An Appraisal of the SMART Board for Collaborative Learning

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Abstract

Being a potential learning paradigm for the current decade, Computer Supported Collaborative Learning will blossom with the support of hardware technologies such as digital whiteboards along with suitable software. We investigated the effectiveness of a kind of digital whiteboard (SMART Board) for supporting collaborative learning. Our study reveals that the key features necessary for group learning such as floor control mechanism and interaction guidance are not supported by the current SMART board software. We designed and implemented software to overcome the important drawbacks of the existing systems which includes facilities to guide written and verbal contribution during the learning with the help of mini-vocabulary and to manage floor control.

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Chapter 1

Introduction

1.1 Overview

Rapid technological advances in computing have paved the way for innovative thinking in learning and teaching. Research linking human cognition with knowledge acquisition and knowledge representation has also contributed much in this area. In the early 1960s, the influence of behaviourism theory was at its height. This led to the emergence of the computer-assisted instruction (CAI) paradigm from the paper-based programmed instruction models (O'Shea and Self, 1983). Learning occurs via CAI as a passive acquisition or absorption of an established (and often rigidly defined) body of information.

The application of artificial intelligence (AI) techniques in CAI systems (ICAI) (Carbonell, 1970) and Micro-world systems (Taylor, 1980) led to other kinds of educational systems. In intelligent tutoring systems (ITS) (Sleeman and Brown, 1982), learning occurs as a process in which the learner acquires a proper understanding of the problem space. In micro-worlds, new information interacts with prior knowledge and triggers a process of assimilation and accommodation (Koschmann, 1996).

Most recent developments in constructivist theory, based on earlier sociocultural theories, introduced a new paradigm known as computer supported collaborative learning (CSCL). In 1996, Koschman declared that CSCL was being recognised as an emerging paradigm of educational technology.

The instruction model behind CSCL is that of collaborative learning. Collaborative learning is a kind of group learning process which is based on the idea that learning is a naturally occurring social act in which the participants talk among themselves. According to (Gerlach, 1994, p. 8) "It is through the talk that learning occurs". Collaborative learning can be enhanced by computer and communication technology, which includes the hardware and related software such as groupware. Special hardware devices such as digital whiteboards may be effectively used to promote the collaborative learning process. For example, the hardware technology such as SMART Board (iThink, 2001), a touch-sensitive interactive digital whiteboard where the image of a computer screen is projected onto it, when used along with some suitable software such as SMART Notebook, would provide a suitable environment for collaborative learning. To provide an efficient collaborative learning atmosphere, those environments need to include facilities for at least the following tasks: basic editing, documentation, visualizing ideas, importing and exporting from other resources, communication guidance/ interaction support, knowledge building, problem solving, and resource allocation.

In this document, we describe research, where we have critically analysed the effectiveness of the hardware technology SMART Board along with the supporting software SMART Notebook for collaborative learning tasks.

1.2 Motivation

With the advanced technological support provided by computers for communication, several tools have been developed to facilitate group learning. Some educational institutions use whiteboards for group learning tasks. Now the digital whiteboard is being used in various countries for education. According to MirandaNet (2002), from their SMART Board evaluation, the students were motivated and stated that their learning had benefited with the help of SMART Board. However, there has been no research reported on the effectiveness of using SMART Board for collaborative learning. Firstly, though, the advantages and disadvantages need to be established for using the SMART Board environment for the collaborative learning tasks. Identifying the strengths and weakness of this environment for group learning process will eventually help us to establish the essential requirements for this type of environment for the group learning process. Finally we could use a suitable prototype implementation to demonstrate our findings.

1.3 Research Objectives

The aim of this research is to give an appraisal of the SMART Board for group learning and to identify the essential requirements for this type of environment for the group learning process. Finally, we will demonstrate those features using a prototype implementation. Though various kinds of group learning processes are discussed in the literature, in this research we will concentrate on collaborative learning.

The objectives of the research can be summarised as:

- Literature Review: To study the important literature related to collaborative learning and computer supported collaborative learning
- SMART Board Analysis: Investigating the effectiveness of the SMART Board for supporting collaborative learning activities, and then identifying the essential requirements for designing the enhanced software.
    - Interaction Guidance: To investigate the facilities for efficient communication in the SMART Board Environment for collaborative learning activities
    - Resource allocation: To determine whether the SMART Board environment allows maximum utilization of resources and whether it supports even participation among members.
- Enhanced Software Design and Prototype: Designing software that incorporates the essential facilities necessary for collaborative learning with the SMART Board. Implementing a prototype to demonstrate some important features of this enhanced software.

1.4 Thesis Outline

Chapter two contains a discussion of the relevant literature for our project. Firstly, it presents group learning, and then collaborative learning as an important kind of group learning process. After that, CSCL and the essential features of various kinds of software that support CSCL are also documented. This chapter also talks about some previous research into the CSCL paradigm.

Chapter three describes digital whiteboards and their current usage as a teaching tool. In particular, the features of the SMART Board environment, and SMART notebook software are discussed. The usage of SMART Board for collaborative learning tasks is considered.

Chapter four mainly reports on the experiments conducted to assess the SMART Board environment for supporting collaborative learning. The experiments are conducted in two phases: the pilot experiment and the main experiment.

Chapter five describes the system design for the enhanced SMART Board software. Also a proposal for enhancing the SMART Board software is given. A prototype is implemented to demonstrate the design of the enhanced software. The justifications for design decisions are given. Using a scenario, an evaluation is carried out and the results are given in detail.

Chapter six concludes the thesis with the findings from this research and suggestions for further work.

Chapter 2

Literature Review – Collaborative Learning

2.1 Introduction

It is now widely believed that learning in groups is much more effective than learning in individual settings. The effects of the group learning process have been critically analysed in the literature on different dimensions. Firstly, this chapter describes the group learning processes and categorises the different approaches. Secondly, the collaborative learning process is described in detail. In this research, the collaborative learning and co-operative learning processes are considered significantly different group-learning procedures. After that, we outline the mechanisms of collaborative learning and some vital issues in collaborative knowledge building procedures. The problem solving process in a collaborative environment is also discussed. Thereafter, the computer supported collaborative learning (CSCL) process is described briefly. In this section, the crucial features of some existing specific application software that supports collaborative learning are pinpointed. The term "groupware" denotes types of software systems that support group learning or group work. In this section, we also outline the features of some groupware, and discuss the related area of computer supported cooperative work (CSCW) and floor control mechanisms. Finally, previous research in collaborative interaction is described.

2.2 Group Learning

Learning in groups is not a new concept in education. There is substantial evidence that students working in groups can master science and mathematics materials better than can students working alone (Slavin, 1989). Several forms of group learning processes are discussed in the literature, and some of them are significantly different (e.g., an informal classroom gathering as compared with a planned collaborative learning group). The effectiveness of the learning process depends mainly on the characteristics of a group.

Some learning theorists argue that peer interaction is important for cognitive development (Doise and Mugny, 1984; via Koschmann, 1996).

2.2.1 Types of Group Learning Processes

The following are some of the different types of group learning processes described in the literature: co-operative learning, collaborative learning, collective learning, learning communities, peer learning, reciprocal learning, team learning, study circles, study groups, and work groups (Davis, 1993). All of these group-learning processes are usually categorised in different dimensions. Co-operative and collaborative learning processes are discussed extensively and some significant distinctions are defined. Depending on the size of the task and duration of the group work, Johnson et al. (1991) categorise all the above mentioned processes into three general types of group learning processes, namely informal learning groups, formal learning groups, and study teams.

Informal learning groups are temporary clustering of students within a single class session. A teacher can organise informal groups at any time in a class of any size to check on students' understanding of the material, to give students an opportunity to apply what they are learning, or to provide a change of pace.

Formal learning groups are teams established to complete a specific task, such as to perform a laboratory experiment, write a report, carry out a project, or prepare a position paper. These groups may complete their work in a single class session or over several weeks. Typically, students work together until the task is finished, and their project is graded.

Study teams are long-term groups (usually existing over the course of a semester) with stable membership whose primary responsibility is to provide members with support, encouragement, and assistance in completing course requirements and assignments. Study teams also inform their members about lectures and assignments when someone has missed a session. The larger the class and the more complex the subject matter, the more valuable study teams can be.

In another dimension, mainly depending on the nature of "division of labour" between the participants, group-learning processes may be categorised into two major factors known as *collaborative* and *co-operative* learning processes. Both processes have their roots in constructivist learning theories and the history of education (Panitz, 1997).

In cooperative learning, students work together in small groups on a structured activity, where they are individually accountable for their work, and the work of the group as a whole is also assessed. This process is usually organised and controlled by a teacher. The whole task is usually divided into separate sub tasks and each is then assigned to a different member. Each member is accountable only for his or her own part. The group-work is evaluated by the end-product (the process is usually determined by the teacher) (ThirteenEdOnline, 2003).

Collaborative learning is a higher-order co-operative learning process where the participants are prepared to share authority and responsibility for group actions. Members are usually mature students and the process is organised and controlled by the group themselves. The role of the teacher is almost negligible. Each member of the group is responsible for the actions of the entire group. Tasks are not usually divided and all the members contribute to the completion of the entire task. Here the process is mainly evaluated more than the product. Knowledge is considered as a social construct and not constructed in a member's head (Panitz, 1997).

Rockwood (1995 ; via Panitz, 1996, p.1) states:

> "In the ideal collaborative environment, the authority for testing and determining the appropriateness of the group product rests with, first, the small group, second, the plenary group (the whole class) and finally (but always understood to be subject to challenge and revision) the

requisite knowledge community (i.e. the discipline: geography, history, biology etc.)........ Most importantly, in cooperative, the authority remains with the instructor, who retains ownership of the task. In collaborative, the instructor--once the task is set-- transfers all authority to the group. In the ideal, the group's task is always open ended. Seen from this perspective, cooperative does not empower students. It employs them to serve the instructor's ends and produces a "right" or acceptable answer. Collaborative does truly empower and braves all the risks of empowerment."

On the other hand, some researchers argue that there is no significant distinction between co-operative and collaborative processes (Strijbos and Martens, 2001, p.569-570). They state:

> "Literature of the 1970s and 1980s is dominated by co-operative learning as the generic term for group-based learning. Since the beginning of the 1990s the concept of collaborative learning came into fashion. ..... In sum, several distinctions between "co-operative" and "collaborative" have not clarified the difference satisfactorily. Moreover, from a group dynamics perspective both can be classified as two sides of the same coin: approaches to group-based learning. However, characterising them as 'approaches' indicates that a difference does exist."

In the last sentence in the foregoing paragraph, however, the authors accept that differences do exist between the co-operative and collaborative learning processes. Lewis (2000) explains clearly this distinction. In this study, we consider these differences are significant and, by *collaborative learning process* we mean *a group-centred group learning process where tasks are not divided individually among members.*

2.2.2 Group Dynamics

Group dynamics involves many aspects of groups: their nature, their formation, and the individual and group cohesion (Jaques, 1992). For our purpose, we examine the dynamics of learning groups. The following section gives information about formation and control, guidance or leadership considerations.

In group learning, the teacher decides the formation of a group according to their study background, age, friendship, interest, cognitive conflict, social conflict, schedule, and geographic location. The teacher interacts with the students in the following ways (Joubert, 2001).

- Observes and intervenes during in-class group work
- Asks open-ended questions during in-class group work
- Praises and encourages during in-class group work
- Extends participation and involving group members
- Facilitates student responsibility and self-evaluation
- Promotes student learning of meta-cognitive and social skills

Crook (1994) describes two main perspectives on this topic. In each case a form of *continuity* is being created for the participants. First, there is a kind of *lateral continuity,* which is required in respect of student activities that might otherwise be left isolated, whereas, in reality they are conceptually related in significant ways. This addresses the problem of achieving transfer of learning; that is allowing students' understandings to generalise in important ways to new situations. Second, there is a kind of *longitudinal continuity.* This perspective provides a recognised platform for the next set of explorations.

Students in the group interact with each other by questioning, arguing, advising and praising. Students learn more from their group through their interaction learning than from teachers' explanations.

2.3 Collaborative Learning

When referring to the term *collaboration* in public conversation, it appears to represent any activity that a pair of individuals or a group of people performs together. On the other hand, researchers and academics in education related fields refer to the term *collaboration* in a different manner. Lipponen (2002) reveals that when considering collaboration, the ideas of co-construction of knowledge and mutual engagement of participants are emphasised:

> "Learning and teaching depend on creating, sustaining and expanding a community of a research practice. Members of the community are critically dependent on each other. No one is an island; no one knows it all; collaborative learning is not just nice, it is necessary for survival." (Brown, 1994, p.10; via Lipponen, 2002).

Many researchers have stressed the fact that collaboration is a special form of interaction or a process of participation:

> "Collaborative learning is based on the idea that learning is a naturally social act in which the participants talk among themselves. It is through the talk that learning occurs" (Gerlach, 1994, p. 8) .

Bielaczyc and Collins (2002) argue that knowledge sharing, cognitive conflict, discussion, reflection and synthesis are the major characteristics found in knowledge-creating communities, from Iona in ancient Greece, where science was first developed, to the most recent Silicon Valley where modern technological innovations are being created. Some recent researchers who advocate a study of a style of thought known as *socio - constructivism* argue that learning effectively occurs in a social environment through interaction (Cobb, 1984; Doise, 1990). A collaborative learning environment encourages students to work in pairs or small groups to explore, discuss, share, analyse, interpret, refine, and examine subject material together.

Learning is an active, constructive process in which students integrate new material with prior knowledge to create new ideas and new meaning (Smith and MacGregor, 1992). The idea of collaborative learning is based on the following premises:

- Learning depends on *rich contexts* that ask students to collaborate with peers to identify and solve problems by engaging in higher order reasoning and problem solving skills. *Rich context* problems are designed to encourage students to use an organised logical problem solving strategy.

- Learners are diverse and have different backgrounds and experiences. The various perspectives that emerge during collaborative work clarify and illuminate learning for all involved – the students, the members of the collaborative group and the teacher.
- Learning is a social act in which students talk to learn. This social interaction often improves the participants' understanding of the topic under consideration.
- Learning has **affective** and **subjective** dimensions: Collaborative activities are both socially and emotionally demanding, requiring students to articulate their own points of view and listen to the views of others. Students realise that working with others enable them to create knowledge and meaning. They no longer have to rely solely on the teacher and the textbook.

Smith and MacGregor (1992) describe collaborative learning in the light of these premises. It encourages an increase in the social development of the intellect. Collaborative learning also provides the practical experiences of the professional behaviours that will help students when they graduate.

Soller (2001) explained that students learning effectively in groups encourage each other to ask questions, explain and justify their opinions, articulate their reasoning, and elaborate and reflect upon their knowledge.

2.3.1 Collaborative Knowledge Building

Knowledge building is a collaborative activity. Stahl (2002) says that new knowledge is actually constructed by groups. With experience it is possible to observe knowledge being built, because it takes place in observable media, like talk. Moreover, it produces knowledge objects or artefacts, which provide lasting traces and a basis for evaluating the knowledge building. Figure 2.1 illustrates how the knowledge is created during collaborative learning.

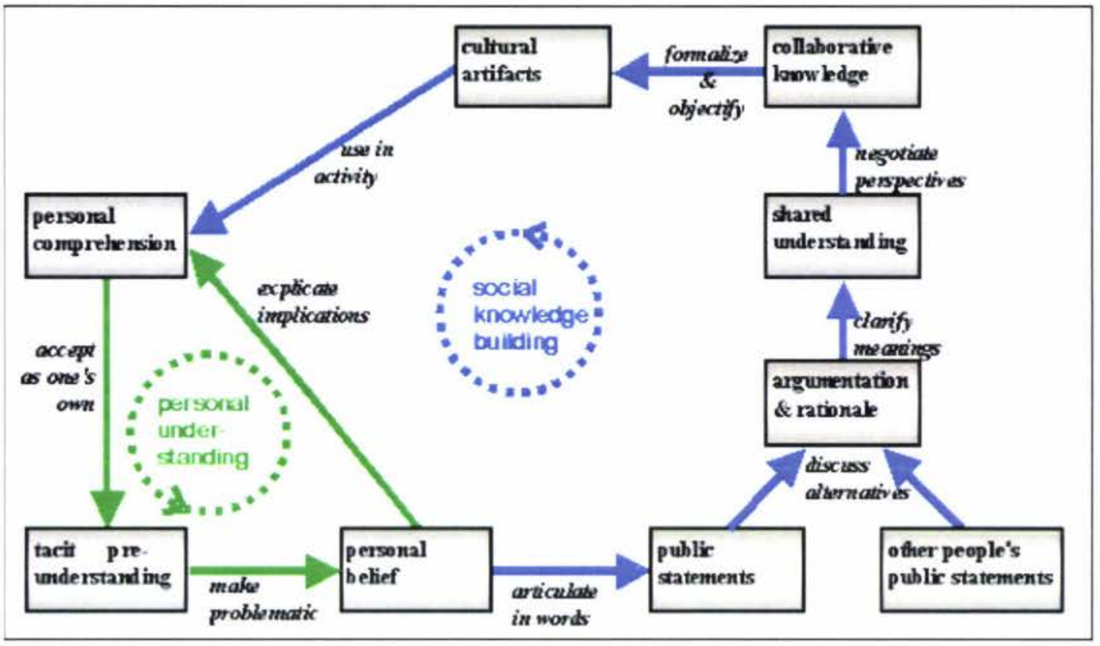

Figure 2.1 The Knowledge Building Process (Stahl, 2000)

Stahl considers learning as a social process incorporating multiple distinguishable phases that make up a cycle of personal understanding and social knowledge building. The diagram starting in the lower left corner shows the cycle of personal understanding. The rest of the diagram depicts how personal beliefs can be articulated in language and enter into the social process of interaction with other people and with the shared culture. This culture, in turn, enters into our personal understanding, shaping it with ways of thinking, motivational concerns and diverse influences.

2.3.2 Mechanisms of Collaborative Learning

Learning occurs in the groups as knowledge transmission. Dillenbourg and Schneider (1995) have listed the following mechanisms which account for knowledge acquisition through collaboration.

- Conflict or disagreement
- The alternative proposal
- (Self-) Explanation
- Internalisation
- Appropriation

- Shared cognitive load
- Mutual regulation
- Social grounding

They state that some of these mechanisms relate to the socio-constructive and socio-cultural approaches in psychological theory. *Socio-constructive* refers to a mechanism which engages students actively in learning and develops social skills of negotiation and consensus building. *Socio-cultural* theory means the "notion of the tools". It means that people invent tools to help get things done.

There are three factors that impact on the efficiency of the collaborative learning process (Dillenbourg and Schneider, 1995):

- Group Composition
- Features of the Task
- Media Communication

Group composition is defined by several variables, including the age and level of the participants, the size of the group, the differences between group members and so on. The members in a well-defined group will have much common understanding and that leads to significant success in the group learning process.

Some tasks are inherently distributed and group members need to work on their own, independently from each other. Interaction occurs when assembling partial results, but not during each individual's process. Some tasks are so straightforward that they do not involve any planning and hence there is no need for mutual regulation. Some tasks cannot be shared, because they rely on processes which are not open to introspection whereas some tasks need extensive interaction and collaboration.

The media of communication also play an important role in deciding the efficiency of collaborated output. Though the group may have been formed well and the task may be suitable for collaboration, it may not work efficiently if the medium used for communication is not adequate.

We shall next see how problem-solving activity is critical in the collaborative learning process.

2.4 Problem solving

Group learning promotes active learning, critical thinking, conceptual understanding, long-term retention of material, and high levels of student satisfaction. The most important collaborative activity is the use of formal problem-solving groups or teams for a long-term goal (Enerson et al., 1994).

Wheeler (2001) says that problem solving is the most important skill any student can learn, as it enables generalisation across diverse problems encountered in every day life. We encounter problems everyday, some of which take minutes or hours to solve. Others take days or even years to overcome, and often there is no guarantee of success. Problem solving then, is a lifelong learning process, involving many cognitive resources and a great deal of practice. Fensel and Motta (1998) state that the problem solving methods (PSM) are essentially domain-independent reasoning components, which specify patterns of behaviour, and can be reused across diverse applications.

Some researchers (Palumbo and Vargas, 1988; Sherman, 1988; viaMerril et al., 1992) report that an effective problem solving activity needs the following requirements at least:

- a desire to solve a problem
- a base of knowledge and experiences
- a repertoire of possible actions or solutions of similar problems
- the ability to take actions once a solution is found
- the resources to monitor and assess the mental and physical actions or solutions as they unfold.

- the controls to effect changes in those actions as the need arises

Merrill et al. (1992) state that the first requirement (a desire to solve the problem) requires the personal effort to get the desire to attempt to solve the problem. Second, some knowledge and experience are often needed so that the solution may be more effectively determined. Thirdly, related actions or solutions to similar problems ought to be understood and that will make the new solution easier. Fourth, there is a need to take action when the new solution is obtained. Fifth, the new solution needs to be tested to determine whether, in fact, it is the desired solution to the problem. Finally, some controls are needed to fine-tune the new solution if there is a need to make the solution more efficient and more effective.

2.5 Computer Supported Collaborative Learning

Computer supported collaborative learning (CSCL), as Koschman (2002) puts it, is a field of study centrally concerned with meaning and the practices of meaning-making in the context of joint activity, and the ways in which these practices are mediated through designed artefacts. CSCL make the use of computer and network technologies for teaching and learning activities. Students are able to share their ideas and views on their topics of interest through this collaboration. This allows many-to-many communications, time and place independent communication and student publishing.

CSCL propagates the idea of socially oriented learning. The most important concept of collaborative learning is the active role of the learner. Brufee (1993, p.3) described it as "a reculturative process that helps students become members of knowledge communities whose common property is different from the common property of the knowledge communities they already belong to."

The advance of communication technology based on computers such as web and other network technologies now gives a different insight into the concept collaboration in CSCL. People can collaboratively learn through the network-based tools or by using just stand-alone machines. In the following sections we will consider details of some of the systems for each category in detail.

2.5.1 Face-to-Face Collaborative Learning

Computers have been used for facilitating face-to-face collaboration, in different kinds of applications like databases, spreadsheets, mathematics programmes, programming languages, simulations, and multimedia authoring tools, and so on. They all have been successfully used for many years as tools to promote collaborative and cooperative learning.

Apart from these general software tools, Lehtinen and colleagues (Lehtinen et al., 1998) list some of the applications that have been developed with a special interface to support and to develop social interaction between students. ALGEBRALAND (Collins and Brown, 1988), GEOMETRY TUTOR (Anderson et al., 1985), TAPS (Derry, 1990) and ALEL (Artificial Laboratory for Exploratory Learning) (Lehtinen and Rui, 1996) are some examples of this applications. ALGEBRALAND and GEOMETRY TUTOR contain essential features for facilitating the learner's reflection in a collaborative manner. ALEL was used in intermediate and advanced university courses on research methodology and statistics. In addition, Table 2.1 provides some applications which help collaborative learning using the computer.

Application	Purpose	Reference
Sherlock II	A tool for training electricians to carry out an electronic troubleshooting system. It provides a collaborative learning extension to Sherlock.	Lesgold et al., 1988
AlgoArena	A tool for the collaborative learning of programming by novices at the beginner level. The aim is to foster programming skill through collaborative programming activities.	Kato and Ide, 1995
Peoplepower	Provides facility to collaborate with some artificial co-learner and learners try to solve problems in collaboration with the imaginary co-learner.	Dillenbourg and Self, 1992
Memolab	Provides the student with several collaboration agents such as coach, tutor and expert.	Dillenbourg et al., 1994
Symphony-Q	Supports learning music through collaboration.	Kusunoki et al., 2002

Table 2.1 Applications Supporting for Collaboration around the computer

2.5.2 Networked Collaborative Learning Systems

Collaborative learning has been facilitated through the rapid development of computer networks. Learners can also collaborate remotely. Table 2.2 shows some networked collaborative learning systems.

Computer Supported Collaborative Learning (CSCL) is becoming more and more important in education. Researchers' attention is turned towards multi-user systems through the Computer-Supported Collaborative /Cooperative Work (CSCW) and GroupWare Technology.

Application	Purpose	Reference
CSILE (Computer Supported Intentional Learning Environment)	The first network system to provide across-the-curriculum support for collaborative learning and inquiry.	Scardamalia and Bereiter, 1993
Belvedere	A networked computer-supported learning environment that provides learners with shared workspaces for coordinating and recording their collaboration.	Suthers et al., 1995
KIDCODE	Allows young children to manipulate symbolic representations and communicate these representations to their peers.	Baker et al., 1997

Table 2.2 Network Based Applications Supporting for Collaborative Learning

2.5.3 GroupWare

According to Greenberg (1991), the definition of Groupware differentiates it from other group-oriented software discussed before.

> "GroupWare is software that supports and augments group work. It is a technically-oriented label meant to differentiate "group-oriented" products, explicitly designed to assist groups of people working together, from "single-user" products that help people pursue only their isolated tasks." (Greenberg, 1991, p.133)

In fact, it has been suggested that GroupWare will lead to increased collaboration among individuals in-group, in part through the creation of networks of shared spaces that facilitate common understanding. Spring et al. (1997) list the following components as the essential features of GroupWare services:

- E-mail
- Database management
- Document management
- Calendaring
- Conferencing
- Management information systems and decision support services
- Network and administrative services.

GroupWare, as can the other collaborative tools, could be used in time-remote or place-remote scenarios. Figure 2.2 outlines the usage of different types of essential technological support for various combinations.

Time \ Place	Same	Different
Same	Meeting support	Conferencing
Different	Email Bulletin board	Email

Figure 2.2 Time/Place framework for GroupWare (Spring et al., 1997)

Grover (2000) mentions that GroupWare offers significant advantages over single-user systems. The following are some of the most common reasons people want to use GroupWare to make business run more efficiently:

- to facilitate communication: makes it faster, clearer, more persuasive
- to enable communication where it would not otherwise be possible

- to cut down on travel costs
- to bring together multiple perspectives and expertise
- to form groups with common interests where it would not be possible to gather a sufficient number of people face-to-face
- to save time and cost in coordinating group work
- to facilitate group problem-solving
- to enable new modes of communication, such as anonymous interchanges or structured interactions.

GroupWare comes in many different forms. In some places, an e-mail system constitutes GroupWare, in other places, GroupWare means Lotus Notes. But all the systems have in common the goal of helping a group of people to share and manage data in a collaborative environment. Table 2.3 provides some examples of GroupWare.

Application	**Purpose**	**Reference**
Lotus Notes	A shared server-based database system that allows users to create databases. Allocates a workspace for each participant.	LotusNotes., 2002
Lotus Learning Space	A course-authoring environment that provides group and individual spaces and a conferencing space.	LotusLearning Space, 2001
WebCT	Contains both an authoring tool and a learning environment available using a web-browser.	WebCT, 2001
Blackboard	Supports team-building (group projects), building-motivation discussion groups, virtual chat, and course - wide e-mail functions.	Blackboard, 2002
WebChat	Allows user to communicate in real-time with other users via text-based messages.	WebChat, 2002
IRC (Internet Relay Chat)	Allows users to chat simultaneously across a number of different servers or channels within a specific network.	IRC, 2002
CUSeeMe – Internet Video Conferencing	Supports 'video chat' and an electronic whiteboard. Supports group and one-to-one conferencing	CUSeeMe, 2002
Microsoft Net Meeting	A windows-based collaboration tool incorporating data, audio and video conferencing in one package	WindowsNet Meeting, 2002

Table 2.3 Example of GroupWare Applications

2.5.4 Computer-Supported Co-operative Work

> "Computer-Supported Co-operative Work (CSCW) is the scientific discipline that motivates and validates GroupWare design. It is the study and theory of how people work together, and how the computer and related technologies affect group behaviour" (Greenberg, 1991).

CSCW is an umbrella collecting researchers from a variety of specialisations such as Computer Science, Cognitive Science, Psychology, Sociology, Anthropology, Ethnography, Management, and Management Information Systems. Each of these disciplines contributes a different perspective and methodology for acquiring knowledge in groups and for suggesting how the group's work could be supported (Greenberg, 1991).

In the collaborative process, everyday meetings among participants include the following activities: sharing information, brainstorming, ongoing design, argumentation, decision-making, and so on. During the meeting, collaborative interpretation will be considered as an important activity. The collaborative interpretation is defined as "a process where a group interprets and transforms a diverse set of information fragments into a smaller, coherent set of meaningful descriptions" (Cox and Greenberg, 2000) .

Another important issue in a collaborative process is "Floor control". The term "Floor control" refers to the managing of interaction between the members of a group. For everyday group tasks, some rules are sufficient to manage interaction. However, for some group tasks, and mainly when the interaction utilises rare physical resources, there should be some floor control mechanism to manage interaction. Myers et al. state that "Floor control is the protocol which determines which user has control and how to take turns when multiple people share a limited resource" (Myers et al., 2003).

Further, Myers et al. specify that all the floor control-guiding principles described in the literature have three primary independent dimensions:

(1) releasing Control
(2) acquiring Control, and
(3) requesting Management.

2.6 Previous Research on Collaborative Interaction

Usually, traditional lecture-oriented classrooms do not teach students social skills they need to interact effectively in a team, and few students involved in group projects or exposed to integrated working environments learn these skills well (Johnson et al., 1990). Collaborative learning can occur in different ways. These are summarised as follows: learning by doing an experiment, learning by observing others, reading a text, viewing a website or learning by communication.

When students learn with peers in a classroom environment, they need support from their instructors. The educational researchers and CSCL tools developers, Capozzi et al. (1996) suggest that when students collaborate in a CSCL environment the group members do not necessarily know social interaction skills to collaborate effectively, but they need practice, support and guidance in learning these skills.

