# A Web-Based Tool To Support Jigsaw Collaborative Learning Technique

*A thesis submitted to*
*the Faculty of Computer Science & Information Technology,*
*University of Malaya*
*in Fulfillment of the Requirements for*
*the Degree of Master of Computer Science*


*by*


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*March 2004*


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# Abstract

The emergent of the Internet and World Wide Web has made collaborative learning feasible to be carried out in a web-based environment. Computer Supported Collaborative Learning (CSCL) utilizes the use of information and communication technology as a mediation tool within collaborative methods of learning. At the same time, a number of applications started to make use of the agent technology to enhance their applications. This thesis endeavors to develop a web-based tool which utilizes web agents in supporting primary schools jigsaw collaborative learning. First, literature reviews on the theoretical aspects of collaborative learning are carried out. It covers the collaborative learning definition, its benefits and limitations as well as various collaborative learning techniques. The reviews further investigate CSCL and its applications for supporting primary schools education particularly in Malaysia. Then, it attempts to support the jigsaw activity proposed by a group of teachers from a workshop carried out in year 2000. As a result, a G-Jigsaw process model is formulated which comprises of Initial Level, Expert Level and Jigsaw Level of collaborations. This process model restructured the Initial Level of Aronson's Jigsaw Classroom technique to allow students' collaboration throughout every level of the collaborative session. Secondly, reviews on software agent literature, specializing on web agent are carried out. It describes how a multi-agent architecture is formulated to enable the web agents to communicate with each other in simplifying and automating the jigsaw activities. Further, this thesis presents the development and implementation of G-Jigsaw that incorporates the process model, the multi-agent architecture and the deployment of web agents in supporting the jigsaw collaborative learning. Next, it highlights the teachers (pilot testing) and students (hands-on testing) evaluations and the results indicated that

web agents greatly simplified the complex jigsaw processes. Finally, the research contributions and future enhancements are enclosed.

# Acknowledgement

Normally, dissertation research resembles a solitary expedition. As one of the team members in this collaborative project however, I view this research as a joint effort too. The work reported here, at least, would not have achieved the current stage without support, discussions, and other forms of collaboration with many people, a few of whom are mentioned below.

Firstly, I wish to express my heartiest gratitude to my supervisor, Assoc. Prof. Dr. Siti Salwah Salim for giving me the opportunity and environment to carry out my research under her supervision. I thank her for her confidence in me, for her intellectual support, for her the time spent reviewing my system and commenting drafts of my thesis chapters.

Secondly, I feel fortunate for being part of the members in Human Computer Interaction Laboratory (HCI Lab). I am grateful to both current and former members who has been working hard the Lab: Siti Soraya Abdul Rahman, Rafidah Pakir Mohamad, Halimah Ab. Rahman, Abdul Majid Hissen, Kasthuri Subaramaniam, Kemalatha Krishnasamy, Nazila bt. Pardi, Latifah bt. Abd Latib. Their contributions range from reviewing G-Jigsaw at various stages (design, prototype and system), to assisting me to coordinate testing which involved large group of users. Special thanks to Rose Zaimi Mohd Zaid for her willingness in assisting me to proof read my thesis chapters.

Thirdly, I sincerely thank to a number of friends who have strengthened and challenged me at difficult moments throughout the research: Chuah Chong Wei, Peh Boon How,

Lim Khong Leng, Simon Seow Chen Siong, Huang Li Li, Ang Ley Poh, Beh Bee Luan, Lim Shueh Lih, Tan Ley Teng and Yap Bee Ling.

Fourthly, I would like to thanks the Sekolah Kebangsaan Putrajaya 2. Thanks to the school's headmaster Mr. Sukimin for his permission to conduct the testing, to Mr. Masnawi for assisting me in setting up the system at their school's environment and to Mr. Meor and Mr. Khairi for their cooperation in coordinating the teachers and students involved in the testing.

Finally, I thank my parents, Low Kwai Teng and Chin Ah Thaim for their fully support through my study and research. I wish I had devoted myself to them as much as I did to this work.

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# Chapter 1 – Introduction

Collaborative learning endorses active student participation in the learning process. In collaborative learning, students generally work together in small groups towards a shared learning goal. Collaborative learning emphasizes the collaborative efforts among students in their group along with the teachers' guidance. Students are accountable for their group members' learning as well as their own. Hence, the success of one student helps other students to be successful (Gokhale, 1995).

As Gokhale (1995) asserted, the concept of collaborative learning as well as the grouping and paring students for the purpose of achieving an academic goal has been widely researched and advocated throughout professional literatures. Therefore, it is undoubtedly that many of the collaborative learning benefits had been identified to date (Panitz, 1997a). For instance, collaborative learning enables more challenging tasks to be carried out without making the workload unbearable. Students engage in collaborative learning tend to be more active throughout the learning process. Besides, collaborative learning encourages diversity understanding by giving students the opportunity to express their opinions and discuss them in groups.

**Collaborative Learning Activities in Primary Schools**

Collaborative learning is a useful teaching method that can help teachers and students accomplish specific learning goal (Enerson et. al., 1997). Collaborative learning activities may range in size either from small assignment groups to large and complicated class projects. Class or group discussion, collaborative projects, group presentation and notes sharing are some of the common collaborative learning activities carried out in the primary schools (Walker et. al., 2000; Kasirun and Salim, 2001).

Traditionally, collaborative learning activities are carried out face-to-face in a classroom. Students engaging with collaborative activities are divided into small groups. In this way, student in a large class are given the opportunity to interact on a smaller scale, and prepare students for "real world" (Enerson et. al., 1997). For example, in a group discussion activity, students in a classroom are divided into smaller groups. These groups are given some reading materials and the students are required to discuss them in their group. Then, students of each group must present the discussion outcomes to the whole class in turns.

Nevertheless, collaborative learning activities require a lot of preparation (Enerson et. al., 1997). The success of a collaborative activity depends on the appropriateness of the task that students are asked to perform. As a result, preparing collaborative learning materials for students to carry out manually in a classroom is very time consuming. Fortunately, the rapid expansion and availability of communication and information technologies have made these collaborative learning activities possible to be carried out with the use of technologies.

**Technologies for Supporting Collaborative learning Activities**

The Internet started to emerge when the National Science Foundation, US withdrew most of its funding and opened the Internet to commercial organizations in 1991. The Internet begins to grow swiftly along with the creation of World Wide Wide (WWW) by Tim Berners-Lee (Aitken, 1999). Ever since then, the web has greatly revolutionizes the way of collecting, processing and manipulating information. Many of the traditional meaning and process of business, commerce, marketing, finance, publishing, education, research and development as well as other aspects of daily life are redefined and modernized (Aitken, 1999).

As the computational technologies emerge along with the prevailing wave of Internet and WWW, some collaborative learning activities are also being shifted to the electronic environments through various types of tools and applications (Scardamalia and Bereiter, 1994; Edelson et. al., 1995; Gibbs, et. al., 1998; Suthers, 1998). Under this new paradigm, new forms of computer mediated learning environment such as Computer Supported Collaborative Learning (CSCL) is introduced. CSCL refers to the field of study that examines the design, adoption and use of groupware. Groupware is a technology designed to facilitate the work of groups. It may be used to communicate, cooperate, solve problems, compete or negotiate (Brinck, 1998).

The rapid growth of network infrastructure and WWW has made both synchronous and asynchronous communication become feasible through the Internet. Hence, CSCL applications can support collaborative learning activities through synchronous and/or asynchronous collaboration. Synchronous collaboration involves the parties (learners, or learner and instructor) being online at the same time and communicating in real-time. On the other hand, asynchronous collaboration involves the parties communicating over elapsed time.

To date, even though there are quite a number of CSCL applications that have been developed to support collaborative learning activities using computer technology through the network and Internet, nevertheless, little attention little attention has been paid to how CSCL applications can support children's collaborative learning (Crawley, 1997b; Cockburn and Greenberg, 1998). In a study conducted by Crawley (1997), only two out of the thirteen CSCL applications support children's collaborative learning. Cockburn and Greenberg (1998) further affirm that although much has been learned about how adults work together through groupware, little attention has been paid to how

children collaborate through real-time groupware. If primary school teachers are provided with the right CSCL applications, they will be able to carry out the collaborative learning activities in their teaching curriculum (Salim, et. al., 2001). As a result, there is an increasing demand on CSCL applications which support children collaborative learning.

In parallel with the successful of Internet and WWW, the agent arena is facing an increasingly active, rapidly evolving and expanding progress. The agent technology is expected to be eventually as profound as the WWW. Web agents have many potential roles in assisting both teachers and students in carrying out their collaborative learning activities (Lang, 1995; Lashkari, 1995; Pazzani el. at., 1996; Starr et. al., 1996; Joachims et. al., 1997; Luke and Hendler, 1997). At the time of writing, there are already a few efforts that attempt to deploy web agents in the educational arena (Adriano et. al., 1999; Jafari, 1999; Andoh et. al., 2001). However, the review on these agent systems indicated that the use of web agents for supporting the collaborative learning is not fully explored yet.

## 1.1 Research Overview

This thesis presents a web-based tool which utilizes the web agents to support jigsaw collaborative learning activity. It intends to formulate a process model to support the teachers' proposed module namely G-Jigsaw during a workshop conducted in year 2000. It describes how the G-Jigsaw process model restructures the initial level of the jigsaw activity based on the teachers' proposal and Aronson's Jigsaw Classroom (Aronson and Patnoe, 1997) to enable the students to collaborate at every level throughout the jigsaw session. Further, it presents the development and implementation

of a G-Jigsaw that incorporates the process model. It also describes how a multi-agent architecture formulated in enabling the web agents to simplify and automate the jigsaw activities. Finally, it highlights the teachers (pilot testing) and students (hands-on testing) evaluations as well as the research contributions and future enhancements.

## 1.2 Research Motivations

This research is motivated by three main trends, i.e. the emergence of the Internet and WWW, the demands of CSCL applications for primary education as well as the maturity and rapid growth of agent technology. The first trend provides a vast network infrastructure that makes the use of information and communication technology (ICT) feasible. The second trend enables the primary school teachers to carry out collaborative learning activities in their teaching curriculum more easily and the last trend has great potentials in augmenting some complex collaborative activity's flows and processes as well as performing some back end tasks on behalf of its user.

The advancement of Internet together with the emergence of WWW has provided an effective medium for web-based collaborative learning (Eugenia and Ada, 2002). This evolution towards a dynamic learning environment through the web has led to an intensive necessitate for communication, collaboration and problem solving. Thus, it is plausible to assume that there is an increasing demand on web-based collaborative learning applications that utilize the Internet and WWW as a medium of communication and interaction to support the collaborative learning activities.

Studies on most of the well known CSCL applications indicated that most of these applications emphasized more on higher education and distance learning collaboration.

Very little attentions are being paid for students in lower education (Crawley, 1997b). In Malaysia particularly, countless hours of searching the journals, conference papers and Internet revealed that no CSCL applications for primary school students are being developed. Investigations carried out by Kasirun and Salim (2001) also highlighted the lack of CSCL applications for schools in Malaysia. Thus, there are needs to identify, design and develop CSCL applications for the teachers and students to carry out collaborative learning activities in Malaysian's primary schools.

At the same time, there is also a drastic switch in software agent development towards Information/Internet agents, or more commonly known as web agents, where they fully utilize the Internet and WWW as a medium of interaction. Web agents are automated programs, which perform tasks of gathering, clustering and filtering information from the web on behalf of their users. In conjunction with this swiftly information superhighway, web agents are getting more and more important roles in the software agent research and development that reside on various domains. The studies of web agents in supporting the collaborative learning activities can help to enhance the collaborative learning applications (Jafari, 1999; Andoh et. al., 2001).

## 1.3 Research Objectives

The research reviews on the collaborative learning and software agent literature, specializing on the jigsaw technique and web agents, in an attempt to develop a web-based tool called G-Jigsaw in supporting jigsaw collaborative learning technique for Malaysian primary schools. The objectives of this research are summarized as follow:

   i. To formulate a G-Jigsaw process model that promotes primary students collaboration in a web-based environment.

ii. To formulate a multi-agent architecture that supports the deployment of web agents to automate and simplify the jigsaw activities.

iii. To develop G-Jigsaw, a web-based tool that incorporates the jigsaw process model in supporting primary students' collaborative learning.

iv. To conduct testing for teachers and students in primary schools to evaluate the success of G-Jigsaw.

## 1.4 Research Scopes

In concurrence with the objectives, the scope of the thesis is defined in order to provide a general guideline on the range and depth of the research. The following statements summarize the scope of the thesis in accordance with the stated objectives:

i. Collaborative learning is a very broad research domain to be studied. This research focuses on CSCL applications that support primary school students' collaborative learning. Other domains of collaborative learning will not be covered.

ii. The field of software agent is rooted from artificial intelligence. However this research does not focus on the artificial intelligence aspects. The emphasis of this research is to utilize the web agent technology in supporting the student's collaborative learning activities. Thus, issues such as intelligent agents will not be considered.

iii. The web agents developed are aimed to automate and simplify the jigsaw activity flows and processes in supporting the student's collaborative learning. Other aspects of web agent implementation such as assessment agents or pedagogical agents are not in the scope of this research.

iv. The testing is intentionally customized for primary teachers and students.

