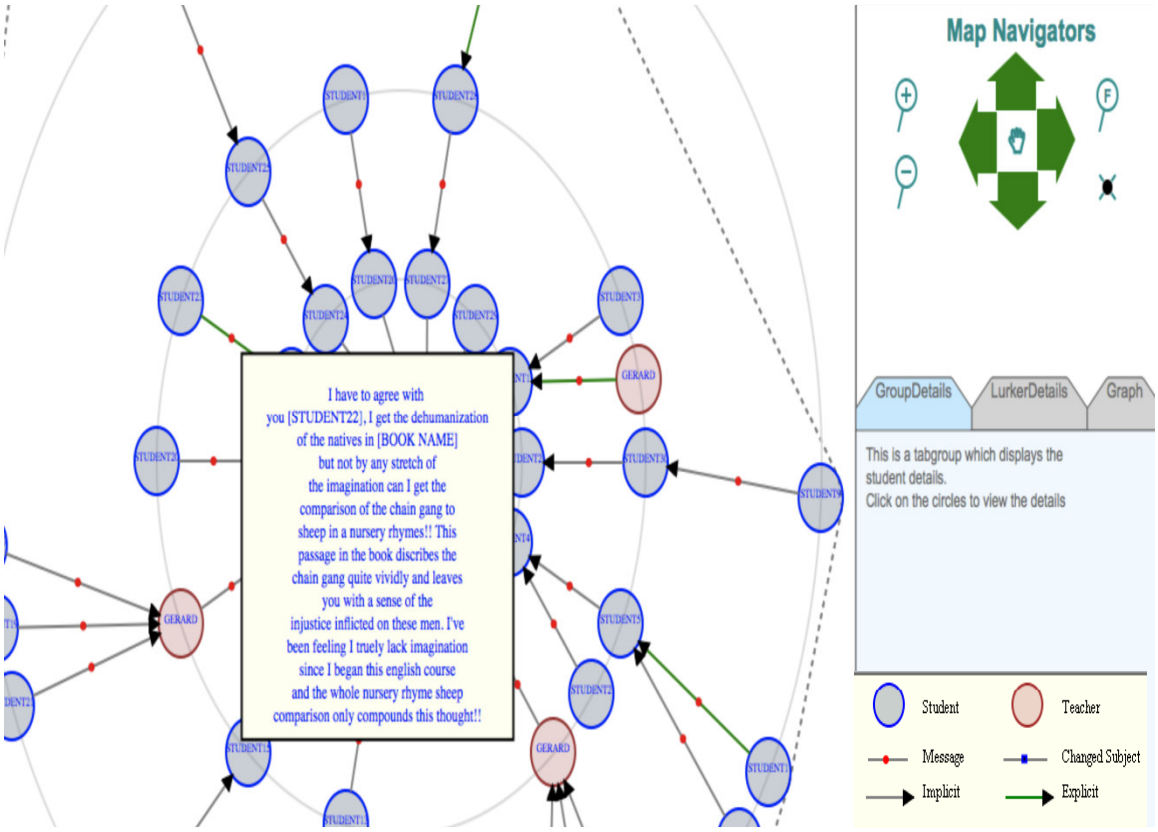


Figure 6.1: Implicit and Explicit Interactions

6.2 Change in Topic Title

According to Herring (1999) online interactions often tend to change the topic of conversation. This happens when the person responding to the earlier message does not take the earlier contribution into consideration. A slow change in topic direction may

occur at various points in the time of discussion. In the example in Figure 6.2 there was a change in the subject three times in three different threads in the same forum.

Although each note was written as a meaningful extension of the previous conversation, the thrust of the conversation may tend to change. As a result the threaded discussion can change the whole area of conversation from one idea to another. Both the messages are related to one another but a change in subject line indicates that there is no direct implication of the previous message. This might indicate drawing a different conclusion altogether. A change in the subject also lets the participants reading a post think about whether they have to reply to the original post or the last post that was posted with the changed subject. Van der Pol (2009) states that such situations suggest participants are trying to develop a new understanding of the subject as the respondents not only have to respond about the subject but also guess the meaning of the discussion statement.

Subramani & Hahn (2000) contest that a change in subject has no great impact on how the conversation is perceived by the participants. However, we disagree with their statement as there is clear evidence in the conversations that we studied that a change in subject will affect the flow of conversations. The attention goes from one issue to another within a thread. We could also see that a change in subject line not only affects the flow of conversation, but also could stop the conversation from continuing. On the whole we can say that a change in area of conversation leads to negligence and lack of awareness to the key area of conversation and this lack of awareness may lead to several educational concerns.

Figure 6.2 show that there was change in the topic title in three conversations, which is clearly indicated by a small blue square box on the arrow representing the flow of conversation. In the conversation between two students, one student started the discussion with the subject title ‘Happy New year’ but the other one responded to the previous student with a changed title ‘Hi’.

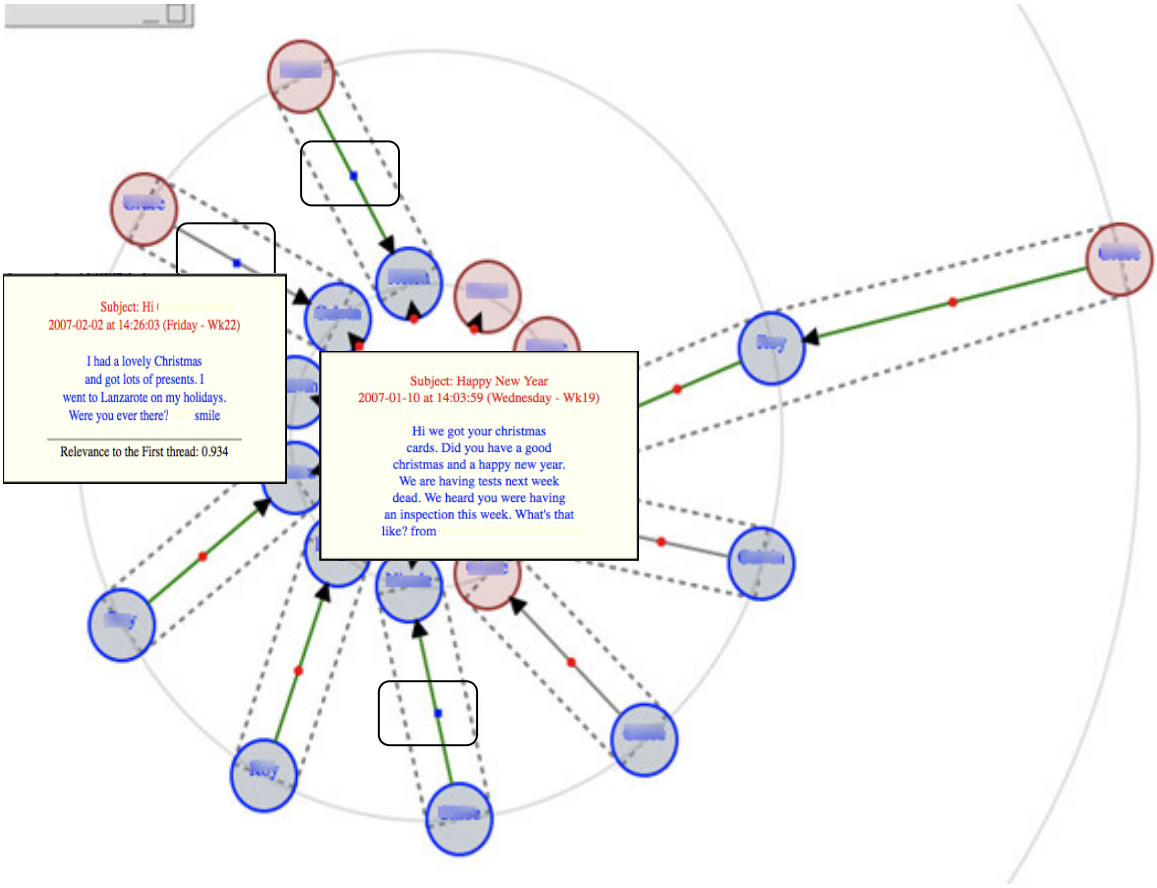
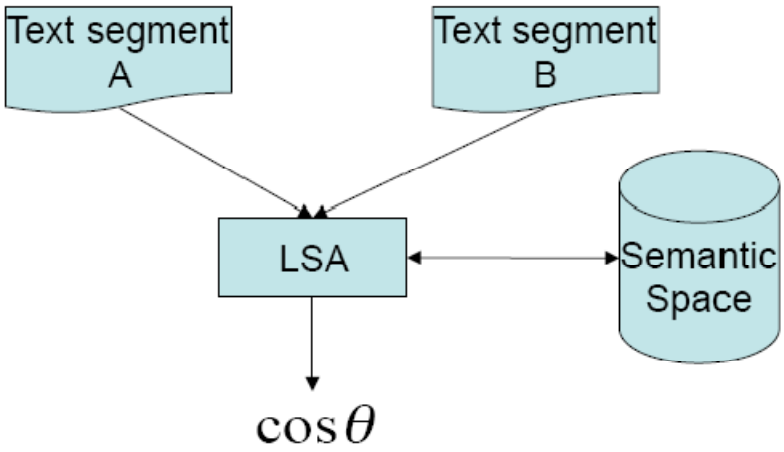


Figure 6.2: Change in Topic title

6.3 Latent Semantic Analysis of the Content

Latent Semantic Analysis (LSA) is a statistical technique for analysing qualitative data (Shapiro & McNamara, 2000) by extracting and representing the similarity of meaning of words and passages of a large corpus (Landauer et.al, 1998). Given a set of word documents, each word in those documents represents a point in the semantic space. The cosine between the vectors for any two documents is calculated to determine the semantic similarity of the documents. Cosine values can be interpreted as, identical documents having inter-vector cosines of 1.0, unrelated documents having inter-vector cosines of 0 and somewhat related documents having inter-vector cosines between 0 and 1.



COS θ	Semantic Similarity between Segments A & B
COS θ –> 1	Very High (Good Match)
COS θ –> 0	Very Low (Poor Match)

Figure 6.3: Representation of LSA by Anders Morch, 2011

LSA allows us to closely approximate human judgments of meaning similarity between text segments and to objectively predict the consequences of overall word-based similarity between passages. As explained by Landauer et al., (1998) the first step is to represent the text as a matrix in which each row stands for a unique word and each column stands for a text passage or other context. Each cell contains the frequency with which the word of its row appears in the passage denoted by its column. Next, the cell entries are subjected to a preliminary transformation in which each cell frequency is weighted by a function that expresses the word's importance in the particular passage.

Next, singular value decomposition (SVD) is applied to the matrix, a form of factor analysis. In SVD, a rectangular matrix is decomposed into the product of three other matrices. One component matrix describes the original row entities as vectors of derived

orthogonal factor values, another describes the original column entities in the same way, and the third is a diagonal matrix containing scaling values such that when the three components are matrix-multiplied, the original matrix is reconstructed. Hence after applying LSA some words share similar points in the semantic space and are semantically similar.

LSA has been used in our research to find out the degree of relation between the messages. It gives the value of relevance in numerical format.