Communication is an important part of collaborative learning. Some of the following research indicates the importance of this communication process. McManus and Aiken (1995) developed the Collaborative Skills Network, a taxonomy of conversation acts based on work by Johnson and colleagues (Johnson, Johnson and Holubec, 1990). Each conversation act in the taxonomy is assigned a key phrase or sentence opener (such as "Do you think" or "I disagree because") indicating the act's intention. Students communicate through a sentence opener interface by initiating each contribution with one of the key phrases, giving the system information about the users' intentions. McManus and Aiken's system imposes a strict ordering on the students' conversation act usage, defining which acts should appropriately come before and after other acts.

Baker and Lund (1996) compared the problem solving behaviour of student pairs as they communicated through both a sentence opener interface and an unstructured chat interface. They found that the dialogue between students who used the sentence opener interface was more task focused.

Matessa and Anderson (1999) compared the performance of dyads communicating through restricted (speech act based) and unrestricted (free text) communication interfaces, while solving a graph completion task. They found that there were no significant differences in these two cases in the number of turns to complete the task, the time to complete the task, or the final score.

Soller (1999) says that "effective collaborative learning interaction falls into five categories such as participation, social grounding, active learning conversation skills, performance analysis and group processing, and promotive interaction". Further, Soller (2001) reports an aspect of the collaborative learning model which focuses on the conversation skills. The researcher uses the collaborative learning skills taxonomy (Appendix C), which illustrates the conversation skills during collaborative learning and problem solving activities. The classification breaks each learning skill type such as Active Learning, Conversation and Creative Conflict into its corresponding sub skills including Request, Inform, Acknowledge, and attributes such as Suggest, Reject. Each attribute is assigned a short introductory phrase or a sentence opener.

Stahl (2002) describes that "in CSCL, especially designed artefacts mediate collaboration. The specific form of the mediation generally affects the nature of the activity profoundly, often determining the nature of the task itself, that is, the choice of medium can define the ends or goal as well as the possible means".

2.7 Summary

Learning in groups is now considered to be as effective as learning individually. Group learning practice consists of many kinds of learning processes, particularly cooperative and collaborative learning processes which are discussed widely in the literature. Collaborative learning is a kind of group learning process where students are encouraged to participate and learn actively and they can share their ideas, views and knowledge. New knowledge is built during the collaborative activity. There are several mechanisms of collaborative learning, which we described in this chapter, concentrating especially on the knowledge acquisition through collaborative activities.

Collaboration can occur in remote or face-to-face locations at the same time, or in remote locations at different times. Computer and Communication technologies can play important roles in the collaborative learning process. Computers and other specially designed computer hardware such as Digital White Boards and suitable software products such as GroupWare are used in general to enhance collaborative learning. GroupWare technologies enhance group work. GroupWare consists of several services such as email, database management and conferencing. Through computer supported cooperative work groupWare design is motivated and validated. Moreover, computer based network technologies now provide vital support for the basic communication facility necessary for many collaborative learning tasks. The term CSCL (Computer Supported Collaborative Learning) is in general used to refer to this collaborative learning process enhanced by computer and related hardware, software and network technologies.

Communication is a very important issue in computer supported collaborative learning environments. Many researchers have studied and reported on the interaction patterns of the subjects involved in this environment. In certain situations a predefined vocabulary is found to be useful to guide interaction. Another related issue is floor control, which regulates the interaction sequence of the subjects.

Computer Supported Collaborative Learning environments provide facilities for knowledge building and tools for problem solving in groups. Problem solving is a lifelong learning process, which demands enormous cognitive resources and a great deal of practice. Knowledge building is a collaborative activity and new knowledge is actually constructed by groups with care and practice.

One particular device that is becoming widely used in educational establishments is the digital whiteboard. In the next chapter, we consider various issues related to its usage, particularly in the context of collaborative learning.

Chapter 3
Digital whiteboards and their current usage as a teaching tool

3.1 Introduction

Digital whiteboards are becoming more important now in education. The digital whiteboard is similar to the ordinary whiteboard except that the images written on it are automatically transferred to the computer. The significance of this facility is only limited by the imagination of the user. The CleverBoard (2003), MimioBoard (2003), TDS ACTIVboard (2002) and SMART Board (2001) are some examples of digital interactive whiteboards. Though there are several types of Digital whiteboards used in education, the most established one is the SMART Board which has been used in many schools and colleges in many countries. In this research we focus on the essential features of the SMART Board that support or hinder the collaborative learning processes.

This chapter contains three sections. The first part describes the features of SMART Board. In the second part the touch screen environment is described. And finally, the third part describes the usage of the SMART Board in education.

3.2 SMART Board and Touch Screen

3.2.1 SMART Board

The SMART Board (electronic whiteboard) by which the learner can use the computer to capture the written or typed information on the board, manipulates data, and stores information from other resources such as the Internet and so on. The SMART Board is being used in many schools in various countries (SmartTech., 2001). It turns the computer and projector into a powerful tool, which supports teaching, learning, presenting and collaborating. There are three sizes (SmartTech., 2001).

- SMART Board 540: 47" diagonal active area
- SMART Board 560: 60" diagonal active area
- SMART Board 580: 72" diagonal active area

Figure 3.1 shows a picture of a floor standing SMART Board.

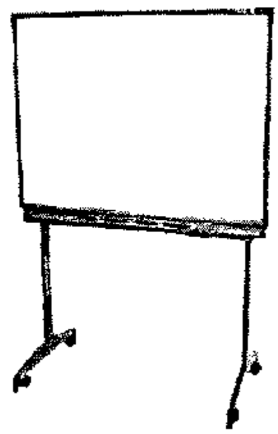

Figure 3.1 SMART Board (floor stand)

SMART Boards use resistive technology for sensing touches on the screen. In resistive technology, two pieces of resistive material with a small gap between them are used to detect where a person touches the screen and returns the co-ordinates correspond to the area on the computer monitor. In the SMART Board, any contact with the Board is converted into mouse clicks or electronic ink. Users can use their fingers as a mouse or write notes on the durable, low-reflective surface (Wedgwood, 2002).

The SMART Board software includes SMART Board Driver and SMART Notebook and is available for multiple operating systems and in multiple languages. The SMART Board driver activates the SMART Board so that users can use their fingers as a mouse or annotate over applications. The SMART Notebook saves notes written on the SMART Board and includes many other capturing and editing features. For more details see Appendix A.

Figure 3.2 shows the SMART Pen tray. Here the optical sensors automatically detect when a stylus or the eraser is selected, while buttons activate the on-screen keyboard and right-mouse click. LEDs in the pen tray indicates the active tool. Four Whisper-tip styluses and an eraser are included, but users do not need special tools to work on this natural whiteboard interface. Users can also begin the orientation procedure for the SMART Board quickly and easily while at the Board itself by holding down the Keyboard and Right-Mouse buttons simultaneously (SmartTech., 2001).

The user can use a projector to display and interact with computer materials or use it in the non-projected mode to save dry-erase marker notes to the computer.

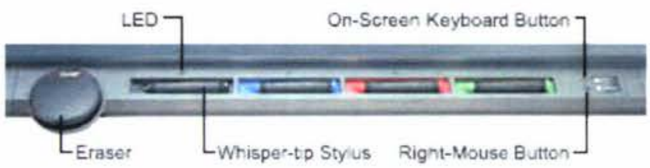

Figure 3.2 SMART Pen Tray (SMART Technologies Inc., 2002)

The computer image projected onto the Board can be accessed and controlled by its large, touch-sensitive surface. The different colour pens from the pen tray can be used to take notes and highlight information. There is also a facility to record information during the session. The SMART Board is activated by the SMART Board orientation. The computer and the SMART Board are connected. The computer screen is projected onto the computer using the projector connected to the computer. More details regarding SMART Board orientation are given in Appendix A.

3.2.2 Touch Screen Environment

A touch screen (TouchScreen., 2002) has three main components: a touch sensor, a controller, and a software driver. The touch screen is an input device, so it needs to be combined with a display and a PC or other device to make a complete touch input system. The controller determines what type of interface/connection is needed on the PC. This makes touching the screen the same as clicking the mouse at the same location on the screen. This allows the touch screen to work with existing software and allows new applications to be developed without the need for touch screen - specific programming (TouchScreen., 2002).

3.3 Utilisation of the SMART Board

The SMART Board is used as a teaching tool in various higher education institutes including the Florida Center for Instructional Technology (FCIT) at the University of South Florida, the Institute of Intelligent Technology, St. Louis area in the U.S.A, and the Missouri Department of Elementary and Secondary Education (DESE) and the Missouri Research and Education Network (MOREnet) at Columbia. The following utilisations have been identified by the users and reported in various literature.

In the FCIT study the teachers found the following advantages of the SMART Board (SmartTech, 2001).

- The touch-sensitive feature encourages hands-on participation and interaction.
- Students in wheelchairs could gather around the SMART Board and use pointers to work on the projected software on the board.
- The learners with underdeveloped fine motor skills could work through the software rather than using a mouse at a computer.
- When doing software presentations, they could point and touch exactly where they want the students to look at the application.
- The screen capture tool provides the ability to capture the screen from the web or other application and could bring it into an existing application at the SMART Board.

The advantages in addition to the above found in the Institute of Intelligent Technology St. Louis are the following (SmartTech, 2001).

- Power of Visuals – When discussing interactive multimedia with the help of SMART Board the large, interactive visual allows people to think about how they will use the new multimedia in their own work situation.

- Exciting Multimedia presentations - They developed an interactive programme for the Iron Kids Bread web site. The SMART Board was used to demonstrate the project live over the Internet. A real-time interactive game for the Iron Kids' web site named Build a Sandwich was developed. The SMART Board allowed people to see, interact and become familiar with the software they had developed for the Web site. Using the SMART Board to present their work is a powerful sales tool for them as well as an effective training and facilitation device.
- Enables quick recording of information on the board with the ability to save it into a computer file.

Additional advantages in the DESE study (Friesen, 2000) have been identified. She found that the SMART Board can be used as

- a presentation tool
- a collaboration tool for
    - ➢ group editing - errors in spelling and grammar are much easier for children to see on the SMART Board.
    - ➢ planning - display many pictures or words that represent different types of foods on the board. Have students work together to plan nutritious meals with these items. Then, have each group drag the items in its meal to form one nutritious meal on the SMART Board.
    - ➢ sorting numbers or words
    - ➢ constructing diagrams - Use "Inspiration software" on the SMART Board to build things that will help students learn. Have students share in webbing content of a unit they study or to review. Move pieces of the web around as students discuss the subject. The final web can be saved and /or printed and copied so that all students have a

representation of what they worked on together. Create a Venn diagram on the board. Begin with a series of words or pictures that can be dragged around into the correct spaces.

- a brainstorming tool
- a consensus building tool
- a demonstration tool

3.4 Summary

This chapter has been an introduction to the usage of digital whiteboards in education. From the several digital whiteboards discussed in the literature, SMART Board has been described in detail. Many schools and higher education institutions are currently using the SMART Board as a teaching tool. In this research, we study the important software and hardware features of this device and analyse the effectiveness of those very features for enhancing group learning. There has only been a little research reported in the literature on SMART Board of this nature. The next chapter examines the SMART Board and its software (SMART Notebook) for supporting collaborative learning with the help of experiments. The objectives of the research are carefully analysed, the experiments described and the results discussed.

Chapter 4

Experiments to assess the SMART Board for supporting Collaborative Learning

4.1 Introduction

As the usage of computers and communication tools (e.g. internet) becomes part of day-to-day activities in many societies, learning tasks in collaboration become more a natural part of life for many people. Recent learning theories advocate collaborative learning activities as an efficient mechanism for knowledge building (Gerlach, 1994,pg. 8).

Collaborative learning activities may be performed in the same location and/or at the same time or in remote time and/or in remote space. Moreover, there are many specifically designed hardware and software tools which play major roles in collaborative learning activities. One of these hardware tools is the SMART Board (and the related software SMART Notebook) as described in chapter 3. This research is related to the appraisal of the SMART Board for group learning. As a part of this research, we designed an experiment to analyse the effectiveness and drawbacks of SMART Board including its software for collaborative learning activities. In addition to this, a questionnaire was designed to analyse the results of the experiment. This document describes the experiment itself and its main protocols. Finally, it includes the discussions about the observations made during the experiment.

4.2 Experimental Issues

The two main protocol issues 'floor control' and 'conversation vocabulary' are discussed in this section. Some of the background information necessary to understand the experiment and the results are provided here. The case study used is described followed by a description of the experimental design.

4.2.1 Protocol issues

Floor control mechanisms can be used in group-learning to ensure even participation between group members. In the SMART Board environment the pen (or board) is a rare resource and needs to be shared (only one person can write on the board at any time). In collaborative learning environments some sort of floor control mechanisms are used to regulate the usage of those rare resources. In this study, we are going to investigate whether any floor control mechanisms could be used to regulate collaborative learning activity in a SMART Board environment.

The user of the SMART Board needs to give-up his/her control for someone else to use the system. The system cannot intervene. The user will not be interrupted as long as s/he is busy using the pen. A negotiation mechanism is necessary to resolve any possible conflicts. In a rule based approach, a 'round robin' mechanism may be used. Alternatively users can be encouraged to take turns voluntarily, ensuring that everyone can participate equally.

A conversation vocabulary, which usually contains a set of sentence openers, is also usually used to guide interaction within the group members. Restricted Conversation Vocabularies are used in some collaborative learning situations to guide the communication between the participating subjects. As described in Chapter 2, Amy Soller used a conversation vocabulary in collaborative learning activities. She used her selection of sentence openers while the subjects were in remote locations. In this study, we are going to experiment whether restricted conversation vocabulary of this kind could be used to support collaborative learning activities in the SMART Board environment. Sentence openers such as "Let me show you.." might also assist with floor control.

4.2.2 Case Study

The case study used in these experiments is described below (for a full account see Appendix B):

The problem involved drawing a use case for a car rental system which needs to handle customer services. The new system would provide all functions directly related to handling customers and other business partners (for example suppliers).

4.2.3 Experimental Design

Two small groups were involved in this experiment. Each group contains four members. The members of both groups were postgraduate students and they were requested to follow the ground rules strictly. The task for each group was explained clearly. One group had to perform the task collaboratively in the SMART Board environment, whereas the control group had to do the same using the Whiteboard. Observations were made during the experiment. For the interaction, both groups were asked to make use of a conversation vocabulary. Finally, a questionnaire was distributed to the group involved in the SMART Board experiment in the main study. The observations of the experiments and the responses for the questionnaire were critically analysed later. By observing the students, it would be possible to determine the advantages and disadvantages of the SMART Board compared to the whiteboard. Questionnaire data would allow student opinions about the SMART Board features and the conversation vocabulary to be ascertained.

The members of each group who participated in these experiments were computer science students from Massey University, Palmerston North. All the participants had previous knowledge of Object Oriented Concepts and Unified Modelling Language (UML) (Booch et al., 1999) notations, especially with regard to use case diagrams. The formal introduction of group members was not necessary for both groups, as they knew each other well.

For both groups the same case study was given (section 4.2.2). Their task in this experiment was to produce a use case diagram in UML. The groups were asked to clearly describe the actors, the system boundary and important use cases in the diagram. They had to perform the task collaboratively and work under the constraints given in ground rules and the procedures. They were also given a sheet containing Amy Soller's conversation vocabulary (Appendix C). They were strongly requested to follow the ground rules and procedures during the experiment.

The groups were given an opportunity to clarify any misunderstanding on the procedures of conducting the experiment or on the issues in the case study. After these initial procedures, each group was given sufficient time to produce a use case diagram. The first few minutes was given for both groups to comprehend the case study. As one of the ground rule demands the groups to ensure even participation among members, the floor control mechanism to be used for this experiment is indirectly mentioned as 'turn taking'.

4.3 Pilot Study

A pilot study was conducted before the main experiment to identify any specific problems in using SMART Board technology for this research. This study was conducted on a SMART Board with the help of three computer science postgraduate students at Massey University, Palmerston North, New Zealand.

The case study (Appendix B) was given and the users were asked to produce a use case diagram. The following rules were applied in the pilot study.

1. Limit discussions.
   Soller (2001) collaborative learning taxonomy (Appendix C) was given to the users and they were asked to use these sentence openers during their interactions.
2. Take turns to write on the SMART Board, participants may use different coloured SMART Board pens.
3. While using the SMART Board, group members may write their own suggestions in their area (may divide the SMART Board area) and agreed answers in the common area.

The participants were asked to:

- Carry out the task collaboratively

- Choose different regions of the SMART Board.
- Choose different coloured pens.

The group members extensively used the conversation vocabulary sheet though they initially found it difficult to use. It was also clear that the working space of the SMART Board is too small for group of four people. Therefore in the main experiment, individual pages were allocated for each member and this is included in the proposed procedures section in main study. After reviewing the pilot experiment results, some changes in ground rules and procedures were made.

4.4 Main Study on the SMART Board

4.4.1 Getting Started

A suitable small room with sufficient space and other facilities (heating, lighting, ventilation etc.) was selected as the venue for the experiment. The set-up time for the experiment was about 30 minutes (this includes the time taken for setting up the SMART Board, projector and the laptop). Initially, the SMART Board orientation (See Appendix A) was done on the SMART Board using 80 points.

The following ground rules were used:

1. Limit discussions.
   Avoid unnecessary and lengthily conversations. Discussions must be constructive and should not refer to any personal issues.
2. Write one at a time on the SMART Board
   This is due to the limitation of the SMART Board hardware. The pen should be placed back immediately after use in its original place according to its colour.
3. Ensure equal participation within groups
   Avoid writing on SMART Board for a long time. Allow / encourage other members also to participate. Participants were asked to use a different colour for each member.

Participants were asked to:

S1 Use separate pages and with each iteration save all the versions of commonly agreed solutions in a separate page.

(It is necessary to allocate a place for each person in order to keep his/her own thoughts. Knowledge building is an iterative process At any time a group may find its current solution is imperfect and may decide to consult a previous suggestion of a particular member.)

S2 Whenever necessary try to highlight/select/save a different region of the SMART Board.

Initially, ten minutes were spent on a short introduction and demonstration about SMART Board. Members were given the chance to experiment with the features of SMART Board for a while.

4.4.2 Observations on the SMART Board experiment

As they were requested, the group used the first 10 minutes to read the case study and finally completed the diagram on the SMART Board. They used the following facilities of the SMART Board and the SMART Notebook.

- Insert pages
- Save as html option
- Screen capture, area capture and window capture options. (in order to save their work)
- Cut and paste
- Drag and drop facilities: using touch - sensitive feature, moved diagram along the screen
- Drawing options
- Eraser tool
- Keyboard facility.
- Different SMART pens
- Touch - sensitive feature to move objects.

The group did not use the help or printing facilities of the SMART Board. Due to the nature of the SMART Board orientation, writing on the board was not accurate. Some of the participants were irritated due to this drawback of the SMART Board.

An excerpt from the group discussion is given in Figure 4.1. While one of the members was working on the Board, others were watching the work carefully, or writing something on paper. The work done in this experiment is given in Appendix D.

Student 1: Do we need to use this vocabulary?
Student 2: It is hard to use this vocabulary.
Student 2: Since SMART Board allows one at a time I want to write my thinking onto a paper otherwise I will lose that. OK. Let's move on.
Student 3 (started writing)
Student 4: Let's move on to the case study.
Student 1: I think that the first actor may be "customer".
Student 2: Yes. That's right.
Student 3: Then we need to think what use cases are for the customer?
Student 1: OK. But we will find the next actors.
Student 1: I think another actor is the "supplier".
Student 4: The next actor may be the "system".
Student 3: OK. Now we will go to use case. Is that right?
Student 1, Student 4: Yes.
Student 2: I have a suggestion that we need to have a Data operator.
Student 2: I couldn't write. It's not clear. Can you see this?
Student 4: That is a technological problem. The company might correct this in future.
Student 3: Let's move on to the use cases.

Figure 4.1 Group discussions in the SMART Board study

4.4.3 Results from the SMART Board Study

One of the protocol issues is the usage of a conversation vocabulary in SMART board environment. The group was strongly advised before the experiment to use Amy Soller's Conversation Vocabulary for the interaction whenever necessary. Though the group in the pilot study used Amy Soller's vocabulary sheet extensively during their experiment, the group involved in the main study on the SMART Board study found it difficult, and only a few sentence openers were used. At the extreme, some group members totally avoided the use of this vocabulary since, they said, this restricted their free expression.

The other protocol issue is floor control in SMART Board. SMART Board software or hardware does not provide support for floor control mechanisms if one person chooses to retain the pen. Therefore the members of the group tended to follow "turn taking" as their floor control mechanism and rarely used sentence openers. Nevertheless, since there was no strict mechanism to maintain floor control the "turn taking" mechanism was not strictly followed by the members. Though the members were asked to ensure equal participation in the group tasks, some members broke this ground rule by dominating the discussion and withholding the resources unnecessarily.

SMART Board does not support simultaneous writing. Only one member was able to write on a SMART Board at a time. If another member needs to write on the board s/he had to interrupt the current user or had to use other means such as paper and pen. The colour determination for SMART Board pen was found to be difficult. The SMART Board pen colour was determined by the hardware. This mechanism was found to be inefficient as the colour of the latest pen lifted from the pen tray was considered as the active colour by the hardware regardless of the colour of the pen actually used to write on the SMART Board. Moreover, the eraser facility is inefficient and sometimes may block others from writing on the board. Since the hardware handles the eraser option, if the eraser is lifted, one cannot write on the SMART Board. In addition to this there is no flag to show whether the eraser is active or inactive.

The workspace of SMART Board area was found to be insufficient. Each member used separate pages to write their own ideas and the commonly agreed answer was written in a separate page. It was very difficult to find the answer page since there were several pages occupying the right side of the SMART Board screen.

One of the main drawbacks of SMART Board is the shadowing problem. The SMART Board we used is a front-projection model. Therefore it is inevitable that the shadow of the user who is currently writing on the board or the shadow of any other person standing in between the board and the projection would fall on the SMART Board itself.

There are many positive issues related to using SMART Board for group learning. Firstly, the SMART Board helps the group as a whole to express their suggestions and to keep records. Also it allows individual members to separately maintain their own ideas, and also to be able to combine others' ideas using copy-paste facility. All the recorded discussions can be retrievable for later usage. However, the SMART Board has no facility to differentiate the pages retrieved as suggestions, facts, or solutions etc. The members should explicitly name them.

Secondly, the SMART Board supports problem solving efficiently. The group used a variety of drawing tools available in the SMART Notebook. This helped members to visualise the combination of ideas effectively. Other than this, using the SMART Board group work can be recorded automatically. This reduces the workload of the recorder of the group. The group saved its work in "html" format, which could be retrieved in any other platform. The SMART Notebook also supported visualising the final and intermediate documents.

4.4.4 Results from the Questionnaire

After completing the session, the participants of the SMART Board experiment were informed about the questionnaire (Appendix E) sent to them via email, and were asked to complete and send it back by return mail. The main result of the questionnaire is given in Table 4.1. The following are some of the important excerpts from this table.

All three subjects agreed on the following main issues:

- For the front projection SMART Board, shadowing problem is an important drawback.
- A carefully selected conversation vocabulary will be useful for interaction while learning in groups.
- Unwanted dominance of any group member will affect the group learning process
- Non-verbal communication is essential for group learning

Two of the three subjects agreed on the following main issues:

- The working space of the SMART Board was sufficient for a group of three or four people.
- Categorising SMART pens according to the type of interaction would be useful for group learning (e.g., green colour for suggestion).
- SMART Notebook is very helpful.
- Conversation vocabulary restricts communication.

Overall the following conclusions were derived from the observation and questionnaire data:

- Some of the hardware features of the SMART board have drawbacks, (e.g. front projection, SMART pen colour determination, etc.)
- The Amy Soller's Conversation Vocabulary in its current form is not very useful for group learning, however a carefully selected vocabulary would be helpful if included in the SMART board software to guide interaction.
- Some mechanism to avoid unnecessary dominance in groups is essential. The SMART Notebook is useful. However, it will be more useful for group learning if the following features are included; a facility to select the SMART pen colour, a facility to associate different colours with different types of interactions, a facility to monitor the usage of rare resources, and a facility to use a carefully selected conversation vocabulary.

Questions	Number of students in agreement
The working space of a SMART Board is enough for discussion for a group of size 3 to 4.	2
If the SMART pens were categorised (e.g., green colour for suggestion), the group learning would be further enhanced.	2
SMART Board cannot extract a particular colour only. Do you accept that such a facility would enhance learning? (for e.g. if above categorisation is used)	3
For a group of size 3-4, assigning a particular colour pen for each person would enhance the group learning.	3
The unwanted dominance of a group member would be a problem in SMART Board learning environment.	3
The SMART notebook is helpful for group learning.	2
The "shadowing" is an important problem in learning through front projection SMART Board.	3
The SMART Board is touch-sensitive. This feature enhances the group learning through SMART Board.	2
The keyboard can be displayed on SMART Board. This feature is very helpful in using SMART Board for group learning.	3
Amy Soller's conversation vocabulary is useful for group conversation.	1
The non-verbal communication is not essential in the SMART Board learning environment	0
The conversation vocabulary restricts the group communication	2
If a carefully selected conversation vocabulary were included in the software, the group interaction will be improved.	3

Table 4.1 Results of the Questionnaire

4.5 Whiteboard Study

4.5.1 Getting Started

A suitable small lecture room with sufficient space and other facilities (heating, lighting, ventilation etc.) was selected as the venue for this study.

The following ground rules were used.

1. Limit discussions.

   Avoid unnecessary and lengthy conversations. Discussions must be constructive and should not refer to any personal issues.
2. Write one at a time on the Whiteboard
3. Ensure equal participation within groups

Avoid writing on Whiteboard for a long time. Allow / encourage other members also to participate. It is advisable to use different colour for each member.

Participants were asked to:

Partition the Whiteboard into five portions. Four equal portions for each member and a centre portion for all commonly agreed solutions. This is only a suggestion, but strongly recommended.

4.5.2 Observations on the Whiteboard experiment

Figure 4.2 gives an excerpt from the discussions of the group in the whiteboard experiment:

Student 1: Can we start this identifying actor first? Do you agree?
Student 2: Yes. That's right.
Student 3: I am not OK with the last paragraph of the case study.
Student 4: You know that the manager does not have direct contact with the customers.
Student 3: Thanks.
Student 1: I think we can now start to draw the diagram.
Student 4: It's good.
Student 1: The "customer "is an actor.
Student 3: Why do you use the "customer " as an actor.
Student 2: I am also disagreeing.
Student 1: Because he needs to book for the car, pay bill ...
Student 4: The "manager" is another actor.
Student 1: Very good.
Student 4: Thank you.
Student 3: We could name the actor "manager" into "staff".
Student 1, student 2, and student 3: That's better.

Figure 4.2 Excerpt from group discussions in the Whiteboard study

4.5.3 Results from Whiteboard Study

In this section, we provide the main observations made during the group learning activity of the control group using the ordinary whiteboard.

- Conversation Vocabulary

  Though the group members initially faced difficulties in using the vocabulary, they managed to get used to that in later stages.

- Simultaneous writing on White board

  Even though there is a facility for Simultaneous Writing, they took turns to use the board.

- Support for knowledge building

  The Whiteboard provides less support for knowledge building. It helped *the group to express members' own* suggestions, differentiating their own ideas and gave them the ability to combine the ideas of others'. It did not provide any help for keeping records.

4.6 Comparison

One of the main objectives of this research was to analyse the degree of effectiveness of using SMART Board for collaborative learning activities.

- The SMART Board was not very supportive for lowering the cognitive load. Since it does not provide facilities for simultaneous writing, this environment demands excess short-term memory.
- The SMART Board provides support for problem solving. It has drawing tools to facilitate visualisation of group work. This allows the members to compare and contrast their ideas efficiently.
- The SMART Notebook has facilities for highlighting, selecting, and saving different regions of the SMART Board.
- The SMART Board supported knowledge building since it helped the group members to express their own suggestions, to keep records, to differentiate their own ideas, and to combine the ideas of others. However it has no facility to differentiate different ideas.

Another objective of the research was to analyse whether or not any conversation vocabulary is helpful for communication among the group members during their collaborative learning sessions. Though it was difficult in the initial stages, the members of the pilot study used the conversation vocabulary for their main interactions. The opinion of this group was that choosing the right sentence openers was difficult from the conversation vocabulary list. The members in the Whiteboard study also used the vocabulary sheet moderately. But they also faced difficulties similar to the Pilot group in choosing the right sentence openers.

On the other hand, the members of the main study group in SMART Board tried to use the vocabulary list initially. However they later decided not to continue the vocabulary list as they felt that the predetermined vocabulary sheet somehow controlled their interaction. The main problem again was identified as choosing the right sentence openers in a short time. They also felt that there were many sentence openers not necessary for that environment. The group rarely used the sentence openers and also it was difficult to give all members an equal opportunity to contribute.

SMART Board has many advantages over the whiteboard: providing support for knowledge building, problem solving. However, many drawbacks of the SMART Board were identified through this experiment. The SMART Board hardware handles the eraser option. If the eraser is lifted, one cannot write on the SMART Board. Also the SMART pen colour is determined by the hardware in a very inefficient way. The latest pen lifted from the pen tray will be active regardless of the selected pen. Sometimes a black pen may write in red and this confused the users many times.

4.7 Summary

Basically, the SMART Board (with SMART Notebook) provides a better environment for group learning than the whiteboard. It supports the members in expressing their own ideas and in comparing them with the other members' ideas. The SMART Board also has facilities to visualise ideas and it provides documentation facilities for group work. In short, the SMART Board is helpful for problem solving and knowledge building.