Further testing on how G-Jigsaw will support the secondary schools, colleges and universities students are beyond the scope of this research.

## 1.5 Research Methodology

The methodology used in this research comprises the following steps as listed below:

1. Carrying out reviews in the field of collaborative learning, focusing on the collaborative learning activities, various collaborative learning techniques as well as the inadequacy of CSCL applications in supporting primary schools education in Malaysia.

2. Inviting a group of primary school teachers to participate in a workshop. The workshop aims to brainstorm the collaborative learning activities carried out in their primary schools and the problems that occurred, as well as to propose modules in supporting activities that are suitable to be carried out in primary schools in Malaysia. G-Jigsaw is one of the proposed modules which is the focus of this research.

3. Identifying and eliciting the system requirements from the literature review and workshop. The literature review provides foundation for the techniques and technologies to support various collaborative learning activities while the workshop provides real life teaching experiences on how these collaborative learning activities can be conducted in a classroom.

4. Formulate a G-Jigsaw process model based on the teachers' proposal and Aronson's Jigsaw Classroom. The process model modifies Aronson's Jigsaw Classroom to fulfill the proposed G-Jigsaw's requirements by restructuring the first level jigsaw activities. This enables student collaborations at every level throughout the jigsaw collaborative learning session.

5. Developing a prototype to incorporate the process model. This prototype provides a good understanding on how well the process model has been incorporated. It serves as a blueprint on how the prototype can be further enhanced.

6. Carrying out reviews on software agent, specializing in web agents, on how to support collaborative learning utilizing web agents. Based on the reviews, the process model and the developed prototype, the potentials of web agents are identified.

7. Developing a multi-agent architecture to support the deployment of web agents. The architecture facilitates the web agents' communication in order to automate and simplify the complex jigsaw process.

8. Implementing a web-based tool called G-Jigsaw. G-Jigsaw provides a web-based collaborative environment and tools for students to participate in jigsaw activities.

9. Evaluating the success of G-Jigsaw by conducting a pilot test with teachers. The suggestions and feedbacks are collected via questionnaire. The bugs and errors detected from the pilot test are fixed. The flow and functionality of G-Jigsaw are improved.

10. The enhanced version of G-Jigsaw is re-evaluated through the student hands-on testing. The feedback is gathered via questionnaires.

11. Producing the first version of G-Jigsaw as a web-based tool to support jigsaw-type collaborative learning.

**Research Methodology**

1. Literature Review on Collaborative Learning
2. Workshop
6. Literature review on Software Agent
3. Jigsaw Classroom technique
   G-Jigsaw Proposal
7. Multi-Agent Architecture
4. G-Jigsaw Process Model
5. G-Jigsaw Prototype
8. G-Jigsaw Module
9. G-Jigsaw Pilot Testing for Teachers' Evaluation
10. G-Jigsaw Hands-on Testing for Students' Evaluation
11. G-Jigsaw Web-based Tool

Note: ① to ⑪ are the steps described in the research methodology

**Figure 1-1 Research Methodology**

## 1.6 Thesis Organization

The organization of this thesis is generally divided into three parts. The first part of the thesis, comprising chapters 2, 3 and 4 cover the literature review, investigation and discussion of various aspects on collaborative learning and software agents as well as introducing a process model in supporting the jigsaw collaborative learning technique.

Chapter 2 investigates the theoretical aspects of collaborative learning in supporting primary schools collaborative learning activities, which serves as the domain of this research. Specifically, it covers the collaborative learning definition, its benefits and

drawbacks and various collaborative learning activities with different collaborative learning techniques. It highlights the CSCL applications and focused on how CSCL can be implemented in Malaysian primary schools. It also presents the WebCL (Web-Based Collaborative Learning System) project and its workshop evaluation.

Chapter 3 introduces a G-Jigsaw process model to support the jigsaw collaborative learning. It studies Aronson's Jigsaw Classroom technique and discusses the formation of the process model in depth. It also investigates tools that support the jigsaw technique. Chapter 4 reviews on various aspects of software agents. These include agents' definitions, typologies and architectures. Then, it specifically focused on web agents, as well as its categories and deployment in supporting collaborative learning activities.

The second part of the thesis, consisting chapter 5 and 6 covers the development of G-Jigsaw. Chapter 5 presents the analysis and design of G-Jigsaw. Chapter 6 further explains the implementation of G-Jigsaw along with the deployment of web agents.

The last part of the thesis consist of chapter 7 and 8, which depicts the evaluation and results of G-Jigsaw as well as its future enhancements. The G-Jigsaw's evaluations are enclosed in Chapter 7. Finally, chapter 8 concludes the entire thesis, highlights the research contributions that have been achieved and provides some suggestions for future work on this research.

# Chapter 2 – Collaborative Learning

This chapter explores the field of collaborative learning, which serves as the domain for this research. It discusses the theoretical aspects (i.e. definition, benefits and drawbacks) and various types of collaborative learning techniques. This chapter also presents Computer Supported Collaborative Learning (CSCL) and its applications for supporting primary and secondary schools education. It further narrows down the scope by focusing on CSCL in the Malaysian schools. Finally, the chapter introduces the WebCL (Web-Based Collaborative Learning System) project, its workshop evaluation and a proposed module namely G-Jigsaw.

## 2.1 Collaborative Learning Definition

Collaborative learning is an umbrella term for a variety of educational approaches involving joint intellectual efforts by students, or students and teachers together (Smith and MacGregor, 1992). To collaborate means to work together, which implies a concept of shared goals and an explicit intention of "add value" – to create something new or different through a deliberate and structured collaborative process, as opposed to simply exchanging information or passing on instructions (Kaye, 1994). Concisely, the term collaborative learning is an idea of small, interdependence groups of students working together as a team to achieve a common learning goal.

Collaborative learning emphasizes on collaborative efforts among students in their group along with the teacher's guidance. It is a process whereby each member contributes personal experience, information, perspectives, insight, skills and attitudes with the intent of improving learning accomplishments of others. The group's collective

learning ultimately becomes possessed by each individual (Klemm, 1994). In most collaborative learning situations students work in small groups, mutually searching for understanding, meanings or solutions while the teachers provide guides for their students. Students are accountable for one another's learning as well as their own. Thus the success of one student helps other students to be successful (Gokhale, 1995).

Besides, Panitz (1997b) views collaborative learning as a personal philosophy rather than just a classroom technique. Collaborative learning suggests a way of communicating with people that respects and highlights individual group members' abilities and contribution in all collaborative learning situations. As a result, there is a sharing of authority and acceptance of responsibility among group members for the group actions. Additionally, Zhao and his colleagues (2001) further supplements collaborative learning where knowledge is not something that is delivered to students, but rather emerges from active dialogues among those who seek understand and apply concepts and techniques (Zhao et. al., 2001). Hence, collaborative learning can be exciting for students because they are actively engaged in a discussion rather than passively attaining information.

## 2.2 Benefits of Collaborative Learning

Proponents of collaborative learning insist that tremendous benefits are found with collaborative learning. There is a list of 59 benefits of collaborative learning that had been identified by Ted Panitz (1997a). This chapter reviews and extracts only the important advantages that are related to this research.

Collaborative learning can help students to develop higher level of thinking skills

(Webb, 1982). In collaborative learning environment, students working together engaged actively in the learning process rather than just passively listening to information presented by their teacher. Throughout the learning process, students formulate ideas, discuss them, receive immediate feedback as well as respond to questions or comments. Therefore, students are able to develop their leadership, oral communication and social interaction skills. These will lead students to a higher self-esteem.

Besides, collaborative learning fosters team building and team approach to solve problems while maintaining individual accountability (Cooper et. al. 1990; Johnson et. al. 1984). One of the key element of collaborative learning is group forming. Students engaged in collaborative learning will gain benefits from the group building and group processing techniques via various collaborative learning activities (e.g. group project). Activities such as group tests or group quizzes that require individual answers but the results are evaluated by groups help to promote individual accountability. Hence, these types of activities maintain a strong element of accountability by each group member.

In addition, collaborative learning will be able to simulate critical thinking and assists students to clarify their ideas (Gokhale, 1995). During the students' discussion and debate activities, they will be able to formulate ideas, except other group members' ideas as well as discuss, criticize and debate these ideas. As a result, these activities are able to enhance students' critical thinking skills. Furthermore, students will be able to accept and understand their own culture and other group members' cultures. Thus, students are able to view situation from different perspectives that will lead them to diversity of understanding and promote multiple perspectives.

Another important advantage of collaborative learning is that it allows more challenging tasks to be carried out without making the working load unreasonable (Felder, 1997; cited from Panitz, 1997a). This is accomplished by creating each group members independency such as in Jigsaw procedure where each student is responsible towards his/her group members and for the group success. This approach results in group members pooling their knowledge and resources. Thus, it is feasible to carry out more challenging and advance activities which are not possible to be carried out individually. Therefore, larger projects become attainable by dividing the project into smaller groups.

## 2.3 Limitations of Collaborative Learning

Even though the above benefits of collaborative learning are established, however there are still some drawbacks in collaborative learning. Laister and Koubek (2001) pointed out some disadvantages of collaborative learning as listed below:

i. Many teachers feel that they are loosing control over the learning process and that therefore their effectiveness and their contribution to the learning process are being diminished.

ii. There are difficulties in evaluating collaborative learning students with traditional individual teaching criteria.

iii. There are pressure on shy students and those who find it difficult to get along in groups in general.

## 2.4 Collaborative Learning Techniques

Over the years, many different types of collaborative learning techniques have been developed to carry out student collaborative learning activities in class. This section briefly overviews some major collaborative learning techniques. The descriptions of

various collaborative learning techniques in the following sections are adapted from (Knight and Bohlmeyer, 1990; cited from Bell, 1996) and (Zhao and Akahori, 2001).

### 2.4.1 Circles of Learning (Learning Together)

Learning Together is a technique originally developed by Johnson and Johnson (1975). Based on this technique, a group of students pursuing a definite goal will share their ideas and learning materials. Then the groups are rewarded according to their level of performance. A new version, which is developed under the name "Circles of Learning" (Johnson et. al., 1984), comprises eighteen steps that can be easily be adapted to fit a particular subject or topic.

### 2.4.2 Student Teams-Achievement Division (STAD)

STAD is a technique developed by Slavin that involves group competition and rewards (Slavin, 1980). In STAD, students are assigned to four-member learning groups heterogeneously by ability, gender and ethnicity. The teacher presents a lesson and the student work together within their group to master the lesson given. Then, all the students are required to take quizzes individually. The group score is accumulated from individual student score that meet or exceed their own earlier performances. The groups that successfully achieve certain criteria may earn certificates or other rewards. The groups have to be of equal strength for this technique to be truly effective.

### 2.4.3 Teams-Games-Tournaments (TGT)

According to DeVries and Slavin (1978) TGT uses tournaments in which students of comparable ability compete with each other. Unlike STAD, this technique replaces the

quizzes with weekly tournaments (academic games). In TGT, students play the games at three-person "tournament tables". The winners for each round compete with the runner up and the loser. Points collected during each tournament will contribute to the group score.

### 2.4.4 Team-Assisted Individualization or Team-Accelerated Instruction (TAI)

TAI is also developed by Slavin. It is a technique that shares with STAD and TGT technique that uses four-member mixed ability learning groups and certificates for high-performing groups (Slavin, 1985). However, the individualization part of TAI makes it differ from STAD and TGT. In TAI, students work on their individual units according to their level of ability. Group members then check each others' work against the answer sheet and help each with any problem before resorting to the teacher.

### 2.4.5 Group Investigation (GI)

GI is a highly structured technique advocated by Sharan and colleagues (Sharan et. al., 1984). In GI, students work in small groups using cooperative inquiry, group discussion and cooperative planning and projects. It comprises six successive stages with high degree of student involvement. Students are engaged in choosing a general topic and sub-topics, involve in the investigation planning and its implementation as well as the analysis and the evaluation on information they gathered. Then, the results of their research are presented to the whole class to be evaluated.

### 2.4.6 Co-op- Co-op

The Co-op- Co-op method is originally used by Kagan with his university students who enrolled in a psychology course with the intention of increasing their involvement and allowing them to explore in depth topics in which they were particular interested (Kagan, 1985). This method tries to foster the intelligence, the natural curiosity and the expressiveness of students and includes provisions for evaluating individual student's work through its ten steps of students' collaboration. It is easier to be carried out by the post secondary level students.