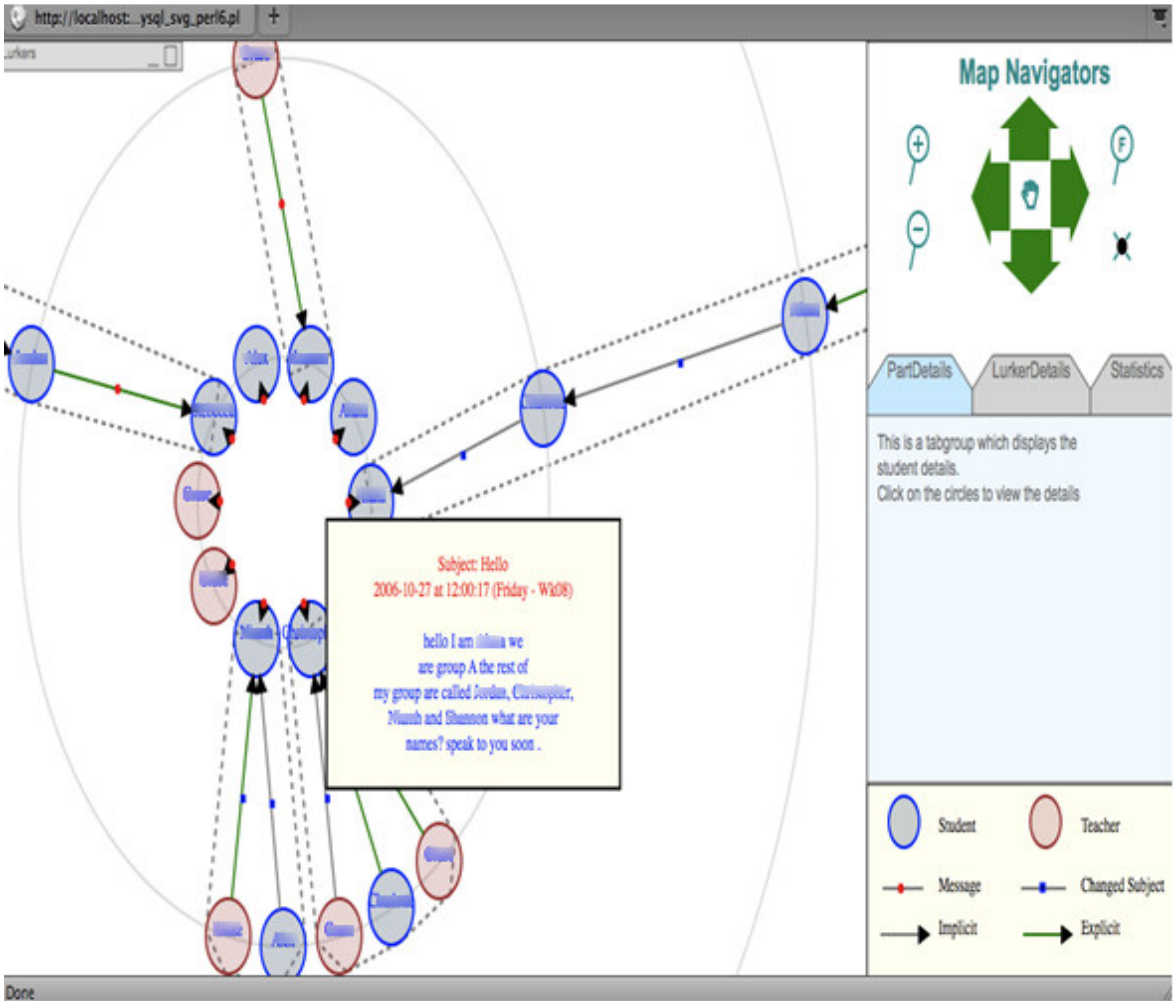


Figure 6.4: Example for Relevance to the Subject

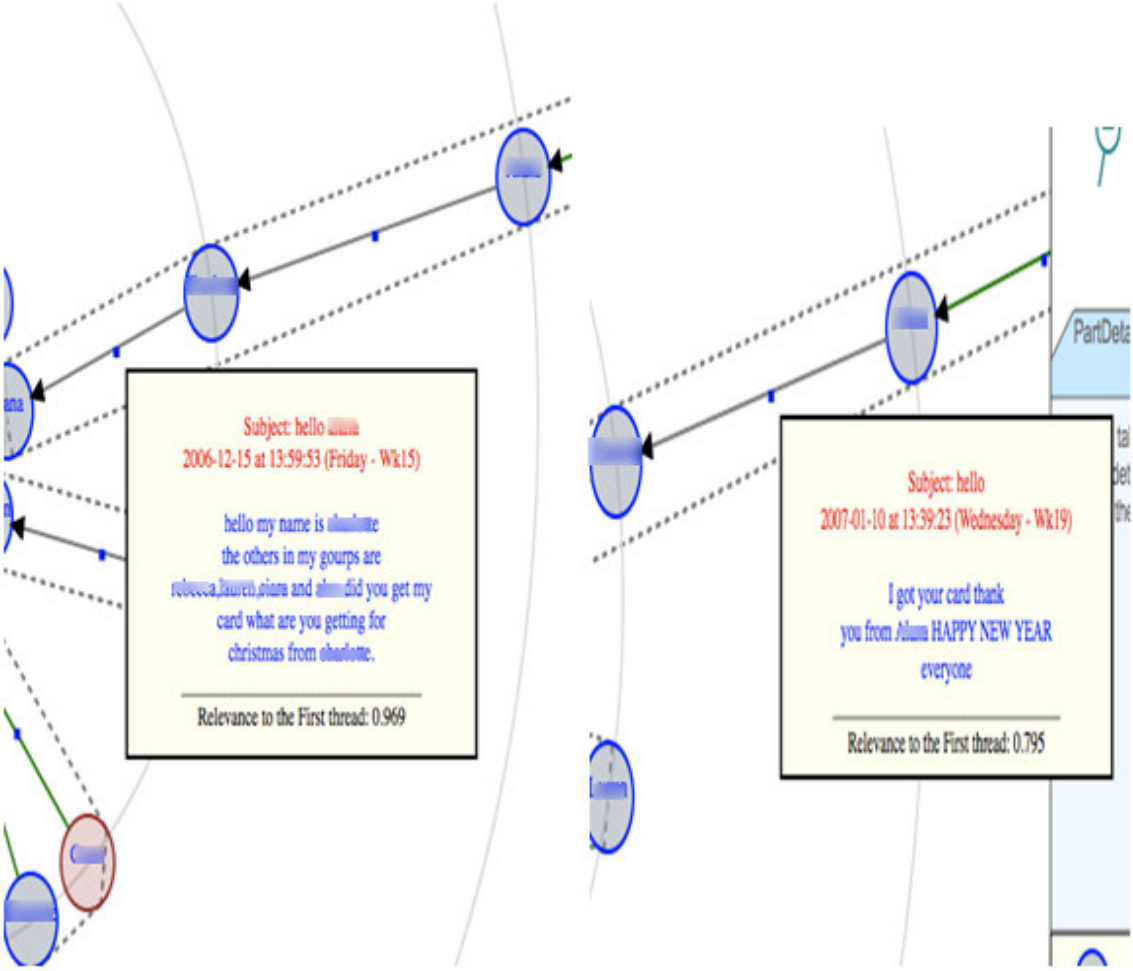


Figure 6.5 & Figure 6.6: Example for Relevance to the Subject

Figure 6.4, Figure 6.5 and Figure 6.6 give a snapshot of one of the threads whose subject was to introduce them selves and make new friends. Figure 6.5 is the immediate reply to the post shown in Figure 6.4, with a relevance to the subject being 0.969. This states that the immediate reply is very close to the subject post and hence there is no deviation in the subject. Figure 6.6 is the reply to the second post and its relevance to the subject is 0.795. This states that the post is almost as close to the subject but not as close as the previous post. This would be a concern for now because as and when the discussion continues the respondents might follow up this post having a relevance of 0.795 and at the end of the

discussion the relevance might further decrease indicating that the participants are deviating from the subject lines. It is hard the find the relevance between two messages if one of the messages is very small having just few words.

LSA need not be the best way to represent the relevance to the subject but could be a useful method for the teachers to check on the students who are drifting from the subject line while interacting in a group. The LSA code has been taken from "airhead research" [http://code.google.com/p/airhead-research/].

6.4 Statistical Analysis

Online asynchronous interaction has always been a common means of building a collaborative learning environment in the educational sector. Researchers have been trying to come up with various different conclusions through analysis of this data. Interpreting the analysed data in various forms improves the understanding of the online activity. The quantitative analysis of online discussions is done by applying some statistical procedures and depicting them in a graphical format. This analysis gives the level of participation, interaction and engagement of the participants involved in this collaborative network. The analysis investigates the relationship between the interaction among participants and their contribution to the collaborative community. The results of this study give the graphical representation of the level of participation and interaction, reveal the performance of different groups involved in the online communication and compares the performance of groups with the performance of the best group, in relation to the number of posts (contributions), number of participants involved and the number of views.

6.4.1 Why Statistical Analysis?

Statistics is a mathematical science involving the collection, interpretation, analysis, and presentation of data (Gravetter & Wallnau, 2000). It is the primary tool of research and development. It is often used to make predictions based on data. Statistics has come to play an important role in almost every field of life and human activity. Statistical methods are also used in analysing the experimental data and drawing conclusions. In this particular area of research, it is another approach to measure the interaction and participation quantitatively. Even though it is hard to correlate group interaction statistics with the actual group performance, this statistical analysis can only help the teachers or the users of this tool to draw their own conclusions.

Judging the ongoing discussion through statistical analysis does not give us a final conclusion about the interaction pattern but gives us some kind of indication about participation and also acts as a backbone for many qualitative analyses. In other words, the quantitative analysis is being followed by, and is informing, qualitative analysis of the discussions to analyse and evaluate the evidence for the desired learning outcomes for the activity. Statistical graphs reveal the data in a sophisticated way after applying the statistical formulas needed for quantitative analysis. The teachers will have a quantitative measure of the analysis which will help them to summarise, interpret and present the results to the students on their use of the asynchronous discussion tool.

6.4.2 Different Statistical Analysis used to obtain the objectives

A few interesting objectives that we wanted to look into as future analysis are:

- To see if there is a correlation between a total number of posts of a user to the number of replies to his threads and his posts. To find out if there is a correlation between the number of views of his threads and posts.

- Many posts are being viewed. But only some get answered. It would be interesting to know the parameters of the "most answered post". Things like: Topic, length, links, images, poster reputation (posts, Registration date), day of week/time, some keywords and so on.
- Some posters write a single line and get the whole attention while others conduct tests, research and write long posts that sometimes get totally ignored. Is there any correlation between post length and number of replies and their length?

6.4.2.1 Ranking

Values of mean and standard deviation represent the average achievement and dispersion of values around the mean. When the two values are taken together they provide information on the consistency of performance of the participants in a group. Performances can then be compared for further analysis.

As described in Case Study 2 (in Section 5.3), the students of every participating partner-school were divided into Groups. For example partner-schools with Course-code AS-K are divided into six groups. We have tried to statistically present the observation of an individual's performance within the Group and the overall Group performance. We had taken the mean number of participants in each group and the number of posts posted by each participant during asynchronous discussions. We compared the means of different groups in a course and ranked them according to their mean and standard deviation. This could give us some idea about the consistency of the group and the individuals in the group.

We have taken the peak points for mean and the maximum standard deviation as that of the group that has the highest mean and highest standard deviation, to plot the means and the standard deviations. The standard deviations are plotted on the x-axis and the means on the y-axis. The midpoints of both x and y-axis divides the graph into 4 equal

quadrants. The mid-points for the axes are considered by taking the average values that lie in each quadrant.

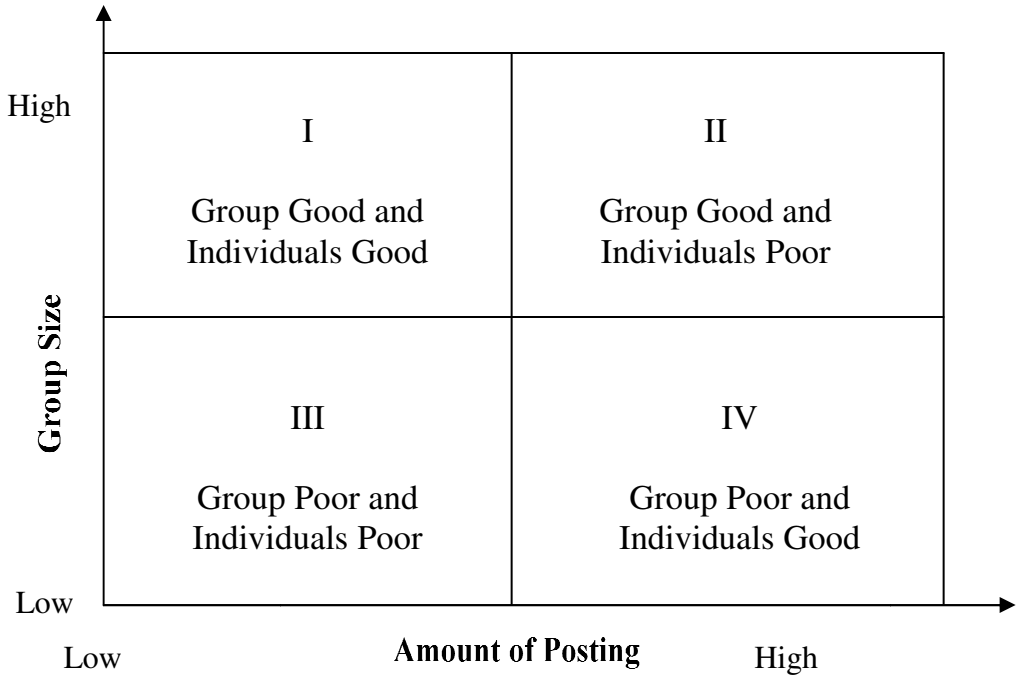


Figure 6.7: Categories of Division of Groups

Students in sections with high mean and low standard deviation or low mean and high standard deviation do well with their individual performance of interaction. Students in sections with low mean and low standard deviation or high mean and high standard deviation do poorly (Hoel et.al, 2006). The Group performance depends on the mean individual performance and the Group size. The groups fall in different quadrants based on the total number of posts posted by individual in a group, the total number of posts posted by the group itself and the group size. For example: if the group size was 10 and only a 4 in the group were active participants by either posting or replying to the previous posts, and even those 4 active participants had few quantity of individual posts, then neither the group as a whole nor the individuals in the group contributed much to the online activity and hence that group will group will fall in the III quadrant.

Table 6.1: Ranking of Groups according to their Mean and SD

Group Name	Mean	SD
Group D Forum	8.077	3.9
Group A Forum	4.75	4.17
Group E Forum	6.176	5.65
Group C Forum	8.571	7.41
Group B Forum	7.462	5.85

Table 6.1 gives the ranking of the groups based on their mean and standard deviation. The lower the standard deviation, the better is the performance of the group. If the two groups had the same SD then the group with the higher mean is much better than the group with lower mean. The average of the quantity of posts taking the group size also into consideration will decide the axis of the graph which divides the graph into various quadrants.

Figure 6.8 illustrates the ranking of one of the courses, which has five groups. The ranks are in the ascending order of the group and individual posts and participants involved in the activity. These points are depicted on the graph on the extreme right.

The different groups are indicated by different colours. According to the ranking Group D Forum is ranked first and Group B Forum has not actively participated in the ongoing discussion. All of them fall in the III quadrant which indicates the teachers through the advice displayed at the bottom that the group and the individuals need to contribute more to make the online discussion more vibrant.

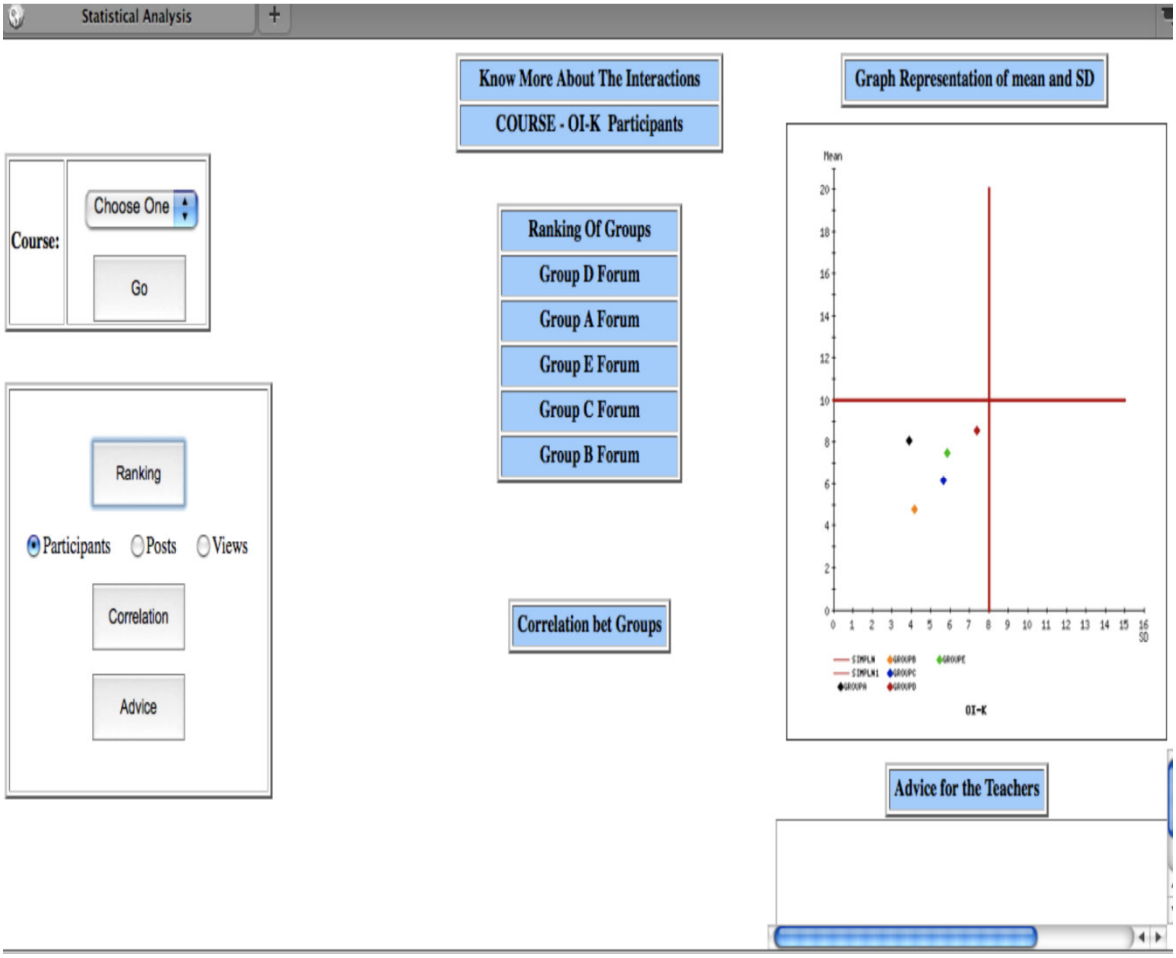


Figure 6.8: Ranking of Groups

With the help of correlation (if total time for the conversations in weeks are the same among all the groups) and dynamic time-warping (if the time-frame of the conversations in weeks differ by a small amount between the groups) we find out which of the other groups are close enough in performance compared to the most consistent group in terms of number of posts, number of views and number of participants.

6.4.2.2 C orrelation

Once the ranking of the groups is done, we correlate the best group with the other groups to find how closely the other groups are related to the best group. With the time frame represented in weeks the correlation is found.

- Compare views, posts and participants of Groups A, C, D, E, F with Group B.
- Views of Groups A, C, D, E, F with views of Group B.
- Posts of Groups A, C, D, E, F with posts of Group B.
- Participants of Groups A, C, D, E, F with participants of Group B.

Correlation is a distance measure usually referred to as Karl-Pearson's correlation. The time series should be of the same length. Its value lies between –1 and +1 (Saleemi, 2006). Figure 6.9 has all the values displayed between –1 and 1. This shows that the time-span of the discussions were the same. Although the groups are ranked according to their means and standard deviations, we might want to correlate the other groups with the best group. The statistical analysis need not always be correctly interpreted but just aims to direct the teachers about the interactions. The end-users might or might-not take this analysis into consideration.