However, there are some drawbacks in the software as well as in the hardware. The main drawback is the inability to write on the board simultaneously. This in turn increases cognitive load. Also, the current colour of the writings on the SMART Board is determined by the colour of the tray from which a pen has been lifted most recently. Therefore, a SMART pen may sometimes write in different colour than its original colour. Also the eraser is handled by the hardware. Another drawback is the shadowing problem due to the front projection of the SMART Board. Finally, there is no facility for directing interaction on the SMART Board.

Nevertheless, if the software and hardware features of the SMART Board could be enhanced, group learning would be more effective. The well-defined conversation vocabulary particular for this type of environment could be useful if the group receives prior training. Alternatively, a built-in conversation vocabulary with more careful selection of sentence openers will be useful to guide interactions. The next chapter describes a software design prototype for the SMART Board that would enhance group learning. This would also eliminate some of the drawbacks of the existing SMART Board software and hardware.

Chapter 5
System Design

5.1 Introduction

This chapter describes the main features of the software which was designed to support collaborative learning tasks using the SMART Board. The results of the experiment as well as the critical analysis of the literature helped to identify the required features. A prototype has been developed using Delphi and its use is demonstrated by walking through a scenario. Finally a senior researcher has evaluated the prototype following this scenario.

This chapter contains five sections. The first section provides proposals for enhancement based on the observations of the experimenter. The second section details the issues on the prototype implementation. The third section provides a detailed description of the main features of the design. In the fourth section, the prototype is demonstrated with the help of a scenario. Finally, the results of the evaluation of the prototype are described.

5.2 Proposals for Enhancements

In the previous chapter, several drawbacks of the SMART Board and SMART Notebook were described. In order to overcome these drawbacks, we designed a new software system for it based on the observations from the experiment. The intended software system not only enhances the software issues but also addresses the hardware problems we encountered.

The first three points listed below relate to specific problems with the SMART Board. The next three consider group issues. The last three focus on sentence openers and colour.

- It includes options to view, save, and print pages
- It includes a facility to highlight a portion.

- It includes a facility to handle eraser actions by software.
- It provides an option to form a group with identification (therefore all the interactions and outcomes could be associated with proper identities)
- It includes a facility to manage floor control
- It includes a facility for maintaining the interaction history including contribution details, member's name, page number, interaction start time and end time.
- It provides a facility to direct interaction with some pre-defined vocabulary related to various types of contribution.
- It provides a facility to differentiate the written contributions promptly, for example, assigning different colours for different actions. (e.g., green for workspace, red for solution and blue for ideas etc.).
- It includes a facility to determine the pen colour by the software (therefore, the SMART board pens become colourless)

5.3 Prototyping Issues

We decided to create a prototype to demonstrate the proposed enhancements mentioned in the previous section for the SMART Board software. Prototypes are developed in a fraction of time to model certain features of complex software. Prototyping for the purposes of demonstration are appropriate for concept development projects (Pressman, 2001).

Some considerations had to be given to the choice of a prototype design tool. The options were PowerPoint, Delphi or VB. The researcher has substantial knowledge and experience with PowerPoint, VB and Delphi. PowerPoint is not flexible enough, however, for graphical programming. For enhanced functionality one needs to amend it using Visual Basic (VB) code. As the size of the VB code increases, the combined prototype becomes more complex. It could be more easily developed using VB alone. Visual languages are more powerful than PowerPoint as the graphical user interfaces can be easily created and modified for a program. In a visual programming environment, the menus, buttons or labels can be added to the program simply using drag-and-drop. The prototype can be developed and tested at the same time. However, when it comes to visual languages, it seemed preferable to choose Delphi rather than others - including VB - for the following reasons:

- Delphi is the Borland's best selling rapid application development (RAD) product for writing applications on windows and can also run ten times faster than Visual basic programs (Reisdorph, 1998).
- The purpose of this prototype is to demonstrate the features of the new design. Delphi programs are compiled, not interpreted like VB. Delphi can produce standalone executables. But VB programs require runtime dynamic link libraries (DLL).

In this prototype, the researcher has used many of the visual component library (VCL) component features of Delphi. They are the graphics device interfaces (GDI) classes such as TImage, TBitmap, TPen, TFont and TCanvas and the standard component classes such as TPanel, TButton, and TCombobox. The following are some of the important procedures used to get the work done; Copyrect, Draw/Stretch draw, CreateOLEObject etc (see Appendix G for more detail). This prototype contains about 3200 lines of Delphi programming code.

5.4 Features of the Design

From Shneiderman's (1997) usability guidelines, consistency is described as follows "This principle is the most frequently violated one, and yet the easiest one to repair and avoid. Consistent sequences of actions should be required in similar situations, identical terminology should be used in prompts, menus, and help screens, and consistent commands should be employed throughout". In the layout adaptation, our design followed visual consistency with the Microsoft package. Though the layout essentially remains the same, some differences still indicate our unique interactive requirements such as a guided interaction facility.

The Achilles' heel of any interactive software system is its interface (Anderson, 1995). When we consider the colour adaptation in the interface, the relationship between usage and effectiveness has to be considered. We have used colour sparingly and avoided saturated colour in our system according to the suggestion given in Najjar (1990).

The features of the design will be described in detail in the following sections.

5.4.1 Group Manipulation

A group is identified by a name with an option to add new group members and their names. The entire group is formed through this process before starting the activity. After forming a group, member names can be accessed through the "group members" option. This enables the system to identify the current person interacting with the SMART Board. The history of members' participation on the board will be automatically maintained by the system. This allows the teacher to give feedback later when necessary.

5.4.2 Guided interaction: verbal and written contributions

According to the experiments described in the previous chapter, Amy Soller's conversation vocabulary proved to be of limited value and it was decided to drop this feature in our new system.

This system is going to be used in a face-to-face mode and in the same location. To make an efficient interaction facility for this type of environment, we designed a mini vocabulary that covers both written and verbal conversation (Kemp et al., 2003). This division guides the verbal communication and facilitates the interaction history maintenance. Table 5.1 shows some example of written and verbal contributions.

The *written* list contains a collection of essential phrases that represent a set of possible different interactive utterances necessary to participate in such a group-learning environment.

The *Verbal* contribution contains the most frequently used spoken sentences in this learning process. The verbal list is a pull up list and it has three options. Each selected item has a further two to four options. Members must choose one of these options to communicate verbally about the physical contribution in the shared page. All the group interaction on the SMART Board will be recorded automatically.

Type of contribution	**Examples**
Written	Given ->Facts
Written	Given ->Known Relationship
Written	Workspace ->Idea
Written	Workspace ->Conjecture
Written	Workspace -> Proposal
Written	Workspace -> Inference
Written	Solution
Written	Continuation ->Addition
Written	Continuation ->Correction
Written	Continuation ->Deletion
Verbal	Agreement->I think that what we have so far is right
Verbal	Agreement->I agree with that last point
Verbal	Neutral -> Lets move on
Verbal	Neutral -> Let me explain

Table 5.1 Example of Written and Verbal contributions

These options also indirectly determine the SMART pen colour and shared page background. The selection of colours in this study for the background and foreground combination of various interaction options is not arbitrary. Naijjar (1990, p. 3) says that "the background colour affects the effectiveness of the other colours. Pick an effective background colour and use only about other five colours. This type of background can cause coloured characters to appear to float at different distances relative to the background". In this design, the background colours used are all light ones.

One of the drawbacks of the SMART board is eliminated by this written contribution facility in the prototype. The SMART Pen colour is determined by the *written* contribution. The written list contains four options and these are **Givens**, **Workspace, Solution** and **Continuation**. Every option has a further two to four options except **Solution**. By selecting one of these options from the written contributions list the SMART pen colour, task and the background colour of the page are chosen. Table 5.2 shows the colour categorisation in the written contribution.

Written Contribution	SMART Pen Colour	SMART Page Background
Givens	Blue	Light Blue
Workspace	Green	Light Green
Solution	Red	Light Red (Pink)
Continuation	No change	No change

Table 5.2 Colour categorisation in Written contribution

5.4.3 New Shared Page Creation

Shared pages occupy the whole SMART board screen. Initially, the page is created according to the contribution type such as solution, givens and workspace. These are done automatically by the system. The purpose of the "New" option is to allow the group to create further pages. When a page is created, the member gives the page name and then the system allocates the page number automatically.

5.4.4 Interaction History Document

All the interactions regarding SMART Board contributions are expected to happen through the *verbal* and *written* facilities. When members start their contribution, the system records the details of the contribution. It logs the member name, type of contribution (e.g., Verbal or Written), page number, page name, start time and end time. For each action on the SMART Board, the system records information onto the log file document. The teacher may look at the log file to know how the session went and also to verify members' even participation. The log is a word document which can be formatted or converted easily into other formats.

5.4.5 Other features

The 'find page' icon (Figure 5.1) allows a user to find previous pages using a page name list. It is located in the top toolbar and when it is clicked a page list appears. By selecting a page name, the image will be displayed on the top of the page names list. Also it contains a page number and when the page name is double clicked the page is fetched to the screen.

Feedback is provided for the members' written contribution. After a certain amount of time, when another member starts to click on the group list, the system will automatically display member names along with the actions which are not contributed by the members.

This design has a "Save" option which could be stored for later use. Also it has another option "Print" to print a page.

The eraser button is located in the bottom right corner of the diagram. It is an alternative to the pen. When clicking this option eraser is activated and using this facility the SMART page's drawn images could be erased when clicking on the same option or it is deactivated.

This system includes a facility to highlight a rectangular area. This highlight option is located in the toolbar. It will be necessary to show a particular area of the page. By choosing this option, a rectangle area selected is shown in yellow colour

This system allows the user to select a rectangular area and the selected area could be cut or copied and pasted in a desired location or to a different page. These facilities "Select", "Cut", "Copy" and "Paste" are included in the toolbar.

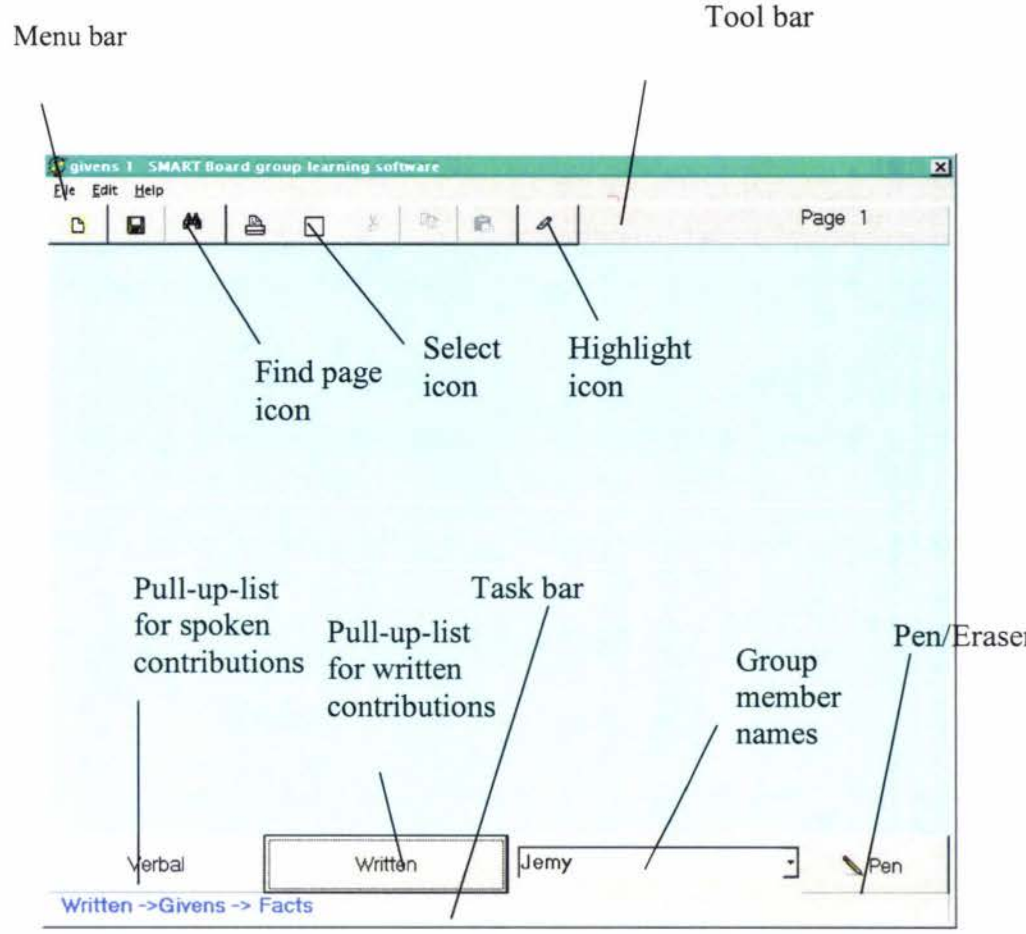

Figure 5.1 Labelled Diagram of a New Page

5.5 Scenario

A group of four people Sam, Jemy, Tania and Suzy are computer science undergraduate students. They are asked to produce a use case diagram on the SMART Board for the following case study. They have to collaborate in a group with the help of this software.

A bank decided to introduce an ATM machine. Customers may use ATM-Cards to access their accounts. The bank needs a program that should allow users to view their balance, withdraw money, transfer money or print balances. This program must also allow the bank clerks to manipulate ATM-Card details along with the existing customer and account bases. Create a use case model for this problem.

For a full description of the system and its corresponding screens see Appendix F. Some key aspects are now illustrated.

After Suzy selects the "Form a New Group" option to form a group. Then Jemy enters the group name and the password. After the confirmation message, the next screen pops up as shown in Figure 5.2. Now the group members can enter their names.

After finishing this process Tania chooses "Back to Main", and Suzy clicks on "Login". Suzy then selects the group name and enters the password. The system shows the group-learning page (Figure 5.3).

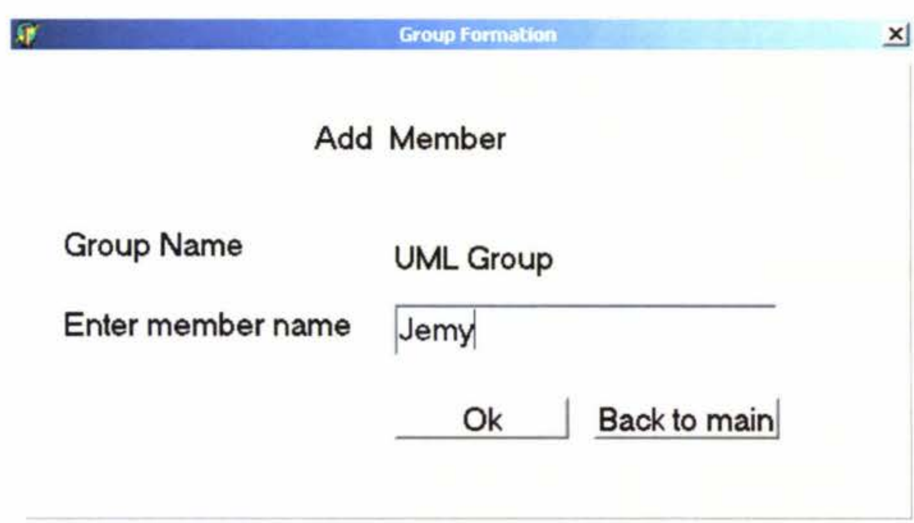

Figure 5.2 Group Formation -> Add Member

Jemy wishes to contribute and she takes the following steps

- Selects her name from the "Group members" list. (Figure 5.4)
- Selects **Written** contribution
- Selects **Givens**
- Selects "**Facts**" (Figure 5.5)
- Clicks on "**Facts**"

Since this is a new page, the system allocates page name "givens 1" and page number 1. Now the background changes to a light blue and the pen colour changes to blue. Jemy makes a contribution (Figure 5.6).

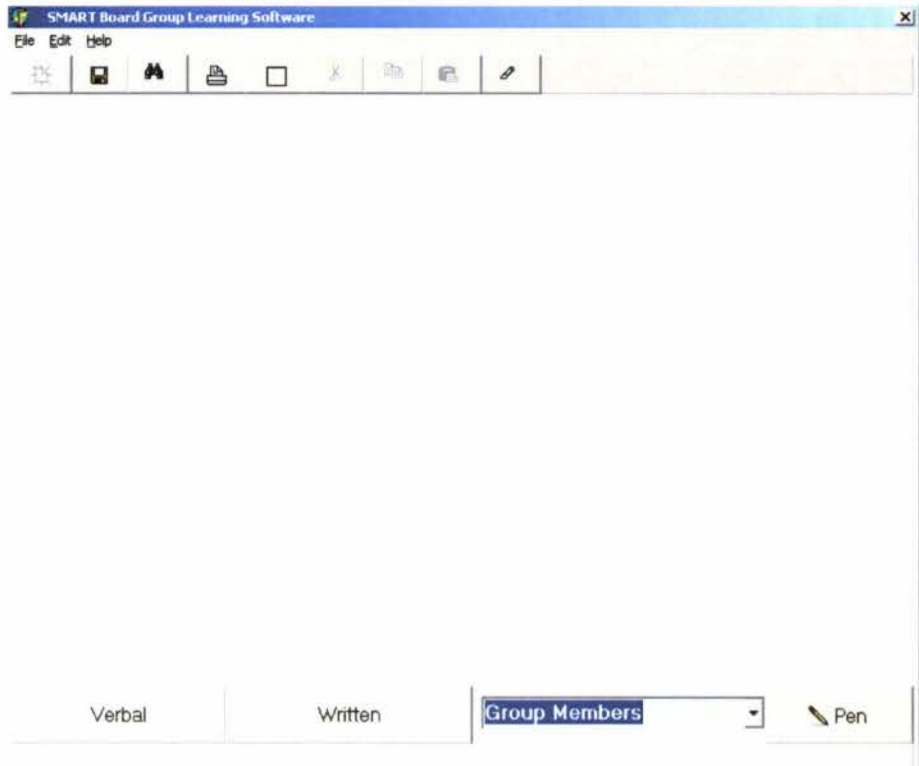

Figure 5.3 Group learning page

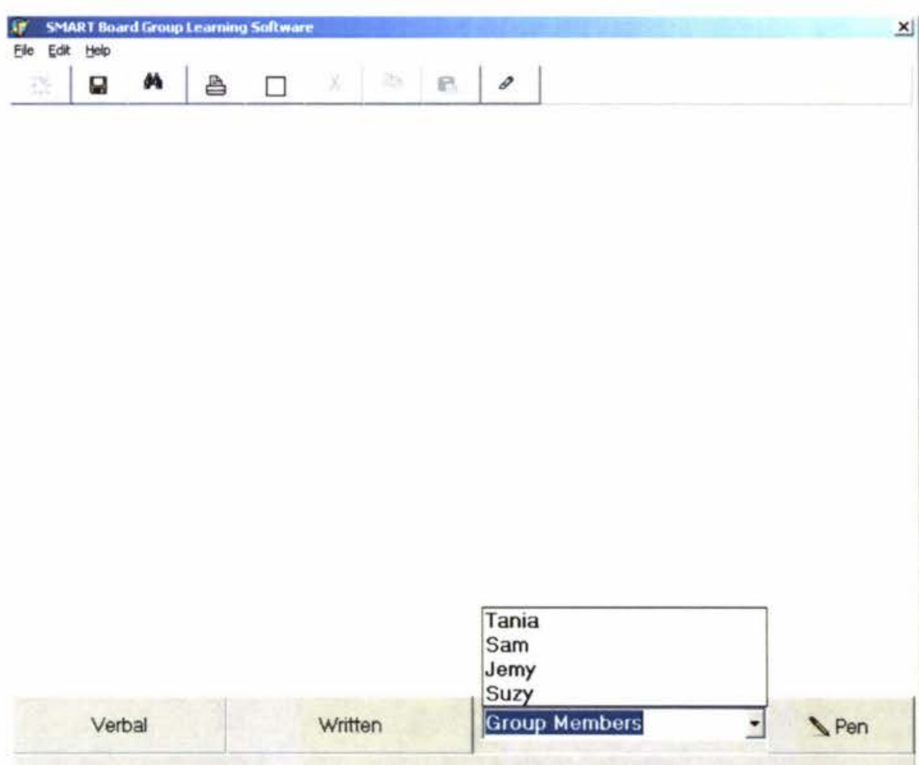

Figure 5.4 Choosing member name

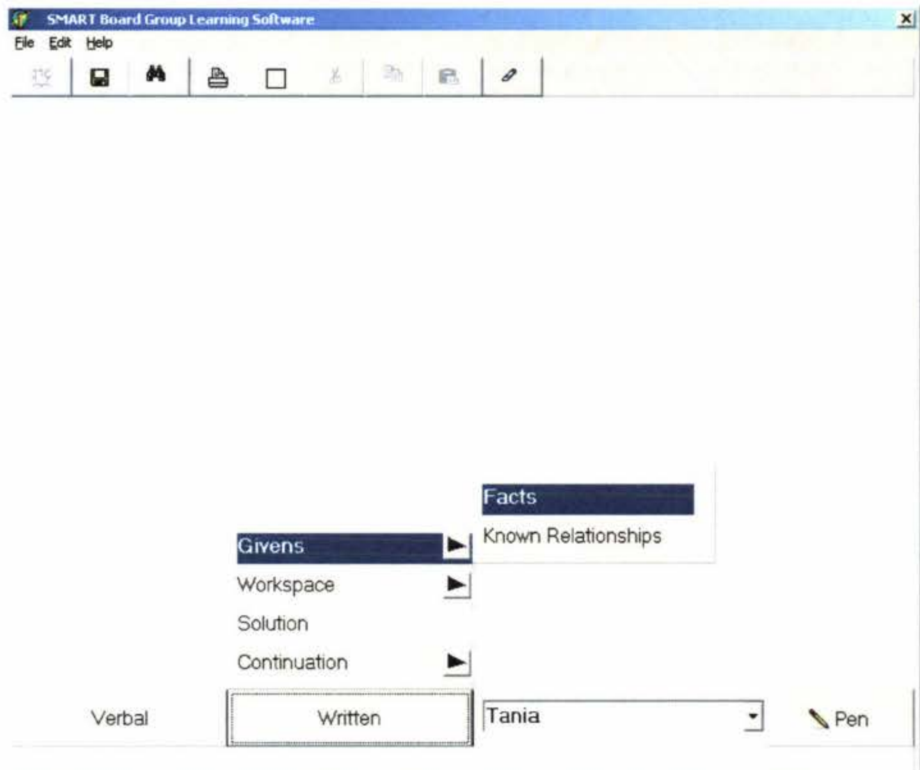

Figure 5.5 Choosing Written -> Givens ->Facts

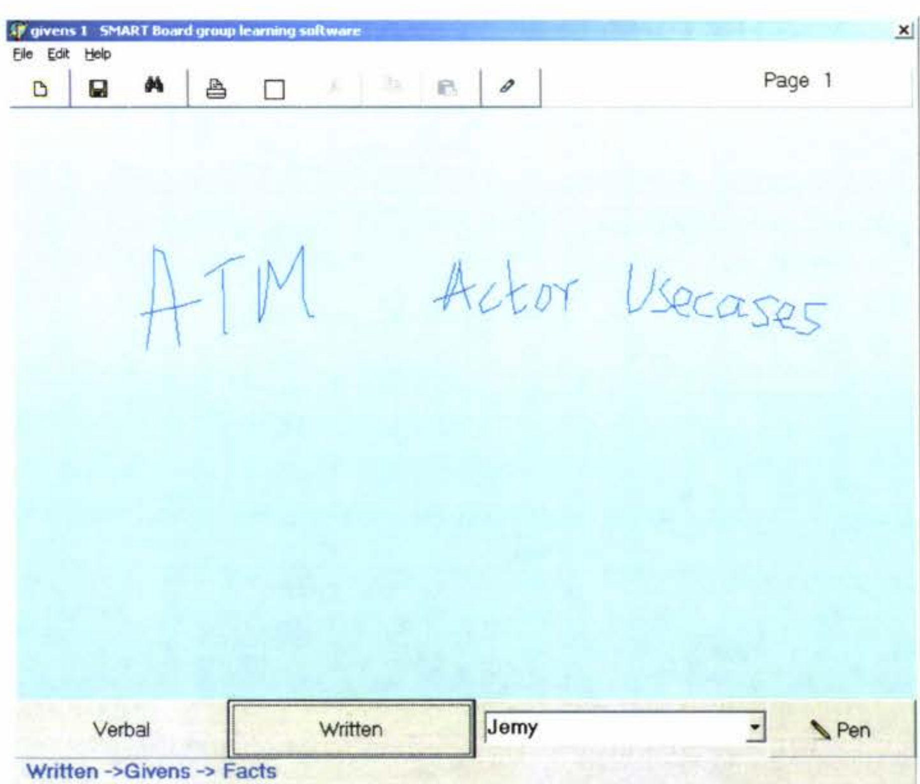

Figure 5.6 Jemy's contribution after Choosing Written-> Givens -> Facts

Tania wishes to contribute next. She takes the following steps

- Selects her name from the "Group members" list.
- Selects **Written** contribution
- Selects **Workspace**
- Selects "**Idea**" (Figure 5.7)
- Clicks on "**Idea**"

Since this is a new page, the system has allocated the page name "workspace 1" and page number 2. Now the background colour turns to light green and the pen colour changes to green. Tania adds her contribution (Figure 5.8).

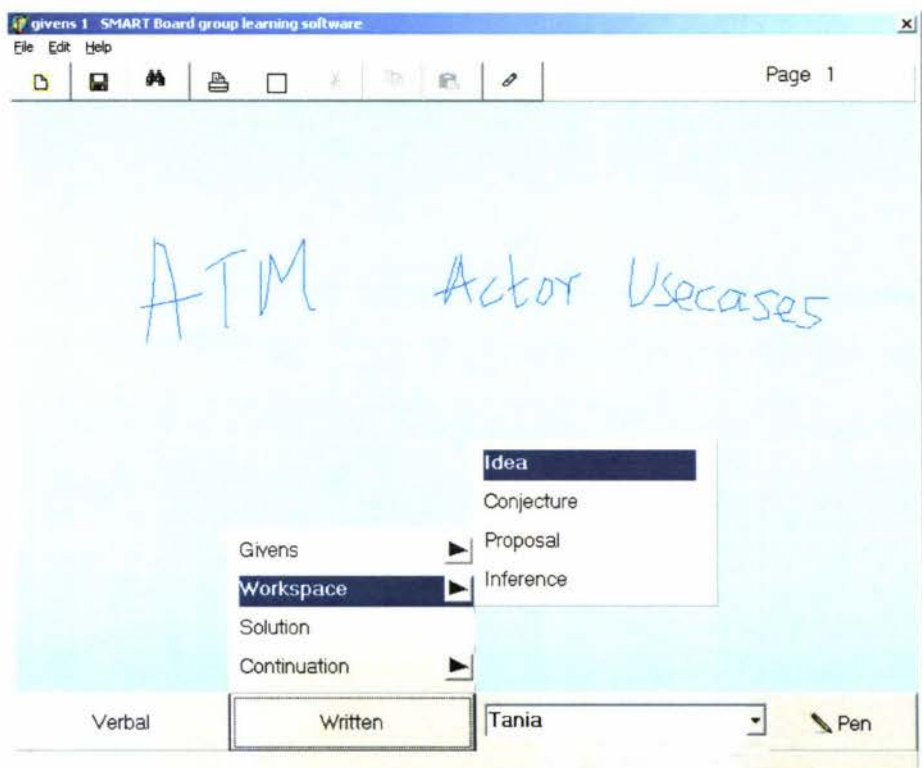

Figure 5.7 Choosing Workspace->Idea

Sam wishes to contribute next and he follows these steps.

- Selects name from the "Group members" list.
- Selects **written** contribution
- Selects **Continuation**
- Clicks on "**Addition**" (Figure 5.9)

Since this is a continuation page, there is no change in the page name, page number, background colour and the pen colour. Sam adds a contribution.