### 2.4.7 Cooperative Integrated Reading and Composition (CIRC)

CIRC is a comprehensive program for teaching reading and writing in the upper elementary and middle grades (Madden et. al., 1986). In CIRC, students work in pairs within their groups on a series of cognitively engaging activities, including reading to one another, making predictions about how narrative stories will be resolved, summarizing stories and practicing spelling, decoding and vocabulary. Therefore, students are able to master main idea and other comprehension skills. During language arts periods, students also write drafts, revise and edit one another's work, and prepare to "publish" their writing.

In most CIRC activities, students follow a sequence of teacher instructions, group practices, group pre-assessments and quiz. Group rewards and certificates are given to each group based on the average performance of all the group members on their reading and writing activities.

### 2.4.8 Jigsaw Classroom

Aronson and his colleagues developed Jigsaw Classroom technique in 1978 (Aronson et. al., 1978). In this technique, each member in each group is assigned to a particular task, problem or topic. Then, members from all the different groups whom are pursuing the same task meet to research and/or discuss their responsible task. Finally, they return to their original group to share the results of their discussions.

## 2.5 Computer Supported Collaborative Learning (CSCL)

Barbara Wasson (1998) defines CSCL as an emerging paradigm for research in educational technology that focuses on the use of information and communication technology (ICT) as a mediation tool within collaborative methods of learning. Its main characteristic is that the role of technology consists of giving assistance to the human elements of the educational process (teacher and student) in order to enable collaborative learning processes.

CSCL focuses on how collaborative learning supported by technology can enhance peer interaction and work in groups as well as how collaboration and technology facilitate sharing and distributing of knowledge and expertise among community members (Lipponen, 2001). Furthermore, CSCL is based on the promise that computer supported systems can support and facilitate group process and group dynamics in ways that are not achievable by face-to-face. However, they are not designed to replace face-to-face communication.

CSCL examines the design, adoption and use of groupware for learning purpose. Groupware is a technology designed to facilitate the work of groups. It may be used to

communicate, cooperate, solve problems, compete or negotiate (Brinck, 1998).

### 2.5.1 CSCL Applications

CSCL applications are applications that have been developed for specific purpose of supporting group learning (Crawley, 1997b). Although studies have been carried out on how colleges and universities students learn together through the CSCL applications, for instances CLARE – Collaborative Learning and Research Environment (Wan, 1994), CaMILE – a Collaborative and Multimedia Interactive Learning Environment (Guzdial, 1997), CoMentor (Gibbs, et. al., 1998) and TheU (Contact Consortium, 1998), little attention has been paid to how CSCL applications can support children's collaborative learning (Crawley, 1997b; Cockburn and Greenberg, 1998). As a result, only a few CSCL applications are intended for primary and secondary school children. The following section reviews four CSCL applications that support children's collaborative learning. The applications include Belvedere (Suthers, 1998), CoVis (Edelson, et. al., 1995), CSILE (Scardamalia & Bereiter, 1993; 1994) and TurboTurtle (Cockburn and Greenberg, 1998).

**Belvedere (Suthers, 1998)**

The Belvedere project aims to develop educational technology and associated student activities in science. The activities introduce students (from 12 to 15 years old) to the give-and-take process of theory formation and revision. It provides a graphical computer environment that can be displayed on networked computer. Belvedere is designed to support problem-based collaborative learning scenarios using evidence and concept maps. Students use it to construct and reflect their ideas through "inquiry diagrams". They work together to state and compare alternative theories and arguments

about them, and change them in response to new evidence or criticism. Through the Belvedere, students learn critical inquiry skills that they can apply in science and everyday life.

Belvedere Inquiry Diagrams are designed to help students express graphically how ideas are connected. These ideas can come from scientific articles or from their own knowledge, experiments and research. Belvedere assists students to keep track on their and other students' ideas by allowing students to map a problem out graphically. It also helps the students to figure out whether there is more information required to strengthen or complete an idea. The visual depiction of ideas and relationships help students to experience the abstract ideas.

Belvedere comprises two significant software tools namely Collaborative Inquiry Tools and programs that coach students. The Collaborative Inquiry Tools include a Collaborative Inquiry Database, which stores various kinds of information relevant to students' projects, including a record of each group's on-line discussion or debate, reference materials with author for each project, suggested experiments and individual notes; Inquiry Diagrams, which uses shapes for different types of statements and link different kinds of relationships between these statements and Textual Displays for students to summarize their work and writing reports. In addition, programs that coach students are used to coach student contributions, point out relevant information and identify problematic argument. Besides, Belvedere supports multiple views of students' evidence models: they can view their model as a graph, matrix or hierarchy. Each view supports students' learning in different ways.

**CoVis – Collaborative Visualization (Edelson, et. al., 1995)**

The CoVis Project is vision to reform and improve science education through the use of moderate and wideband computer networks. Therefore, it is able to establish distributed learning and teaching communities through software to support collaboration and communication, Internet direct to the classroom, scientific visualization and inquiry tools, video or audio conferencing with screen sharing as well as professional development for teachers (Gomez and Pea, 1996). It serves as a test-bed that explores issues of scaling, diversity and sustainability as they relate to the use of networking technologies that enable high school students to work in collaboration with remote students, teachers, and scientists.

In CoVis project, students (K-12) study science through inquiry-based activities. Utilizing the scientific visualization software, which specifically modified to be appropriate in a learning environment, students have access to the same research tools and data sets used by leading-edge scientists in the field. "Collaborative Visualization" thus refers to development of scientific understanding, which is mediated by scientific visualization tools in a collaborative context.

CoVis provides students with a range of collaboration and communication tools. These include: desktop video teleconferencing; shared software environments for remote, real-time collaboration; access to the Internet resources; a multimedia scientist's "notebook"; and scientific visualization software. In addition to deploy new technology, the CoVis project team works closely with teachers at participating schools to develop new curriculum and pedagogical approaches that take advantage of the project-enhanced science learning.

**CSILE – Computer Supported Intentional Learning Environments (Scardamalia & Bereiter, 1993; 1994)**

CSILE is an educational knowledge media system for Studies in Education that focus in intentional learning. It is designed to support students in purposeful, intentional, and collaborative learning in a local network environment. CSILE emphasizes on building a classroom culture supportive of active knowledge construction that can extend individual intentional learning to the group level. Its purpose is to make students (fifth or sixth grade) think and reflect their thought process that provoke question asking and answering in a public forum.

Students can select different communication modes (text, video, audio, animation) to generate "nodes." These nodes contain ideas or information that is related to topics they study. Nodes are available for others to comment on, lead to dialogues and an accumulation of knowledge. CSILE promotes student cognitions through "thinking type" prompts that direct individuals to define personal learning goals, reflect on personal knowledge gaps, construct theories and so on. Such facilities were developed to help students practice and hopefully master some of the higher-level cognitive operations that are typically associated with autonomous thinkers and learners.

In a CSILE classroom, each computer workstation is connected to a multimedia database that contains the ongoing research of the class. All "notes" (the files used in CSILE) are placed in a common area, where they are viewable by all. Students connect their notes to other students' notes through facilities provided. This enables student to share information, answer each other questions and provide advice more easily in CSILE's on-line environment. The strength of this approach is that it objectifies the knowledge of the classroom and makes the advancement of that knowledge a social

activity. All questions, theories, ideas, information and discoveries are preserved in the database for the analysis of the entire class.

**TurboTurtle – (Cockburn and Greenberg, 1998)**

TurboTurtle is a dynamic multi-user microworld or computer simulations of restricted environment and it's used for the exploration of Newtonian physics. It promotes discovery and exploratory learning by enabling students (from 7 to 17 years old) to experiment with concepts such as gravity, friction, force, velocity and so on, and see how values change affect the objects moving within the simulation. TurboTurtle's design rationale includes concepts such as equal opportunity controls, simulation timing, concrete versus abstract controls, recoverability and how strictly views should be shared between students. It attempts to make extensive use of sound, color, and animation to capture the interest of young students. It also develops user interfaces that producing an educational environment, which is both engaging and easy to use.

TurboTurtle is a truly collaborative microworld, where students have their own displays, their own mouse, and an ability to do anything at any time. With TurboTurtle, students can alter the attributes of the simulation environment, such as gravity, friction, and presence or absence of walls. Students explore the microworld by manipulating a variety of parameters, and learn concepts by studying the behaviors and interactions that occur. As a free-form microworld, students can manipulate TurboTurtle as they wish. However, teachers can modify TurboTurtle to display a prescriptive set of tasks containing questions, lines of investigation, and hints of things to try. Teachers can also add structure to the group's activities by setting the simulation environment to an interesting state, which includes a set of problems and questions. This allows teachers to scaffold the student's passage through TurboTurtle's educational domain.

TurboTurtle has evolved into a groupware system where several students, each on their own computer, can simultaneous control the micro world and gesture around the shared display. The efforts involved to make it as a groupware system is trivial, primarily because it was built with a groupware toolkit called GroupKit. This toolkit uses its remote procedure call facility to tell all processes to execute an action at all sites. As a result, TurboTurtle gained its extensive facilities for group-awareness, such as telepointers and WYSIWIS (What-You-See-Is-What-I-See) display. It also has the ability to update the latecomers, ensuring that their view of the micro world is same as their fellow students.

Table 2-1 summarizes the CSCL applications discussed above.

**Table 2-1 CSCL Applications that support Children's Collaborative Learning**

| CSCL Application | Educational Objectives | Software/Tools | Classroom Activities | Stage/Year |
|---|---|---|---|---|
| Belvedere | To help students to learn critical inquiry skills using evidence and concept maps | Collaborative Inquiry Tools (i.e. Collaborative Inquiry Database, Inquiry Diagrams and Text Displays) for creating Inquiry Diagrams. Guided Programs for accessing on-line materials | In a classroom, students construct and reflect their ideas through "inquiry diagrams". They work together to state and compare alternative theories and arguments about them and change them in response to new evidence or criticism | 12-15 years old students |
| CoVis | To help student to develop scientific understanding mediated by scientific visualization tools in a | Desktop video teleconferencing Shared software environments for remote, real-time collaboration Internet access to the resources | In CoVis project, students study science through inquiry-based activities. Utilizing the customized scientific | K-12 students |

| | | collaborative context | Multimedia scientist's "notebook" Scientific visualization software | visualization software, students have access to the same research tools and data sets used by the scientists in the field | |
| --- | --- | --- | --- | --- | --- |
| CSILE | To make students think and reflect their thought process in a public forum | A tool for generating "nodes" in different communication modes (i.e. text, video, audio, animation) A multimedia database that contains the class ongoing research A common repository for storing and accessing CSILE's "notes" | In a CSILE classroom, students can select different communication modes to generate "nodes." These nodes are an accumulation of knowledge and are available for others to comment on and leading to dialogue. Students share information, answer each other questions, and provide advice more easily in CSILE's on-line environment. | Fifth/sixth-grade students |
| TurboTurtle | To promote discovery and exploratory learning through microworld (restricted computer simulation) | Utilizing many features of GroupKit, TurboTurtle enables students to alter the attributes of the simulation environment, allows teachers to modify turbo turtle's displays and add structure to the group's activities | With TurboTurtle, students experiment the micro world with concepts such as gravity, friction, force and velocity by manipulating a variety of parameters to learn those concepts by studying the behaviors and interactions that occur | 7-17 years old students |

## 2.6 CSCL in Malaysian Schools

In Malaysia, a new innovation of schools was introduced in 1996 called the Smart School (Smart School Project Team, 1997. pg 6). Then in 1999, 90 schools were picked to pilot the Malaysian Smart School project. The Smart School project is one of the seven flagship applications that are part of Malaysian Multimedia Super Corridor (MSC). The Malaysian Smart School is defined as a 'learning institution that has been systematically reinvented in terms of teaching-learning practices and school administration in order to prepare children for the Information Age' (Smart School Project Team, 1997. pg 20). The idea of Smart School is dedicated to the task of regaining excellence in Malaysian education. It restructures Malaysian education by changing the teaching and learning environments in schools.

Under the Malaysian Smart School initiative, collaborative learning is selected as one of the key teaching and learning practice. It is stated clearly in the conceptual blueprint that tools which facilitate group work within the class and across the class are one of the key requirements (Smart School Project Team, 1997. pg 102). Even though the empirical research has revealed many of the promises and benefits of collaborative learning (refer section 2.2), however managing and carrying out these collaborative learning activities without the support of computer technology are not going to be an easy (Enerson et. al., 1997; Salim et. al., 2001). In this sense, CSCL applications play significant roles in supporting student's collaborative learning activities.

As of countless research through the Internet and a workshop with a group of primary school teachers for duration of three weeks, it is indicated that no CSCL applications are being developed in Malaysia. In addition, investigations carried out by Kasirun and Salim (2001) also highlighted the lack of CSCL applications for schools in Malaysia.