From Figure 6.9 we can say that:
Group F is highly correlated to Group C when the number of participants involved in the discussion is taken into consideration. Group D is the least correlated Group with Group C with a value of 0.743 when the total number of participants is taken into consideration. The correlation might vary according to the Number of participants, posts and views.

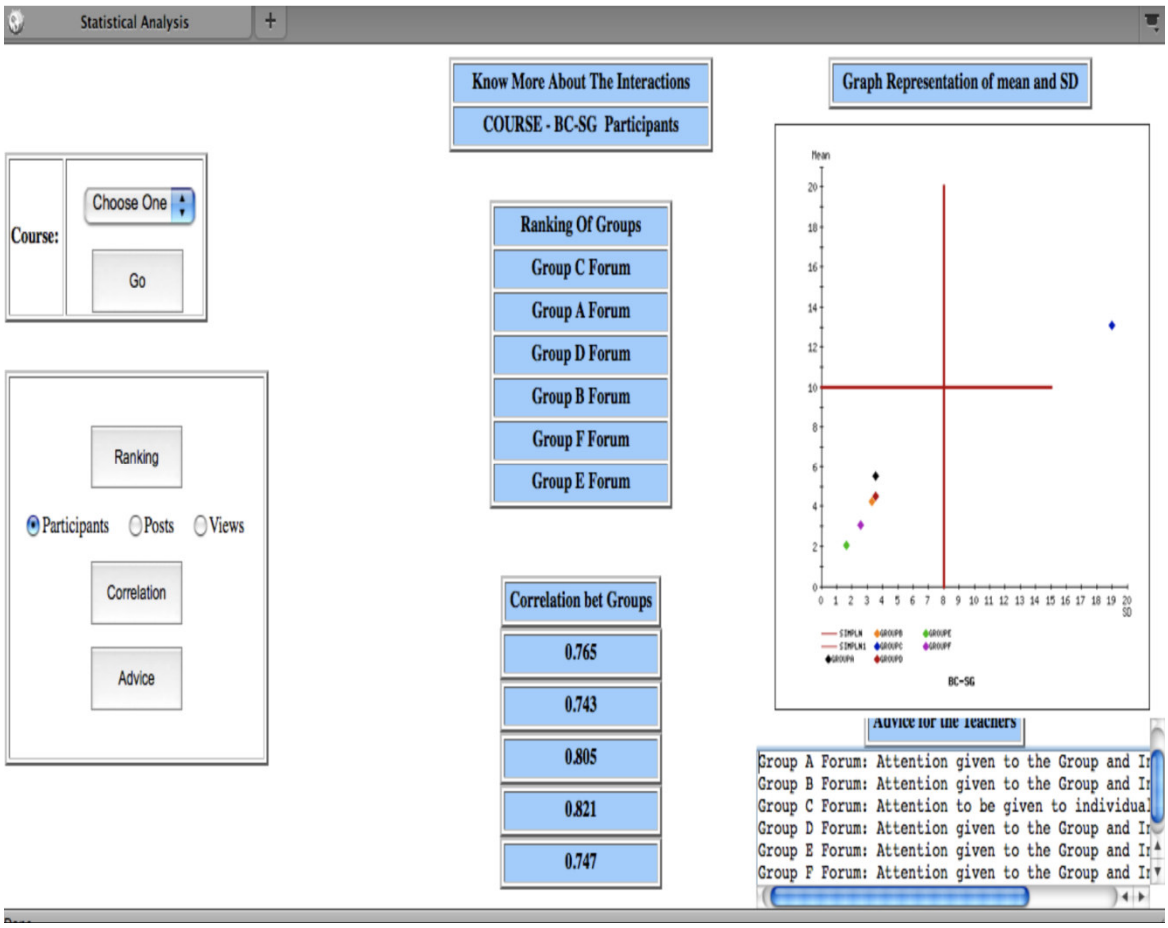


Figure 6.9: Correlation of Groups according to the Participants

6.4.2.3 Dynamic Time Warping

Dynamic Time warping (DTW) is an algorithm used as a distance measure for similarity search and unsupervised clustering of time series (Saleemi, 2006). It is a non-linear method for finding the shortest path between two data series that are normally of different lengths. When the time series is of different lengths, containing different values, re-sampling can be used to make the time series of two groups of equal lengths. DTW works well and can be applied only when the difference in the time series is very small. If the difference large then neither correlation nor DTW could be applied.

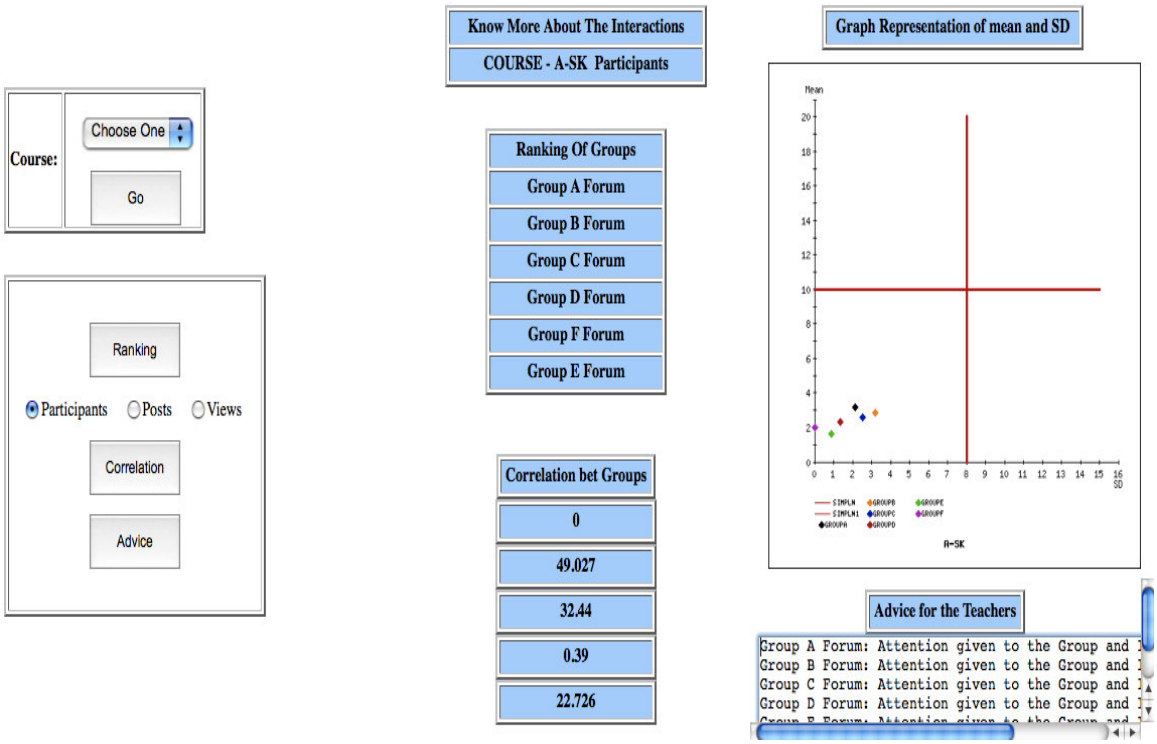


Figure 6.10: Time warp used to correlate between groups according to the Participants

Figure 6.10 shows an example of when the Groups' participation time frame varies. If the difference in the time span of the group compared to the best group is very large then neither correlation nor DTW can be applied, as it is hard to correlate such groups. In such cases the value of correlation is displayed as zero. The smaller the minimum distance between the groups the higher they are correlated with the best group (except zero).

In the example given in Figure 6.10, the course was divided into six groups. The groups are ranked according to their participation and Group A is ranked first. So, the other five groups are compared with Group A in terms of the number of participants involved in discussion. Table 6.2 gives the details of that course (course A-SK) placed according to their rankings.

Table 6.2 Details of a Group to find a Method to Correlate with the Best Group

Group Name	No. of Weeks	Method to correlate	Correlation values
Group A	37	Best Group	_
Group B	16	Cannot be correlated	0
Group C	35	DTW	49.027
Group D	38	DTW	32.44
Group F	37	Correlation	0.39
Group E	36	DTW	22.726

Group A and Group F had their discussions for the same time frame and hence correlation can be used to correlate with the best group (Group A). Group B was active only for a period of 16 weeks. Since the difference in the time frames of Group B and Group A is high, Group B cannot be correlated with Group A and hence is zero. Group C, Group D and Group E can be compared with Group A using DTW. Figure 6.11 and Figure 6.12 show the plots of DTW done on the three groups to find the minimum distance between the three groups. Although Group C is third in the ranking, we see that Group E is closely correlated with the best group when compared to Group C and Group D, when the number of participants is taken into consideration.

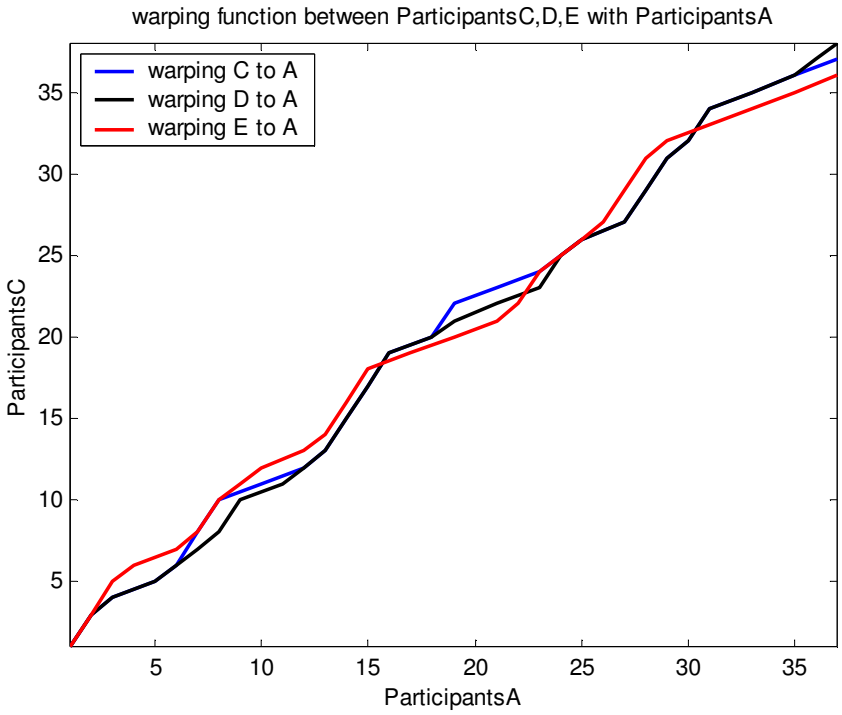


Figure 6.11: DTW Graph for Optimal Scaling

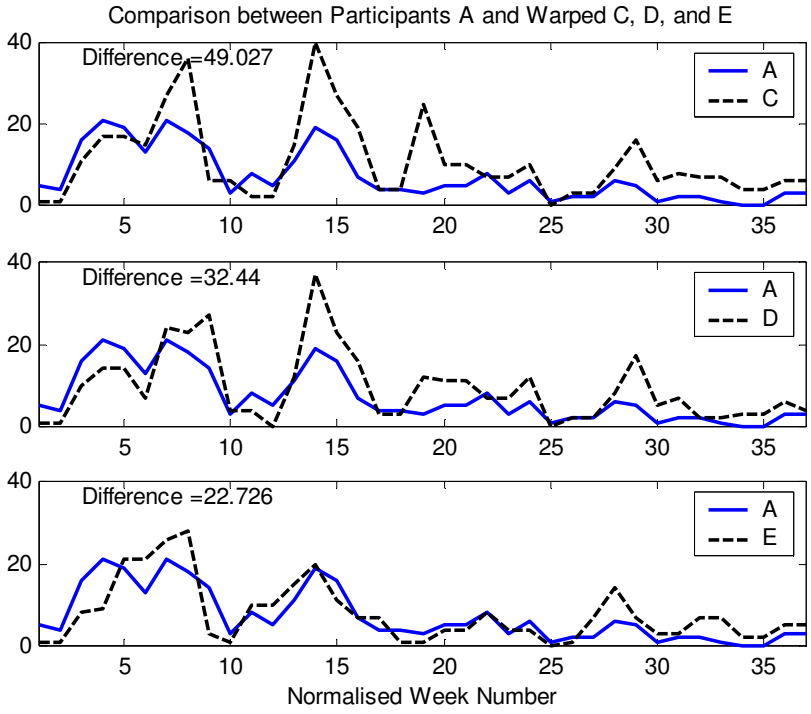


Figure 6.12: DTW Graphs Comparing the Different Groups using the Warping Function

6.4.3 Advice to the teachers

Depending on the ranking, consistency of groups and individuals and correlating the other groups with the most consistent group, advice is printed at the bottom of the page. This helps the teacher to intervene between and among the groups.

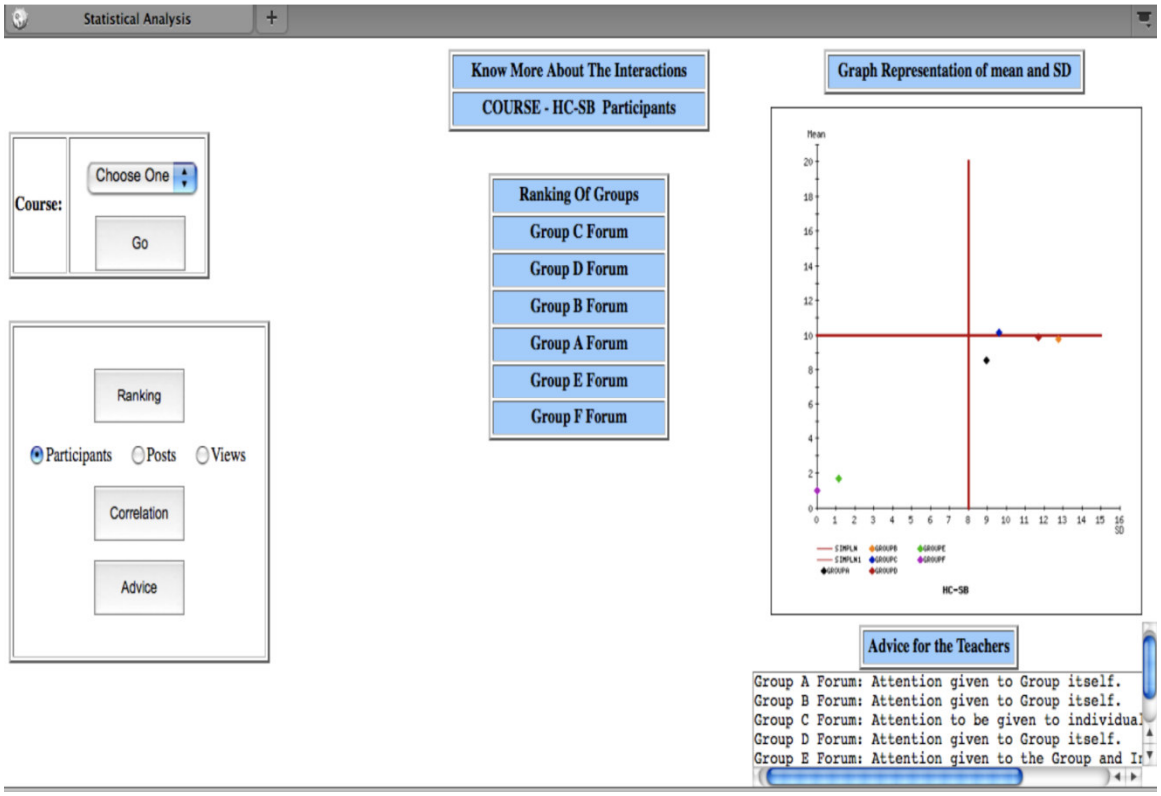


Figure 6.13: Advice to the Teachers according to their Ranking

Figure 6.13 displays the advice to the teachers giving them information of which Groups and/or individuals need attention.