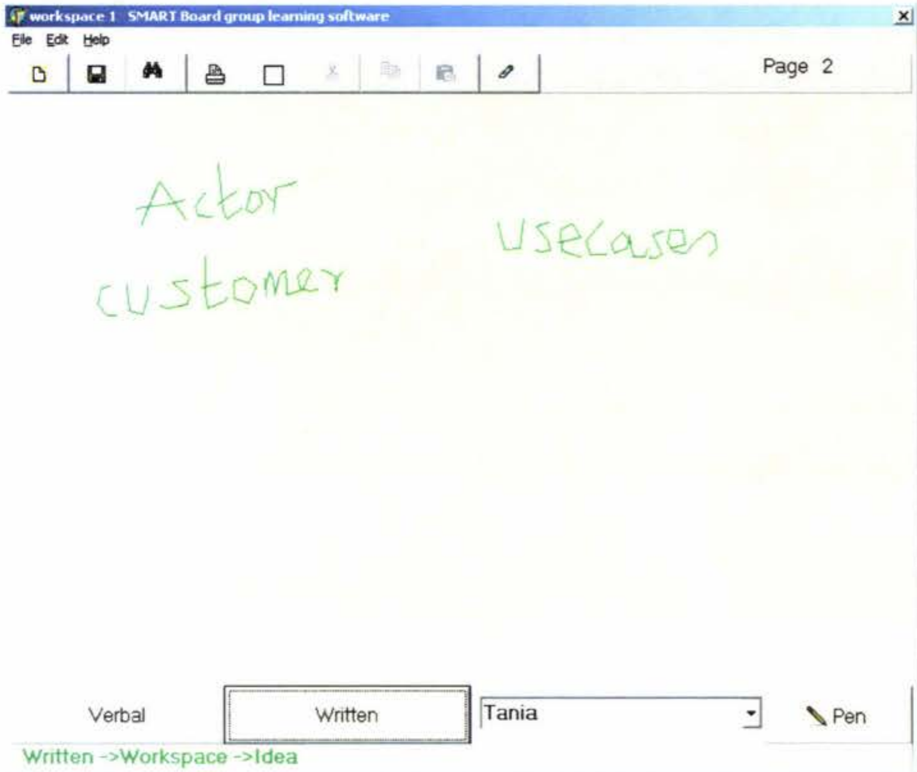

Figure 5.8 Contribution on workspace page

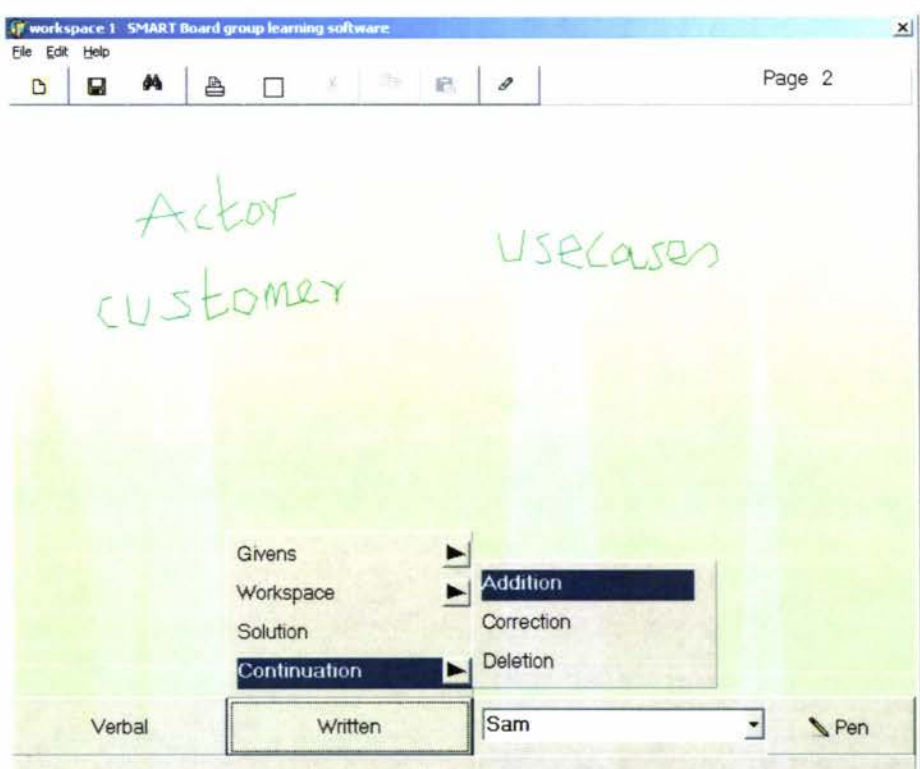

Figure 5.9 Choosing Continuation->Addition

Suzy wishes to contribute to the solution and follows the steps below

- Selects name from the "Group members" list.
- Selects **Written** contribution
- Selects **Solution**
- Clicks on **Solution**

Since this is a new page, the system has allocated the page name "solution 1" and page number 3. Now the background colour turns to pink and the pen colour changes to red. Suzy adds her contribution on to the page (Figure 5.10).

Tania wishes to contribute next and she follows these steps.

- Selects name from the "Group members" list.
- Selects **written** contribution
- Selects **Continuation**
- Selects **Addition**

Since this is continuation page, there is no change in page name, page number, background colour or the pen colour. Tania adds a contribution to the Solution page (Figure 5.11).

Jemy wishes to say something so she follows these steps below.

- Selects name from the "Group members" list.
- Selects **Verbal** contribution
- Selects **Agreement**
- Selects **I think that what we have so far is right** (Figure 5.12)
- Clicks on it (Figure 5.13)

Jemy then highlights an area.

- Clicks on the "**highlight**" option in the toolbar
- Highlights a rectangular area (Figure 5.14).

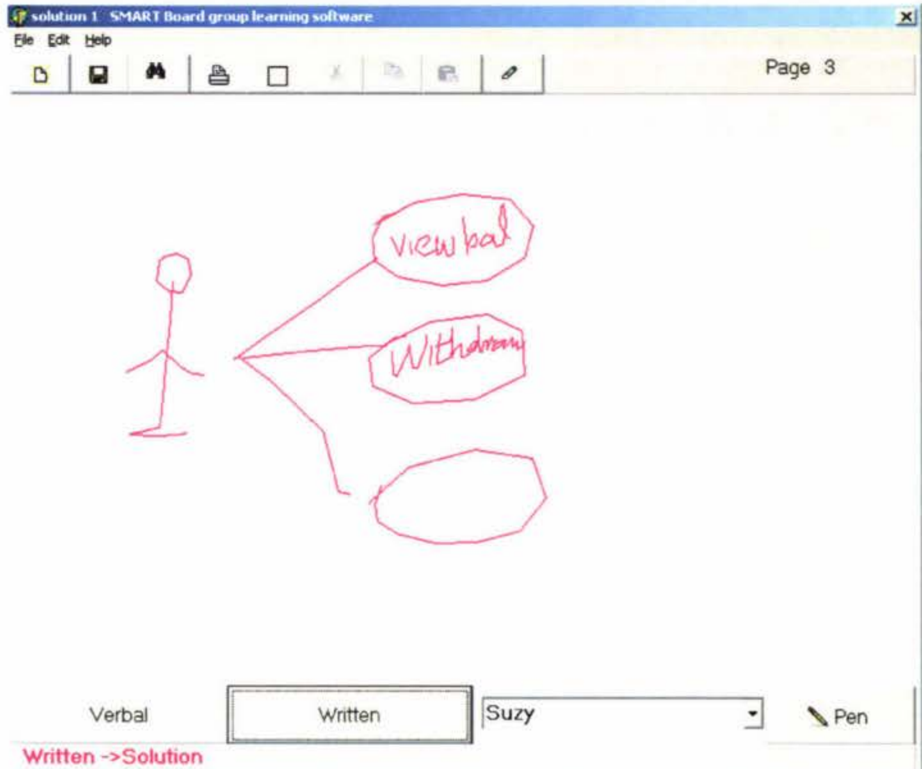

Figure 5.10 Contribution to Solution page

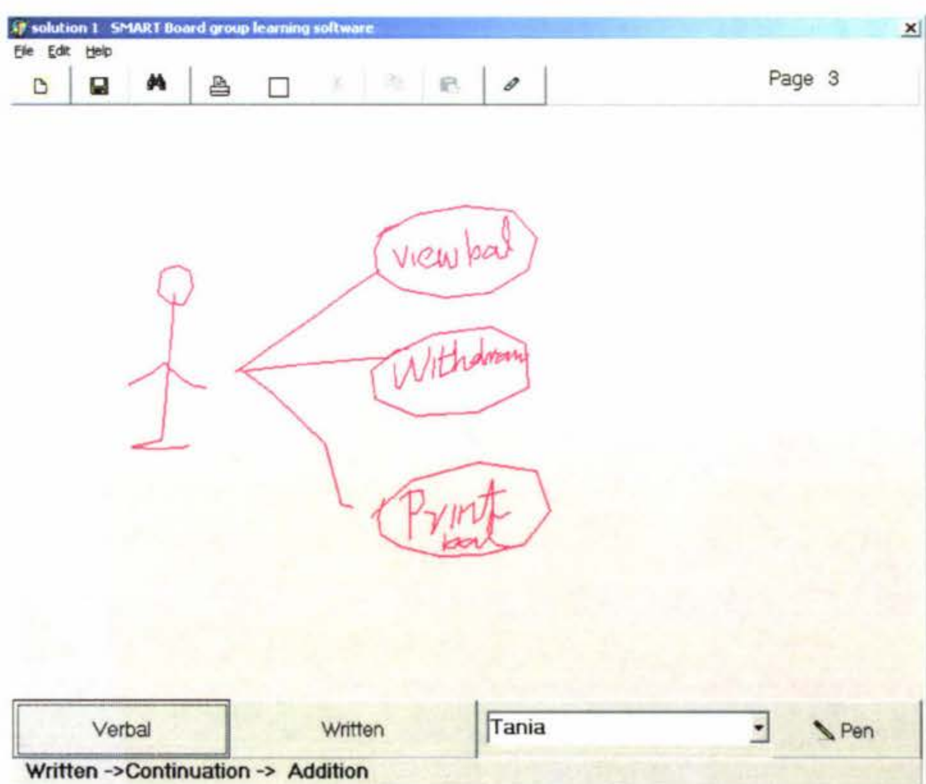

Figure 5.11 Contribution to Solution

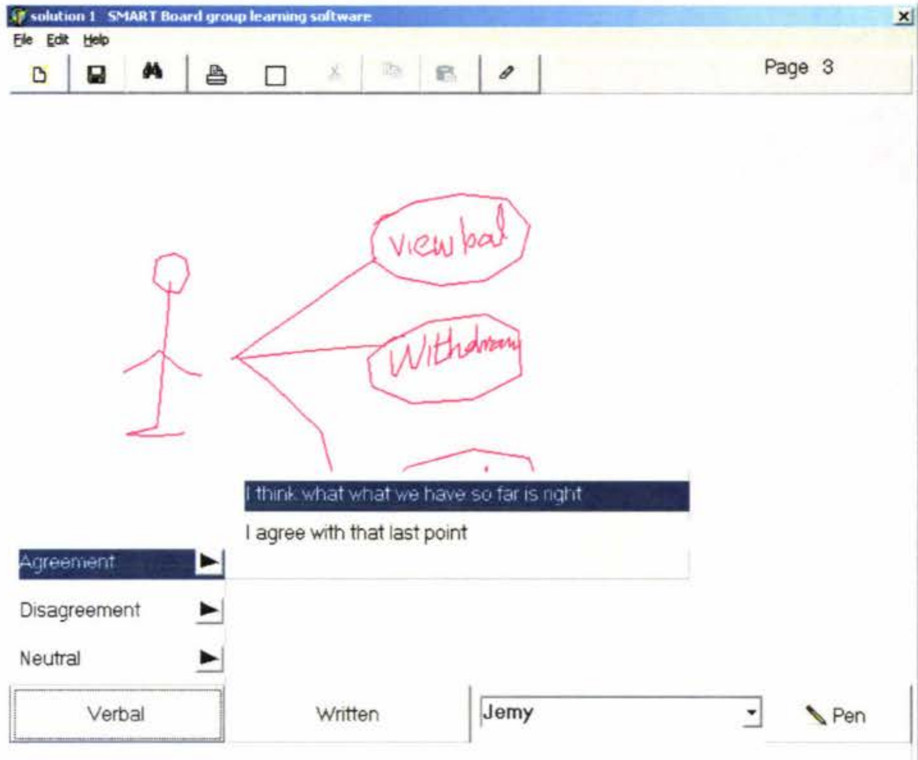

Figure 5.12 Verbal contribution

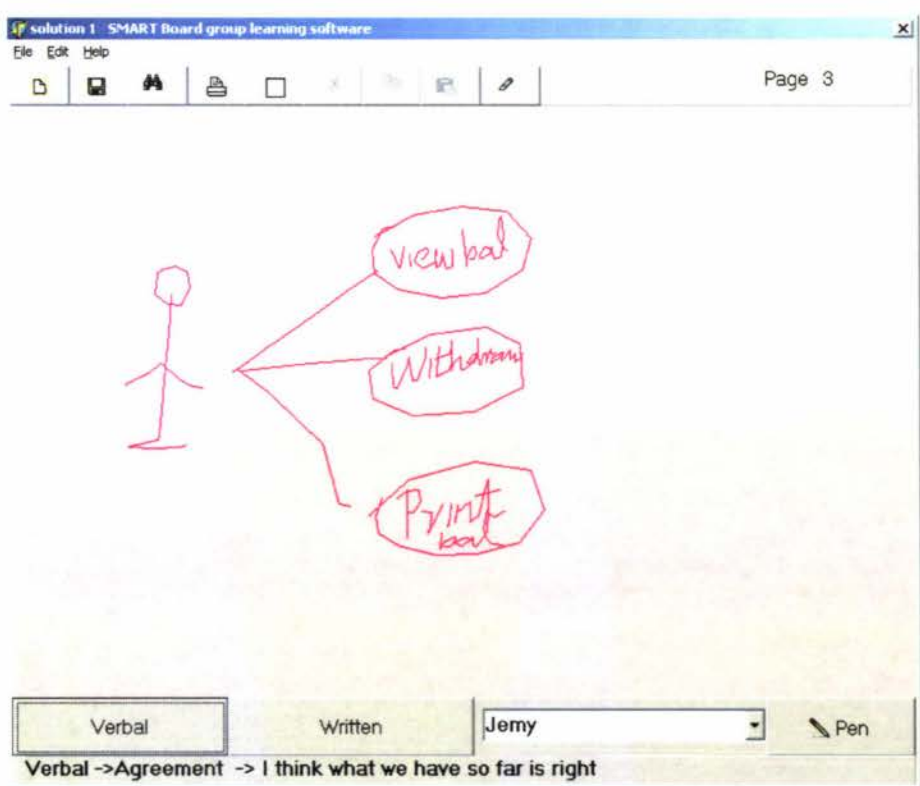

Figure 5.13 Verbal contribution ->Agreement

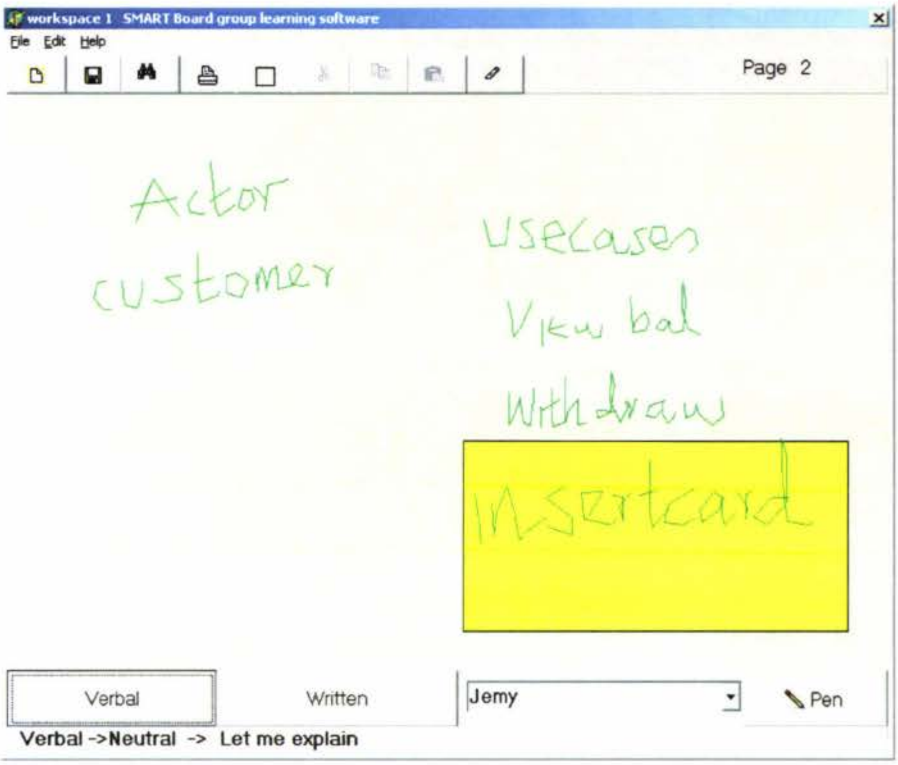

Figure 5.14 Highlighting an area

Then Jemy chooses **Written -> Continuation -> Deletion.** She:

- Clicks on the "**select**" option in the toolbar
- Selects that area (Figure 5.15)
- Selects "**Cut**" option
- Selects "**Save**" option

Sam wishes to contribute to the solution. Sam follows the steps below

- Selects name from the "Group members" list.
- Selects **Written** contribution
- Selects **Solution**

Sam adds his contribution to the solution and he creates a new page for the final solution (Figure 5.16).

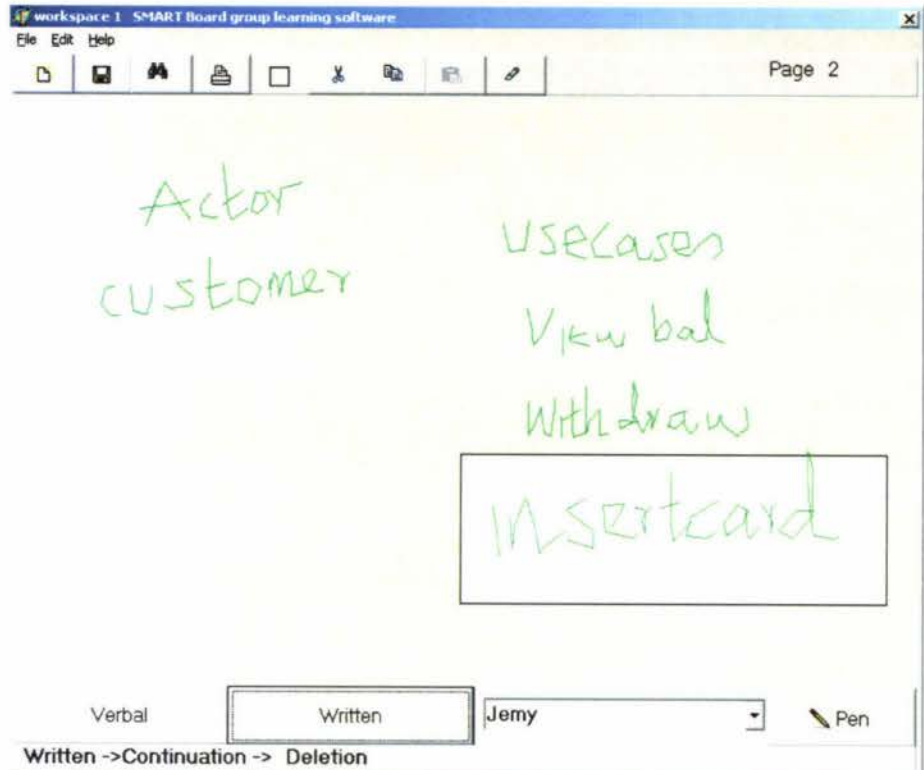

Figure 5.15 Selection for "cut"

Sam opens the **solution 1** previous page and selects an area from the previous solution page and he uses the following steps

- Clicks "**Find page** "
- Select **solution 1** (Figure 5.17)
- Double clicks on the page name
- Clicks **Select** and Selects an area (Figure 5.18)
- Selects **copy**
- Clicks "**Find page** " and select "**Final Solution**" page
- Selects **Written->solution**
- Selects **paste**
- Clicks on the **final solution** page (Figure 5.19)

Sam adds the heading to 'Final Solution' page (Figure 5.20)

During the session the system created an interaction history document. Part of this is shown in Figure 5.21.

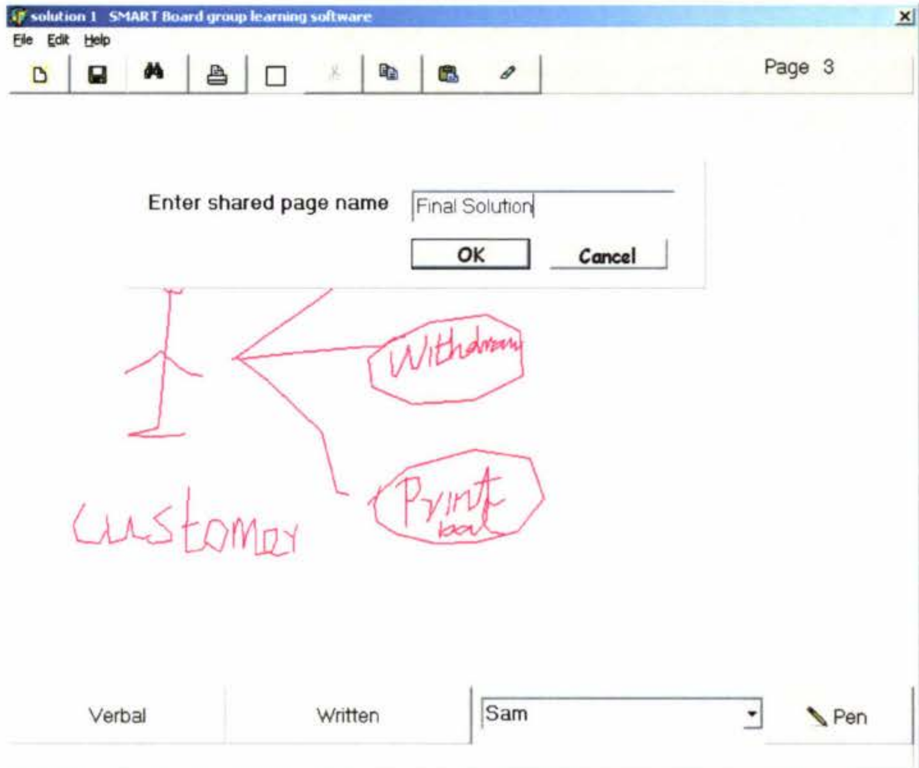

Figure 5.16 Create new page "Final Solution"

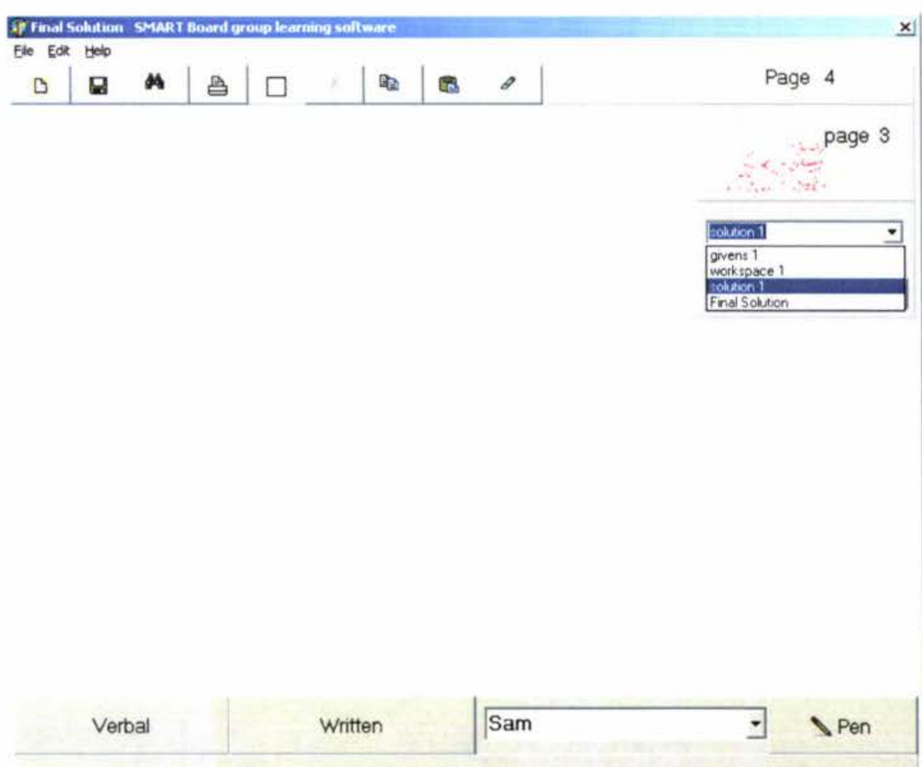

Figure 5.17 Choosing page name

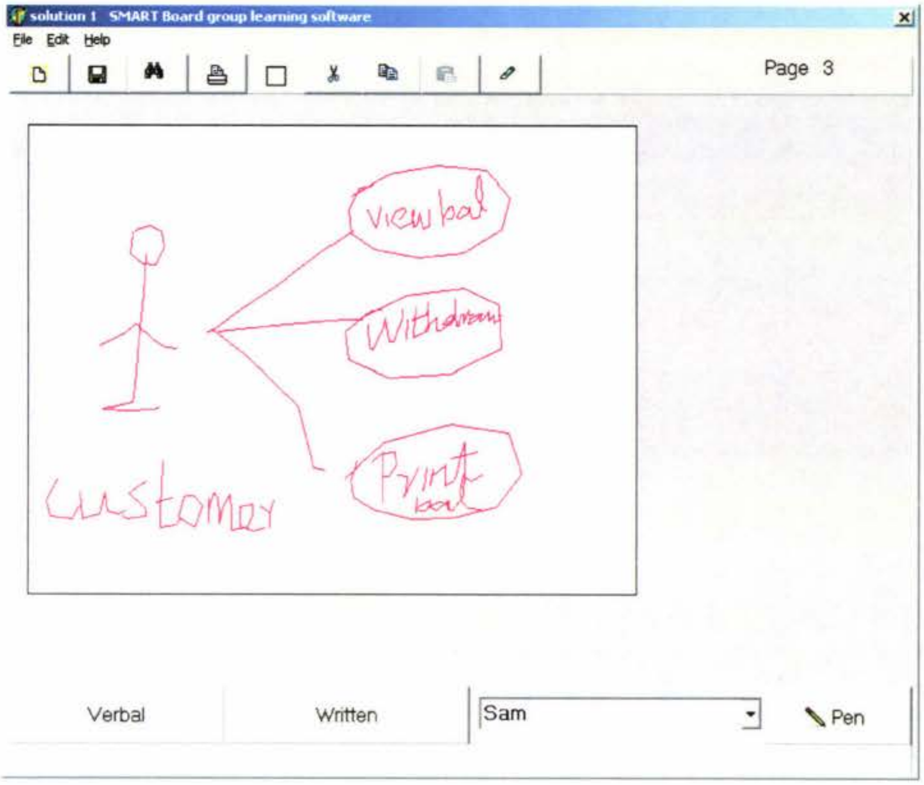

Figure 5.18 Selecting area for copying

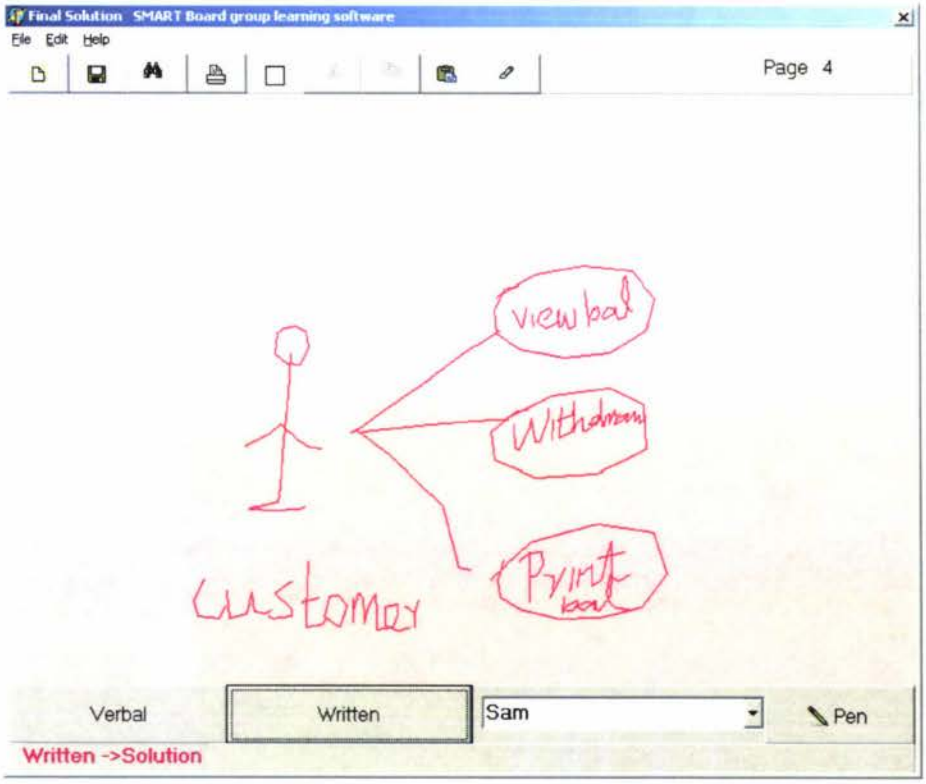

Figure 5.19 After pasting the copied area

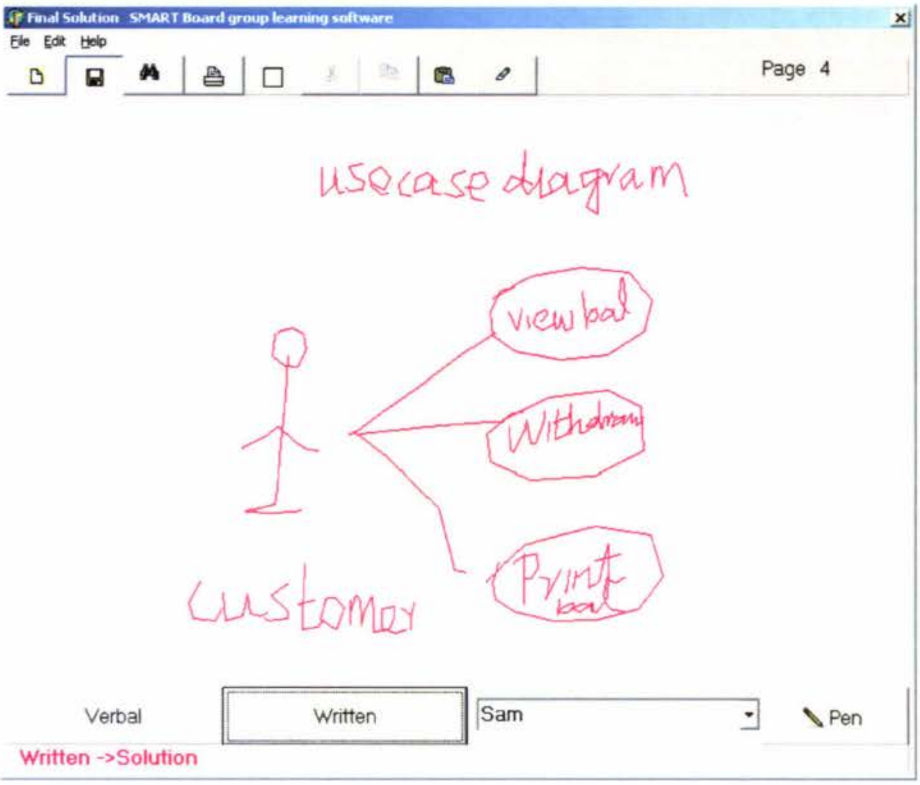

Figure 5.20 Final Solution

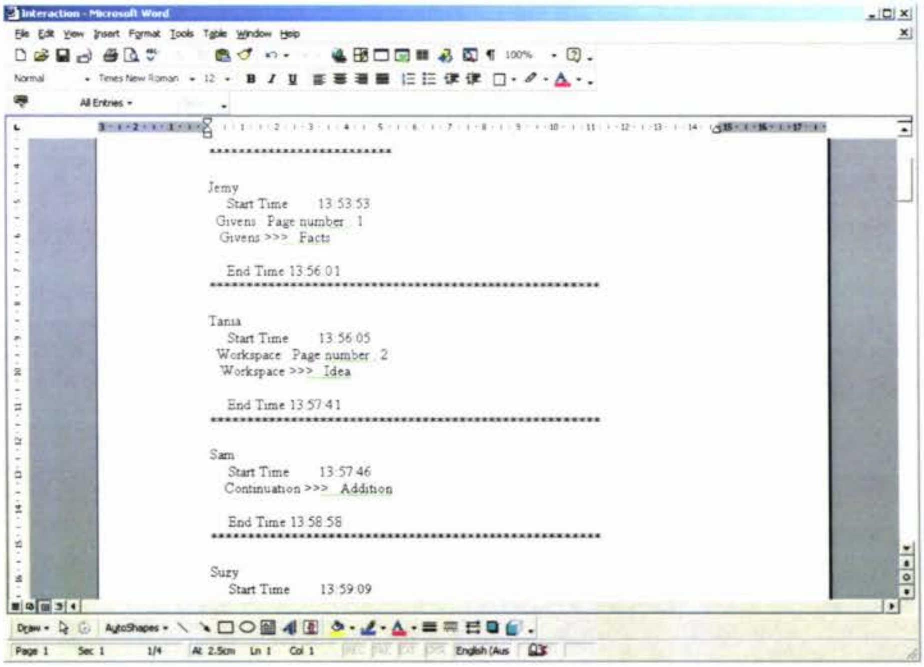

Figure 5.21 Section of Interaction History Document

5.6 Evaluation

The prototype was evaluated based on the scenario described earlier by a senior researcher. The purpose of the evaluation was to explore functionality of the system and to find out shortcomings. This could be useful for future enhancements. The evaluation was carried out on the SMART Board using the prototype for approximately two hours. The evaluator reported the following observations.