Currently, only a few education portals that provide limited collaborative features such as email, chat and discussion databases are available. Basically, teachers and students use email or chat tool to communicate with each other. Discussion databases are used to share information on a particular topic. Some examples of such education web portals include CikguNet (Rahman, 2000), Malaysian SchoolNet (Tajul-Arus, 2000) and TIGETWeb Project (Osman, 2000).

CikguNet is Malaysia's first education portal developed by the MIMOS (Malaysian Institute of Microelectronic Systems) that aims to support and prepares educators for the e-learning environment. It creates a major repository for teaching and learning resources. Teachers in Malaysia can share their ideas and teaching experiences in a particular subject via threaded discussion, email and chat. Tools for content development are provided. Students can also use these tools to ask questions or seek advices on problems they faced in their studies.

The Malaysian SchoolNet is a Ministry of Education's (MOE) project that utilizes the Internet technology as a medium for Malaysian schools educational activities. It enables students, teachers and administrators to communicate, share information and access the Internet information for knowledge gathering, skills upgrading and at the same time contribute to Malaysia's k-economy development.

TIGERWeb (Terengganu Intelligent Gateway to Educational Resources) is one of the projects undertaken by Terengganu State Education Department (TSED) under the MOE to pilot-test an interim project aimed in preparing normal and traditional schools to migrate to the smart school learning environment. This project is piloted by TSED in collaboration with Terengganu State Education Resource Center. TIGERWeb connects

all school in Terengganu to a central site and it serves as an education portal that allows access, retrieval and sharing information.

Beside these educational web portals, there are also some CD-based educational applications used in Malaysia for teaching and learning purposes. This type of applications provides limited interaction throughout the learning process.

On the other hand, although there are commercial applications that provide full ranges of collaborative features (e.g. WebCT (WebCT, 2001) and LearningSpace (IBM Lotus Team, 2000)) to support student collaboration, nevertheless, they are not solely designed specifically to support group learning. These applications tend to focus on the delivery of learning materials utilizing various communication tools rather than the types of collaborative learning activities. For example, these applications support the messaging, calendaring, document generation as well as workflow management through both synchronous and asynchronous communication tools.

Due to these reasons, there are needs to develop collaborative learning applications to facilitate the collaborative teaching and learning. As a result, the Faculty of Computer Science and Information Technology in collaboration with the Faculty of Education, University of Malaya is researching and developing a system that will fulfill such needs under the WebCL project (Salim, 2001). WebCL, or Web-based Collaborative Learning System, is a project lead by Associate Professor Dr. Siti Salwa Salim that aims to identify, design and develop a wide range of collaborative learning modules, each of which can be used to facilitate teachers in the preparation of collaborative learning activities, the execution of activities by students and the monitoring of the activities while students are collaborating in accomplishing the learning goals. This project is

supported by the provision of Intensification of Research in Priority Areas (IRPA) research grant 04-02-03-0704.

WebCL project began with reviews on collaborative learning literatures and existing technology-mediated collaborative learning tools. The main focuses of this review are: the collaborative learning and processes; the activities and features incorporated in the tools; the interface adopted by the tools; as well as the problems and inadequacies of existing technology.

Based on the review compiled, the first version of WebCL was developed. This version of WebCL comprised of six modules namely Group Discussion, Group Project, Group Presentation, Group Quiz, Group Debate and Group Study. These collaborative modules were founded based on the work proposed by theorist of group learning and processes such as Johnson et. al. (1984), Aronson et. al. (1978), and Slavin (1980). These modules are then formatively evaluated by a group of primary school teachers in a workshop.

## 2.7 WebCL Workshop

In the July of year 2000, a workshop was conducted at the University of Malaya with three major objectives: to brainstorm the collaborative learning activities carried out in primary schools and the problems faced, to formatively evaluate the first version of WebCL modules and to propose possible modules to support primary school students' collaborative learning activities. Section 2.7.1 to 2.7.3 discusses these in more detail.

A group of ten primary school teachers participated in the workshop for the duration of

three weeks as part of their professional attachment. This group of teachers is equipped with some computer and programming skills on educational technology and they are well trained in Instructional Design.

### 2.7.1 The Workshop's Brainstorming Sessions

Throughout the workshop, several discussions were conducted with the teachers in order to gain a clearer understanding on the current primary schools practices and collaborative learning involvement. Feedback from these teachers indicated the following aspects:

- Collaborative learning is not new among Malaysian primary school teachers.

- Teachers have conducted various group activities at their own school to promote student collaboration.

- Collaborative learning activities are usually being carried out manually in a classroom without any CSCL applications support.

- In order to carry out collaborative learning activities, teachers need to incorporate some collaborative learning techniques in their teaching lessons.

- Teachers find the task of preparing collaborative activities are very time consuming and require them to be more creative and imaginative.

- The student monitoring process is not easy since the teachers need to wonder around and make interventions from time to time.

### 2.7.2 The Workshop Formative Evaluation

During the workshop, the teachers evaluated the WebCL modules. The evaluation covered four major aspects: the activity supported by each module; the contents; appearance and ease-of-use of each modules.

The teachers were asked to access and use each module to perform several tasks. These tasks including setting questions for each activity and answering the prepared questions. Besides, the teachers were also asked to participate in the activity as students. By doing so, the teachers have the opportunity to explore all the system features and functionalities. Based on this investigation, the teachers evaluated the suitability of each collaborative learning activity in supporting the primary schools students.

For the content aspect, the teachers evaluated the suitability of each module in supporting the level of primary students to carry out such collaborative learning activities. For example, the teachers found that the Group Quiz module is suitable to support all primary students from year one to year six. However, module like Group Discussion and Group Debate are much more suitable for year four and above students since these activities require the students to construct their own sentences.

In the appearance aspect, the teachers also evaluated the layouts for WebCL modules and the multimedia elements involved. The teachers also provided suggestions and recommendations for improving the appearance of each module.

In evaluating WebCL modules' ease-of-use, the teachers evaluated aspects such as the easiness to navigate from one module to another; the user interface used in each module as well as the management of WebCL. Based on the feedback, the teachers commented that the system should be more interactive such as prompting the users when a task has been performed or notifying the user about their current location. The teachers also suggested some opinions on how to improve the ease-of-use in assisting the teacher in preparing a task and how to enable the students to participate the activity much easier.

### 2.7.3 The Workshop Outcomes and Proposal

At the end of the workshop, the following results have been achieved:

- The Group Presentation module should merge with Group Project because most of the group projects normally require students to present their work to the class.

- The Group Study module is omitted since most of its features and functionalities can be found in Group Discussion and Group Project.

- Two new modules have been proposed, named Group Creativity and G-Jigsaw (Group Jigsaw).

- The proposed Group Creativity supports students to collaboratively participate in answering subjective questions.

- The G-Jigsaw proposed in this workshop encourages students to generate ideas, ask questions, helping and learning from each other in the classroom. G-Jigsaw is the focus of this thesis. Section 2.8 further describes this module in more details.

## 2.8 The Proposed G-Jigsaw Module

G-Jigsaw is proposed with the aim to simulate student's skills and capabilities in generating ideas collaboratively, asking questions and learning from each other, as well as integrating the shared works in a group. Fundamentally, this module is based on the concept of Jigsaw Puzzle, the term used by the teachers to encourage every student in the class to work collaboratively. This group activity has been carried out in primary schools to promote students collaboration. During this activity, the students give general feedback on each group member responsible segment, master a specific segment through the collaboration with members from other groups and present the segment to the group in turns. This activity highly promotes student's collaboration processes.

Nevertheless, it is currently carried out in the classroom manually without any support of CSCL application.

Hence, G-Jigsaw is proposed to support this activity using a web-based tool. The proposed requirements of this module are listed below:

The teacher should play the following roles:

- Create a problem that consists of several segments

- Break the problems into smaller segments

- Distribute the segments to the students

- Monitor and evaluate the students' work.

The students should perform the following activities:

- Students form their own groups consist of 5 – 6 students.

- The segments are divided to each group members accordingly so that each member in the group will responsible a specific segment of the problem

- Students in the same group contribute their ideas and opinions towards their group members segment and receive comments from their members at the same time

- Students group will split in order that students with the same segment will form a new group to discuss among themselves in order to find a solution for their responsible segment

- Students will return back to their original group to present the results from the previous group discussion

- The group leader will combine each segment into a complete solution for the problem

Based on the requirements obtained for this module, it has many similarities with the Jigsaw Classroom technique described in section 2.4.8. This Jigsaw Classroom technique will be studied in depth in chapter 3.

## 2.9 Chapter Summary

This chapter has reviewed the theoretical aspects of collaborative learning. Various kinds of collaborative learning techniques used in supporting collaborative learning activities are also investigated. CSCL and its applications are discussed. The CSCL in Malaysian schools is reviewed. The WebCL's workshop and the proposed module of G-Jigsaw are enclosed at the end of the chapter.

# Chapter 3 – G-Jigsaw (Group Jigsaw) Process Model

This chapter studies the Aronson's Jigsaw Classroom technique in depth. It also exemplifies an example of Jigsaw Classroom activities and describes the benefits and limitation of this technique. Next, it discusses the similarities and differences between the Jigsaw Classroom and the proposed G-Jigsaw by the teacher discussed in chapter 2. This chapter further formulates a G-Jigsaw process model with three levels of collaborations to support the proposed G-Jigsaw. It summarizes the steps to be performed in both the Aronson's Jigsaw Classroom as well as the G-Jigsaw Process Model. This chapter also investigates tools to support the jigsaw technique. Lastly, it discusses G-Jigsaw prototype that incorporates the G-Jigsaw process model.

## 3.1 Jigsaw Classroom

The Jigsaw Classroom (Aronson et. al., 1978) was first introduced by Elliot Aronson to cope with cultural diversity in classrooms. In Jigsaw Classroom (also referred as Cooperative Classroom), the students achieved success through paying attentions to their peers, asking good questions as well as helping, teaching and assisting each other rather than outshining their competitors as in present traditional classroom. Aronson and his colleagues shifted the role of teachers to become the major resources to each of the learning groups and the students treat each other as resources (Aronson, 2000a). This surroundings is accomplished in three ways:

1. The learning process was structured so that individual competitiveness was incompatible with success.

2. It is convinced that success occurs only after cooperative behavior among the students in a group.

3. Each student is in a position to contribute a unique gift of knowledge (i.e. a piece of vital knowledge that is only available by a particular student) to his/her group-mates.

According to the jigsaw technique, students are first divided into small groups (e.g. 5 students in a group) and these groups are called "jigsaw groups". The learning materials (e.g. exercises, tutorial questions, group project etc.) are also divided into five sections accordingly. Every student of each group is assigned to one section of the learning materials and can only access to their own section. Each student read and learns his own section and then joined his counterparts from other groups. These temporary groupings are called "expert groups".

"Expert groups" are where students who are assigned the same section of the learning materials discuss about their section in more detail. This process is important because it provide the opportunity, space and practice for less articulate and skilled students to learn their materials and see how smarter students organize and present their answers. The "expert groups" provide all students with the possibility to gain a clearer picture on how to present their answers – regardless their inequities skills knowledge.

After spending some amount of time in their "expert groups", the students returned back to their original "jigsaw groups". Then, each student in the "jigsaw group" take turns to teach or present his section answers and the knowledge and experience gained from his "expert group". Therefore, the students are able to produce a final outcome covering the entire sections of the learning material. Based on these activities, the author draws a diagram to illustrate the jigsaw classroom processes in a diagrammatic way as shown in figure 3-1.
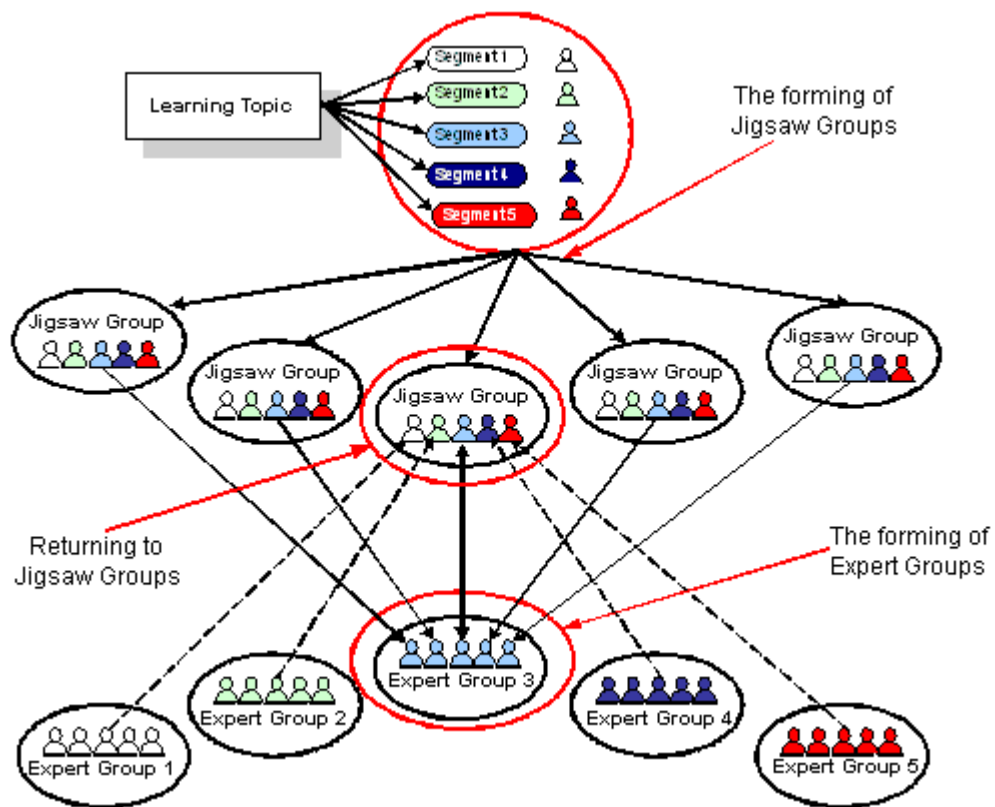
**Figure 3-1 Aronson's Jigsaw Classroom Process Model**

The Jigsaw Classroom is a highly structured technique. Interdependence among the students is required. Students learn from each other and try not to out perform each other because one student's learning will enhance the performance of the other students. This interdependence makes the Jigsaw Classroom a unique learning method and encourages the students to actively take part in their learning activity.