6.5 Graphical Representation of the Analysis of Discussions

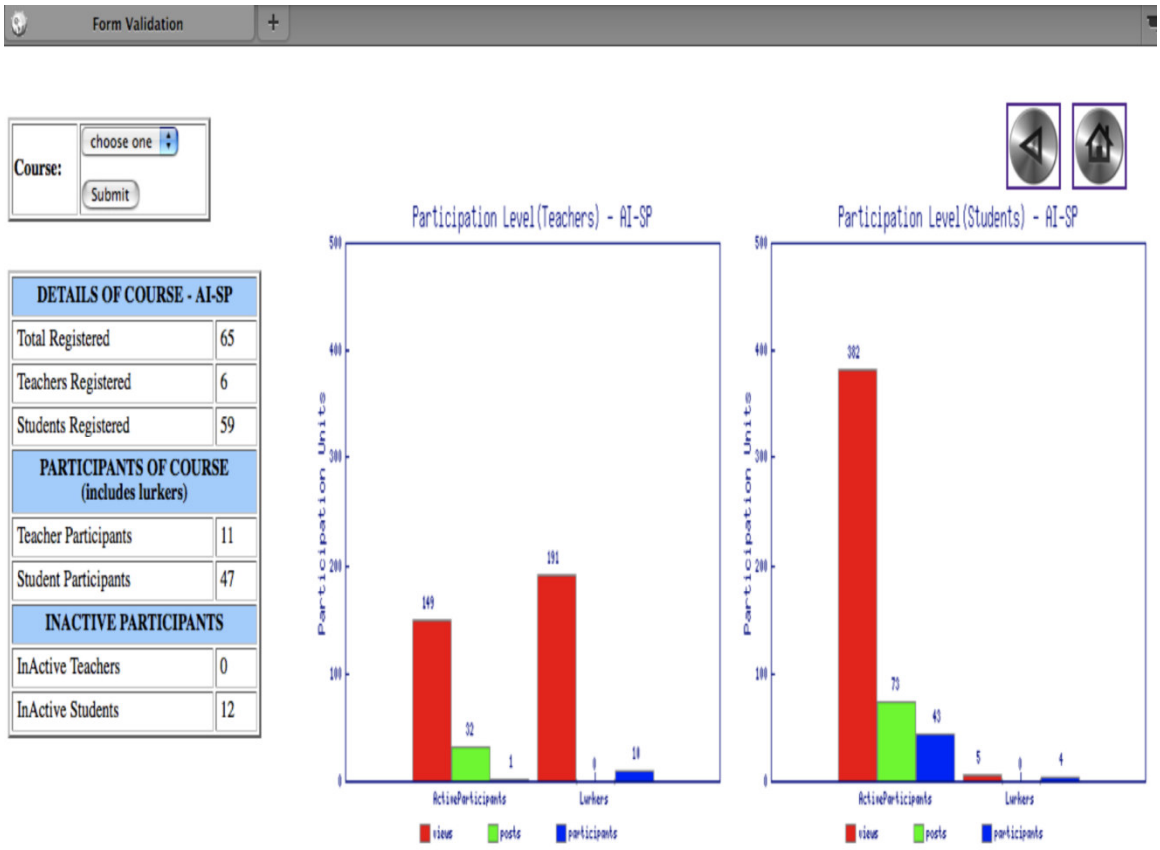


Figure 6.14: Statistical Analysis

The graph shown in Figure 6.14 gives the teachers and students details on the whole, belonging to one of the courses, in a bar chart format. The graphs depict the overall number of views, posts and participants of active participants and lurkers of both teachers and students.

The tables to the left of the graph in Figure 6.14 give more details about the total participants registered, active and inactive participants. We observe that out of 59 students, 47 of them participated in the ongoing discussion, of which 43 contributed to the ongoing discussion by posting 74 messages while 4 of them participated by just

reading the posts. The participation of the lurkers was not great as they had only 5 views, which implies that 3 of them had logged in and viewed the discussion only once. We can argue from this analysis that the lurkers had not actually participated and were inactive most of the time and so there would have been no learning going on by the lurkers. There were 12 inactive students who neither posted nor viewed the discussion. It is now the role of the teacher to involve those 12 inactive students and 4 lurkers in the ongoing discussion by sharing their views and opinions about the discussion. Teachers and moderators can easily view the list of inactive students.

From the details given, it lists 6 registered teachers for this course but we also observe that there are 11 teacher participants for this course. Only one contributed regularly to the discussion by posting 32 posts and constantly viewing the ongoing conversations with a high value of 149 views and the rest viewed and kept a track of the ongoing discussions. The reason for more teacher participants than teachers registered is that there are administrators who also monitor the discussion.

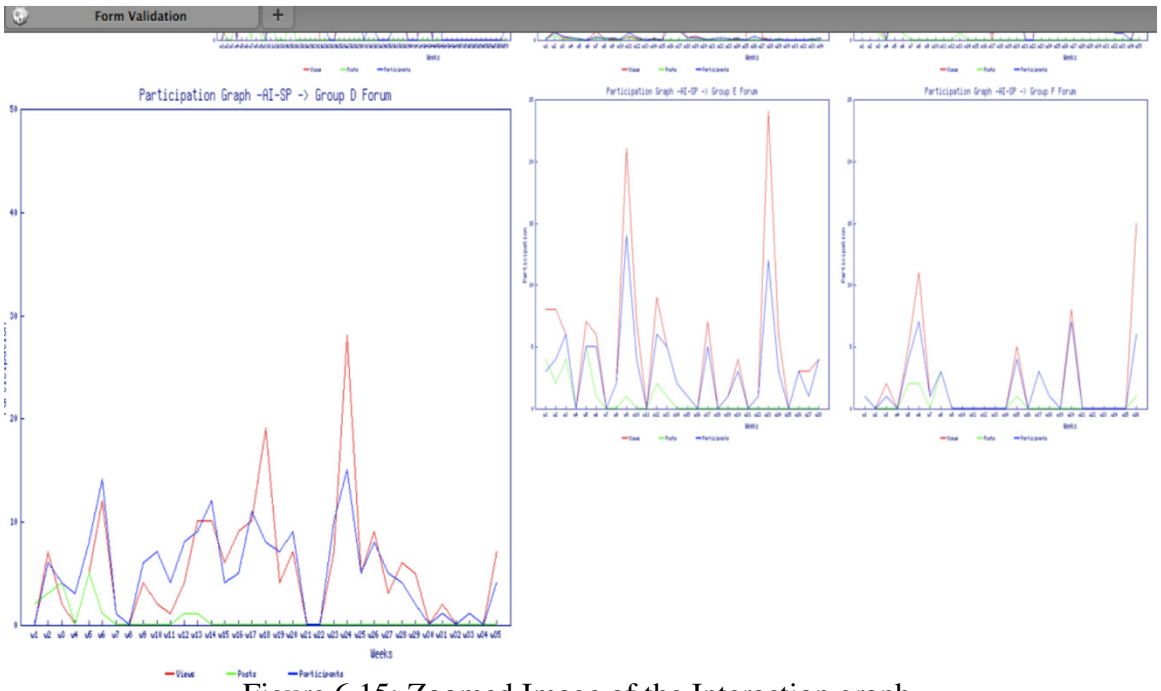


Figure 6.15: Zoomed Image of the Interaction graph

Figure 6.15 give another graphical view depicting the interaction process over a period of time for all the groups participating in the interaction. These graphs show the number of views, posts and participants of one of the courses. The total registered participants (65) were divided into 6 groups. This representation also tells us how many weeks duration the groups were active. Not all the groups had the same time frame. Group F kept their forum live for 26 weeks, and Group A had their conversations going up to 59 weeks. Groups C and D had 35 weeks of conversation and Group B had 34 weeks. From the zoomed image we can analyse the activity to a little extent and draw statement that Group D had the highest number of participants in week24 who actually participated by just viewing the discussions and not posted any. The students actually stopped posting after week14, but stayed online to check for more postings until week35.

6.6 Graphical Representation of Participant's Analysis

Participant's participation analysis gives an overview of their online discussion activity. This representation gives the participants' participation in terms of posts and views. The measure of posts and views is calculated by taking only the active participants as an index and not all the participants enrolled to make the analysis more meaningful. Therefore, the quantity of participants post/views is calculated by taking the number of participants posts/views divided by the number of participants participating in the online discussions. The quality of the posts of the participant is calculated by taking the average of the relevance of the postings which is shown in the graph in Figure 6.16. The collaboration of the participant in the online discussion with the participants of their own school as well as their partner school is calculated by taking the percentage of the number of posts replied to the participants of the respective schools by the total number of participants' participating in the online discussion. The maximum value of this calculation is not more than 100. Any value above this is taken as 100. From Figure 6.16, the participants' participation is high in terms of viewing the discussion but very low in terms of postings.

Almost all of the participants' postings are on topic with an average relevance of 86.28. This gives the quality of the posts of this particular participant.

Figure 6.16 also shows that participant has been interacting not only with his/her school but also with the partner school. The different schools are indicated by different colour codes. We also see that the participant is not only interacting with the students but also interacting with the teacher. This again is indicated by the change in colour.

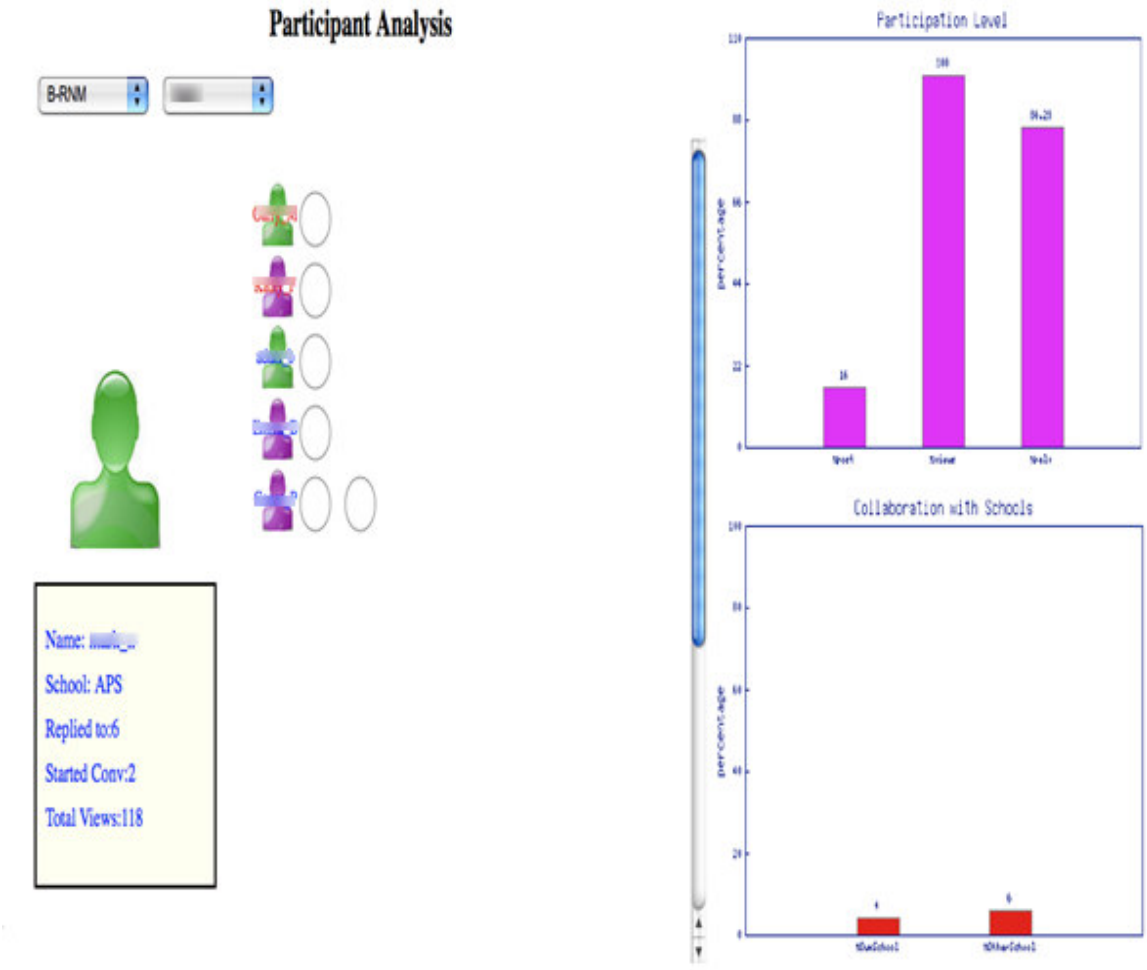


Figure 6.16: Overview of the Participant's Participation

6.7 Outcomes from this Analysis

There is considerable interest in finding ways to use graphical tools to identify and effectively represent those patterns of interaction thought to be pedagogically effective and to distinguish these from those considered less robust or educationally effective (Erickson, 2003). There are two key uses of such representations:

6. The first use of these visualisations is for research and evaluation, to compare and contrast collaborative and discursive interaction patterns as an aid to analysis, particularly in triangulation with other qualitative data (such as content analysis). In this way it is hoped to gain greater insight into those patterns of interaction which seem to signal or accompany more effective collaboration.
7. The second potential use of such visualisations is as an aid to the teacher. Here the aim is to monitor and reflect on the quality of the ongoing discussion.

The results of the analysis give in-depth statistical data that conveys extensive information about the online discussions in an easily accessible format. The analysis results serve as a useful guide to conduct further research. Results from the various analyses revealed that interaction among different groups is not the same. Some groups were moderated with teacher intervention and some were unmoderated. It also revealed the total number of student participants and teacher participants. It not only revealed statistical data but also helped us to identify the various types of ongoing interactions through different representations. With the help of mean and standard deviation, we analysed the consistency of the group interaction and helped reveal the correlation between the different groups involved in the discussion. The chart representation revealed the behaviour of the groups in a time frame.

6.8 Embedding Statistical Graphical Representation in VIMS

The Visualisation aspect is added as a block in the Moodle environment. At the moment only the teachers and administrators logged in would be able to view the visual interaction. The statistical graphs are another form of representation of ongoing discussions in the Moodle forum. The teacher or administrator has the option to view the analysis of the raw interaction data in the form of charts. These charts give an insight into the level of participation and give the results of some quantitative analyses of the asynchronous discussions. The information derived though this statistical analysis can help us find the quality of the interaction, to some extent, and reveals information such as 'most consistent group' in terms of participation and interaction.

6.9 Appearance of Moodle pages after embedding the visualisation tool

Figure 6.17 shows us the Moodle page with the block of visualisation added and gives the view of a guest logged in and a teacher or admin logged in. The teacher has the ability to display or hide the visualised interaction graphs from the students who log in. However, a guest would be able to see the visualisation block with just information of how the visualisations are formed and how they appear.

Figure 6.17 gives the first page of the VIMS on Moodle. This page can take the users to view either the visualisation of interactions in various forms or view the statistical analysis of the discussions. Figure 6.18 shows the first page where user has the option to view either various forms of visualisations available to the user or the statistical analysis. The various forms of visualisation could be either coloured radial tree visualisation or grey-scaled radial tree visualisation or the tabular form of visualisation which is shown in Figure 6.19. The user has the option to navigate back and forth the tabs.