The following tasks were found to be very easy from the start:

- Accessing verbal and written contribution,
- Toggling between pen and eraser.

After working with the system for a while the following tasks could be performed quickly and easily:

- Creating a new page,
- Finding a previous page,
- Selecting a portion in the screen,
- Cutting the selected area,
- Copying the selected area,
- Pasting in a desired location (also between pages),
- Highlighting a portion in the screen.

And also, it was easy to identify

- the current user of the SMART Board and
- the kind of interaction currently active.

  E.g

  Written -> Givens->Facts

  Verbal -> Agreement -> I agree with that last point

The following problems were identified in this prototype:

- Slow to detect the pen movement
- Misleading hint when selecting page name

- When the previous pages have been found using the 'Find Page' option, the page is displayed in the screen. But it does not change the background colour of the page according to Givens, Solutions or Workspace
- To form a group and login only, the SMART Keyboard can be utilised. In the learning process there is no option to use the keyboard.
- Problem in using eraser. The eraser has to be moved diagonally from left to right.
- Once the session was closed, the system did not save group details such as members' names and password and their worked files with group identity for later usage.
- Informative feedback and help would have been useful.
- By accident, a page was not saved. Page name appeared in the finding pages list. But that page was unable to be retrieved.

A major problem was the detection of pen movements. The user's movements were little bit faster at the beginning. Since SMART Board did not recognise the faster movements, the pen was moved too slowly. For convenience the finger was sometimes used to write on the SMART Board.

Overall the evaluator found the prototype easy to use and enjoyed the experience.

5.7 Summary

In this chapter, we have provided the prototype design for enhanced software for group learning. A scenario was used to demonstrate the features of the design. This system provides new ways to share the group members' contributions. The vocabulary provided structures the interaction and should help users consider the different aspects of a problem. It will also be of particular importance when English is not the first language of all the group members. Further, this design will save SMART Board workspace. The working space could be utilised by eliminating the slide sorter, which occupies the right side of the SMART Board workspace in the SMART Notebook software. An Interaction history document could be used to assess the work to see if learning has occurred. However, only one person at a time can write on the board. From the evaluation we have found advantages and problems of the design. These lead to the conclusions and recommendations for future work that are contained in the next chapter.

Chapter 6

Conclusions and Future Work

6.1 Introduction

This chapter summarises the findings of the research undertaken and suggests areas for future research. The first section briefly reviews the contributions made by the research. In the second section, a number of vital issues raised by our study are discussed.

6.2 Contributions of this Work

In the first part of this section, we outline the results of the experiment that was conducted to evaluate the support provided by the SMART Board and its associated software for collaborative learning. Thereafter, in the second section, we describe the facilities provided in the newly designed SMART Board system to address the problems identified in the experiment.

The following issues arose from the experiment conducted to compare the level of support for collaborative learning using both the SMART Board (and SMART Notebook) and the ordinary whiteboard:

- Verbal Communication: To examine the role of verbal communication for supporting collaborative learning activities in both environments a pre-defined communication vocabulary sheet (Soller, 2001) was used. The results suggested that Soller's vocabulary is unsuitable for the SMART Board environment.
- Floor Control: Floor control is not efficient in the SMART Board environment. Though a "turn taking" mechanism is naturally used for floor control, the members did not follow the turns strictly.
- Lowering Cognitive Load: The SMART Board does not allow simultaneous writing on the board but whiteboard does. Only one person at a time can use the SMART Board.
- Inconsistency due to the SMART Board hardware:

- The colour of the pen-tray from which a pen is lifted most recently determines the foreground colour of the board. For example, a red pen may write in a green colour.
- If the Eraser is not on its place, no one could write on the SMART Board. There is no flag to indicate the status of the eraser.

- Basic Facilities: The SMART Board supports the following basic tasks more efficiently than the whiteboard: documenting work, visualising ideas, and importing and exporting documents.

From the results of the experiment, the following enhancements have been incorporated in designing the proposed software:

- Support for Interaction Guidance

  A built-in mini vocabulary is provided for **verbal** and **written** contributions in a SMART Board. This vocabulary is used to guide group members during the group learning process.
- Managing floor control

  A limited facility for floor control is incorporated.
- Managing SMART Pens

  The colour produced on the SMART Board screen by each pen is independent of its colour. Different background and foreground colours are assigned for the different types of written contribution. The foreground colour assigned for the selected type of contribution determines the SMART pen colour.
- Handling Eraser

  In the eraser mode, a pointing device may be used to delete a rectangular area.
- Facility for group manipulation

  This facility allows people to form a group and to enable the system to indicate the current user involved in the learning process.
- Monitoring the group involvement

  While the group learning process is occurring, the system records a history of members' contributions in a log file (interaction history document). This could be used to monitor members' participation.

- Providing feedback

  Feedback is provided on the members' participation to encourage active learning.

Kemp et al. (2003), using the ideas of verbal and written contribution, suggest that the SMART Board along with this enhanced software would provide support for collaborative learning. The verbal contribution list contains candidate sentences that are spoken most frequently in collaborative learning activities. Each option in the written list contains a number of sub-options. The background and foreground colours of the page are fixed for each option.

6.3 Further work

Our research work raised several important suggestions that are found to be useful for supporting collaborative learning in the SMART Board environment.

I. **Facility to support collaborative learning in remote locations**

In this research, we have considered only face-to-face and same location modes of collaboration in the SMART Board. We envisage that the future enhanced versions of our software will support collaborative learning activities in the SMART Board environment via networked based links. For this purpose, our software would be extended to incorporate several elegant features found in groupware such as, email, message boards, videoconferencing, web searching, and so on. Besides, the existing facilities in our software need to be enhanced to support remote learning tasks. For example, the current verbal and written contributions need to be extended. The floor control mechanisms should be modified while keeping the wastage of resources to minimum. Network-bandwidth becomes the main rare resource. The interfaces need to be redesigned to suit the remote learning tasks.

II. Testing the system for effectiveness of learning

Any proposed learning system that claims it enhances group learning processes, needs to be evaluated properly to estimate the impact on the learning processes. Though, we had systematically evaluated the SMART Notebook software for this purpose, we could not do the same for our proposed system due to the limitation of time. Similar to the experiment explained in this study (Chapter 4), the proposed software could be evaluated using two groups. Both groups would work on SMART Board, but the control group would use SMART Notebook while the other group would use the proposed software. Video recording the experiments would be desirable in order to analyse the processes effectively.

III. Improvements in the current design

The following improvements in the current design would enhance the effectiveness of the SMART Board environment for collaborative learning processes:

- Floor control mechanisms

  Currently, registering the user name before s/he starts to work on the board supports the floor control. The members follow "turn taking" for resource sharing. The usual etiquette rules govern the floor control. But these are not sufficient for any serious collaborative learning tasks. For example, while one member is using the board, another member can interrupt the work by just touching the board. The system must have a facility to prevent this type of interruption. The system may have a facility to handle the floor control by monitoring time and frequency of individual member contributions, and providing a way to record the requests for contributions and managing the queue. Another suggestion is that a pen may be disabled if it is not used for a long time. Further, the system may include a facility to save the work and disable the pen if a member is using it for a long time. The group may select their preferred floor control mechanism before or during their session.
- Improving Eraser facility

The users would be able to erase an arbitrary portion of the SMART Board as if they were using an eraser on a white board.

- Providing a facility to utilise the SMART Board keyboard
  Currently, the new SMART Board software does not have a facility to add keyboard text on the Board after the group formation and login. A facility to bring the keyboard on board would increase flexibility.
- Improving facility for bookkeeping
  Storing the information about group including member names, password, interaction history document and the files worked is useful.
- Providing full help facility to get usage of the features and how to use the features
  A help facility is essential for any interactive software. A context-sensitive help facility is to be incorporated.

In sum, being the potential learning paradigm for the current decade, Computer Supported Collaborative Learning will blossom with the support of hardware technologies such as digital whiteboards along with suitable software. Our study reveals that the current software facilities are not sufficient to gain the maximum group learning effect. We hope that the proposed software with the features described in this study will fill the above gap and play an important role in CSCL in the near future.

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Appendix A

SMART Board

In this appendix, the SMART Board orientation and the SMART Notebook features are presented.

1. SMART Board orientation

Before using the SMART Board, orienting the board is necessary. This process defines sensitive points so that the board is accurate and the board is active. Figure A.1 shows the orientation window.

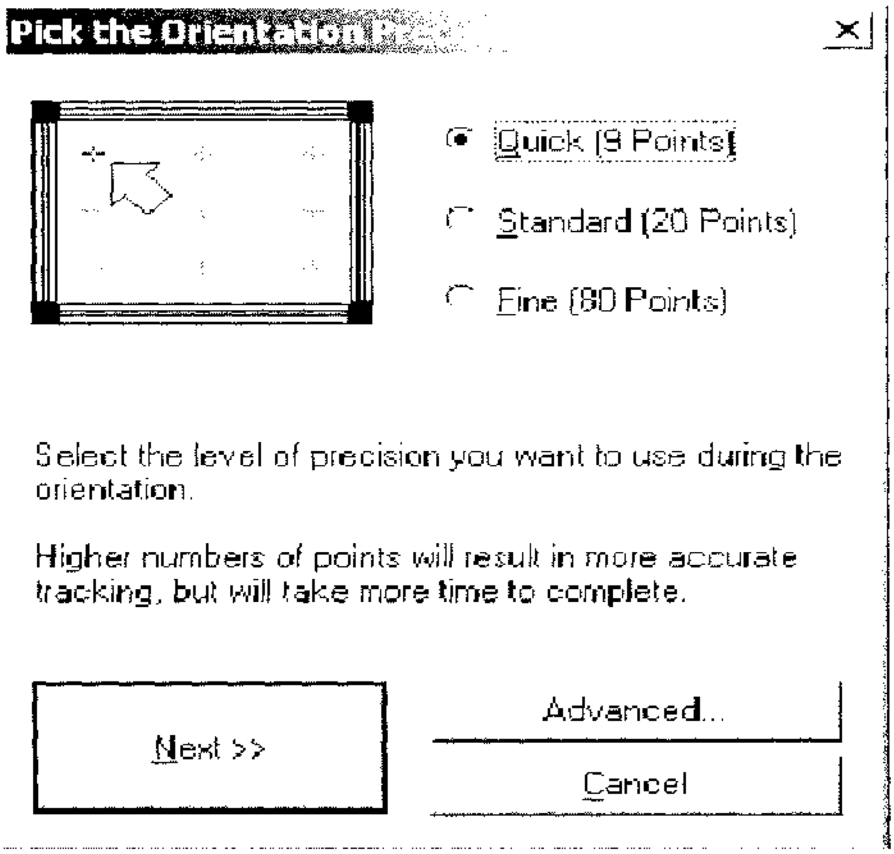

Figure A.1 SMART Board Orientation

The quick orientation requires 9 points. The standard needs 20 points and this is the recommended one by the manufacturers. It will take only few minutes. If we want fine orientation, it requires 80 points. This will consume more time than the previous.

2. SMART Notebook Software

When we capture notes written over applications, both the background and the annotations appear in SMART Notebook software. Notes and images become objects that we can move and resize (Figure A.2). We can also change electronic ink colour, reorganize notes and save all our work to a file.

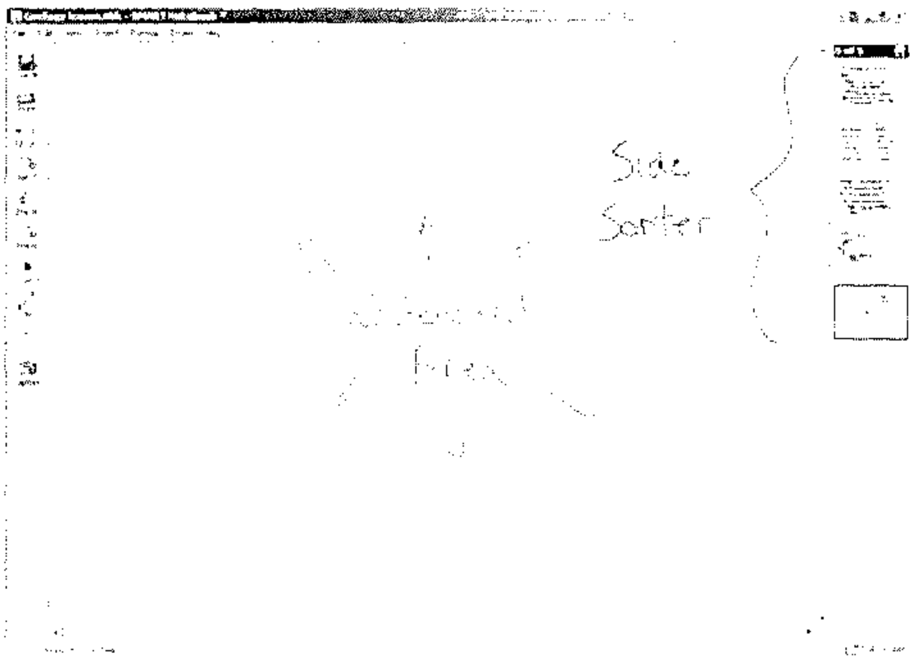

Figure A.2 SMART Board page

Other features of Notebook software include:

Side Sorter

View thumbnail images of each page to easily scroll through we work.

Drag and Drop (Windows operating systems only)

Move objects between SMART Notebook pages, or drag and drop them into other open applications.

Screen Capture

The screen capture toolbar floats over any open application. Press a toolbar button and the captured image automatically appears in the Notebook file.

Appendix B

The Case Study

In a car rental company, all customer-related processes are to be supported by coherent, unique information system. Currently, some business processes are not at all or only insufficiently supported by electronic data processing. For the remaining ones, there are various specialised systems. Several systems are needed to be able to handle all sides of customer service.

The new system to be developed should provide all functions directly related to handling customers and other business partners (for example suppliers). These include customer information, management of core data (addresses, bank details, and so on), reservations, vehicle rental and customer billing.

Inbound areas and those that touch business partners only remotely, such as internal accounting, tariff and product planning, vehicle transfer and disposition are not part of the system.

Problem : Identify the use cases, actors and draw the use case diagram.

A possible Solution

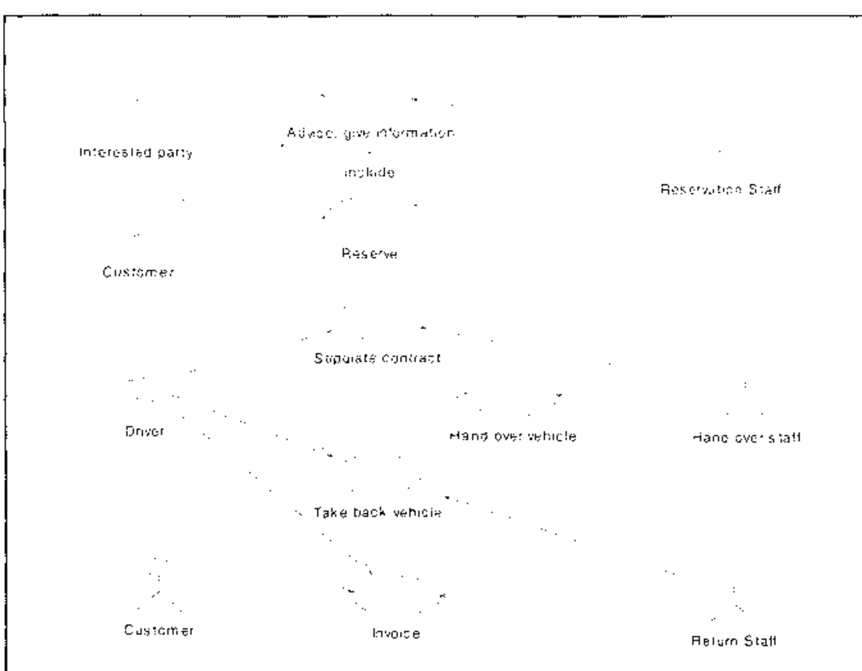

Figure B.1 Use case diagram (Oestereich, 1997)

Appendix C

Amy Soller's Conversation Vocabulary

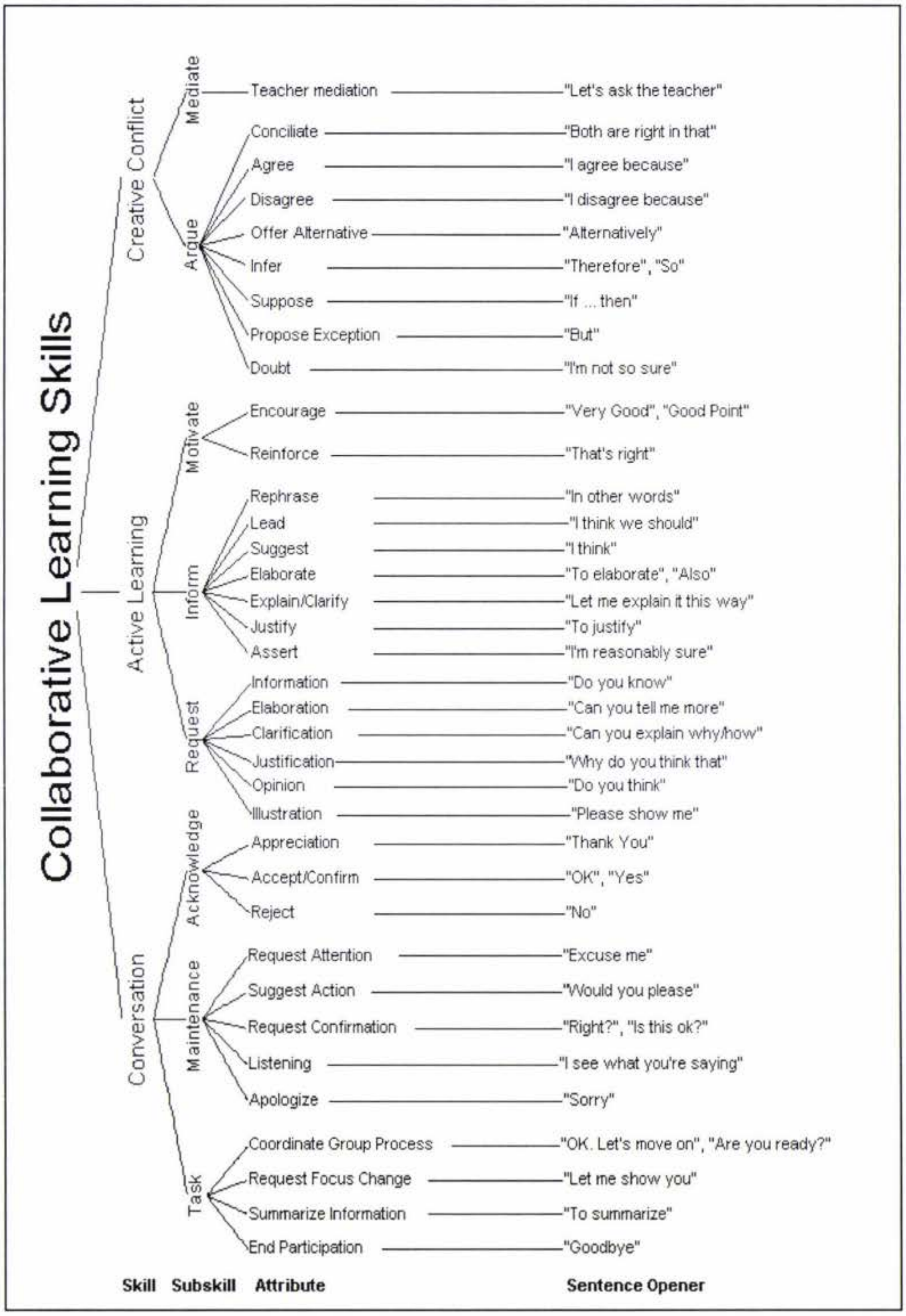

Figure C.1 Communication Vocabulary (Soller 2001)

Appendix D

Main Study on SMART Board

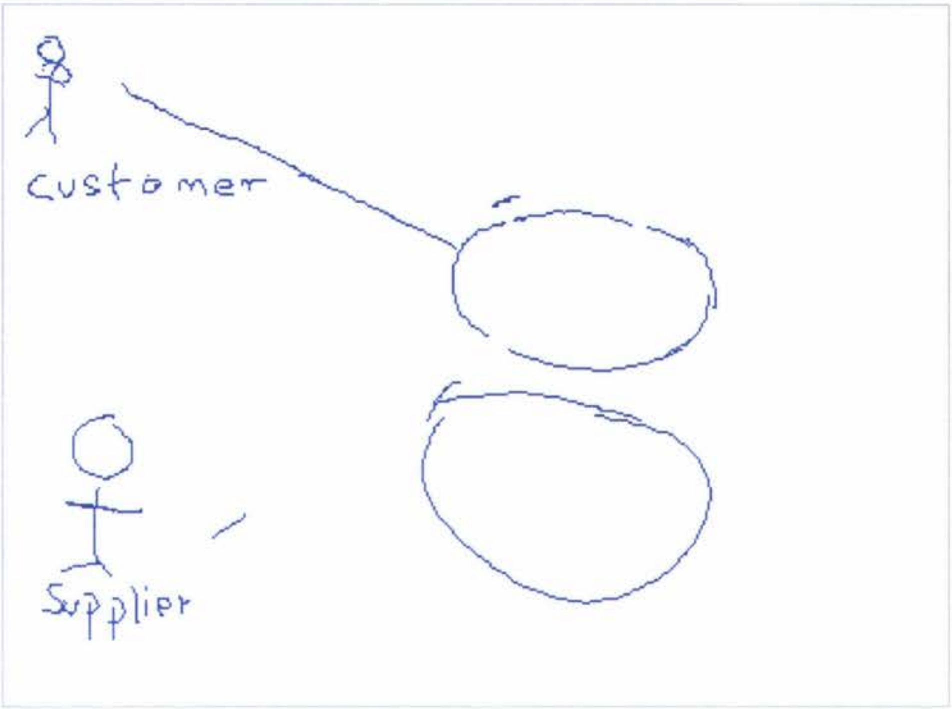

Figure D.1 Diagram 1

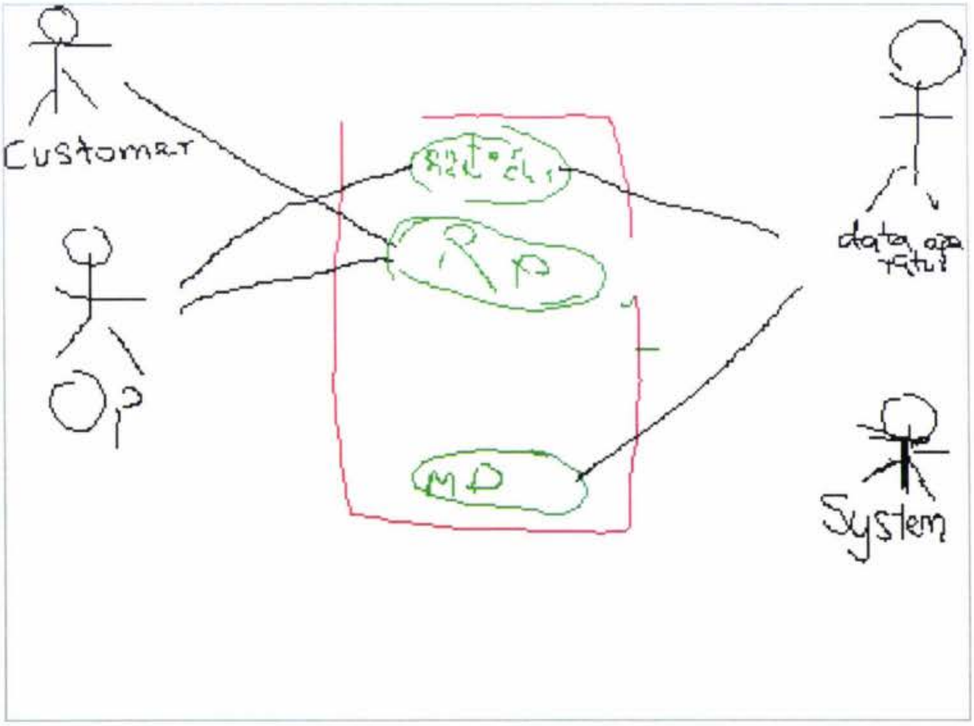

Figure D.2 Diagram 2

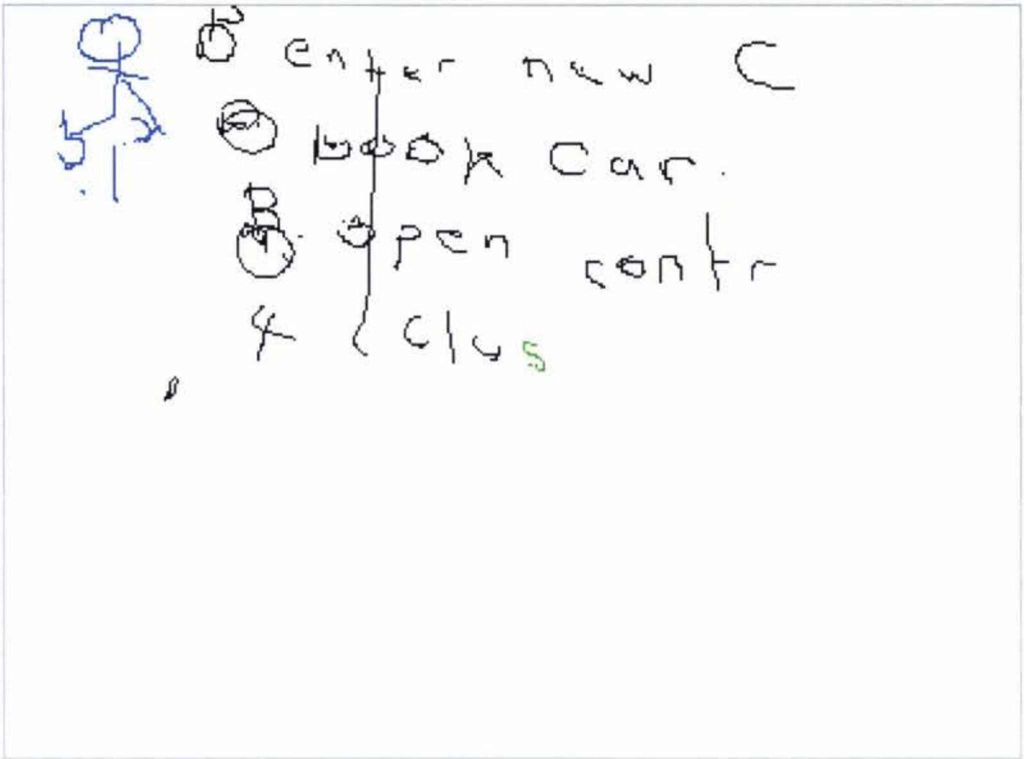

Figure D.3 Diagram 3

The Figure D.4 shows the html view of the group work.