Clearly, students in a jigsaw classroom have to depend on each other to learn all their learning materials. This situation initiates students to be responsible for his/her own learning and to help the entire group understand the entire scope of the learning materials. The jigsaw process is highly reminiscent of a jigsaw puzzle, where each student possesses a single vital piece of the big picture. Because of this resemblance, Aronson and his colleagues refer this process as the "jigsaw" model.

## 3.2 An Example of Jigsaw Classroom Activities

This section illustrates how the jigsaw classroom technique can be carried out by year 5 students focusing on Science subject. The example below presents the steps for both teacher and students in a jigsaw classroom.

Step 1: Forming jigsaw groups

The teacher should divide the students into several jigsaw groups. Ideally, each group should consist of five or six students.

Step 2: Appointing group leaders

Each jigsaw group should have one group leader.

Step 3: Preparing the jigsaw materials

The teacher should prepare learning materials that could be divided into several smaller related segments. Let's say the jigsaw activity is about "Mammals", the following are a few possible questions that can be used.

1. What is the largest mammal in the world?
2. What are the characteristics of mammals?
3. How do mammals take care of their children?
4. Why are some mammals dangerous to people?
5. Why are some mammals useful to people?

Step 4: Assigning topic segments to each student

The teacher should assign each student with one segment and ensure that he/she can only access his/hers segment. For example, Rahman, Adip, Fahmi, Husna and Sarah are in the same jigsaw group. Rahman is assigned to question 1, Adib is assigned to

question 2, question 3 is assigned to Fahmi, question 4 is assigned to Husna and question 5 is given to Sarah.

Step 5: Reading the segments

Then, the students are required to read their segment for at least twice to familiarize with it and this will prepare them for the expert group discussion.

Step 6: Forming the expert groups

Next, the students are required to form temporary groups called expert groups. Each student in a jigsaw group will joint other students whom are assigned to the same segment. For example, Rahman will joint students from other jigsaw groups who are also responsible for question 1.

In the expert group, the students will discuss the main points of their segment as well as rehearse their presentation, which they will present when they return back to their jigsaw group.

Step 7: Return to jigsaw groups

After the students are ready with their segment, they return back to their original jigsaw group.

Step 8: Presenting the segments to the jigsaw groups

Every student is required to present their segment to their group. Other students should listen and learn from each other presentation. At the same time, students are also encouraged to ask questions to clarify the information presented.

Step 9: Monitoring the jigsaw group.

During the student's presentation, the teacher should move from group to group to observe the process. The teacher will intervene if there are any groups that encounter problems. The group leader should be trained gradually to take over this role.

Step 10: Evaluating the students' achievement

At the end of each jigsaw classroom session, the teacher should give a quiz on the topic that the students have learned.

## 3.3 The advantages and limitation of Jigsaw Classroom

Aronson's jigsaw classroom is a technique with a three-decade track record of success (Aronson, 2000b). The research findings (Aronson, 2000a) have consistently showed the following desirable results:

1. Students in the jigsaw classrooms tend to establish a strong relationship within their group-mates compare to others in their classroom.

2. The students in the jigsaw classrooms enjoy school better than the students in traditional classroom thus reduced the absenteeism among the jigsaw students dramatically.

3. The self-esteem of the students in the jigsaw classrooms increased to a greater extent compare to students in competitive classrooms due to the opportunity on hand for the students to teach and learn from their group-mates.

4. In terms of mastering classroom learning materials, students in the jigsaw classrooms tend to out-performed students in competitive classrooms especially for the underprivileged minority students.

5. As the result of their experience in jigsaw groups, students learned to understand

and respect one another.

Besides, individual students in jigsaw classroom develop and share expertise in different aspects. This highly structured technique facilitates interaction among all students in the class lead them to value each other as contributors towards their common task. It is especially useful in modeling technical assignments or projects. These activities normally require the expertise of a variety of individuals in order to complete them. Under such circumstances, students developed an expertise in one specific aspect, teach the knowledge and skills to their group or to the class and at the same time learn different points of views from other students with different expertise.

The Jigsaw approach is certainly not limited to technical areas solely. In fact, it may be applied to any subject where pieces of information need to be gathered to produce a group work. According to Clarke, "The use of the reconstituted work groups in classrooms, such as in the Jigsaw approach, is based on the same principles of interdependence that operate in the cross-team roles in the workplace. Class members bring their personal abilities and ways of thinking and working, as well as specialized knowledge, to analogous cross-role groups. The Jigsaw approach was developed as one way to help build a classroom as a community of learners whereas students are valued" (Clarke, 1994, cited from Panitz, 1997a).

Despite of the advantages discussed previously, the jigsaw approach also has its challenges. For instance, students who are first time exposed to the jigsaw technique may have some difficulty to understand the complex jigsaw approach (e.g. the forming of jigsaw and expert groups, the teaching and learning activities such as material preparation, segment discussion and rehearsal of presentation involved at different

levels). This is remarkably true especially for students who are not familiar to this technique. Table 3-1 summarizes the benefits and limitations of Aronson's jigsaw classroom.

**Table 3-1 The advantages and limitation of Jigsaw Classroom**

| The Advantages of Jigsaw Classroom | |
|---|---|
| 1 | Encourages strong friendship among group-mates. |
| 2 | Decreases the student's absenteeism dramatically. |
| 3 | Increases the student's self-esteem. |
| 4 | Increases underprivileged minority student's performance. |
| 5 | Promotes listening, engagement and empathy among students. |
| 6 | Facilitates interaction among all students in the class. |
| **The Limitation of Jigsaw Classroom** | |
| 1 | Students who are first time exposed to the complex jigsaw technique may encounter difficulty to understand the technique. |

## 3.4 The proposed G-Jigsaw versus Jigsaw Classroom

Table 3-2 compares the requirements of the Jigsaw Classroom with the proposed G-Jigsaw from the workshop (discussed in chapter 2). By observing the comparison as depicted in table 3-2, it is found that the Aronson's Jigsaw Classroom (refer section 3.1) have much similarities with the requirements proposed by the group of teachers. Differences between the requirements are marked in bold.

**Table 3-2 Jigsaw Classroom and G-Jigsaw Requirements Comparison**

| Requirements for the Jigsaw Classroom | Requirements for the proposed G-Jigsaw |
|---|---|
| Students are first divided into jigsaw groups. | Students form their own groups consist of 5-6 members. |
| One student from each group is appointed as the leader. | Each group is assigned with a group leader. |
| The lesson is divided into 5-6 segments. | The problem is broken into smaller segments. |
| Each student is assigned to learn one segment. **Students have direct access only to their own segment**. | Each student is responsible for one segment. **Students must respond to all other segments first before they have access to their own responsible segment.** |

| Students are given time to read over their segment at least twice and become familiar with it. | Students in the same group first contribute their ideas and opinions to their group members and receive comments from their members at the same time |
|---|---|
| Temporary "expert groups" are formed by having one student from each jigsaw group join other students assigned to the same segment. Students in these expert groups are given time **to discuss the main points of their segment and to rehearse the presentations** they will make to their jigsaw group. | Expert groups are formed by having students with the same segment from each group. Students in these expert groups **present the main point of their segment, comment on the main point presented and recompose a report to improve their previous answer** they will present when they return to their original group. |
| Students are brought back into their jigsaw groups. | Students return to their original group. |
| Each student is required to present his/her segment to the group. **Others in the group are encouraged to ask questions for clarification.** | Students present his/her segment report to the group. **The group leader will combine each segment report into a complete piece of group work.** |
| The teacher floats from group to group, observing the process. If any group is having trouble, the teacher can make an appropriate intervention. | The teacher wanders from group to group, monitoring the activity session and intervening when necessary. |
| **At the end of the session, the teacher will give a quiz on the discussed material.** | **The quiz assessment is not supported in this module.** |

The major difference from this comparison occurs in the first stage of the activity. In Aronson's Jigsaw Classroom, no collaboration is allowed among the students at the first stage. Students obtained their segment and they are given time to read the segment at least twice to become familiar with it. The students' collaboration only begins at the expert group level. Conversely, in the proposed G-Jigsaw, the student collaboration exists at the first stage. Students are required to give comments to other members in their group during the first stage.

According to Aronson's jigsaw classroom, students are only allowed to collaborate during the discussion in "expert" groups. The students will only gain full understanding of their learning topic after the completion of the final stage at "jigsaw" groups. Even though this technique enables the students to share their ideas and solve conflicts during

expert and jigsaw group, however it prevents them from gaining an overall picture of the task beforehand. In other words, student who is responsible for one section of learning materials may not be aware of other sections until at the final stage of the jigsaw group. Therefore, this method leaves the space for further enhancement.

On the other hand, based on the G-Jigsaw proposal, during the initial level students must respond to all other members' segments first before they have access to their own responsible segment. This allows students to gain an overview picture about the learning topic before they start to prepare their segment answer. In this way, students will have a brief understanding about the entire learning topic beforehand and get the complete understanding during the jigsaw group.

As a result, the author makes use of Aronson's jigsaw classroom technique with some modification to fulfill the proposed requirements. In order to achieve the desired results, the activities at the first level are restructured. Rather than forming the jigsaw group for students to obtain their question segments as what Aronson did, students in G-Jigsaw are required to respond to other members in the same group. The member-to-member collaboration is fostered during this early level of collaboration. Groups that are formed during the initial level of collaboration are named "Initial Group". Student's activities in "Expert Group" and "Jigsaw Group" are very much similar to Aronson's Jigsaw Classroom. During the expert level, the group-to-group collaboration is emphasized. As such with G-Jigsaw, the students' collaborations occur at every stage. The details of group jigsaw process model are explained in section 3.5.

Another difference is that in Jigsaw Classroom, the students are required to rehearse their presentation during the expert group whereas this feature is not proposed in the G-

Jigsaw. The presentation rehearsal is replaced during the expert group where students are able to give comments and learn from each other. Therefore, students can improve their previous answer and compose a report for their segment and present it during the jigsaw group.

Besides, the proposed G-Jigsaw module does not support the last step of Aronson's jigsaw technique, which is having a quiz on the material learned. This is due to the reason that G-Jigsaw is designed as one of the WebCL module, since the WebCL has a module called Group Quiz, thus G-Jigsaw does not support this feature. However, students accessing WebCL can make use of Group Quiz to carry out the evaluation after the jigsaw session in G-Jigsaw.

## 3.5 The G-Jigsaw Process Model

The G-Jigsaw process model is formulated based on the teachers' proposal and Aronson's Jigsaw Classroom to support the proposed G-Jigsaw requirements. The process model restructures the first level of jigsaw activities to enable student collaborations at every level throughout the jigsaw collaborative learning session.

In this process model, students collaborate by responding to each member's different segment, received feedback for their own segment, prepare their segment's draft, read and comment on other members same segment drafts, improve their draft and compose a report, review group members report and finally integrate the reports into a complete integrated report.

To accomplish these goals, students are required to engage actively in three levels of

group collaborations namely initial level, expert level and jigsaw level throughout the process model. The following sections describe each level of collaboration in more detail.