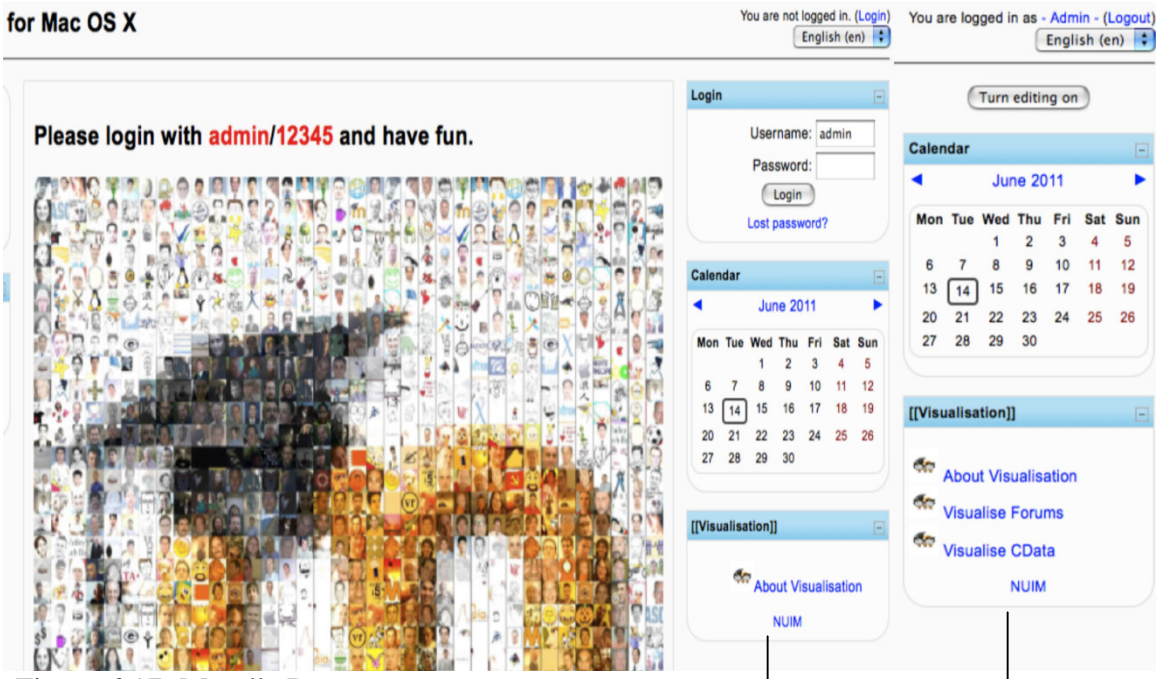


Figure 6.17: Moodle Page

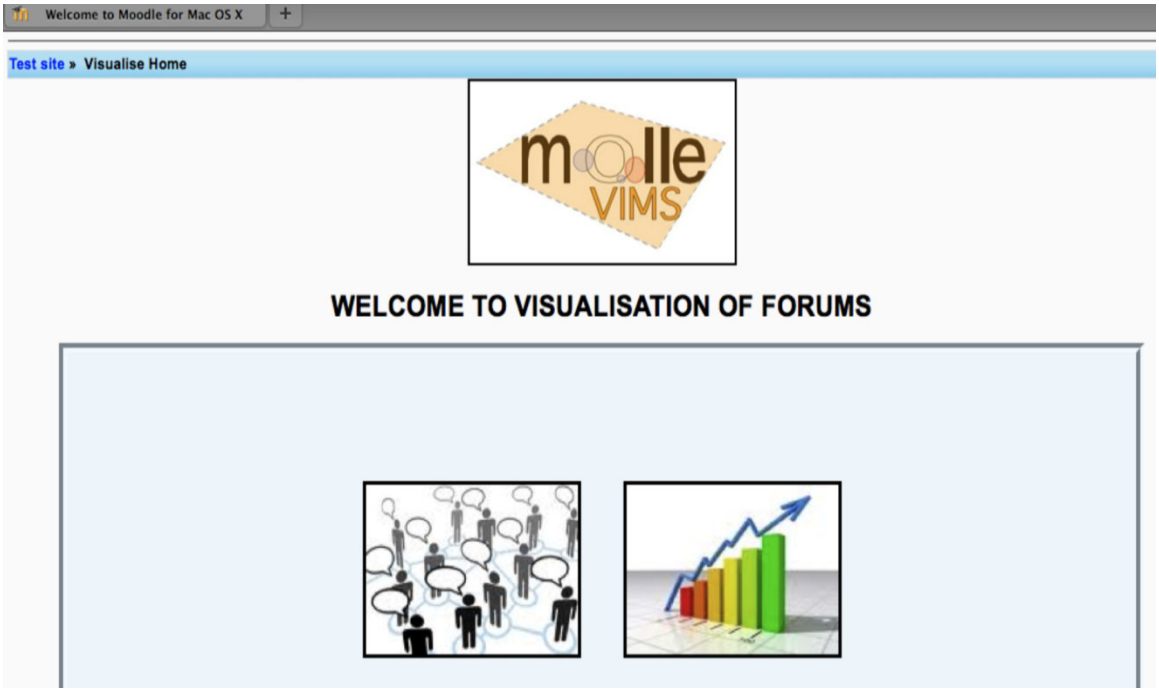


Figure 6.18: VIMS Visualisation Page on Moodle

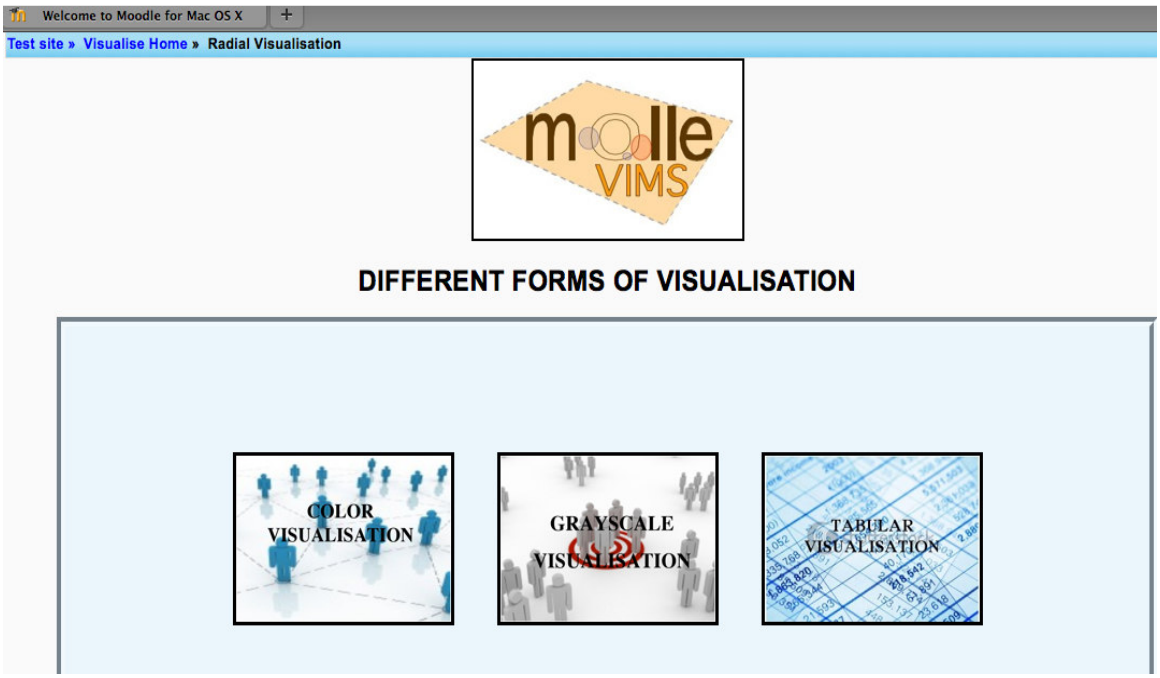


Figure 6.19: Forms of Visualisation

6.10 Summary

This chapter analysed the results that were generated through experimentation and case studies. Our work introduces many novel features in a visualisation tool. Several distinctive patterns were identified with varied statistical results. Since the online interactions are dynamic, it is hard to identify the exact reason for these varied results. However, different patterns can indicate different online behaviour and represent the way participants are interacting when taken together with the context. This can be an extremely effective first step towards teachers identifying and responding to, developing problems.

7 Conclusion and Future work

This chapter summarises the research, describes conclusions drawn and results achieved as well as directions for future work. This chapter highlights the contribution of this research and outlines its contribution to relevant research fields. It then describes the limitations of our approach and suggests possible areas for further investigation and study.

7.1 Review of thesis contribution

A change of an online environment into a collaborative online learning environment is important. To achieve this transformation we wanted the teachers to be able to better understand the discussion space and evaluate the participation of the students in ongoing discussions and then intervene either personally or through online discussion posts, where appropriate. The necessity to flag potential problem areas as they are developing was a primary consideration.

Our research started with an in-depth study of the use of an LMS such as Moodle, the online interactions on the Moodle forum and the format in which this raw information is stored in the Moodle database. Moodle renders not all but most of this information in the form of lists and researchers who developed a tool for Moodle specifically represented that information in the form of charts which is useful to some extent. We identified the need for a visual tool that could assist any user who wanted to study the online interactions. We then explored different tools that were being used and found their usability features and their limitations. Our concentration was mainly on the collection of raw information and parsing the massive data into useful information, identifying a structure of visualisation that could be easily understandable by any teacher or moderator without any difficulty and extracting most of the statistical and qualitative information and representing in a simpler form.

This research has lead to development of a visual tool (VIMS) that aids a teacher or a moderator as well the participant to gain an insight into the ongoing group interactions in an interesting way. VIMS includes a number of features to assist the teacher understand and explore the patterns and level of interaction. The results are displayed both in graphical and numerical form. In due course we also identified important indicators that were needed in a visualising tool. We incorporated those identifiers for a better analysis of the online activity.

There were two case studies that revealed the usefulness of our tool and exposed the participation level of the participants and met the objectives of this research. The evaluation on the representations provided by the tool proved that they were easily understandable and made it easier to identify the discussion space. The indicators on the visual tool and the statistical interpretation helped them analyse the discussions. There were a few recommendations which we would definitely look at as a future study. Without this visualisation, teachers would not be able to view the discussion space in detail.

The quantitative analysis gave the measure of the participation, in terms of the quantity of posts, the total number of active and inactive participants, the participation level in terms of posts, views and participants on a weekly basis. The statistical figures derived from the quantitative analysis can lead to qualitative analysis and helps the teacher to predict the interaction level of the participants.

The qualitative analysis proved that in two the case studies, the discussions were mostly on-topic and thus maintained the rules on an online learning environment. Since most of the students did not deviate from the subject lines their cognitive presence was good throughout the conversations.

7.2 Revisiting Research Questions

The study was based on the five research questions that informed the need of a visualisation tool to understand the online asynchronous interactions. Various tools for interpreting the interactions in different ways have been reviewed and many indicators for measuring the asynchronous interactions were identified through the literature review. This section outlines how each research question has been answered.

Question 1: Can teachers and administrators be made aware of the ongoing discussions on Moodle?

The first research question aimed to identify instruments and tools for supporting the awareness of online interactions to teachers which can then improve the nature of interactions. Not many of the current tools were found to be useful for teachers to understand the discussions that were happening in forums. None of the tools focused on analysing the group collaborative activities. Our research ascertained that a highly interactive, easily understandable Virtual Interaction Mapping System that visualises the asynchronous discussions should be developed. A Visual mapping can be easily scanned and understood. This was then realised as our VIMS tool.

Question 2: Can informative features be extracted from data gathered from online discussions and activities?

A lot of time was spent to understand the how Moodle stores all the forum details in that vast database. We then made a note of all the essential fields needed to indicate the participants involved along with their online activity. With the help of a sequence of SQL statements we then parsed the necessary information needed and stored the extracted data onto VIMS database. We also identified various indications (important indicators) that represent these extracted features and found a way to represent them. Some of the representations used where indicated by Schrire in her model (Schrire, 2004). We started the research with very few indicators as described by Schrire and as research progressed,

we identified more indicators according to the teacher's needs. We tried representing those indicators in different ways, and finally came up with representations which followed the information visualisation strategies, HCI concepts and representations best understood and identified by the teachers.

Question 3: Can this information be presented in a better way to the teacher?

As stated earlier, graphical representations are easily captured, analysed and understood by a teacher. VIMS proved to dynamically generate the radial tree representation of the online asynchronous discussions. Hierarchical structure is always better to trace the conversational branches without being distracted by unrelated nodes from other threads (Hewitt, 2001). Hence we chose the radial tree structure which combined all the hierarchical threads of various discussions in a forum. Radial tree representation can be used either to see the whole conversation at a glance group-wise (if students are divided into groups) or course-wise. If there are groups then the teacher might want to view the conversations happening in a particular course to compare it with the other course. In such a situation, a tabular representation is used, which shows the number of messages posted by each individual in the course. This gives the picture of who-is-interacting-with-whom. The radial tree is represented both in colour and gray scale. A detailed analysis of the participant's contributions, collaboration with participants from cross-border (in case of inter-cultural education) and their cognitive presence during the discussions in a graphical format is presented. VIMS incorporates most of the indicators essential for a good visualisation of the online discussions. Interactive visualisations enabled even richer insights and investigations of the previously unknown information. Thus in a sense we can state that the visual representations provided by VIMS and the analysis done by the tool convey meaningful information about the interaction characteristics of the online communication.

Question 4: How best to implement a visualisation tool that will enhance the means by which asynchronous online communications in discussion forums can be analysed?

We have chosen to use SVG's to represent the radial tree as SVG supports dynamic interactive representations which are far superior in raster format when compared to the image files. SVG lends itself quite naturally to server-side generation. Because of its support of Synchronized Multimedia Integration Language (SMIL) and JavaScript/ECMAScript, SVG graphics can be manipulated and generated client-side as well. This allows SVG to generate on-the-fly applications from the server side and create environment on the client side which can be manipulated by the user. The perl coding enables itself to embed the SVG syntax to dynamically generate the graphs. The software clearly fits into the architectural framework and hence makes it easily understandable to other researchers who would like to modify the code and explore new visualisations.

Question 5: Choose evaluation procedures that can be integrated with the visualisation tool that will allow comparisons between groups participating in the online discussion environments?

After a thorough literature review and a clear idea of what's missing in the current tools, we came up with a Virtual Interaction Mapping System. The tool is embedded with the functionality for group comparisons. It not only gives a radial representation of the online discussions but also provides with a tabular and graphical view of the group analysis. We ranked the groups according to their performance and compared the other groups with the best group to see how the other groups correlate with the best group. The advice is given to the teachers after the statistical analysis is done and this could only assist the teacher to draw their own conclusions. The results drawn from using VIMS proved to be a positive and acclaimed by many teachers who had used the visualisations for testing purpose. VIMS proved to be an easily understandable tool which gives clear indications visually with the legends of the various attributes of the asynchronous discussions. Following the information visualisation strategies made it very reliable for the teachers to use the tool.

7.3 Benefits, limitations and future work

The advantages of VIMS are:

a) The VIMS tool generates dynamic interactive visualisations that can be rendered while a discussion is taking place or after it is complete.
b) VIMS is built on Moodle platform, so there is no need to learn a new environment.
c) VIMS has been constantly upgraded taking the instructors requirements into consideration.
d) The tool can be adopted to support other Learning Management Systems and not just restricted to the use in Moodle environment.

In relation to the software itself, we have found that VIMS has considerable advantages as a visualisation tool. However, there are areas for development in the software and in a discussion with large number of messages; it may still be somewhat difficult to navigate on-screen. Having said that, we feel our tool would still provide a much clearer and more easily navigable visualisation than other tools would, if using the same message data. It is important to acknowledge the limitations of the VIMS tool too: it is in essence a support for coding and management of the data, rather than offering in and of itself a new method for analysing that data. For that analysis, we need to consider the wider model used by Schrire or indeed to pursue existing qualitative methods. It does not yet allow us a way to analyse either the multi-modal nature of the student discourse in unmoderated forums or the inclusion of images, sounds and other media which students are now accustomed to using. However this can be implemented as extension of our tool in future.