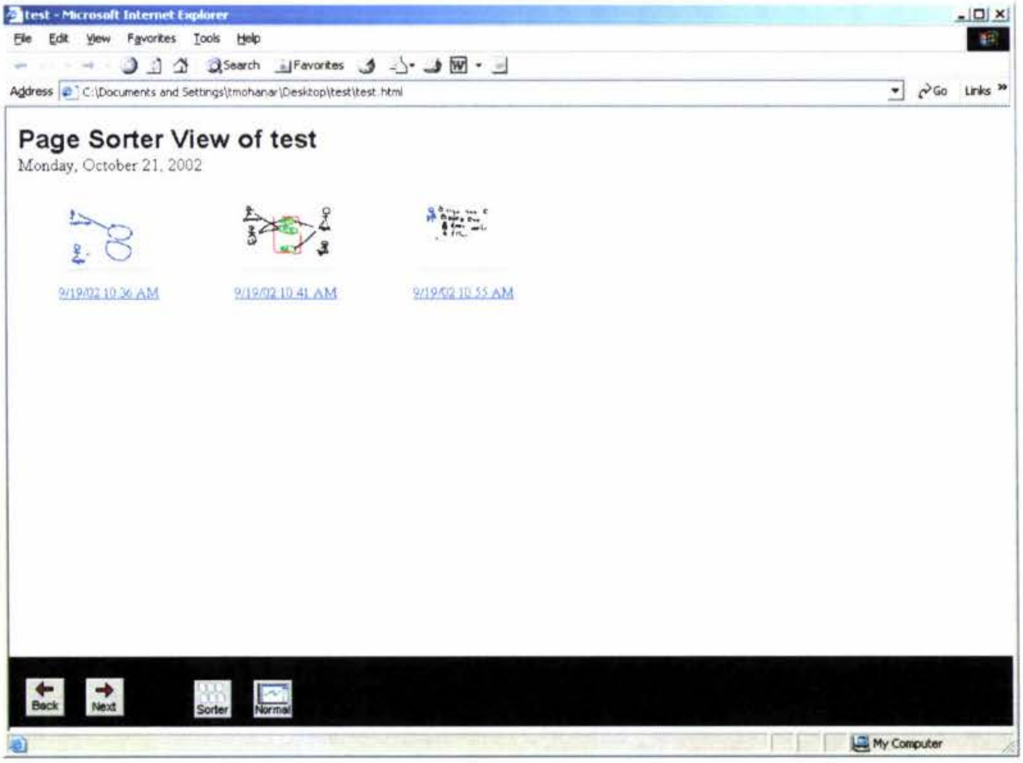

Figure D.4 Diagram 4

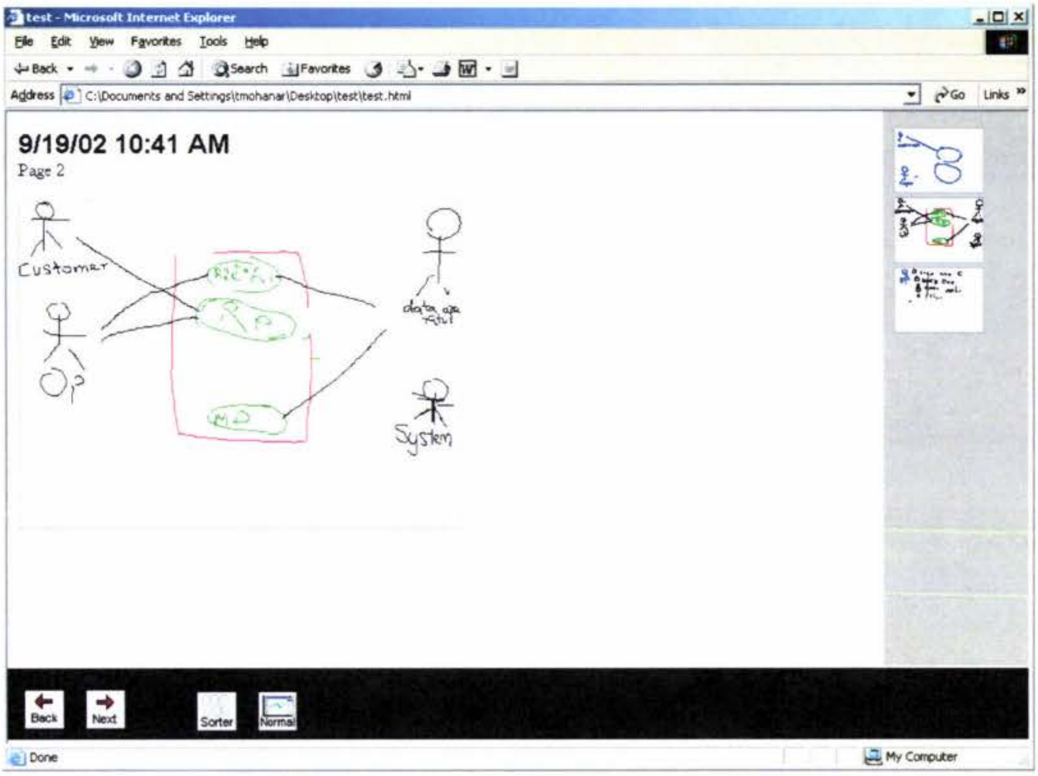

Figure D.5 Diagram 5

Appendix E

Questionnaire

Strongly agree –1 Agree-2 Slightly agree-3 Neutral –4

Slightly disagree –5 Disagree-6 Strongly disagree-7

Circle the most appropriate response for you to the sections 1 and 2

Section 1: Usage of SMART board for group learning

1. I agree that the working space of a SMART Board is enough for discussion for a group of size 3 to 4.

   1 2 3 4 5 6 7

2. If the SMART pens are categorised (for example, green colour for suggestion), the group learning would be further enhanced.

   1 2 3 4 5 6 7

3. I accept that the Amy Soller's conversation vocabulary is useful for group conversation

   1 2 3 4 5 6 7

4. I think that the non-verbal communication is not essential in the SMART board learning environment

   1 2 3 4 5 6 7

5. The unwanted dominance of a group member would be a problem in SMART board learning environment. I prefer to use a buzzer to prevent any such dominance.

   1 2 3 4 5 6 7

6. For a group of size 3-4, assigning a particular colour pen for each person would enhance the group learning.

   1 2 3 4 5 6 7

7. I think “shadowing” is an important problem in learning through front projection SMART Board.

1 2 3 4 5 6 7

8. SMART Board cannot extract only a particular colour. Do you accept that such a facility would enhance learning?

1 2 3 4 5 6 7

9. The keyboard can be displayed on SMART board. This feature is very helpful in using SMART board for group learning.

1 2 3 4 5 6 7

10. The SMART Board is touch sensitive. This feature enhances the group learning through SMART board.

1 2 3 4 5 6 7

Section 2: Software on SMART board- example- SMART notebook

1. I accept that the SMART notebook is helpful for group learning.

1 2 3 4 5 6 7

2. SMART Notebook doesn't have the colour extraction facility. Do you think will enhance the group learning in the case of categorised pen usage.

1 2 3 4 5 6 7

3. The conversation vocabulary restricts the group communication

1 2 3 4 5 6 7

4. Do you think the conversation vocabulary, if included in enhanced software will improve the group interaction?

1 2 3 4 5 6 7

Section 3: General issues in SMART board

1. How valuable a resource was the SMART Board within this collaboration?

   Of little use (could have used an ordinary board as effectively)

   Some use

   Very useful

   couldn't have done without it

Please comment :

2. How effective was the SMART Board in terms of collaboration?

   Very / Okay / Not

Please comment :

3. Give two advantages of SMART Board over the students around the computer/around the table /library meetings

4. Give any two disadvantages of SMART Board over the students around the computer/around the table /library meetings

5. Do you think SMART Board is an effective tool for collaborative learning?

   Yes/ No

6. Do you think without SMART Board (using some other hardware), collaboration can be done effectively?

   Yes/ No

7. During the session, did you use any non-verbal communication?

   Yes/No

8. Do you think the usage of verbal communication easy during collaboration using the SMART Board?

   Yes/No

Appendix F

Scenario Description

1. Diagrams

Initially Sam does the SMART Board Orientation. The initial screen is as shown in Figure F.1:

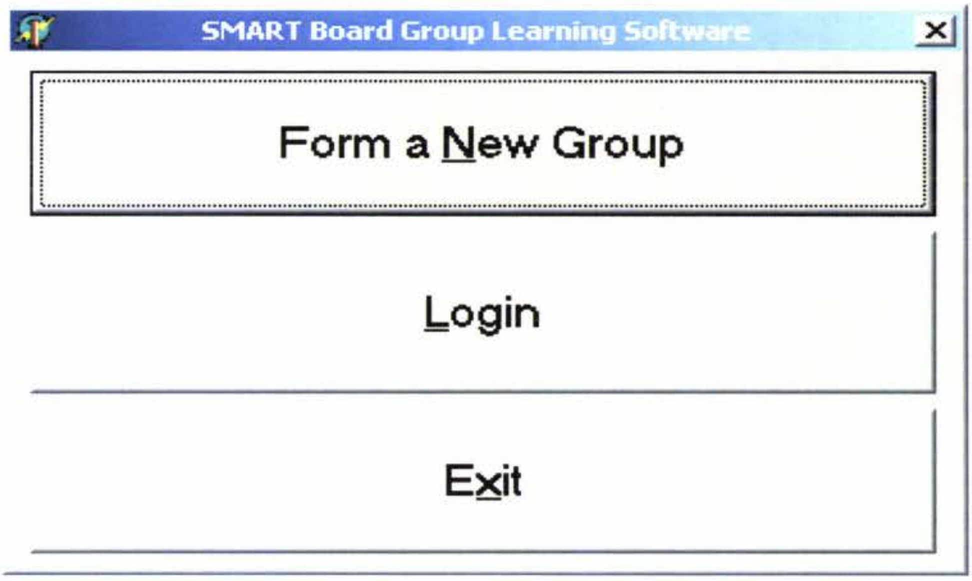

Figure F.1 Main Screen

Then Suzy selects "Form a New Group" option to form a group. The next screen pops up as the following. Then Jemy enters group name and the password.

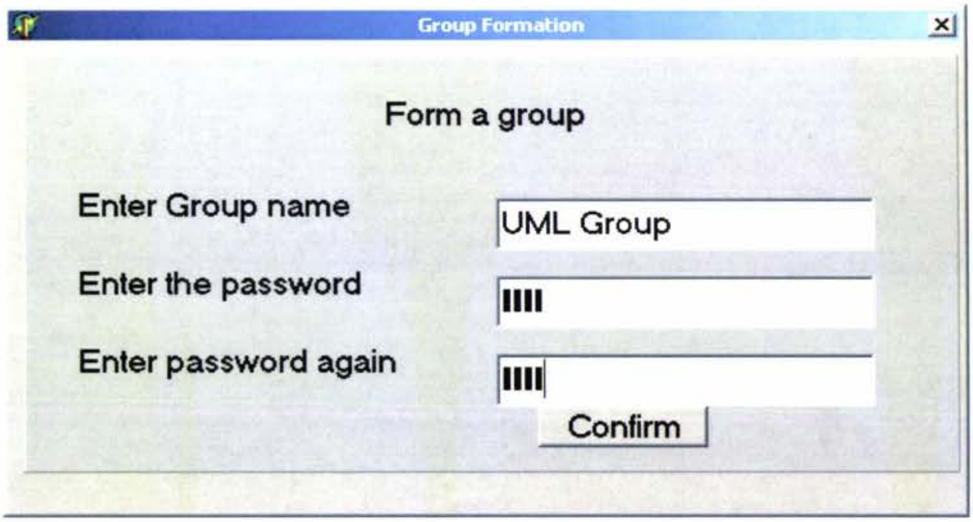

Figure F.2 Group Formation

After the confirmation, the next screen pops up as shown in Figure F.3. Now the group members can enter their names.

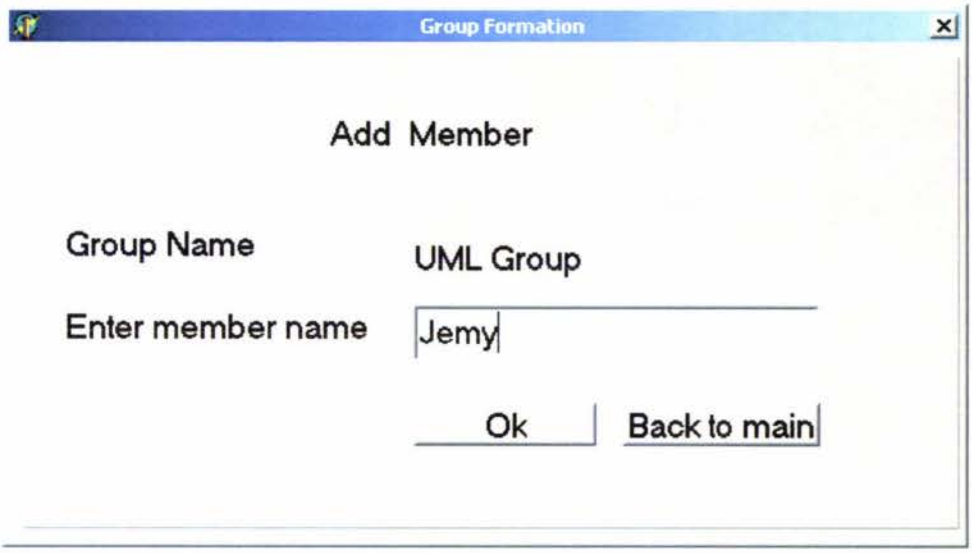

Figure F.3 Group Formation -> Add Member

After finishing this process, Tania chooses "Back to Main "and Suzy clicks the "Login", the screen is as shown in Figure F.4.

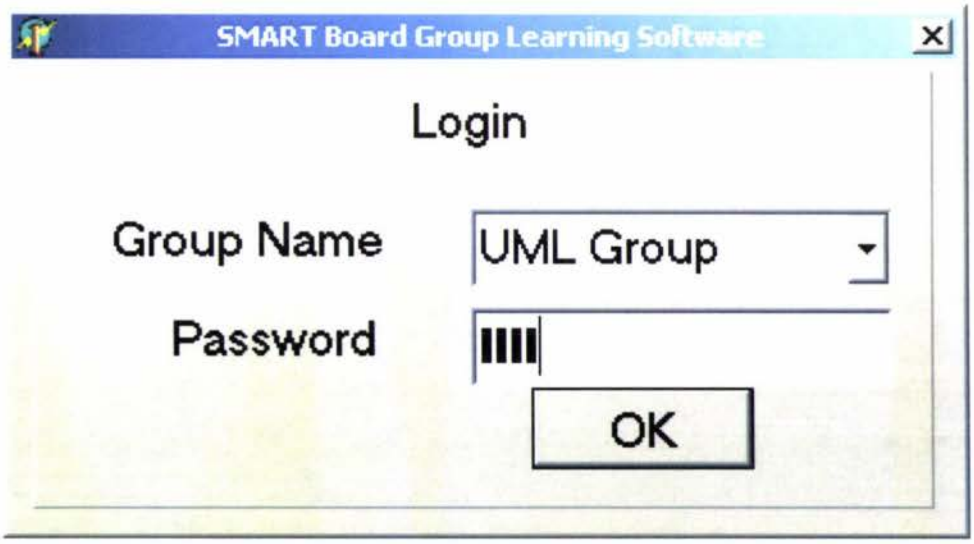

Figure F.4 Login Page

After Suzy selects group name and she enters the password, the system shows the group learning page (Figure F.5).

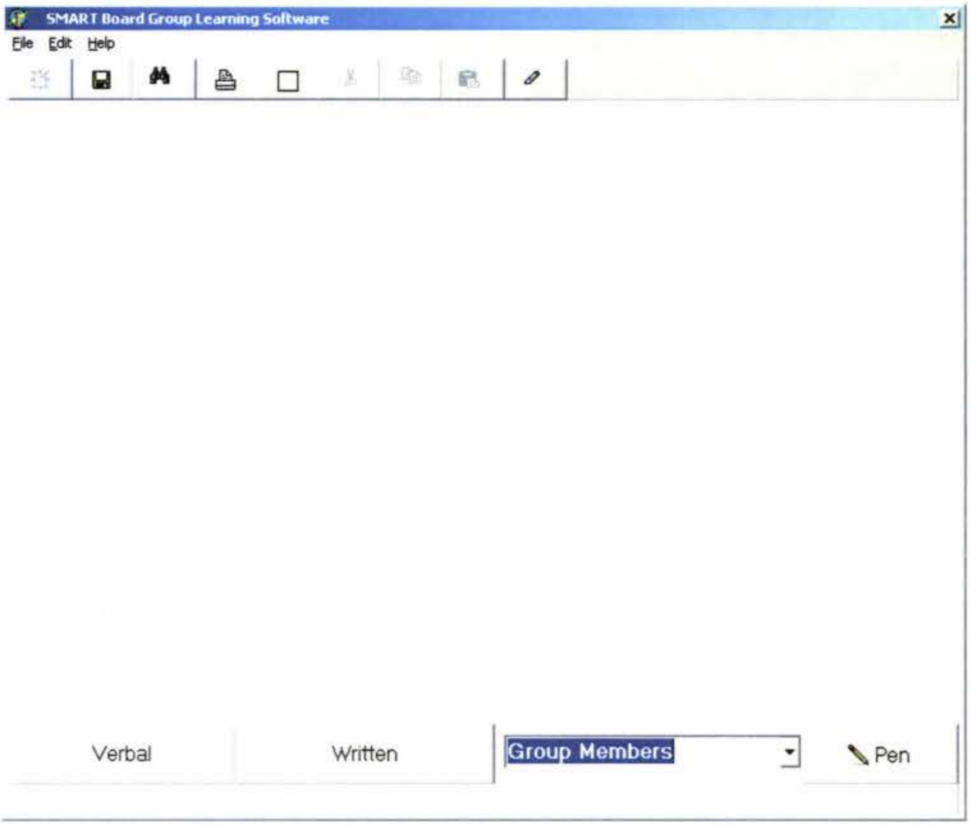

Figure F.5 Group Learning page

Jemy wishes to contribute and she takes these following steps

- Selects her name from the "Group members" list. (Figure F.6)
- Selects **Written** contribution
- Selects **Givens**
- Selects "**Facts**" (Figure F.7)
- Clicks on "**Facts**"

Since this is a new page, system allocates page name "givens 1" and page number 1. Now the background changes into light blue and the pen colour changes to blue. Jemy makes a contribution (Figure F.8).

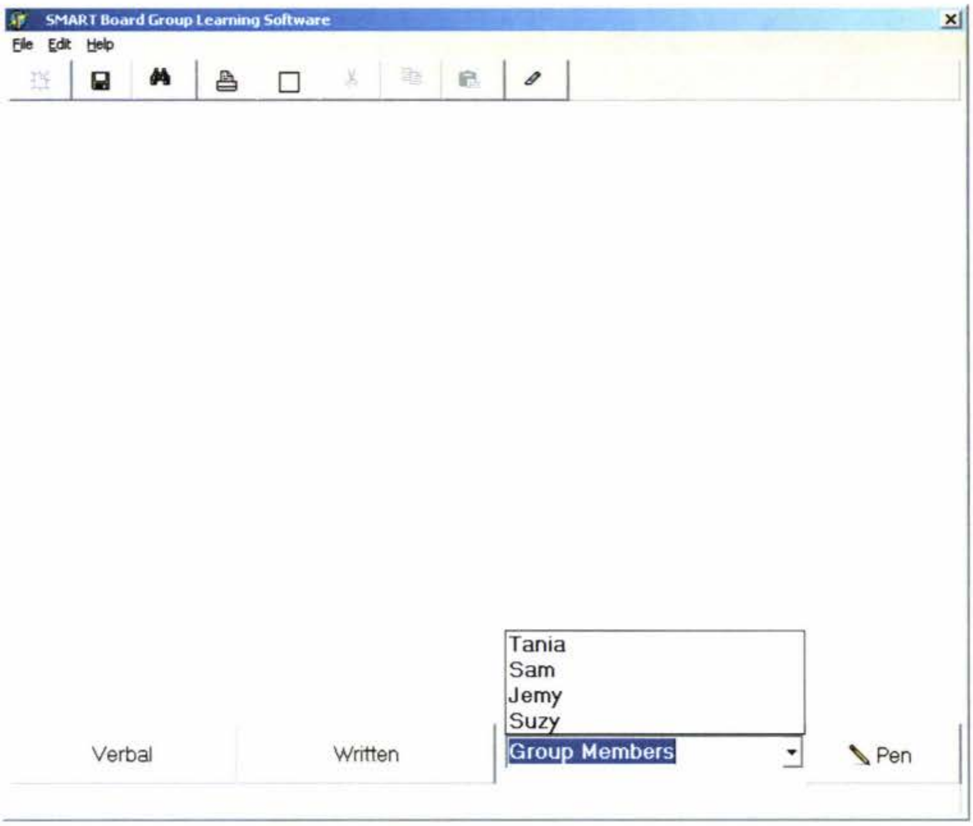

Figure F.6 Choosing member name

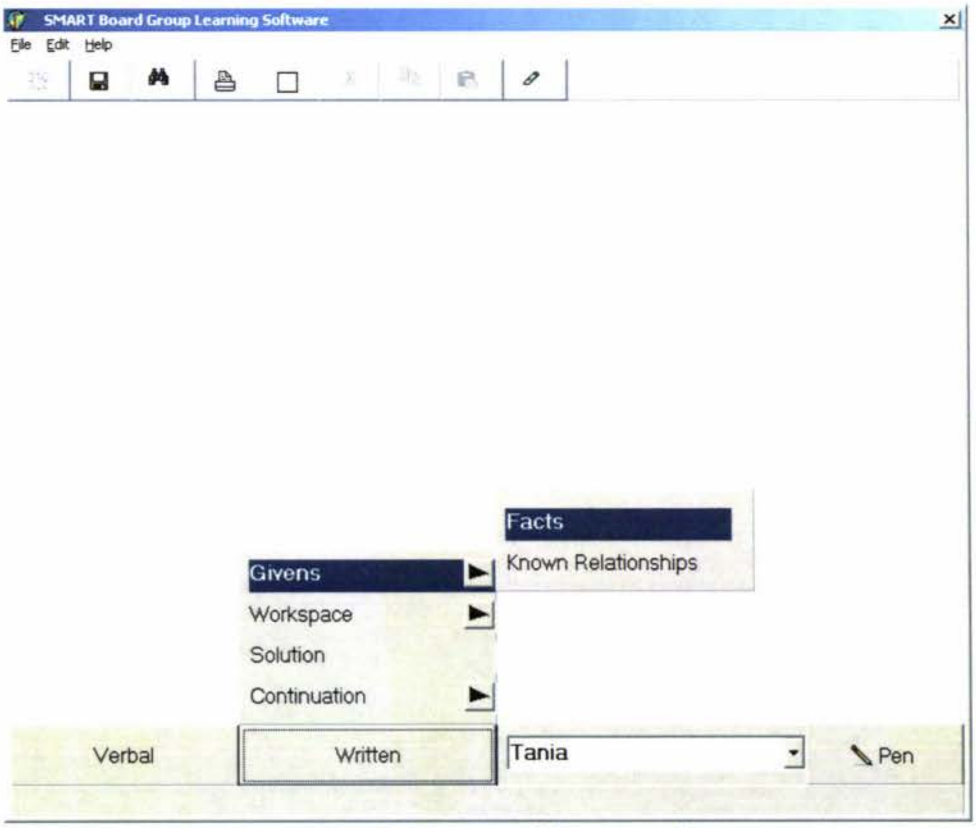

Figure F.7 Choosing Written-> Givens -> Facts

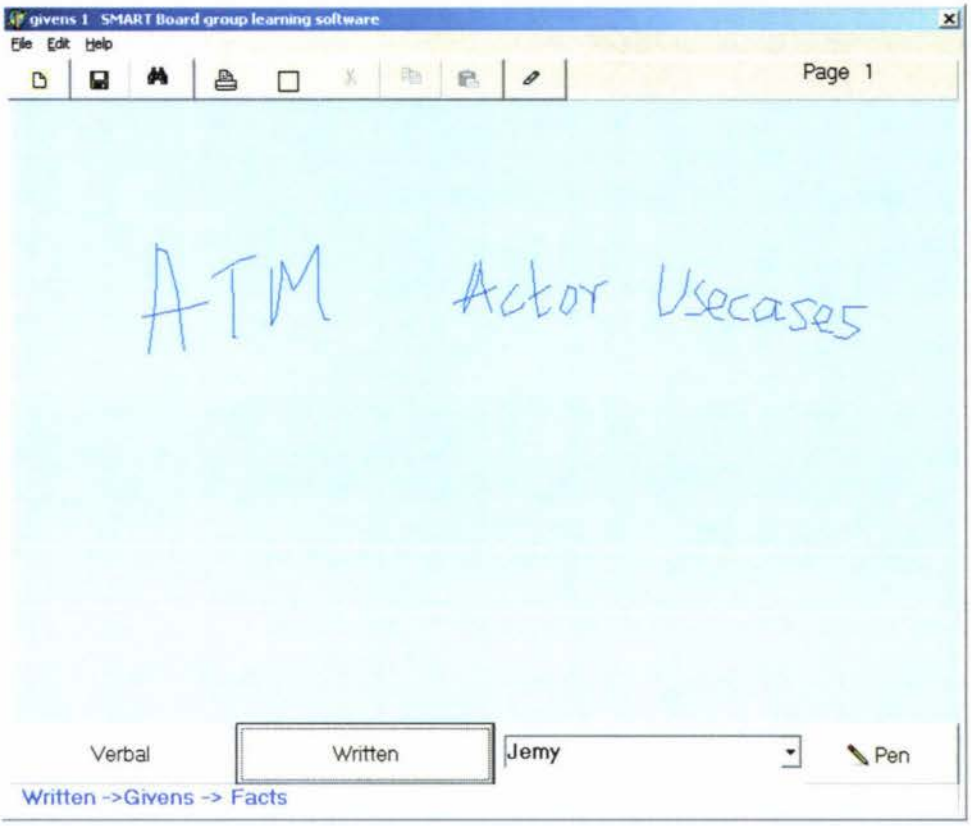

Figure F.8 Jemy's contribution after Choosing Written-> Givens -> Facts

Tania wishes to contribute next. She follows these following steps

- Selects her name from the "Group members" list.
- Selects **written** contribution
- Selects **Workspace**
- Selects "**Idea**" (Figure F.9)
- Clicks on "**Idea**"

Since this is a new page, system has allocated page name "workspace 1" and page number 2. Now the background colour turns to light green and the pen colour changes to green. Tania adds a contribution (Figure F.10)

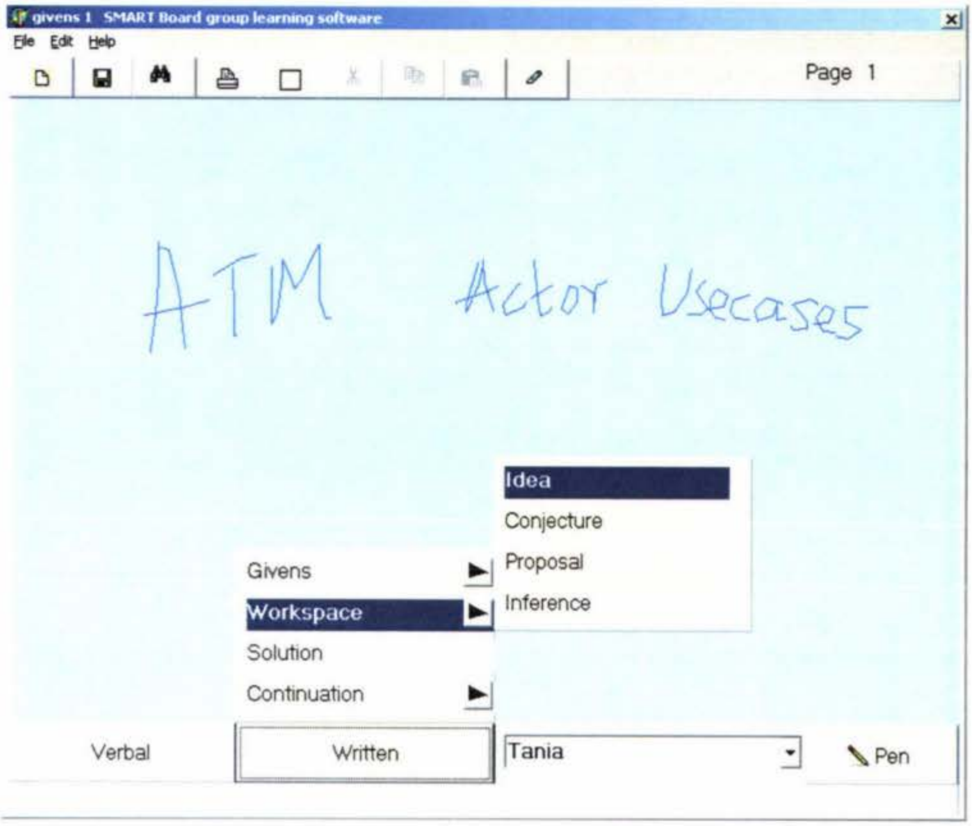

Figure F.9 Choosing Workspace->Idea

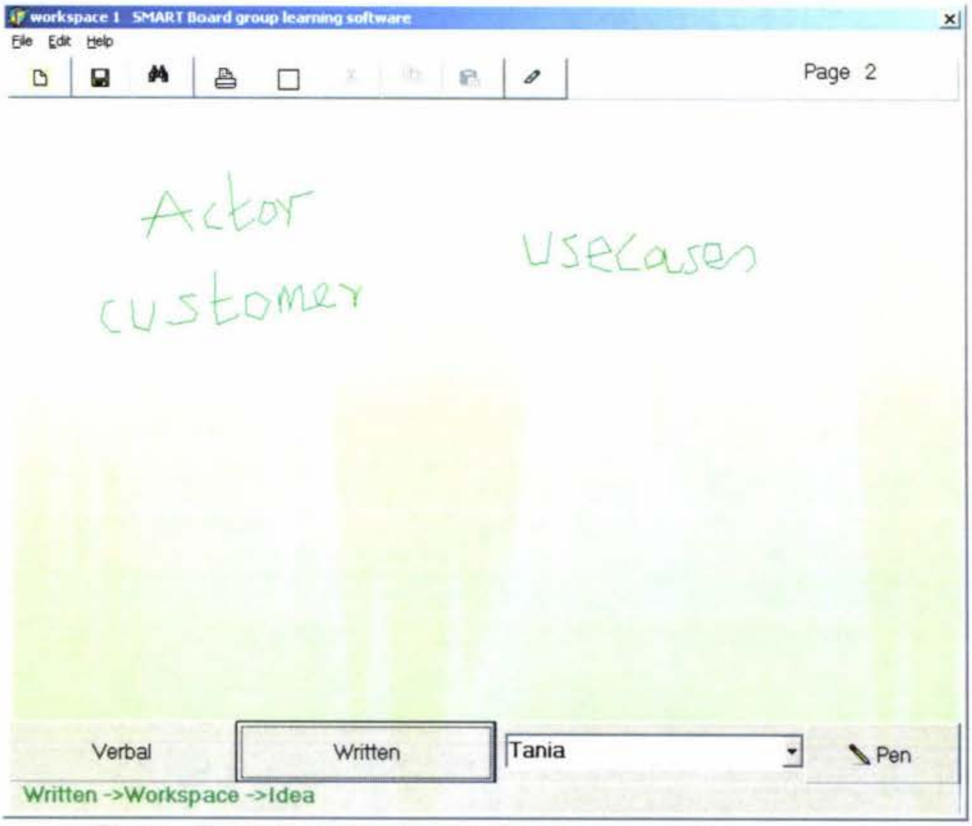

Figure F.10 Contribution on Workspace page

Sam wishes to contribute next and he follows these steps.