### 3.5.1 Initial Level of Collaboration

In the initial level of collaboration, the teacher must divide the learning topic (jigsaw task) into three or more smaller segments. The students are then divided into three or more groups according to the number of segments. Each group should consist of three or more members according to the number of segments. These groups are called "Initial Group" rather than "Jigsaw Group" because unlike the original jigsaw technique, students in the Initial Group are also required to engage in the member-to-member collaboration. Another reason for renaming the group as "Initial Group" is because it is the first collaboration level in the process model. Figure 3-2 shows the formation of Initial Group. As shown in figure 3-2, each student in the "Initial Group" is responsible to a different segment of the learning topic. The learning topic can be a case study or a group project.
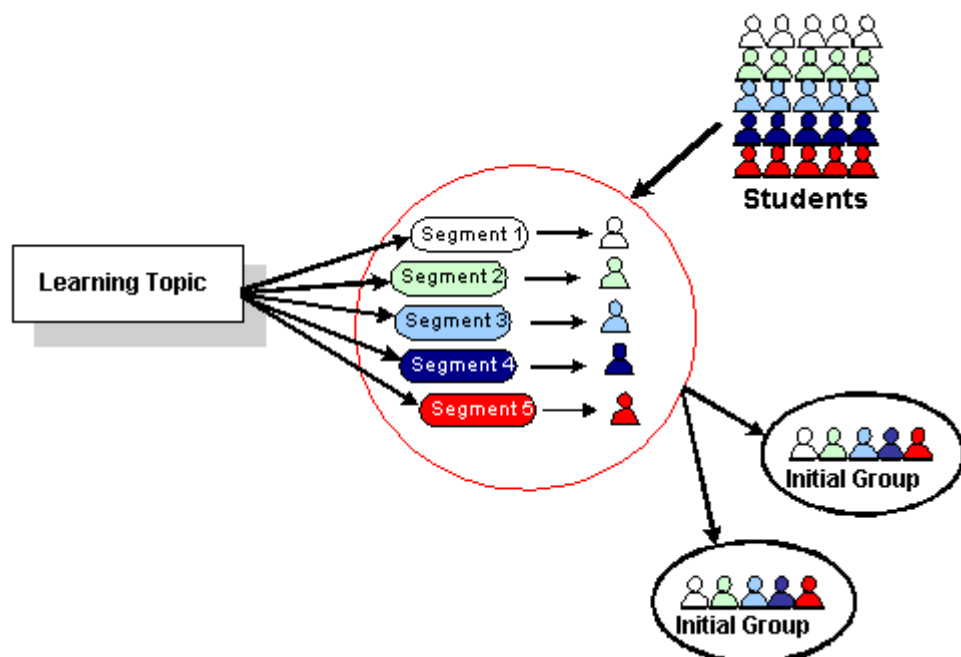


**Figure 3-2 The Forming of Initial Groups**

As stated earlier, students are required to collaborate among their group members in the Initial Group before they are allowed to enter the expert stage. During this inter-member collaboration, rather than just working on their own segment, each student is required to respond to other his/her group members' segments. Therefore, each student will receive feedback from each group members.
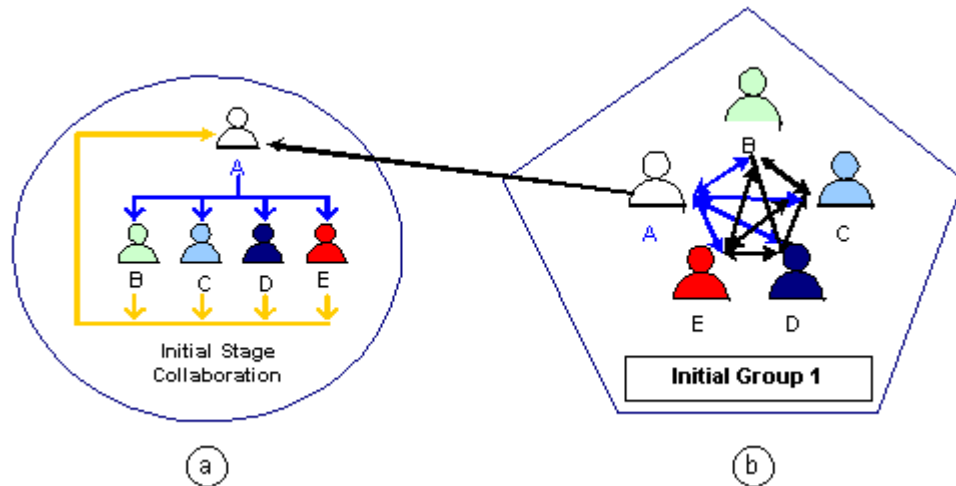


**Figure 3-3 Initial Level of Collaboration**

For instance, let's take a scenario where the learning topic consists of five smaller segments. Under such circumstances, five Initial Groups must be formed with five students in each group. Figure 3-3 illustrates the initial level of collaboration in Initial Group 1. Assume that student A in Initial Group 1 is responsible for segment 1, hence he/she need to propose his/her ideas and opinions for the other four segments (i.e. segment 2, 3, 4 and 5) which are responsible by students B, C, D and E respectively.

Similarly, other students (B, C, D and E) in Initial Group 1 are also required to respond to four other segments as described for student A. As a result, every student in Initial Group 1 will receive responses from his/her group members. This process is presented in figure 3-3 (a). Subsequently, student A will receive four responses from his/her group

members. He/She will be able to use these responses as guidance and references in preparing his/her segment 1 draft.

Through this initial collaboration process, students become more prepared before they start discussing their own segment in more detail in the Expert Group during the expert stage. The entire student collaboration process of Initial Group 1 promotes multiple perspectives and is depicted in figure 3-3 (b).

### 3.5.2 Expert Level of Collaboration

After the first level of collaboration in the Initial Groups, students engage with another level of collaboration, which is the expert level. Every student with the same segment from each Initial Group will split into five newly formed groups called the "Expert Group" as shown in figure 3-4.
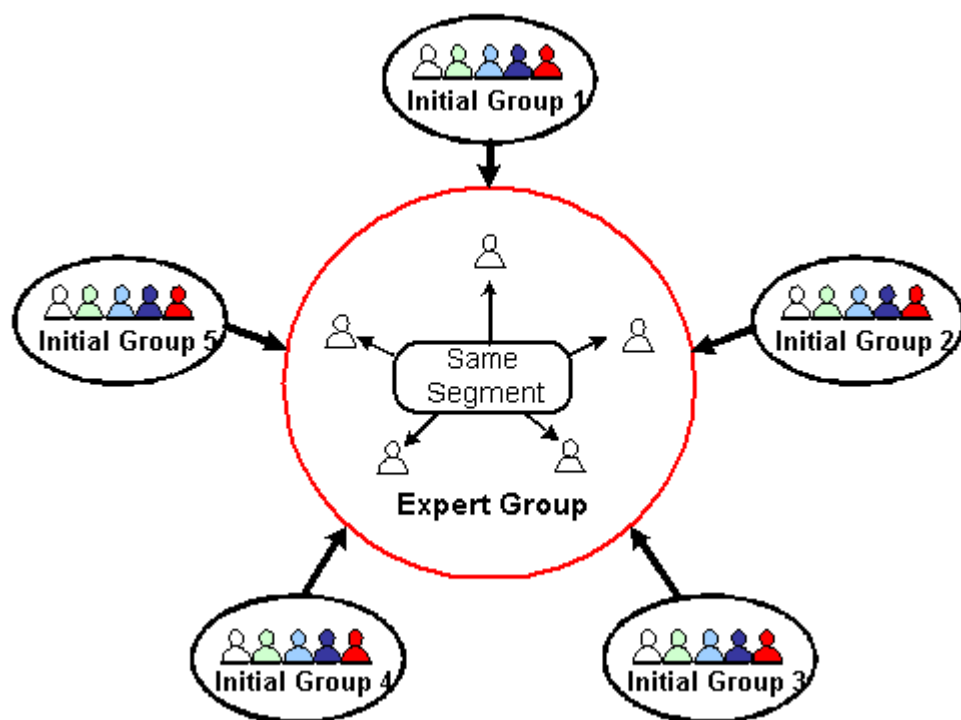


**Figure 3-4 The Forming of Expert Groups**

Figure 3-4 shows the student collaboration in the expert level. During the inter-group collaboration process, each "expert" member will present their draft to his/her expert group members. Every draft from each group member is studied in depth. Students in Expert Group collaborate through giving comments, discussions, arguing and defending their point of views. At the same time, they also receive feedback from their expert group members. Students will take note on they members' strong points and improve their segment draft own weaknesses or incompleteness. At the end of this collaboration, each student should become an "expert" in their responsible segment. Therefore, they should be able to bring the knowledge gained via the collaborative process in Expert Group to the "Jigsaw Group".
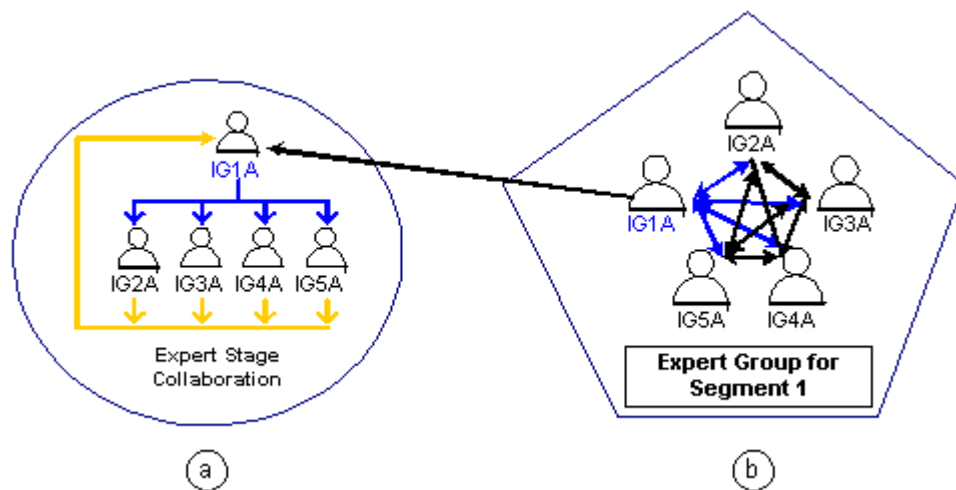


**Figure 3-5 Expert Level of Collaboration**

Take a look at Expert Group for segment 1 for instance. This Expert Group consists of students from each Initial Groups (i.e. IG1, IG2, IG3, IG4 and IG5). Suppose every student A in the Initial Groups is responsible for segment 1, thus Expert Group for segment 1 will have 5 students (i.e. IG1A, IG2A, IG3A, IG4A and IG5A).

Student IGA1 will present his/her draft to the group and are discussed further among

other expert group members. If there are any unclear points presented in the draft, students, other members will be able to raise the issue through a discussion. The author of the draft must try to clarify or defenses their points. At the end of this session, the students are able to improve their segment draft and produce a segment report.

**3.5.3 Jigsaw Level of Collaboration**

The last level of collaboration is named the jigsaw level. In this level, every student from the Expert Groups will return back to their original groups. Since the activities involved at this level are different from what they have carried out during their initial level, thus these groups are now called "Jigsaw Group". The forming of Jigsaw Group is presented in figure 3-6.
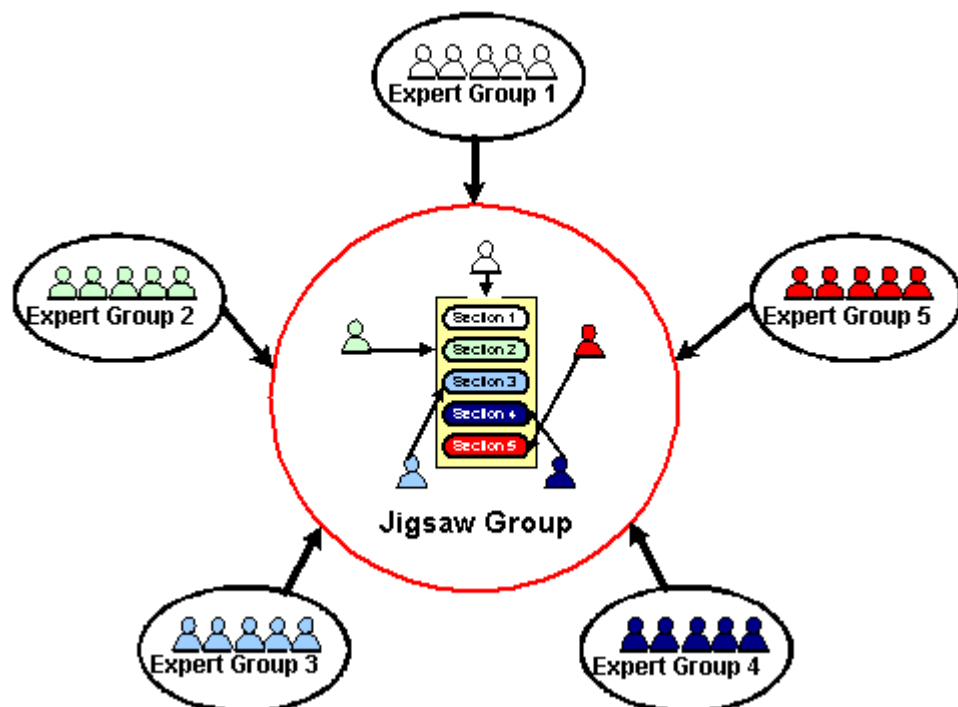


**Figure 3-6 The Forming of Jigsaw Group**

During the jigsaw level of collaboration, students teach and learn from each other. Each "expert" of a particular segment takes turn to present his/her segment report. After each

presentation, questions are raised and answers are provided until every student in the Jigsaw Group obtains a full understanding about the segment presented. Therefore, the student now has the knowledge for the entire learning topic.