Although the tool helps us to find the percentage of relevance to the subject, we still need to find the level of critical thinking during and after the ongoing discussion. This limitation could however lead us to future research in this area. The tool gives the SVG graph of the participants on a weekly basis but could be improvised by adding another functionality to depict the representation on a daily basis. This would help users to identify the level of interaction on a daily basis.

The goal is to release VIMS as an open source project at the earliest opportunity, so that interested people can explore the usability of VIMS and researchers can expand the tool in the near future. The visual representation can be extended to viewing e-mail, wiki's and synchronous chat messages.

As future work, we also want to look at tracking the emotional behavior of the participants. This can be done by capturing emoticons, which indicates social interaction being more expressive and searching for the prevalence of ALL UPPER CASE letters, which indicates shouting and/or fighting. We would also be interested in looking at more statistical findings which had been indicated in section 6.4.2.

7.4 Closing Remarks

This research described and presented a tool, building on the existing and extensive work undertaken by other researchers, in methodologies for the analysis of asynchronous discussion forums in virtual learning environments. Our piloting and evaluation of the visual representations presented by the tool suggests that it offers an appropriate and effective means of coding and managing discussion forum messages in a visual format which then facilitates decision-making in relation to additional in-depth analysis. The initial visual pattern suggests broad categories into which discussion threads may be falling, and again, offers directions for further analysis.

In relation to the methodological concerns, we propose that the software developed and piloted offers the ability to analyse large numbers of discussion messages quickly and comprehensively. The facility with which interaction pattern maps can be produced using the VIMS software described here should enable greater numbers of teachers to analyse CMC interactions, typically in VLE forums. The embedding of the tool within a VLE will allow anyone editing a course space to use it. The visual representation benefits from a clear structure and uncluttered appearance on-screen, but retains the message text

through hyper linking to the Forums. Data is anonymised during the parsing process. The visualisations can then be used to assess whether there was learning going on by finding the percentage of relevance to the subject, or the formation of social network, or a combination of the two.

The patterns of interaction as described by Schrire help to analyse the maps and identify patterns of collaborative learning as opposed to linear messaging. A deeper analysis of the structure and quality of the postings, as well as students' cognitive abilities, will give indications of higher-order thinking and a clear insight of collaborative learning. The instructor can also view the profile of the student with a click on the node that represents that student. This gives a detailed description and involvement of the student, by highlighting all of their posts in the discussion under investigation, as well as an aggregation of their contribution history compared to the other participants.

In relation to the software itself, we have found that VIMS has considerable advantages as a visualisation tool. First, the discussions are shown in a systematic way, with participant's initiating the discussion placed at the first level. Easy to visualise where a posting is located within the structure of a thread. It is easy to view the complexity or simplicity of a thread. There is no on-screen clutter from message text. All threads in a discussion forum can be viewed at a glance. Navigation on-screen allows the discussion to be viewed as a whole, or for the viewer to zoom in on certain areas of discussion. One or more threads can be compared easily. The presence of lurkers is also shown.

This visual aid is a supportive tool to help the instructor develop a collaborative environment. The tool supports the instructor to visualise the active and inactive participants and gives clues if the participants responding are deviating from the subject lines, allowing the teacher roles in implementing interventions by asking the lurkers and inactive participants to participate in the collaborative network, and for participants diverging from the topic to return to it.

We cannot conclusively argue that phases of critical thinking (such as those identified by Schrire) are present or absent from the threads we have analysed thus far but can identify if the participants posts are relevant to the subject of their discussion. A further issue is the blurring of threads as 'moderated' or 'unmoderated': although this may depend on our own definitions of what constitutes a moderated Forum. If we regard moderation as presence of a teacher, then we have evidence of learning with very limited teacher presence and, conversely, evidence of linear messaging with a teacher intervening. The use of 'Topic' spaces in Moodle as, in effect, course notice boards and news spaces also complicates the notion of moderation as taking place only in the Forum space. We suggest that conventional boundaries of moderation (Salmon, 2000) are being blurred by the flexibility of certain areas of the Moodle VLE, in particular, but we acknowledge that this issue requires further exploration.

Appendix A: Analytical Framework of Henri (Henri, 1992)

DIMENSION	DESCRIPTION
Student participation	Number of messages Number of message units Length of message unit (lines)
Interaction patterns	Chain of connected messages • explicit interaction direct response, • explicit interaction direct commentary, • implicit interaction indirect response, • implicit interaction indirect commentary.
Social cues	Statement or part statement not related to the formal content of the subject matter.
Cognitive skills and depth of processing	Statement exhibiting knowledge and skills related to the learning process. • cognitive skills: elementary clarification, in-depth clarification, inference, judgment, strategies. • processing information: surface processing, in-depth processing.
Meta-cognitive skills and knowledge	Statement relating to general knowledge and skills and showing awareness, self control, and self regulation of learning. • meta-cognitive knowledge, • meta-cognitive skills.

Appendix B: Bloom's Taxonomy of Cognitive Domain

(Bloom, 1956)

LEVEL	DEFINITION
KNOWLEDGE	Student recalls or recognizes information, ideas, and principles in the approximate form in which they were learned.
COMPREHENSION	Student translates, comprehends, or interprets information based on prior learning.
APPLICATION	Student selects, transfers, and uses data and principles to complete a problem or task with a minimum of direction.
ANALYSIS	Student distinguishes, classifies, and relates the assumptions, hypotheses, evidence, or structure of a statement or question.
SYNTHESIS	Student originates, integrates, and combines ideas into a product, plan or proposal that is new to him or her.
EVALUATION	Student appraises, assesses, or critiques on a basis of specific standards and criteria.

Appendix C: Principles of Social Constructivism

(http://docs.moodle.org/20/en/five_key_principles)

PRINCIPLES	EXAMPLES
All of us are potential teachers as well as learners - in a true collaborative environment we are both	In Moodle, 'traditional' roles of who-teaches-and-who-learns can be changed, reversed and adjusted by changing editing permissions of a course or an activity. Students can, for example, be moderators of a forum.
We learn particularly well from the act of creating or expressing something for others to see	A collaboratively constructed wiki answering a complex question to benefit the group is a powerful way to learn by creating with and for others.
We learn a lot by just observing the activity of our peers	Reading and posting thoughtful forum posts can challenge and reveal our own depth of understanding.
By understanding the contexts of others, we can teach in a more transformational way	Via private online conversation, a teacher finds out the career aspirations and difficulties of a very shy and reserved student and adjusts her teaching approach.
A learning environment needs to be flexible and adaptable, so that it can quickly respond to the needs of the participants within it	A multimedia teacher loves inserting media and links for his creative class, her colleague in mathematics often challenges his students to solve tricky problems via forum, the language students appreciate the scaffolding of foreign language tasks through Lesson modules.

Appendix D: Steps involved in installing VIMS module

1. The block can be downloaded as a zip file.
2. There are two folder files which are to be unzipped in two different folders in the two different directories of Moodle.
3. All the files related to the authentication of the user have to be extracted (unzipped) to a folder in the Moodle directory. This is the folder '**visualisation1**'.
4. Name the Folder as **visualisation1** (case-sensitive) after downloading the files from visualisation1.
5. Now all the files related to the visualisation (folder name **visualisation2**), have to be extracted to a folder in the blocks/blocks directory. Name this folder as **visualisation2**.
6. The installation of this block automatically parses all the necessary information from the Moodle database and creates a VIMS database with the necessary tables needed for the visualisation.
7. Once these files are extracted in respected folders in respective directories, the teacher or administrator can use the option of turning the student view on/off.

Appendix E: List of Software Needed

Moodle	Version 1.8 or higher
Perl	Version 5.8.6 or higher
MySql & PHP	Depending on the Moodle version
Firefox	Version 3.5.9 or higher
Abode SVG Viewer (Internet Explorer)	Only when using IE. Not necessary for Firefox (specified version).

Appendix F: List of Perl Modules Needed to Generate SVG Graphs

Math::Trig	Defines many trigonometric functions not defined by the core Perl. (http://search.cpan.org/~jhi/Math-Complex-1.56/lib/Math/Trig.pm)
Math::Complex	To create and manipulate complex numbers. (http://search.cpan.org/~jhi/Math-Complex-1.56/lib/Math/Complex.pm)
HTML::FormatText::WithLinks	This takes HTML and turns it into plain text but prints all the links in the HTML as footnotes. (http://search.cpan.org/~struan/HTML-FormatText-WithLinks-0.09/lib/HTML/FormatText/WithLinks.pm)
Data::Dumper	Takes a list of scalars and returns a printable string (http://search.cpan.org/~smueller/Data-Dumper-2.126/Dumper.pm)
Math::ConvexHull	Calculates convex hulls from a set of points in 2D space (http://search.cpan.org/~smueller/Math-ConvexHull-1.03/lib/Math/ConvexHull.pm)
GD::Graph	A suite of Perl modules for plotting data (http://search.cpan.org/~mverb/GDGraph-1.43/Graph.pm)

Appendix G: Final Feedback

Survey form and feedback materials

As mentioned in section 4.10.2 this section details the documentation and second survey. An e-mail was sent to the teachers which are displayed below:

Dear Lecturers.

I had been working on building a visualisation tool which visualises the asynchronous interactions of students and teachers in any learning environment (Eg. Moodle forum).

I'm forwarding you a zipped file which consists of a few images and a description of a virtual interaction mapping tool. For my research purpose, I would like to get some feedback from few of the lecturers from computer science department and so I request you to please take a look at them and give me your comments and suggestions on it please. I would be grateful if I could get a feedback before the end of this month please as I need to meet the deadlines.

Description of the images (Description.pdf) to get a general idea and a few .png files of other statistical analysis related to forum interactions are also attached.

(You will need to download the files and view the images. The SVG images open only in firefox or opera).

Thankyou.

A Brief Description of the Visualisation Tool (VIMS)

We propose Virtual Interaction Mapping System (VIMS), which aside from providing a visual representation of an online discussion can also analyse the extent of involvement of the participants, thereby giving a detailed picture of the communication pattern. This tool can help teachers or moderators to intervene in the communication process if necessary, changing the participants' focus and activity. Furthermore, the visualisations generated can support further analysis, including qualitative and quantitative research.

The messages posted by the participants are represented as circles and the arrows connecting them represented the dialogue between those connected participants, flowing in the direction of the arrowhead. The message text can be viewed by placing the cursor over the dot present on the message-flow arrow. The instructor can also view the profile of the student with a click on the node that represents that student. This gives a description and shows the involvement of the student.

The interactions are depicted in layers: the person starting the thread is placed at the centre (the first level), and the people responding to the thread are placed at different levels around it. The presence of the node on the farthest circle (of each thread) indicates its level and depth in the structure. The increase in layers and the movement of circles far away from the centre indicates conversation in progress. The depth and the number of levels represent the complexity of the discussion thread, and are explicitly clear from this structural layout. The arrow between the two nodes represents the flow of information (the message). For example, an arrow from one node in level2 connected to another node in level1 with the arrow head (always) facing to the lower node (level1) indicates that the participant at level2 is responding to the participant at level1. If the participant at level1 (starter of the thread) replies to the participant at level2, then that message is indicated at level3. If there are more than one nodes with arrows pointing to a node at a lower level,

this implies that there were more respondents to that post. The arrowheads with a dot in the nodes at the first level are used to view the post of the initiators.

The dotted outline surrounding a set of circles represents a boundary around a particular thread within the discussion. Tabs located to the right of the visualisation show the details of the participant, lurkers, and other statistics about the forum (like the total number of posts, views, participants, threads, lurkers; the average number of posts per participant, average number of views of a typical discussion and average number of words per message).

Click on the circles to view information of the participant who posted that message.
Click on the dots on the arrow reveals the message with its relevance to the subject.
Mouse on the boundary (dotted line) gives information of the thread.

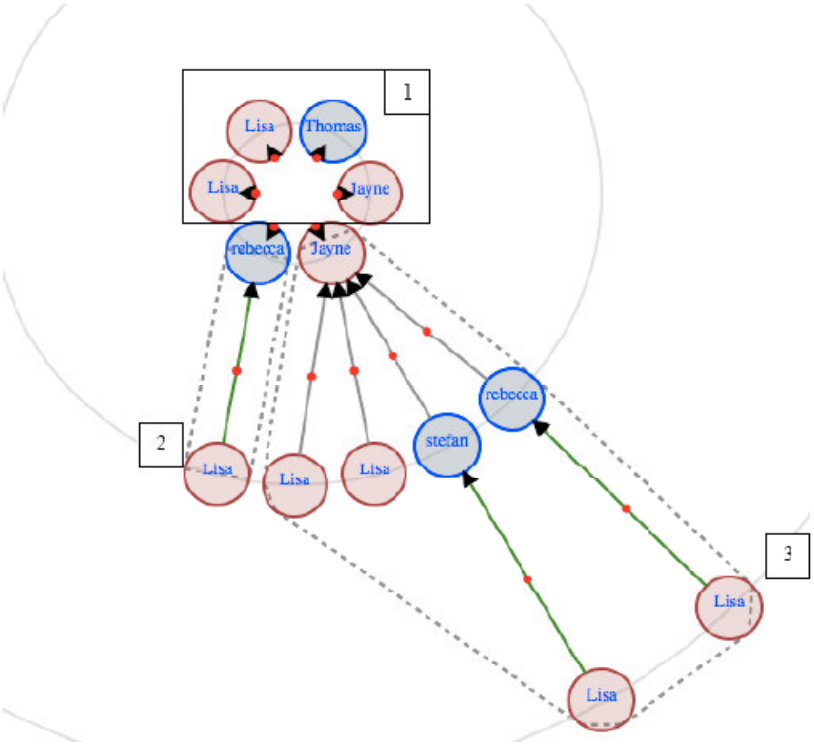


Figure1: One of the forum discussions (Group C)

From Figure1 we see that there are six discussion threads in a forum started by Lisa, Rebecca, Jayne and Thomas. Four threads [1] have no responses. Thread started by Rebecca has one reply [2] by Lisa and there are four responses to the message posted by Jayne. This conversation moves onto the next level where Lisa replies back to Stefan and Rebecca [3].

Indicators of VIMS:

You can actually visualise the indications of the participation level, distinguish between teachers and students, view the student and message details, and view the lurkers. You can even view the relevance of a message to the subject and a few statistical details.

Statistical Analysis:

With help of correlation (if total time for the conversation in weeks are the same among the groups) and time-warping (if the time-frame of the conversation in weeks differ by a small range) find out which of the other groups are close enough in performance compared to the most consistent group (Group who Ranks First) in terms of number of posts, number of views and number of participants. If correlation is zero then there is a large difference in the time frames and hence cannot be compared.

Depending on the ‘ranking’, ‘consistency of Groups and individuals’ and ‘correlating the other groups with the most consistent group’, advice is given to the teachers at the bottom of the page. This helps the teacher to intervene between and among the groups in order to make the interaction environment more meaningful and collaborative.

I would be delighted if you could please give a feedback on this tool with your comments and valuable suggestions.

1. **In your opinion how useful is a Visualisation tool with respect to monitoring the student's online discussions in a Learning Management System (LMS) like Moodle?**

2. **What other indicators like time difference between two posts, posts read … do you think can be added to the visualisation in VIMS tool? (In other words what other important aspects of the forum details would you prefer to be viewed) If you can think of a few more indicators that could help the teachers through visualisation, please mention.**

3. **Can you suggest from your experience what needs to be improved in the tool? (Could be help information on the buttons or the graphs).**

README.TXT

All the SVG (Scalable Vector Graphics) files could be opened either in Firefox or opera. Internet explorer might need an svg-viewable plug in.
GroupA.svg, GroupB.svg, GroupC.svg, GroupD.svg, GroupE.svg, GroupF.svg are visualisations of interaction in those groups who belong to the same course 'A-SP'.
(You can ignore all the .js files….they are just embedded into the svg images)

Look_at_this.svg and Look_at_this2.svg are two more examples of visualisations of two other groups. This is to show the difference between those two group interactions. The visuals show the group that is very active and the group that is very silent.