- Selects name from the "Group members" list.
- Selects **written** contribution
- Selects **Continuation**
- Clicks on "**Addition**" (Figure F.11)

Since this is continuation page, there is no change in page name, page number, background colour and the pen colour. Sam adds a contribution to workspace page (Figure F.12).

Suzy wishes to contribute to the solution. Suzy follows these steps below

- Selects name from the "Group members" list.
- Selects **Written** contribution
- Selects **Solution** (Figure F.13)

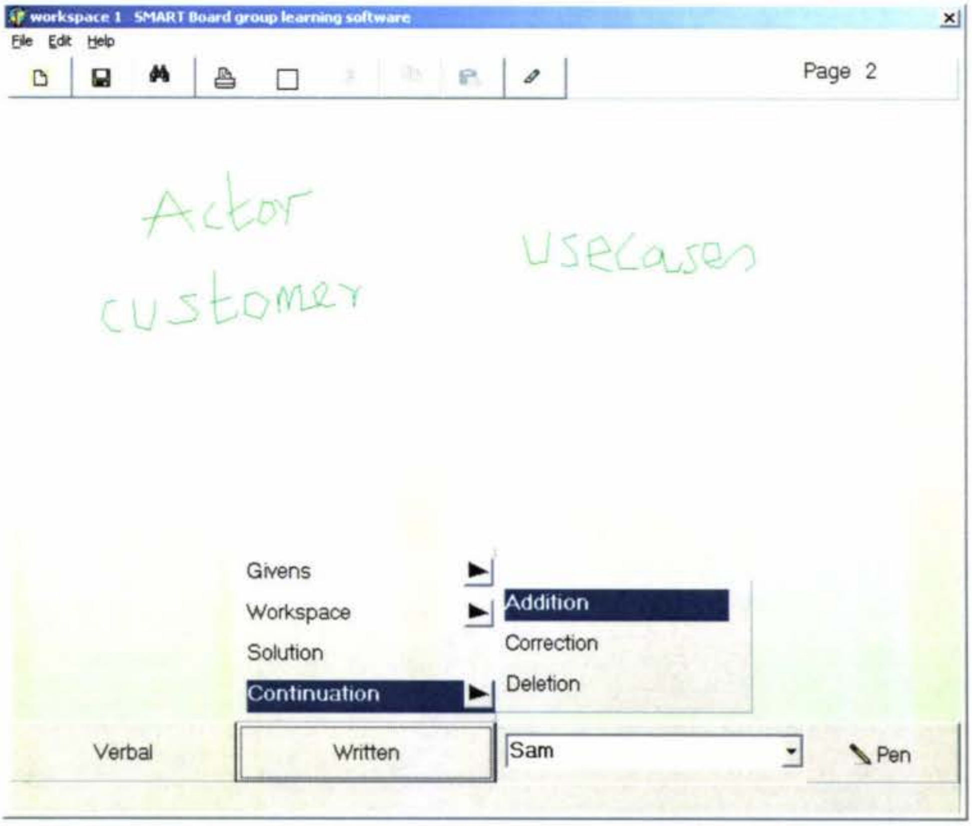

Figure F.11 Choosing Continuation->Addition

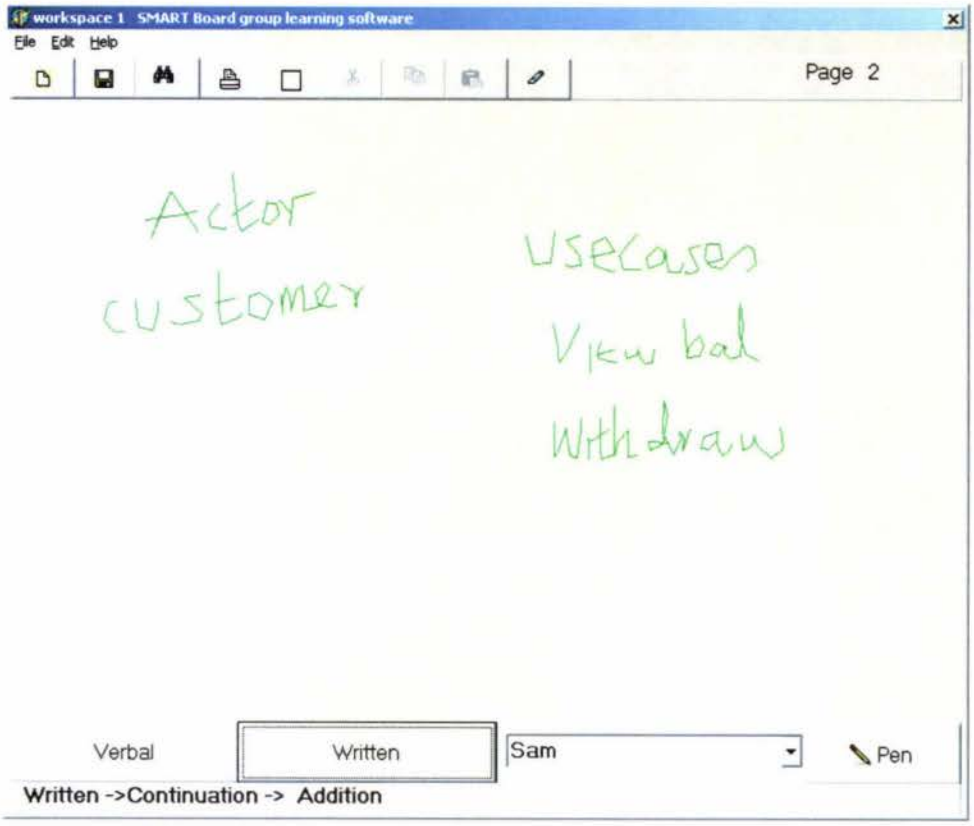

Figure F.12 Contribution to Workspace

Tania wishes to contribute next and she follows these steps.

- Selects name from the "Group members" list.
- Selects **written** contribution
- Selects **Continuation**
- Selects **Addition** (Figure F.14)

Since this is continuation page, there is no change in page name, page number, background colour and the pen colour. Tania add her contribution to workspace page (Figure F.15).

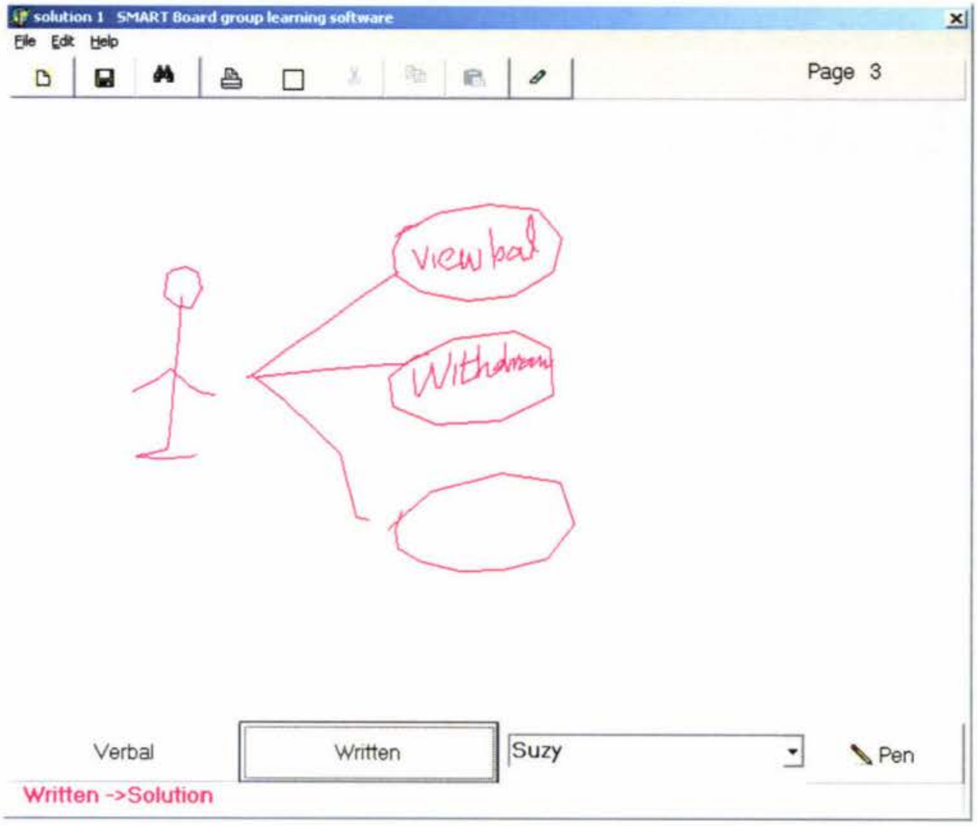

Figure F.13 Contribution to Solution page

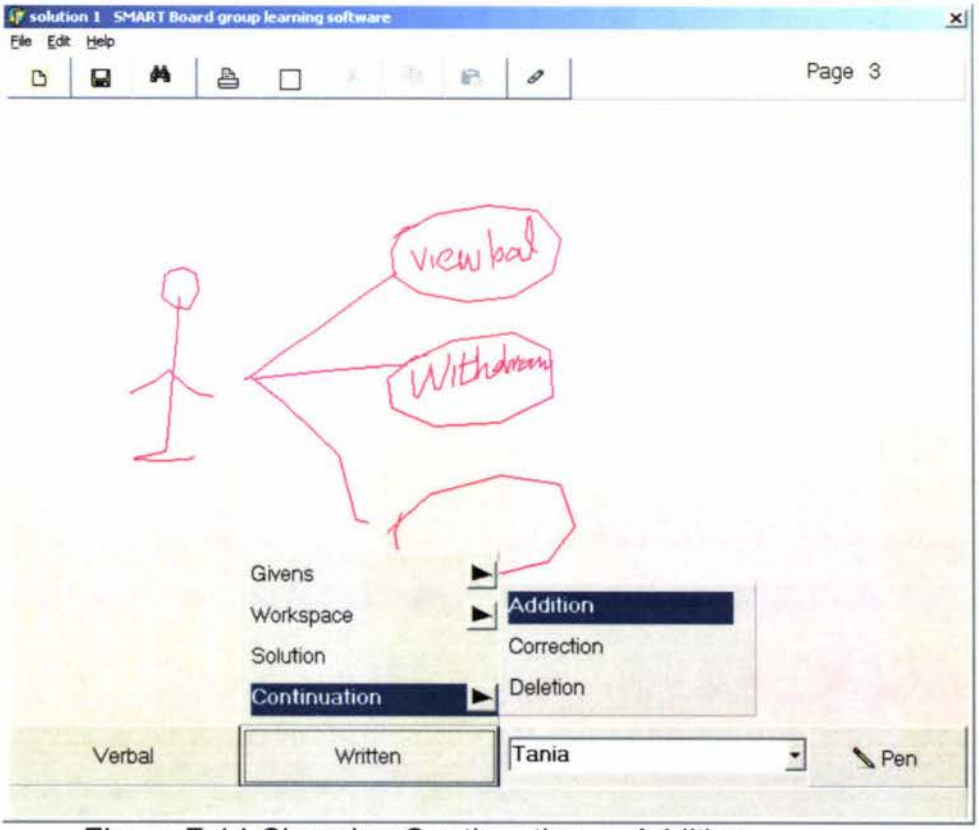

Figure F.14 Choosing Continuation -> Addition

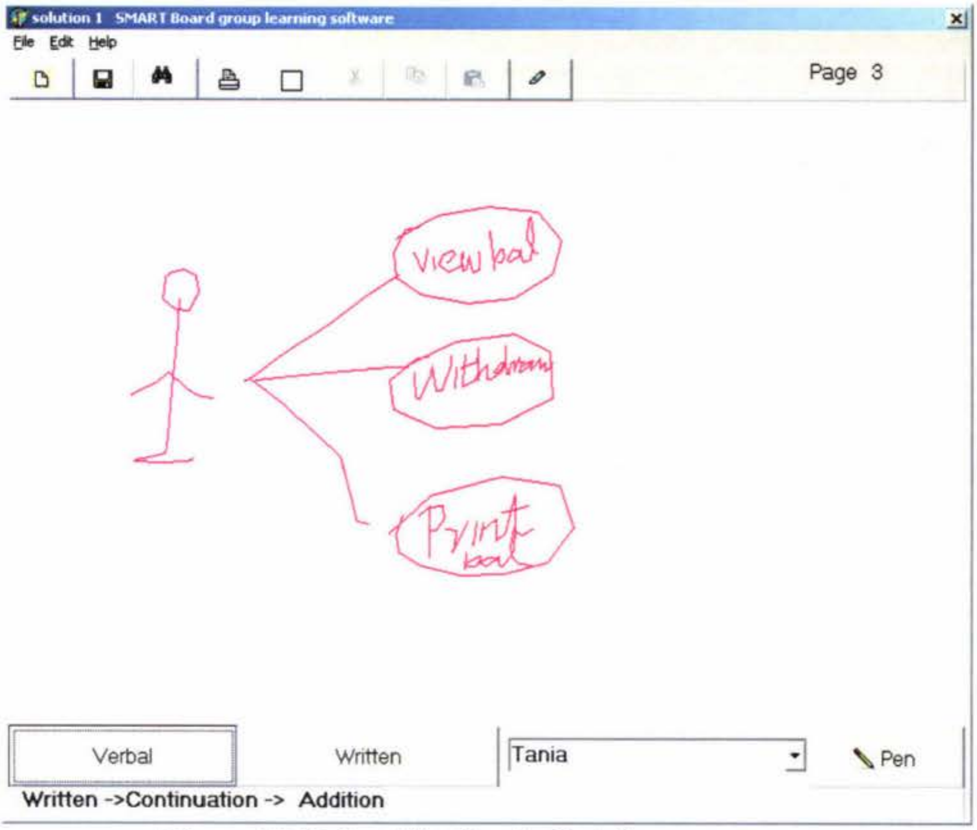

Figure F.15 Contribution to Solution

Jemy wishes to say something so she follows these steps below.

- Selects name from the "Group members" list.
- Selects **Verbal** contribution
- Selects **Agreement**
- Selects **I think that what we have so far is right** (Figure F.16)

This is shown in Figure F.17.

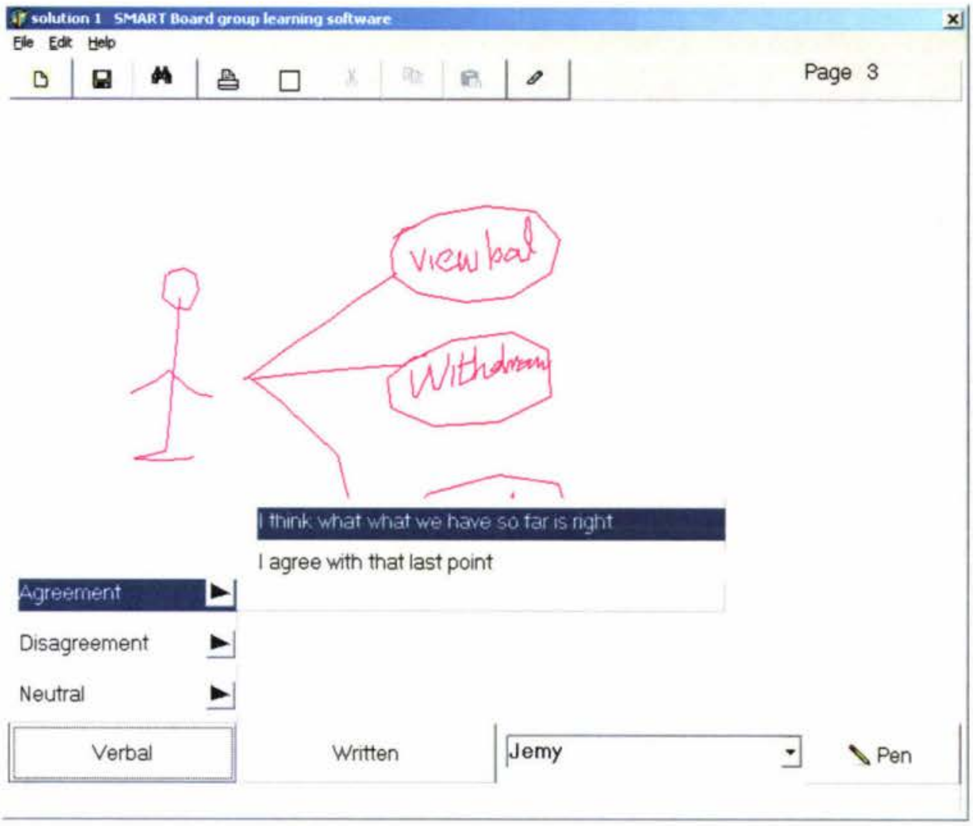

Figure F.16 Verbal Contribution

Sam wishes to contribute next. He follows these steps below.

- Selects name from the "Group members" list.
- Selects **written** contribution
- Selects **Workspace**
- Selects "**Idea**"
- Clicks on "**Idea**"

Since this is already created page, the latest accessed given page is shown in the screen. Sam adds a contribution (Figure F.18).

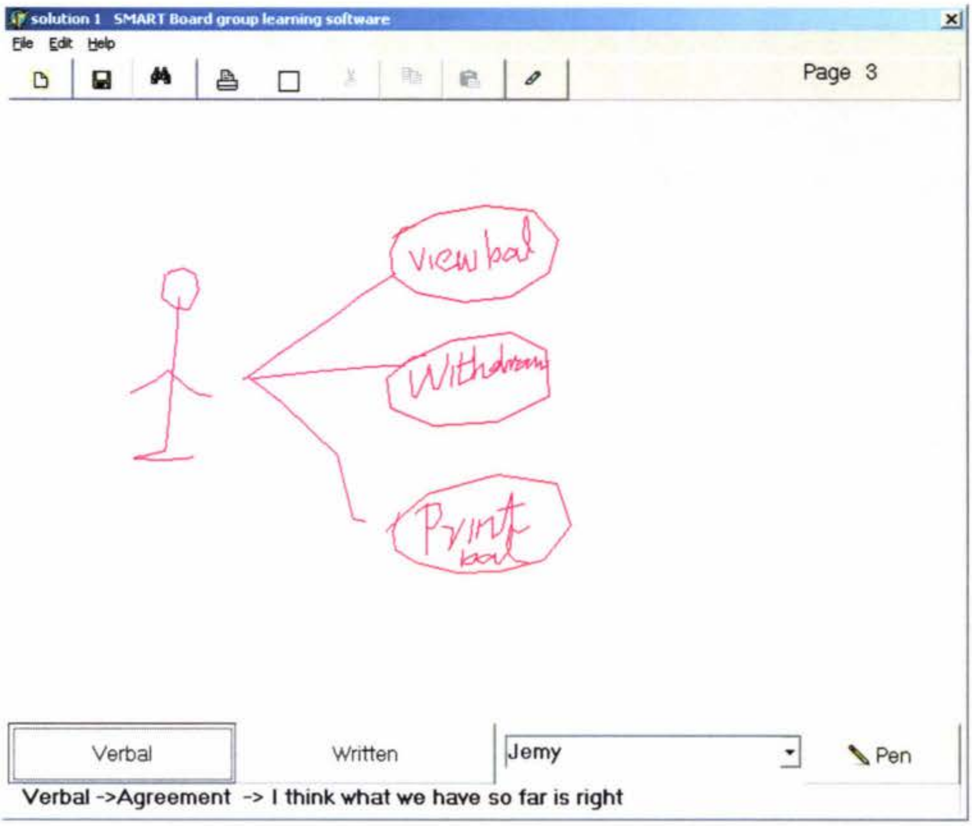

Figure F.17 Verbal Contribution

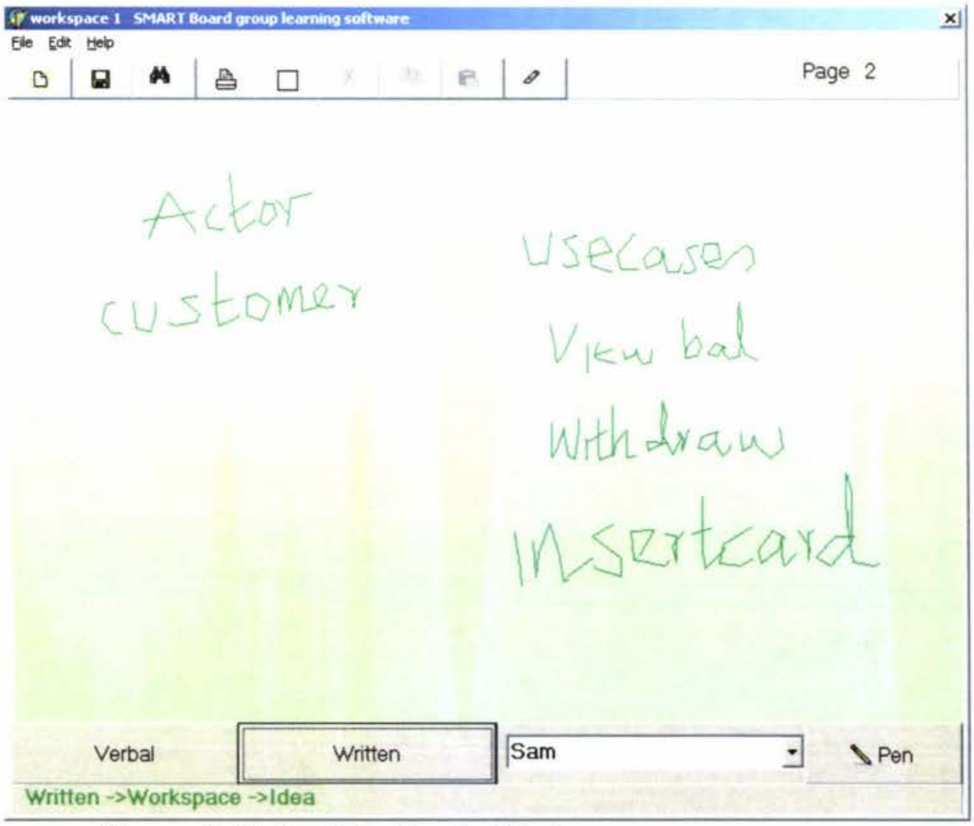

Figure F.18 Contributing to Workspace page

Jemy wishes to say something regarding this so she uses a verbal contribution and she follows these steps below.

- Selects name from the "**Group members**" list.
- Selects **Verbal** contribution
- Selects **Disagreement**
- Selects **I disagree with the last point** (Figure F.19)
- Again selects **Neutral** and then selects "**Do you agree with me**"
- Again selects **Neutral** and then selects "**Let me explain**" (Figure F.20)

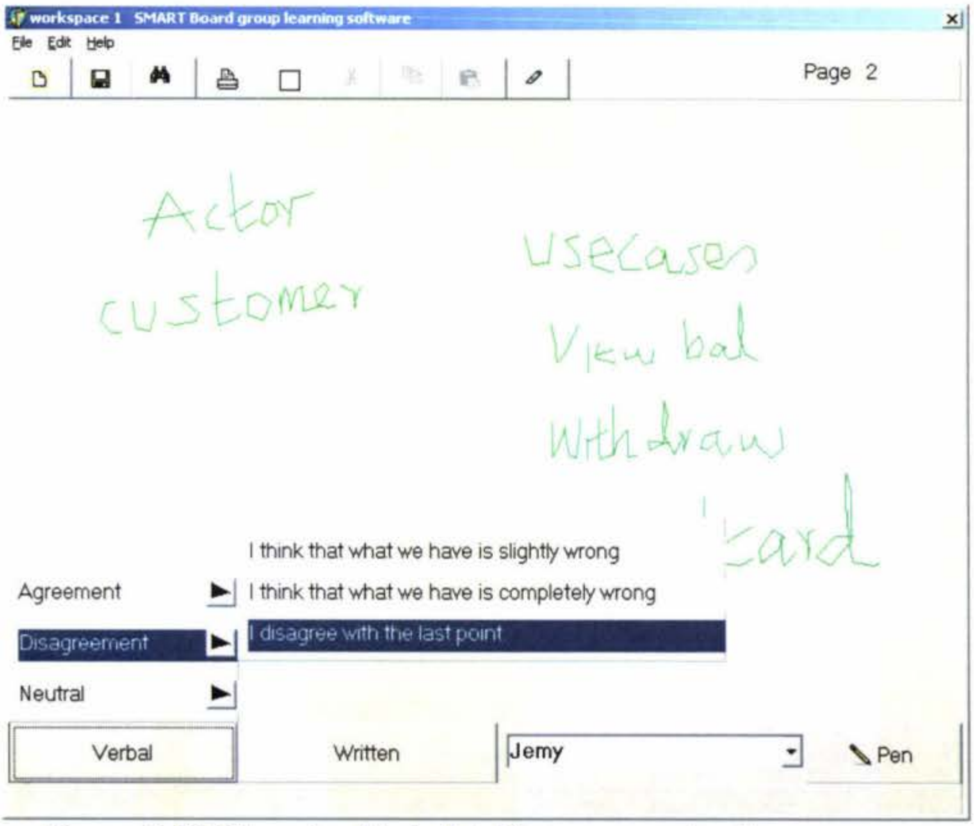

Figure F.19 Choosing Verbal ->Disagreement option

Jemy first highlights this area and then explains:

- Clicks on the "**highlight**" option in the toolbar
- Highlights a rectangle area (Figure F.21).