Then, they are required to produce a full report of the learning topic discussed. During the integration process, students in Jigsaw Group once again collaborate in order to produce the best outcomes for their group. The outcomes should then be presented to the whole class group by group so that the whole class would achieve maximized collaboration and cover as much as they can on the learning topic.

## 3.6 Summary of Aronson's Jigsaw Classroom and G-Jigsaw Process Model

Table 3-3 summarizes the steps for both Jigsaw Classroom and G-Jigsaw process model.

**Table 3-3 Steps for Aronson's Jigsaw Classroom and G-Jigsaw Process Model.**

| Steps in Jigsaw Classroom | Steps in G-Jigsaw |
|---|---|
| 1. Teacher forms the jigsaw groups. | 1. Teacher prepares learning materials that can be divided into three or more smaller segments. |
| 2. Teacher assigns group leader for each jigsaw group. | 2. Teacher forms initial groups for the students. The number of segments, number of initial groups and number of student in each initial group should be the same. |

| | |
|---|---|
| 3. Teacher prepares learning materials that can be divided into five or six smaller segments. | 3. Teacher assigns each student with one segment. Students must respond to other segments in their group before they can start answering their own segment. |
| 4. Teacher assigns each student with a segment. Make sure the students have direct access to their responsible segment only. | 4. Students read the responses posted by their group members toward their segment. |
| 5. Students read their segment at least twice to make them familiar with their segment. | 5. Students create a summary for their own segment after considering each group members responses. |
| 6 Students form expert groups. Students assigned with the same segment will meet together in the expert group. Students discuss the segment's main points and rehearse their presentation. | 6 Students form expert groups. Students assigned with the same segment will meet together in the expert group. Students read other expert group members' summaries and give comments. |
| 7. Students return to their original jigsaw group. | 7. Students read comments provided from other expert group members toward their own summary. |
| 8. Students present their presentation for each segment in turns. Students ask questions for clarification during the presentations. | 8. Students improve their previous summary based on the feedback from expert group members and create a report for the segment. |
| 9. Teacher and group leaders monitor the jigsaw process and intervene when necessary | 9. Students form jigsaw groups. Students present their report and presentation for every segment in turn. Students also ask questions and give suggestion on each report presented. |
| 10. Teacher conducts quiz on the topic learn during the jigsaw session. | 10. Teacher assigned group leaders for each jigsaw group. The group leader is responsible to integrate the entire collaborative group outcomes into a complete piece of work. |

## 3.7 Tools to support jigsaw technique

To date, there are hardly any thriving computer-based efforts to support the jigsaw technique. Although this technique has been introduced for more than 30 years ago, its application in classroom is mostly unsupported with any computer applications. Countless hours of searching the journals, conference papers and Internet revealed that no tools for supporting jigsaw technique are being developed. Only until recently in the year 2003, Gallardo and his colleagues attempt to support the jigsaw technique through a web-based tool for both the preparation of the collaborative learning activities and the execution of the activities.

The approach of this research is different from the Gallardo and his colleagues' works. Firstly, Gallardo's system supports the jigsaw session via the pairs and groups interaction in face-to-face setting whereas the G-Jigsaw process model enables all the students communicate with each other in a group basis. Secondly, in Gallardo's pair interaction, the students only change partner once. As a result, each student only communicates with the two out of three other students with same segment. Contrary, the group collaborations in G-Jigsaw process model involve the mutual engagement of students in a coordinated effort to solve the problem together. Hence, every student in the group will communicate to each group member.

Gallardo's system intends to support Aronson's jigsaw technique by providing tools for teachers and students in participating the collaborative learning session. It has a collaborative editor, a chat tool allowing teachers and students to communicate through various channels, a wizard for supporting the interventions while monitoring the activities controlled by teacher and two viewers (group and pair) for the teacher to

monitor the students' work at any phases. The students have access to three user interfaces, according to the phase in which they are working.

The collaborative learning session has six phases. In phase 1 (Group Creation), students log in to identify their group members and group name, get the lesson, objectives and topics to be studies. The material is assigned to each group members. Then the group splits to carry out their individual research. In phase 2 (Preparation Pairs), Students leave their groups and form pairs. Students in each pair are assigned with the same material piece. The pair of students use collaborative editor to access the material and produce a joint document at the end of this phase. In phase 3 (Practice Pairs), Two of the previous pairs that studying the same subject exchange partner to form a new pair. Students make contributions to the shared document prepared in previous phase using the collaborative editor. Students practice their presentation in turns, where one student presents his document while the other criticizes on it. When this is done, students return to their original group and present their work in turns to the group. During each presentation, discussions, questions and new concepts can be annotated with the presentation tool. When the presentations are over, teacher closes the session and evaluates each student in an on-line test (Phase 6: Evaluation). Throughout the entire session, teacher monitors and makes interventions if necessary (Phase 5: Monitoring).

## 3.8 G-Jigsaw Prototype

A prototype was developed using a fast prototyping method to incorporate the G-Jigsaw process model into a computer supported web-based environment. The purpose of developing this prototype is to determine how well the process model in supporting the jigsaw collaborative learning technique. It provides a good understanding in tracing the

drawbacks that occurs in the prototype. Thus it serves as a blueprint on how the prototype can be further enhanced.

An informal testing on the prototype was carried out by a group of primary school teachers. This group of teachers had participated in the WebCL workshop as described in section 2.7. The teachers were asked to create G-Jigsaw learning materials, highlight the difficulties and problems for preparing the learning materials. Besides, the teachers were also asked to participate in the jigsaw activity as students. By doing so, the teachers could predict the problems faced by the students.

Feedback from the teachers indicated the following drawbacks:

1. The prototype was not easy to use due to the complex level of collaboration.

2. For the first time users, it is difficult to understand the concept of Jigsaw.

3. The prototype should enable the teachers to share and reuse the learning materials.

4. Students had to remember the levels of collaboration starting from their Initial Group until Jigsaw Group.

Web agents have many potential roles in assisting both teachers and students in carrying out their collaborative learning activities (Lang, 1995; Lashkari, 1995; Pazzani el. at., 1996; Starr et. al., 1996; Joachims et. al., 1997; Luke and Hendler, 1997). The author attempts to utilize web agents to automate and simplify the G-Jigsaw activities. Chapter 4 explores the field of web agents and attempts to utilized these agents to support the collaborative learning activities.

## 3.9 Chapter Summary

The Aronson's Jigsaw Classroom technique is studied in depth and its pros and cons are discussed. An example of how to participate in Aronson's jigsaw session is also described. A comparison on the requirements between the Jigsaw Classroom and the proposed G-Jigsaw has been made and the similarities and differences between the Jigsaw Classroom and the proposed G-Jigsaw are pointed out. The formulation of a process model with three levels of collaborations to support the proposed G-Jigsaw is discussed. The steps for both the Aronson's Jigsaw Classroom technique and Group Jigsaw process model are summarized. Tools to support the jigsaw technique are investigated. A prototype that incorporates the G-Jigsaw process model is discussed at the end of the chapter.

# Chapter 4 – Web Agents for Supporting Collaborative Learning

This chapter explores the field of web agents and attempts to utilize these agents to support the collaborative learning activities. The first part of this chapter discusses the roots of web agents through theoretical aspects of software agents such as agent definitions and classifications. This is followed by the discussion of web agents that includes its definition, deployment potentials and types.

Furthermore, this chapter discusses a review of three existing educational applications on their agent architecture that implement web agents with different roles to assist student's learning process and investigate an architectural scheme of a Multi-Agent System for distributed collaborative learning environment. Next, this chapter discusses web agents' potentials in supporting collaborative learning activities. Lastly, it focuses on web agents to support G-Jigsaw collaborative learning.

## 4.1 Agent Definitions

According to Alan Kay, the idea of agent was originated from John McCarthy in the mid-1950s and Oliver G. Selfridge coined the term "agent" a few years later, when they were both at the Massachusetts Institute of Technology (Kay, 1984). Although the term has been widely used for almost 20 years, yet there is not a single universal accepted definition to date (Wooldridge and Jennings, 1995; Nwana, 1996; Bradshaw, 1997).

In explaining why it is so difficult to define precisely what agents are, Nwana (1996) has pointed out two major reasons that defy attempts to produce a universal accepted definition for agent. Firstly, the term "agent" is not only being used in Artificial

Intelligence field, but it is also used widely in everyday parlance as in travel agents and estate agents. Secondly, even within the software fraternity, the word agent is really an umbrella term for a heterogeneous body of research and development.

Due to the lack of a universal accepted definition for the term agent, researchers in agent arena invented yet more synonyms including knowbots (i.e. knowledge-based robots), softbot (software robot), taskbots (tasks-based robot), userbots, robots, personal agents, autonomous agent and personal assistants (Nwana, 1996). Bradshaw (1997) also claimed that varieties of 'Agents' have proliferated. There has been an explosion in the use of the term without a corresponding consensus on what it means. In his book entitled "Software Agents", he provides many examples of claimed 'agents' but with different meanings.

Even though there is yet to have a consensus definition for 'agent' at present, a general agent definition can be obtained by summarizing several definitions provided by the researchers working in the field of agent. Based on this general definition, an agent is defined as an entity (software/program and/or hardware) that performs some tasks or set of tasks on behalf of its user within a computer environment such as operating systems, databases, or computer networks (Andoh et. al., 2001; Yahya, 2001; Baylor, 1999; Nwana, 1996).

Along with this line, Olguin and colleagues (2000) regard an accepted definition of an agent as "An agent is a computational entity that (i) executes in behalf of other entities (users, programs, etc) in an autonomous way; (ii) makes actions in a pro-active and/or a reactive way; and (iii) presents some capabilities to learn, cooperate and move" (Olguin et. al., 2000). For more agent definitions, refer Franklin and Graesser's (1996) paper

entitle "Is it Agent, or just a Program?: A Taxonomy for Autonomous Agents".

## 4.2 Agent Classifications

The classification of agents provides a simpler way of characterizing the various types of agents. There are many classifications of agents such as Wooldredge and Jenning's agent notation (Wooldredge and Jenning, 1995), Nwana's agent typology (Nwana, 1996), Franklin and Graesser's taxonomy of agent (Franklin and Graesser, 1996) and Bradshaw's classification schemes and taxonomies of agent (Bradshaw, 1997). This chapter discusses Nwana's agent typology with an attempt to determine which category should the web agents belong to.

### 4.2.1 Nwana's Agent typology

A typology refers to the study on types of entities (Nwana, 1996). Nwana proposes a typology of agents that attempts to classify most of existing software agents into different agent classes. These agents are categorized according to five major dimensions.

The first dimension categorizes agents by their mobility. Mobility means the agents ability to move and travel around the network. This dimension yields the classes of static or mobile agents. Mobile agents are computational software process capable of wandering wide area network, interacting with foreign hosts, gathering information on behalf of their users and return home upon completing their tasks. In contras, static agents are agents that perform their tasks in a local environment without the capability of moving.

The second dimension classifies agents as either deliberative or reactive agents. Deliberative agents possess an internal symbolic, reasoning model and they engage in planning and negotiation in order to achieve coordination with other agents (Nwana 1996). On the other hand, reactive agents do not have any internal, symbolic models of their environment. They act using a stimulus/response type of behavior by responding to the present state of environment in which they are embedded (Ferber, 1994).

The third dimension compartmentalizes agents along several ideal and primary attributes that agents should reveal. Nwana and his colleagues have identified three attributes, namely autonomy, learning and cooperation. Autonomy refers to the principle that agents can operate by themselves without the need of human guidance. Therefore, agents with this attribute contain individual internal states and goals and they perform on behalf of its user to meet their goals.

Cooperation with other agents is paramount. In order to cooperate, agents need to possess a social ability, which means the ability to interact with other agents and possibly humans via some communication language (Wooldridge and Jennings, 1995). Agents also need to disembody bits of intelligence via learning attributes. Agents would have to learn as they react and/or interact with their external environment to enhance their performance over time.

Nwana and his colleagues use these three minimal attributes to derive four more types of agents to include in their typology, which are collaborative agents, collaborative learning agents, interface agents and truly smart agents. Collaborative agents emphasize more on cooperation and autonomy, collaborative learning agents stress more on cooperation and learning, whereas interface agents focus more on autonomy and

learning attributes. Truly smart agents have all the three attributes, which are autonomy, cooperative and learning.