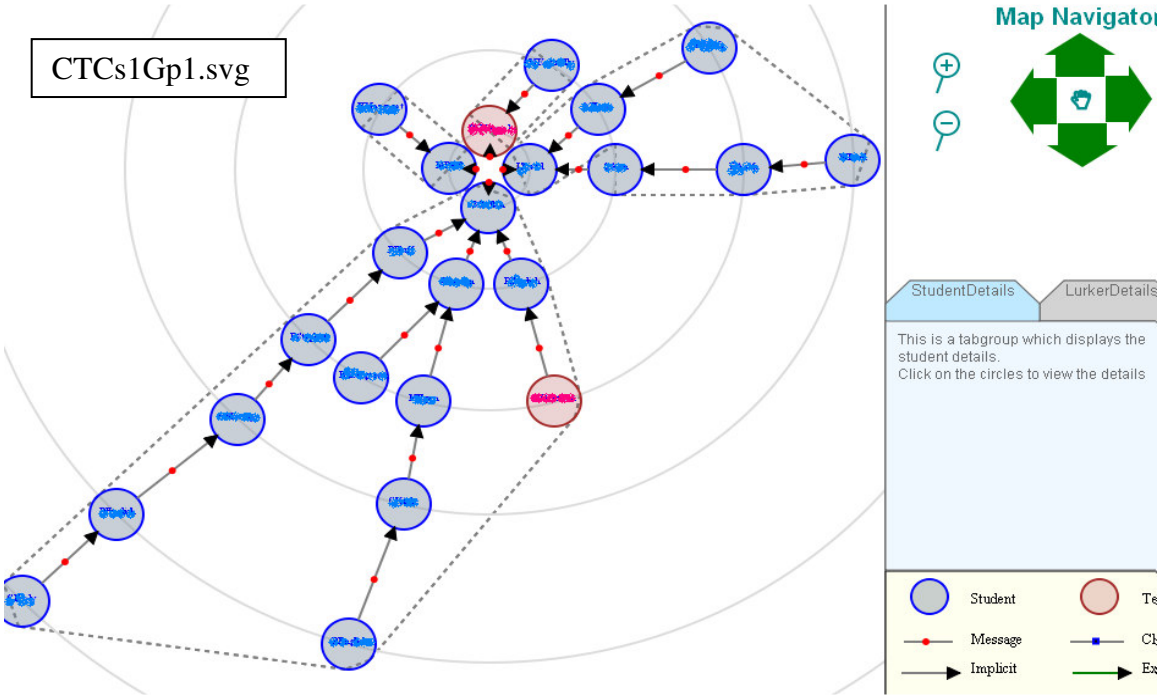
Picture_0.jpg – This details more statistics of the course A-SP whose 6 groups visuals (svg's) are attached.

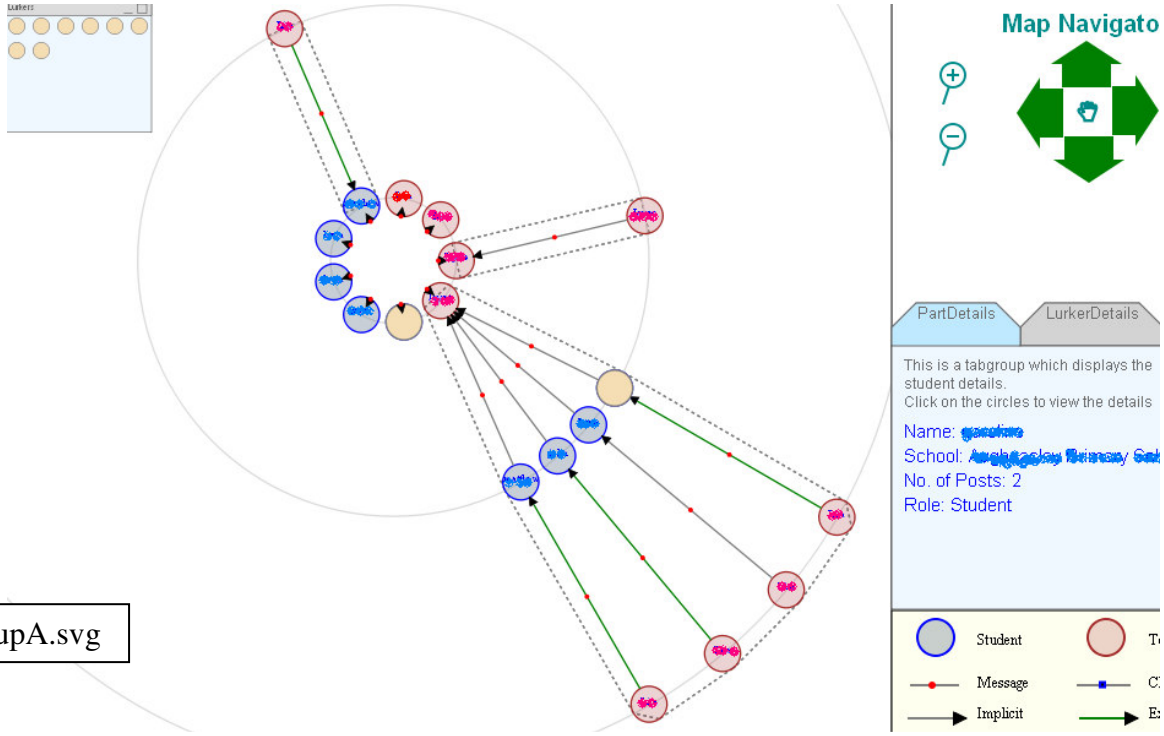
Picture_1.jpg – This is related to some more statistical analysis of the same course A-SP. This image shows the ranking of the groups based on the number of active participants and the total number of posts posted. It also gives how the other groups are correlated to the Group A, which stands first in ranking when the number of participants is taken into consideration. Also gives advice to the teachers based on the ranking.

Picture_2.jpg – This give the analysis of some other group. This is just to show a variation of the Picture_1.jpg.

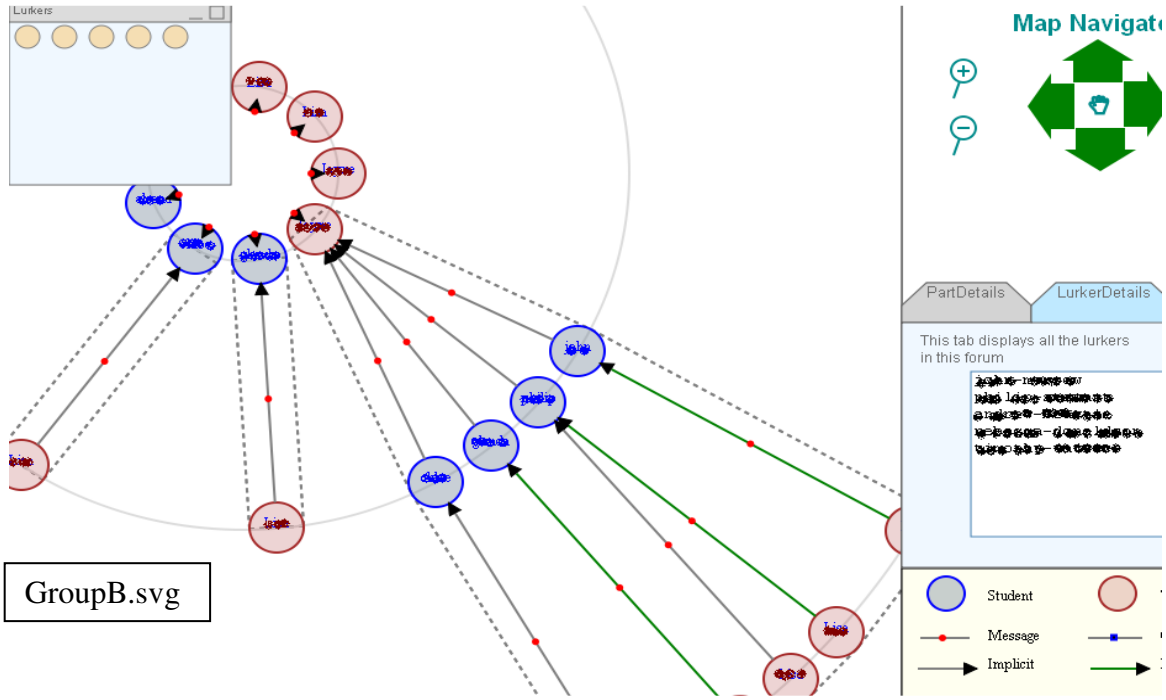
Selection.bmp – this is just to show how a teacher can make selection. The visualisations can be viewed as a whole or could be seen weekly.