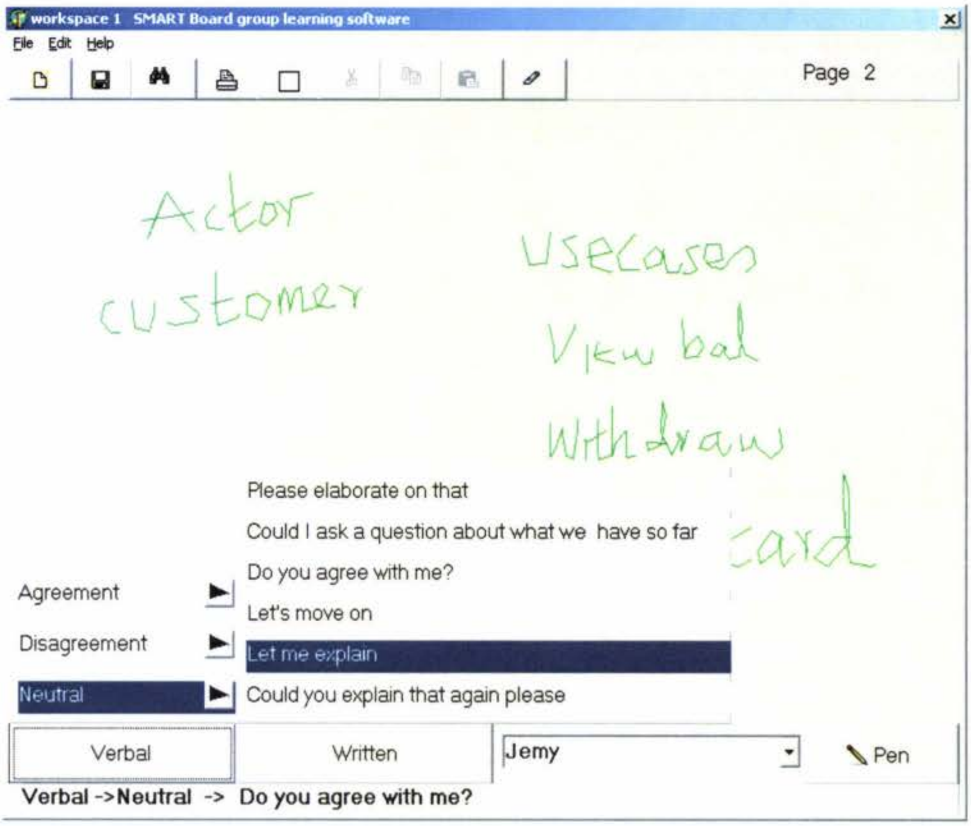

Figure F.20 Choosing Verbal ->Neutral option

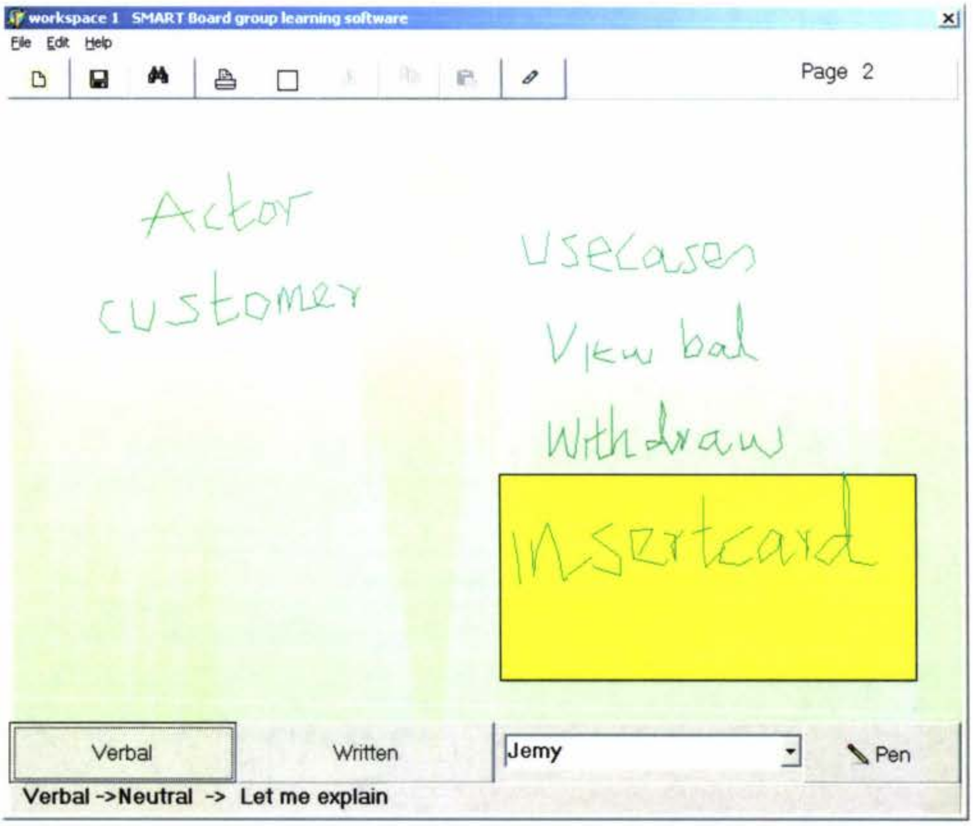

Figure F.21 Highlighting an area

Jemy explains and others agree with that. Then Jemy chooses the steps below

- Selects **written** contribution
- Selects **Continuation**
- Selects "**Deletion**" (Figure F.22)
- Clicks on "**Deletion**"

And she wants to delete that area and follows the steps below

- Clicks on the "select" option in the toolbar
- Selects that area (Figure F.23)
- Selects "Cut" option (Figure F.24)
- Selects "Save" option

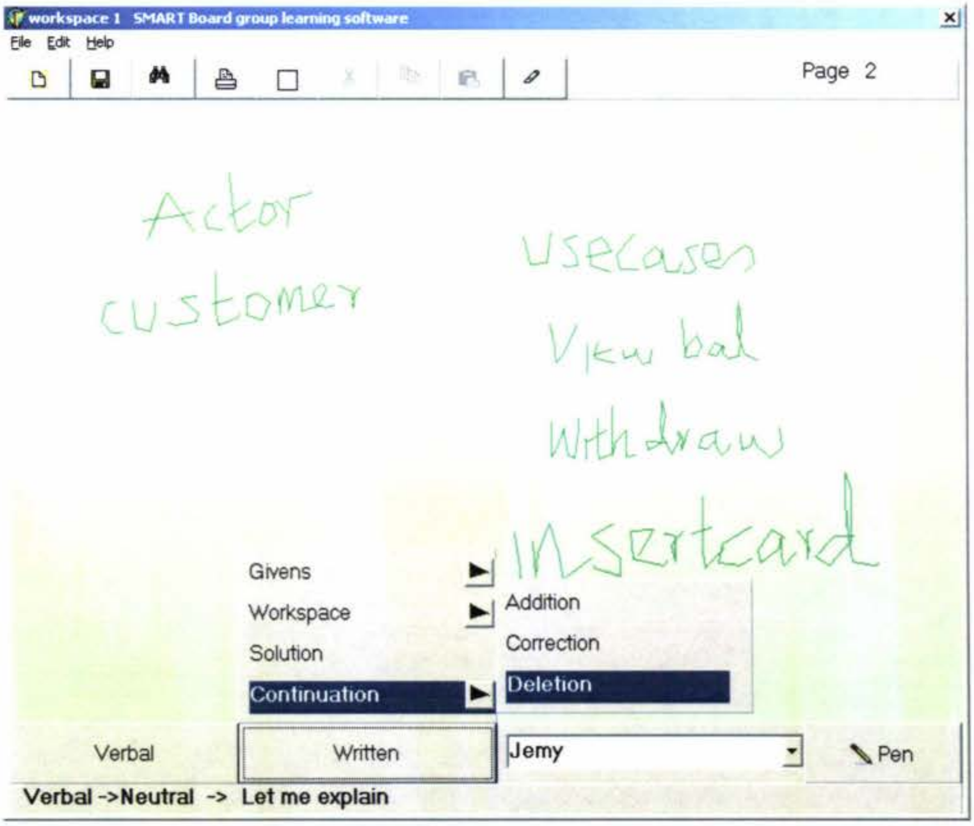

Figure F.22 Choosing Continuation ->Deletion

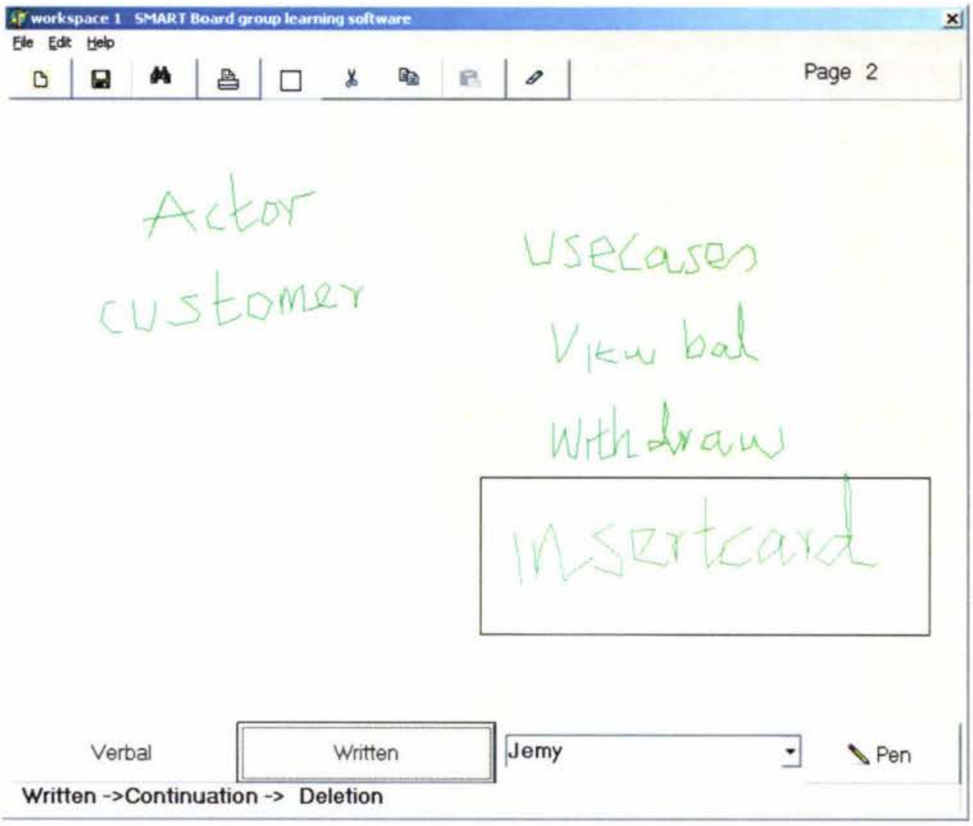

Figure F.23 Selection for "cut"

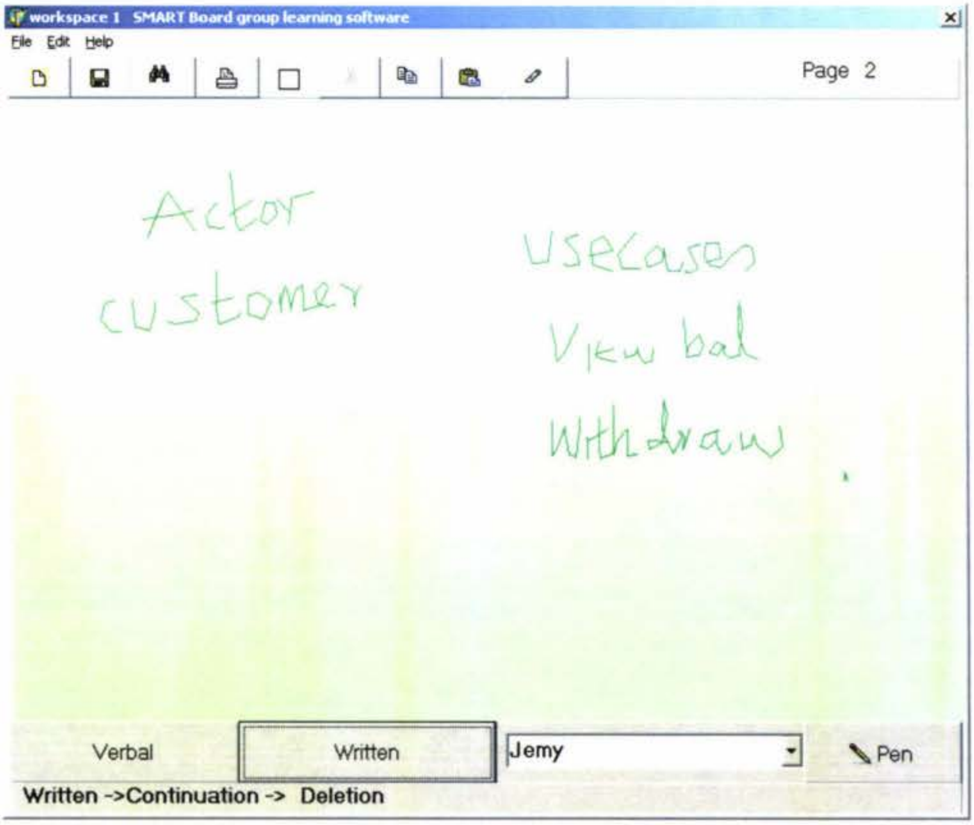

Figure F.24 Deleted the area

Sam wishes to contribute to the solution and he uses these steps below

- Selects name from the "Group members" list.
- Selects **Written** contribution
- Selects **Solution**

Sam adds contribution to the solution and he creates a new page for the final solution (Figure F.25)

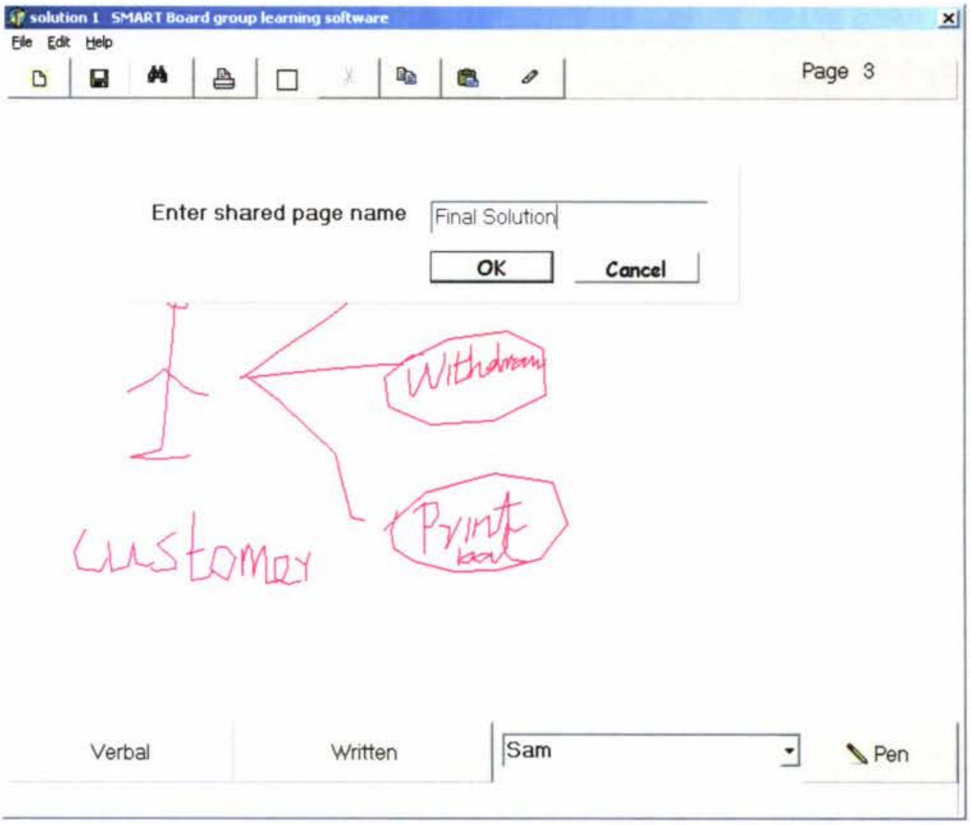

Figure F.25 Create new page "Final Solution"

Sam opens the **solution 1** previous page and selects an area from the previous solution page and he uses the following steps

- Clicks "**Find page** "
- Select **solution 1** (Figure F.26)
- Double clicks on the page name
- Clicks **Select** and Selects an area (Figure F.27)
- Selects **copy**

- Clicks "**Find page** " and select "**Final Solution**" page
- Selects **Written->solution**
- Selects **paste**
- Clicks on the **final solution** page (Figure F.28)
- Sam adds the heading to page (Figure F.29)

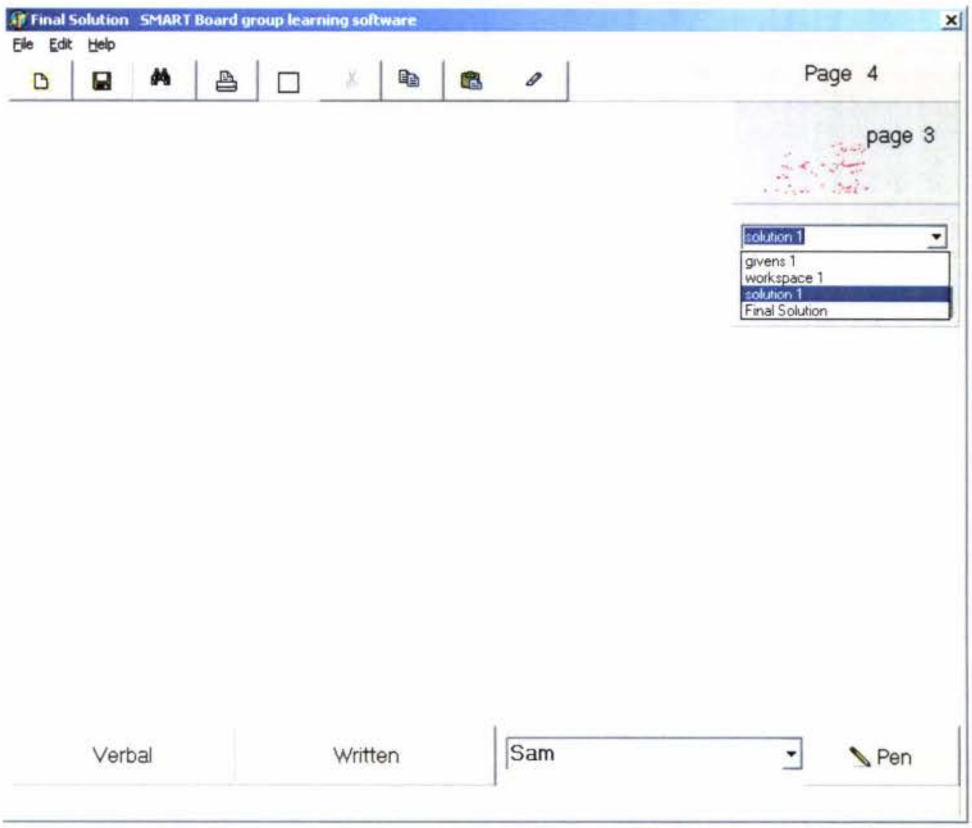

Figure F.26 Choosing page name

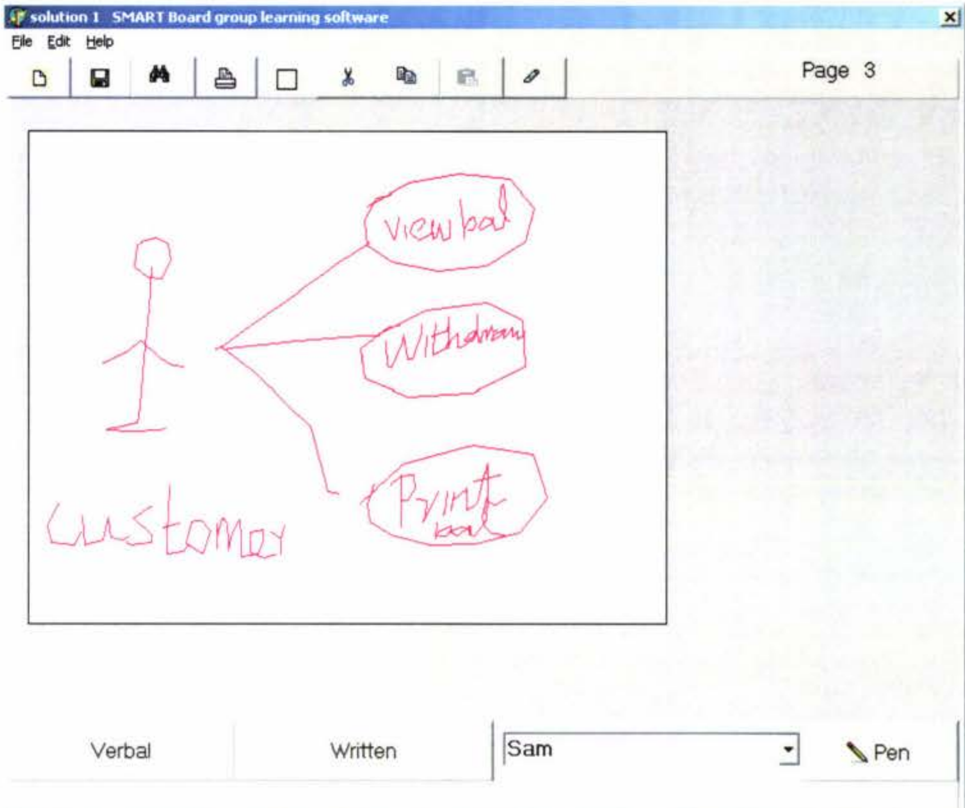

Figure F.27 Area selection

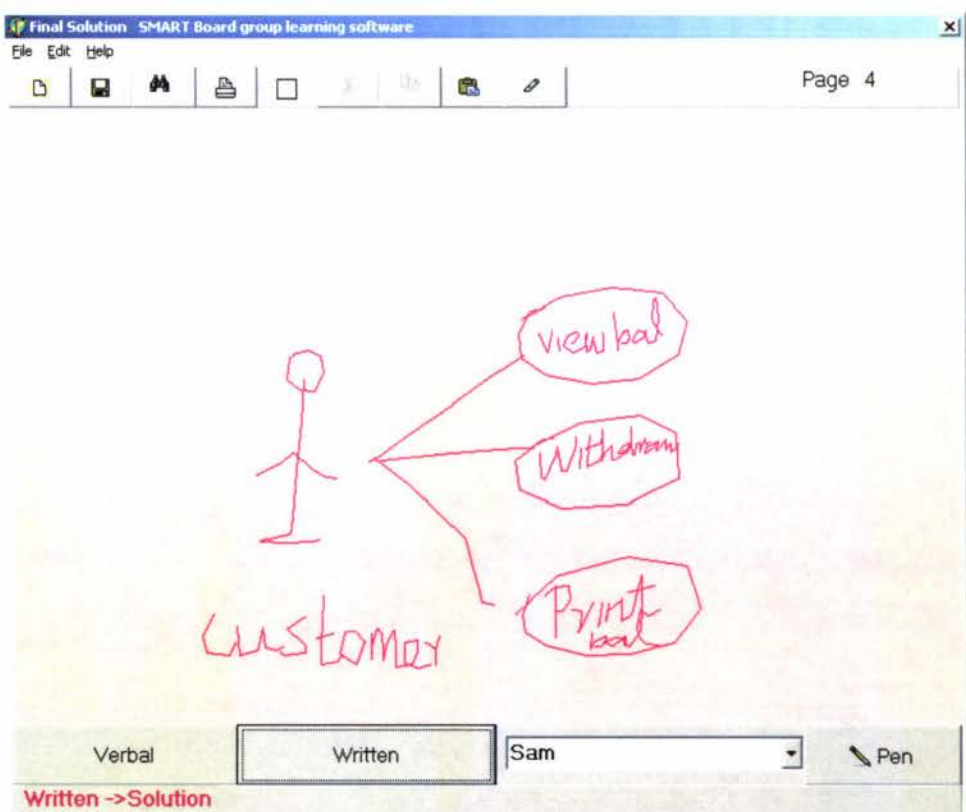

Figure F.28 Pasting the Area

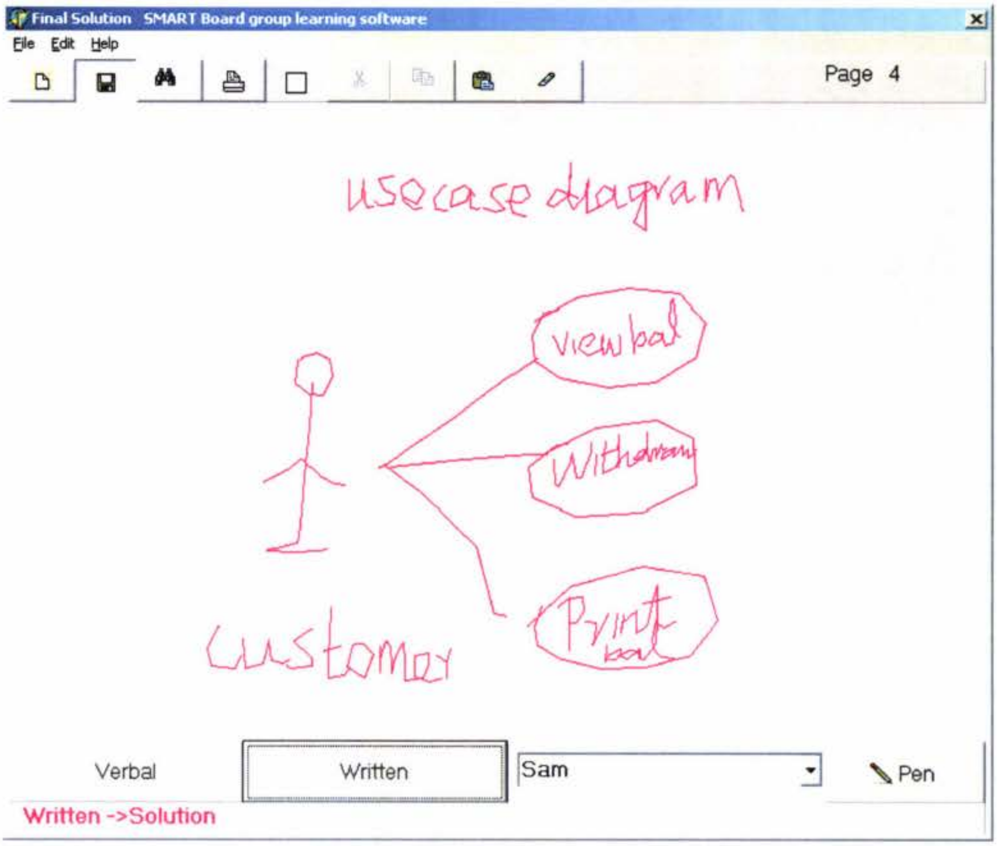

Figure F.29 Final Solution

2. Interaction History Document

During the session the system created an interaction history document. The following section provides the details of the document.

****

****
Group interaction document
Date : 19/05/2003
Time : 13:52:01
****
****

Jemy
Start Time 13:53:53
Givens Page number : 1
Givens >>> Facts

End Time 13:56:01

****

Tania
Start Time 13:56:05
Workspace Page number : 2
Workspace >>> Idea

End Time 13:57:41
****

Sam
Start Time 13:57:46
Continuation >>> Addition

End Time 13:58:58
****

Suzy
Start Time 13:59:09
Solution Page number : 3
Solution >>> Solution

End Time 14:00:47
****

Tania
Start Time 14:00:50
Continuation >>> Addition

End Time 14:02:07
****
Jemy
Start Time 14:02:09
Verbal ->Agreement -> I think what we have so far is right

End Time 14:02:48
****
Sam
Start Time 14:02:56
Workspace Page number : 2
Workspace >>> Idea
Solution Page number : 3
Solution >>> Solution
Workspace Page number : 2
Workspace >>> Idea

End Time 14:04:27
****
Jemy

Start Time 14:04:30
Verbal ->Disagreement -> I disagree with the last point
Verbal ->Neutral -> Do you agree with me?
Verbal ->Neutral -> Let me explain
Continuation >>> Deletion

End Time 14:07:12
****

Suzy
Start Time 14:07:14
Solution Page number : 3
Solution >>> Solution

Page number : 4

New Page name Final Solution

End Time 14:09:12
****

Sam
Start Time 14:10:15
Solution Page number : 4
Solution >>> Solution

End Time 14:11:14
****

Appendix G

Some useful Delphi programming code from the design

1. Drawing on the image

```
procedure TForm1.Image1MouseUp(Sender: TObject; Button: TMouseButton;
 Shift: TShiftState; X, Y: Integer);
begin
   if ssleft in shift then begin
                              stx:=x;
                              sty:=y;
                               image1.canvas.MoveTo(stx,sty);
                         end;
end;

procedure TForm1.Image1MouseDown(Sender: TObject; Button:
TMouseButton;
 Shift: TShiftState; X, Y: Integer);
begin
   if ssleft in shift then begin
                              stx:=x;
                               sty:=y;
                               image1.canvas.MoveTo(stx,sty);
                         end;
   ......
end;

procedure TForm1.Image1MouseMove(Sender: TObject; Shift: TShiftState; X,
 Y: Integer);
var i, j:integer;
begin
    newx:=x;newy:=y;
    if tool=pen then
    begin
        if ssleft in shift then
         begin
            if(((x>=left) and (x<=bmw)) and  ((y>=top) and(y<=bmh)))   then
                    begin
                        image1.canvas.pen.Width:=1;
                        image1.canvas.pen.style:=pssolid;
                        image1.canvas.lineto(x,y);
                    end;
         end;
    end;
end;
```

2. Pasting image (From 'Cut' or 'Copy')

```
procedure Tform1.imagePaste;
var  arect,src:Trect;
begin
    image2.Canvas.CopyMode := cmWhiteness; { copy everything as white }
    src:= Rect(0,0,sw,sh);  { get bitmap rectangle }
    arect:= Rect(newx,newy,newx+sw,newy+sh);
    image1.canvas.CopyRect(arect,Image2.Canvas, src); {copy bitmap over
                                                                 itself}
    arect.Left:=newx;arect.Top:=newy;
    image2.Canvas.CopyMode := cmSrcCopy; { restore normal mode }
end;
```

3. CreateOLEObject (Creating Word document)

```
      WordApp:= CreateOLEObject('word.Application');
       WordApp.Visible := True;
       WordApp.Documents.Add;
       WordApp.Documents.Item(1).SaveAs('Interaction.doc');
       WordApp.Documents.Item(1). paragraphs. add;
       Range:= WordApp.Documents.Item(1).Range;
numpars:=numpars+1; //variable name numpars
Range := WordApp.Documents.Item(1).Range(
              WordApp.Documents.Item(1).Paragraphs.Item(NumPars+
1).Range.Start,
             WordApp.Documents.Item(1).Paragraphs.Item(NumPars+
1).Range.End );
```

4. StretchDraw

```
name:= pagelist.Items[pagelist.itemindex]+'.bmp';
bm:=Tbitmap.Create;
r:=rect(8,8,161,89);
bm.LoadFromFile(name);
pageimage.canvas.StretchDraw(r,bm);
```