CTCs1Gp1.svg

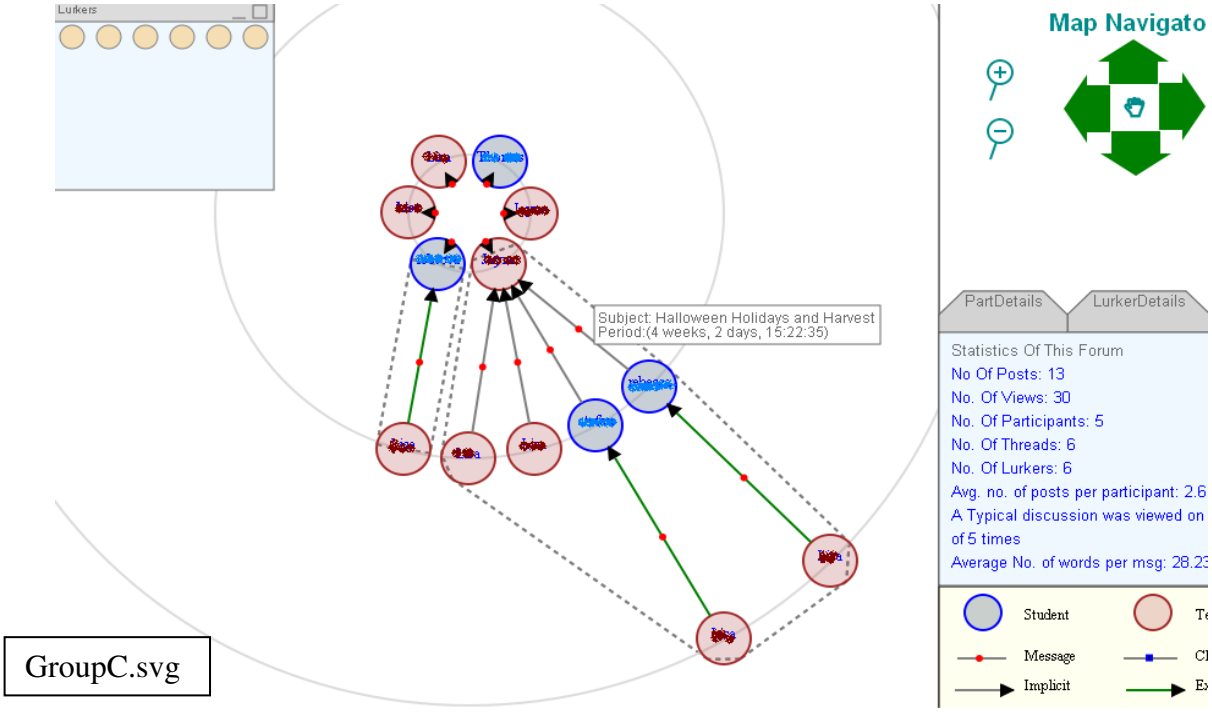




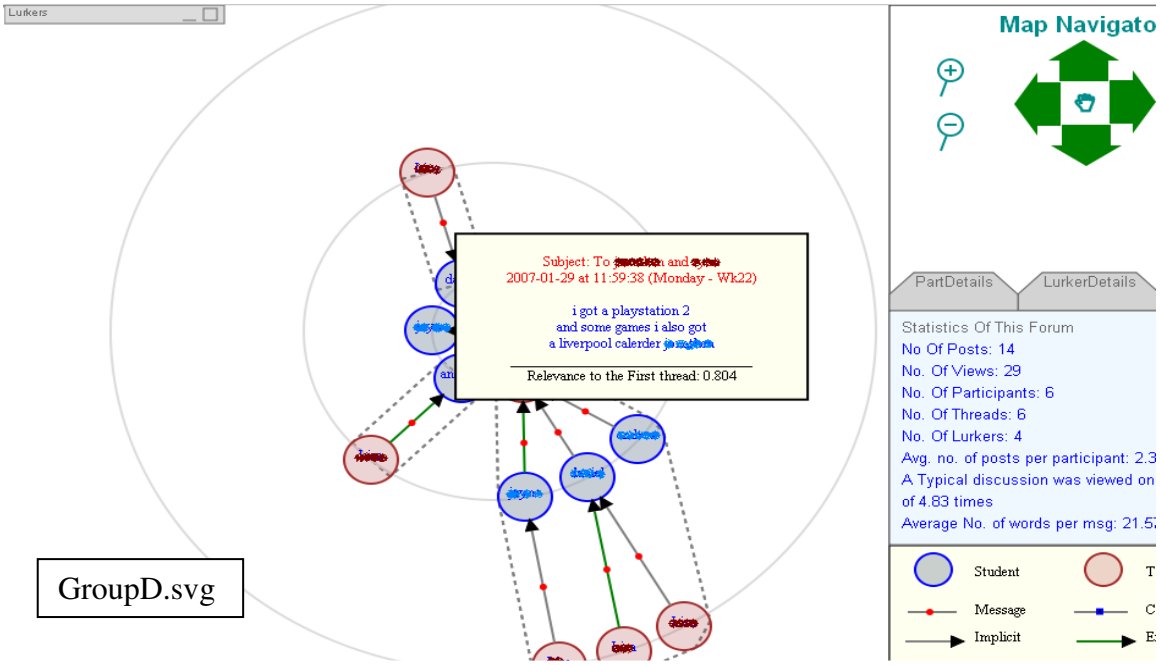
GroupA.svg



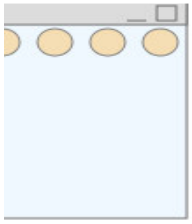
GroupB.svg

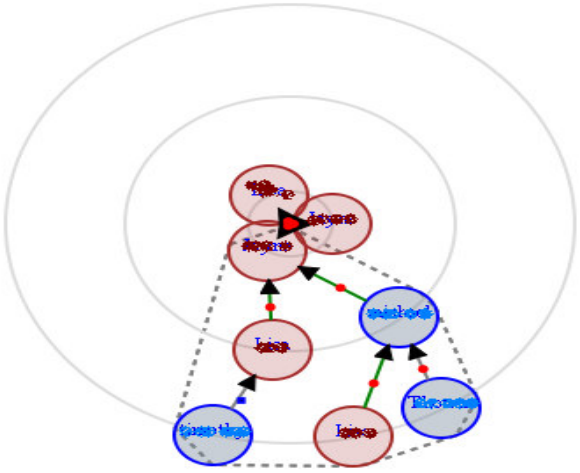


GroupC.svg

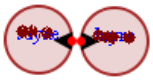


GroupD.svg

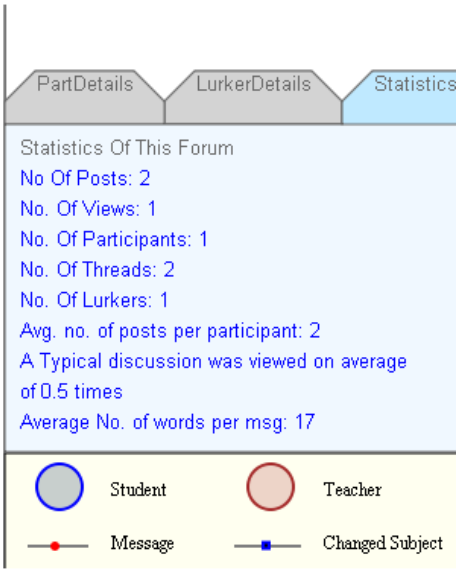


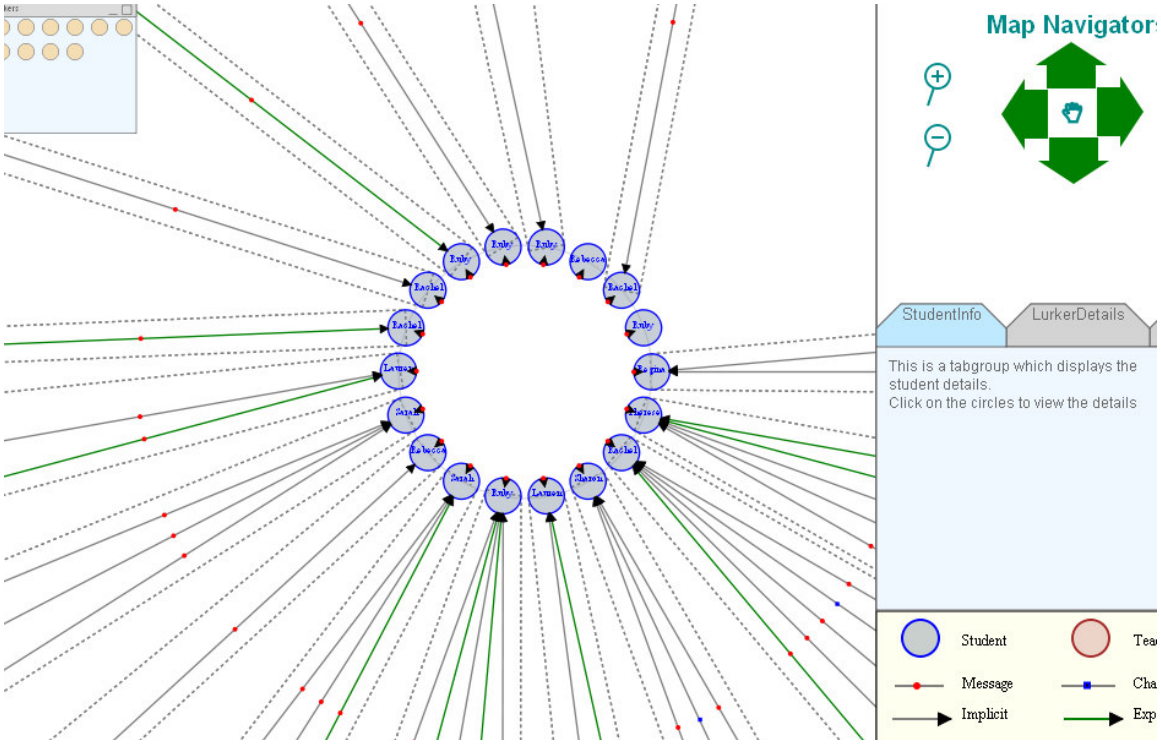


GroupE.svg

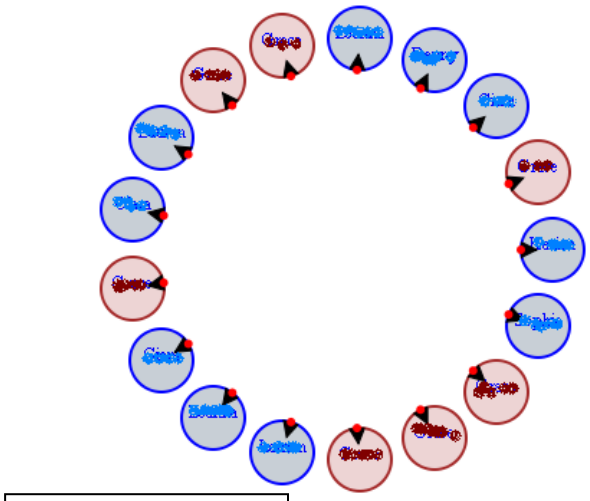


GroupF.svg

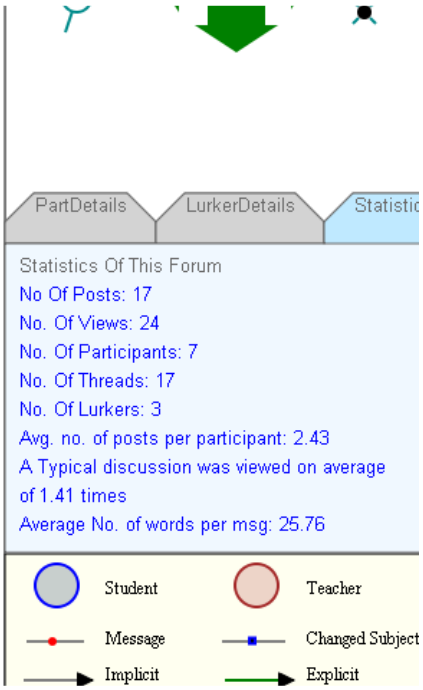




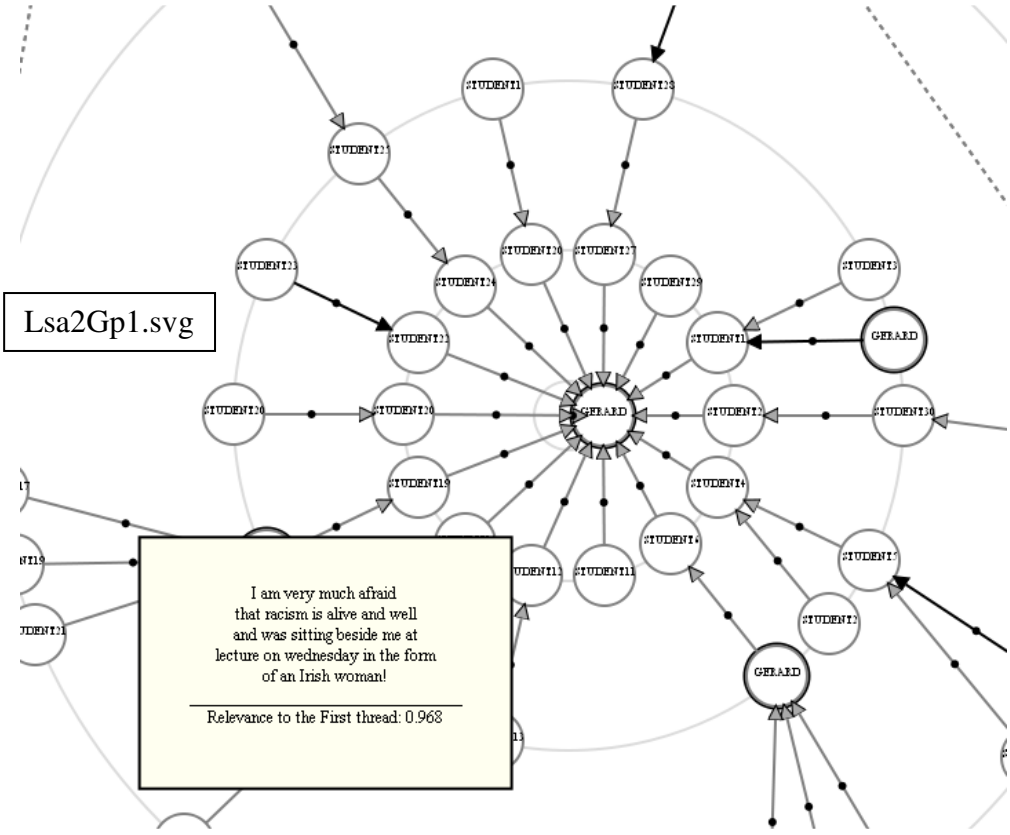
Look_at_this.svg



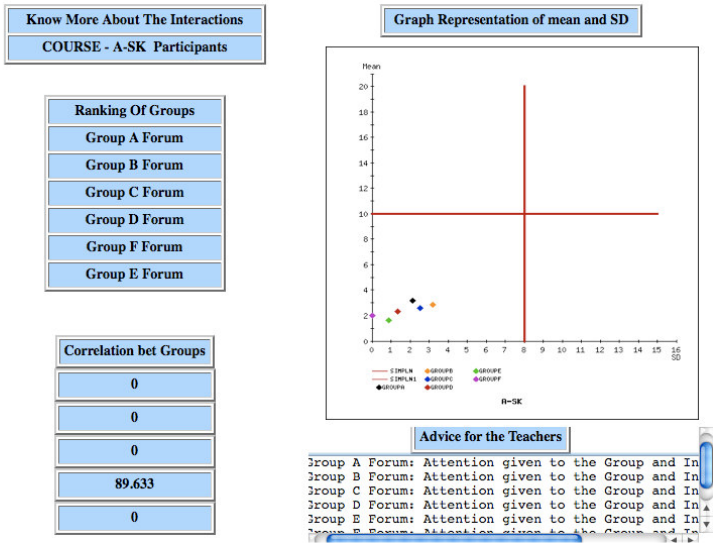
Look_at_this2.svg



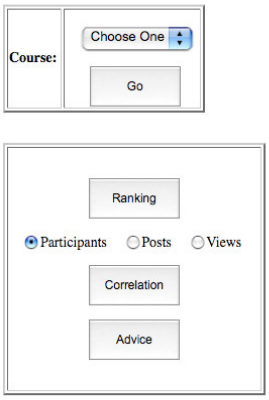
Lsa2Gp1.svg

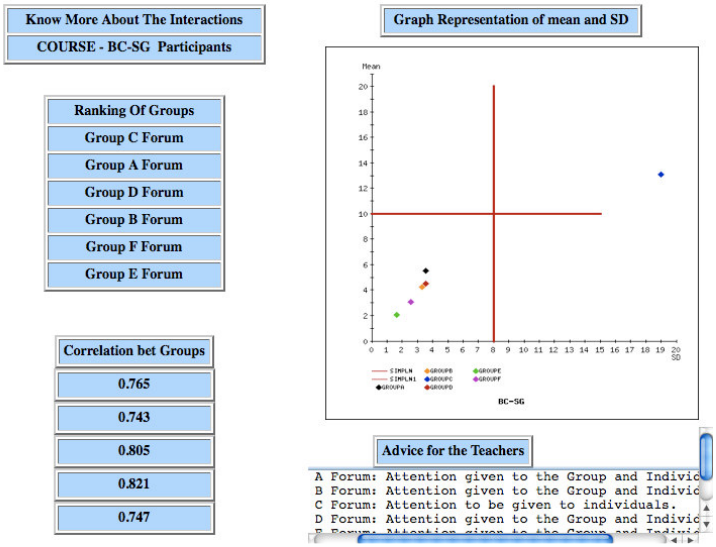


Picture_1.jpg

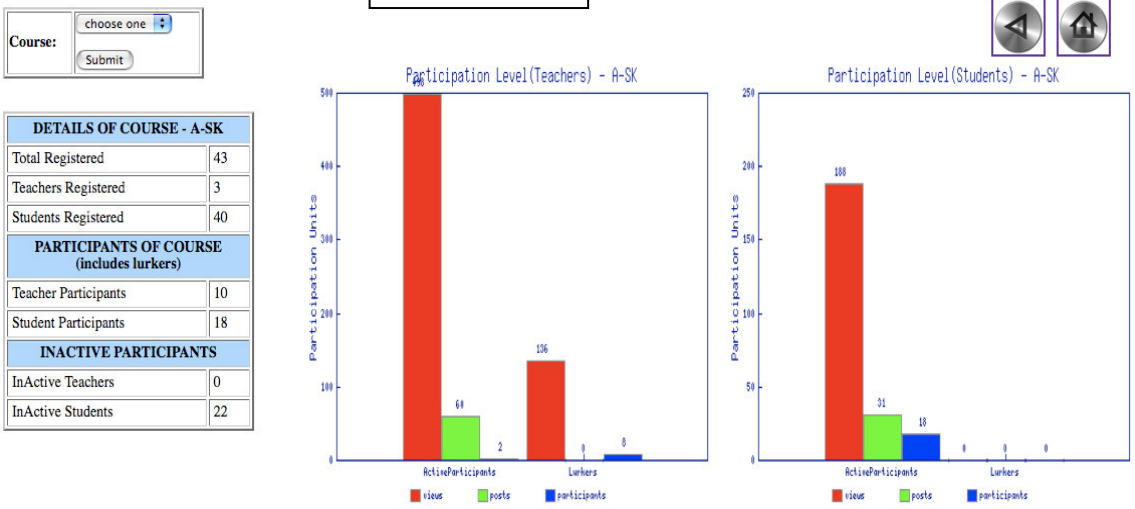


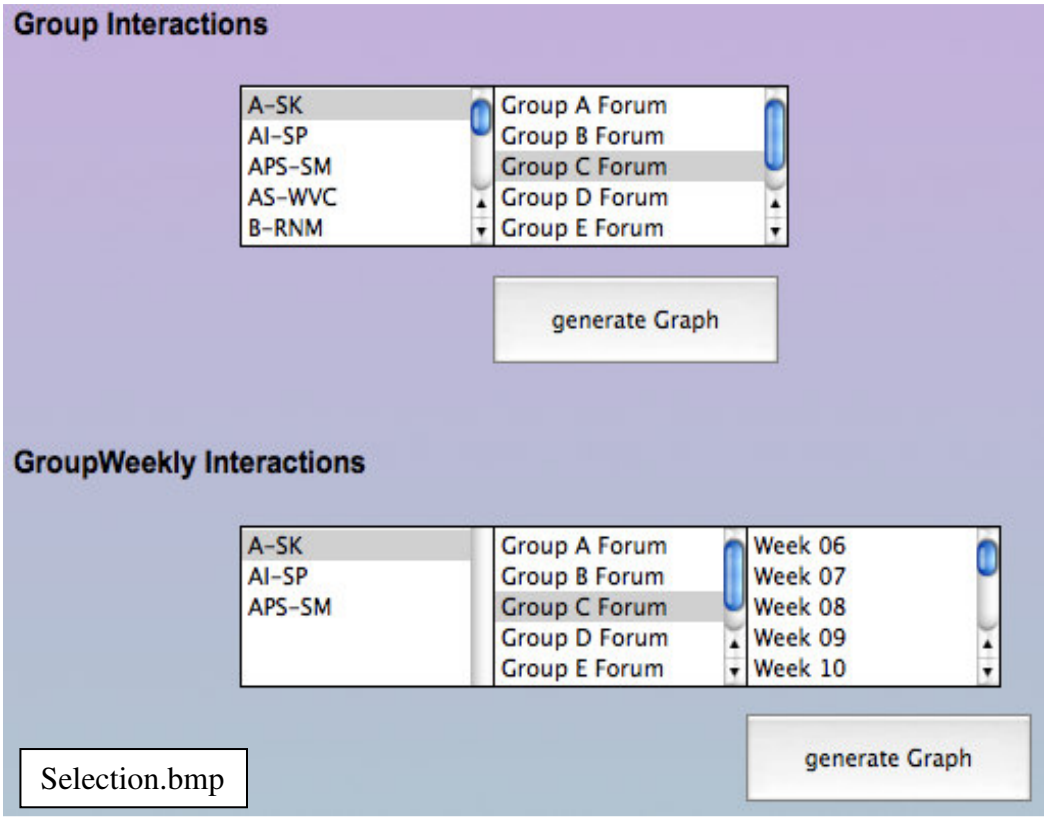
Picture_2.jpg





Picture_0.jpg





Selection.bmp

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