However, these distinctions are not definitive. If collaborative agents inherit a combination of cooperation and autonomy attributes that does not imply that this agent will never learn. It only shows that collaborative agents emphasize more on cooperation and autonomy rather than learning. Figure 4-1 below shows Nwana's Agent Typology.
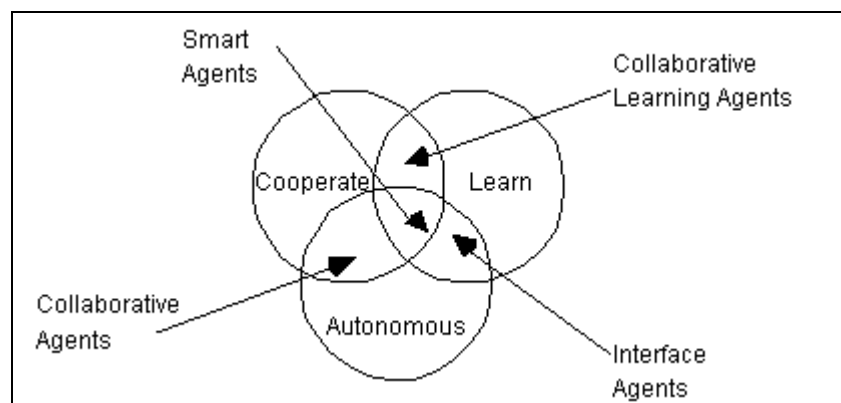


**Figure 4-1 Nwana's Agent Typology (from Nwana, 1996)**

The fourth dimension groups the agents according to their major roles. A typical example of these types of agents is WWW information agents. This category of agents usually exploits Internet search engines (e.g. WebCrawlers, Lycos and Spiders). These types of agents sometimes are referred as Internet/Information agents. Essentially, they assist in managing the vast amount of information in Wide Area Network, Local Area Network and Internet.

The last important dimension is a special form of categorization of agents. This dimension classifies agents that combine two or more agent philosophies in a single agent, namely the hybrid agents.

Other attributes such as versatility, benevolence, veracity, trustworthiness, temporal continuity, ability to fail gracefully; and mentalistic and emotional qualities are considered as secondary attributes in this typology (Bradshaw, 1997).

From the typology, Nwana and his colleagues pointed out that they did not find any agents that could fit the collaborative learning agents and truly smart agents' descriptions. Hence, only 7 types of agents are identified in this typology: Collaborative agents, Interface agents, Mobile agents, Information/Internet agents, Reactive agents, Hybrid agents and Smart Agents. These categories of agents are discussed in the subsequent section.

**4.2.2 Different Agent Types Identified by Nwana**
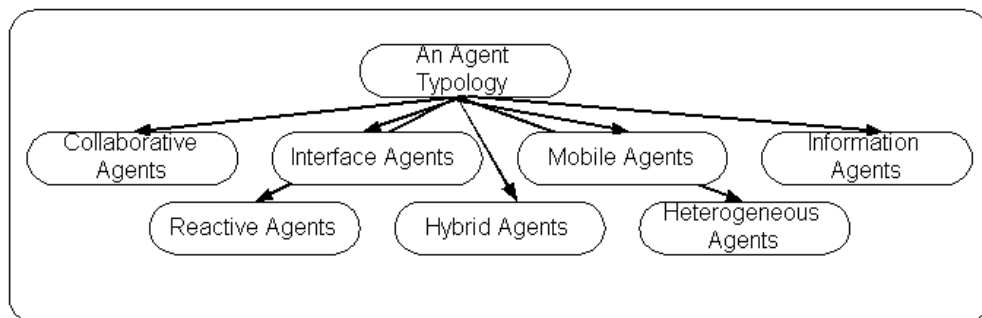


**Figure 4-2 A Summary of Nwana's Different Agent Types (from Nwana, 1996)**

As mentioned in section 4.2.1, there are all-together 7 different agent classes identified in Nwana's typology. Figure 4-2 above summarizes all the agent types in Nwana's typology. This section briefly overview each type of these agents. For more detailed information on these agents such as their metaphors, hypothesis/goals, motivations, roles, prototypical examples, potential benefits, key challenges and some other general issues, refer to Nwana's (1996) paper "Software Agent: An Overview".

### 4.2.2.1 Collaborative Agents

Collaborative agents emphasize on autonomy and cooperation while carrying out operations for their owners. Even though these agents have the ability to learn, however most of them do not perform any complex learning. Some researchers provide stronger definitions such as beliefs, desires and intentions or emotional attributes to these agents. Collaborative agents must have the ability to negotiate in order to reach an equally acceptable consensus when carrying out their operations. Autonomy, social ability, responsiveness and pro-activeness are the key characteristics of these agents. As a result, they are able to act rationally and autonomously in open and time-constrained multi-agent environments.

### 4.2.2.2 Interface Agents

Interface agents emphasize on autonomy and learning in order to assist their owners to perform their tasks. As noted by Pattie Maes, the underlying key metaphor of interface agents is that it is a personal assistant who collaborates with users in the same work environment. Interface agents usually support and provide users with assistance in using a particular application. Essentially, operations performed by these agents include observing and monitoring user's actions, learning new shortcuts and proposing better ways of doing a task. (Maes, 1994) has reported that interface agents learned by observing and imitating the user, receiving user's positive and negative feedback, receiving user's explicit instructions and inquire advice from other agents.

### 4.2.3.3 Mobile Agents

Mobile agents are computational software process that is capable of traveling around wide area network, interacting with foreign hosts, collecting information on behalf of

its owner and return home upon completing its tasks. Although mobile agents inherit the autonomy and cooperation attributes but they are distinguish from collaborative agents. This is because they are able to exchange only requested information with other agents without exposing other information. In other words, mobile agents may communicate or cooperate with one agent to make some of its internal objects and methods available for other agents.

### 4.2.2.4 Information Agents

Unlike other types of agents described previously, information or Internet agents are defined by their role, not by their attributes. In other words, they are defined by what they do, in contras with other agents such as collaborative and interface agents, which are defined by what they are. Information agents are created due to the great demands for a tool to assist users in managing the explosive growth of information. Generally, these agents perform the role of managing, manipulating and gathering information from many distributed sources. Interface agents that are employed with WWW-based roles are also called information agents.

### 4.2.2.5 Reactive Agents

Reactive agents, in contras with deliberative agents, do not possess internal and symbolic models of their environments. They behave in a stimulus-response manner towards the current state of the environment where they are embedded. Although this type of agents is relatively simple and only interact with other agents in basic ways, however when they are viewed globally, these interactions appeared to be a complex patterns of behavior. (Maes, 1991) emphasizes three key ideas that underpin reactive agents which include the emergent functionality (i.e. the dynamic of interaction leads to

the emergent complexity), tasks decomposition (i.e. a reactive agent is viewed as a collection of modules which operates autonomously and is responsible for specific tasks) and the tendency of reactive agents that operate on representation that are close to raw sensor data.

### 4.2.2.6 Hybrid Agents

Hybrid agents refer to those agents that are formed using the combination of two or more agent philosophies (such as mobile philosophy, interface agent philosophy and/or collaborative philosophy) within a singular agent. Since each type of agents has their own strengths and deficiencies, therefore, the hybrid approach is adopted with the goal to maximize the strengths and at the same time trying to minimize the deficiencies for a particular purpose. As a result, the key concept of implementing hybrid agents is based on the belief that for some application, benefits gained from using a singular agent with combination of philosophies are greater that using an agent with a singular philosophy.

### 4.2.2.7 Heterogeneous Agents

Heterogeneous agents system refers to an integrated setup of at least two or more agents, which belong to two or more different agent types. This type of agents differ from hybrid agents because it consists of two or more agents from different types that work independently yet collaboratively in an integrated environment, whereas hybrid agents try to combine two or more different agent philosophies within a singular agent. The motivation of this type of agents was articulated by Genesereth & Ketchpel (1994), that the world abounds with a rich diversity of software products providing a wide range of services for a similarly wide range of domains. Though these programs work in isolation, there is an increasing demand to have them interoperate - hopefully, in such a

manner such that they provide added value as an ensemble than they do individually.

## 4.3 Web Agent

In conjunction with the vast growth of the Internet and WWW, web agents are getting more and more important roles in software agent research and development that resided on various domains. In Sean Luke and James Hendler's (1997) introductory paragraph, they gave a good illustration on the emergence of web agents in the near future.

> *"There are two kind of information-seeker currently wandering the World Wide Web. First there are us humans, the web surfers for whom the web was designed. Second, there are increasing numbers of automated systems, Web Agents, which gather information from the web on our behalf. At the present time, humans far outnumber web agents, but this could soon change: as the sheer volume of information on the Web increases, and the ratio of junk and useful information continues to grow, we will increasingly rely on web agents to dig through all that muck to find our germs for us" (Luke and Hendler, 1997).*

Essentially, web agents are deployed especially in collecting, filtering and manipulating the vast information via the Internet. Indeed, some of these agents even exploit artificial intelligence and advance information technology on the Internet and WWW. Intelligent web agents offer a profusion of useful features such as provide a convenient graphical user interface to present information in a Web browser, securely handle users' Web site and autonomously perform various repeating tasks on behalf of the users.

Fundamentally, web agents are some automated programs, which perform tasks of gathering, clustering and filtering information from the web on behalf of their users. Besides, there are also some intelligent web agents that assist the users to browse and

search through the web, suggesting useful links to help the users to obtain their information easily and timeliness.

Based on Nwana's typology presented in section 4.2, web agents are best suit under the category of Information/Internet Agent (discussed in section 4.2.2.4). However, as time pass by, more and more web agents of other categories (e.g. Interface Agent, Mobile Agent and Reactive Agent) exist. Due to this, web agents should be defined by their role, not by their attributes. In other words, they should be defined by what they do not by what they are.

### 4.3.1 The Potentials of Web Agents

A recent review on software agents' research has indicated that web agents usage have great potentials in the future. In 1999, Nwana and Ndumu reported that agents started to become an exhortation around 1994 and the agent field is becoming more matured ever since then.

> *"Though "agents" research had been going on for more than a fifteen years before, agents really become a buzzword in the popular computing press (and also within the artificial intelligence and computing communities) around 1994"(Nwana and Ndumu, 1999).*

In the same paper, they further concluded that this change was due to the growth and explosion of the WWW.

> *"During late 1994 and throughout 1995 and 1996, we saw an explosion of agent-related articles in the popular computing press. It is no coincidence that this explosion coincided with that of the World Wide Web (WWW)."(Nwana and Ndumu, 1999)*

Since information posted in the Internet and WWW are progressively increasing, this opens opportunities to utilize the web agents. Furthermore, an independent telecommunication, new media and information technology analyst group named Ovum Inc. produce a report titled "Intelligent agents: the new revolution in software". In this report, they wildly speculated the total market sector for software agent and products by the year 2000. It predicts a $4 billion software agent market in the year 2000 with applications of agent technology appearing in the computing, telecommunications, consumer, entertainment, manufacturing and military market segment. Besides, Ovum anticipates that the Internet will support 500 million users worldwide by 2005. The findings are available in a new report from Ovum, Internet Market Forecasts: Global Internet Growth 1998 – 2005. Hence, in the next five years, agent-based technologies and services will become common. The growth in Internet and WWW will encourage towards the use of web-based agents.

**4.3.2 Types of Web Agents**

As web agents come in various shapes and size, Luke and Hendler have identified three categories of web agents: "Off-line" agents, "On-line" agents and "Guide" agents. "Off-line" agents gather all the information they possible find on Web, then allow users query this information according to their needs later. This type of agents is usually in the form of text indexing search engines like Lycos & AltaVista. Conversely, "On-line" agents search the web with a query in-hand. ShopBot search engine is an example of on-line agents. Lastly, "Guide" agents work alongside the users, helping the users focus their browsing in real time as they search for information on their own. These agents act as tour guide and steer the users along an appropriate path through the collection, based

on its knowledge of user's interests, of the location and relevance of various items in the collection, and of the way in which others have interacted with the collection in the past.

In addition, there are many web agents exist in various web applications. Besides the three general categories of web agents (i.e. "Off-line" agents, "On-line" agents and "Guide" agents) that have been identified by Luke and Hendler, these web agents can be further categorized into more specific types of agent according to their roles. These agents include information filtering agents (e.g. NewsWeeder (Lang, 1995) and Webhound (Lashkari, 1995)), information search assistant agents (e.g. WebWatcher (Joachims et. al., 1997), LAW & ELVIS (Edwards et. al., 1997) and Syskill & Webert (Pazzani el. at., 1996) ), information clustering agents (e.g. CUSTARD (Edwards et. al., 1997)), information advising agents (e.g. MAVA (Edwards et al., 1997)), collaborative web agents (e.g. Do-I-Care (Starr et. al., 1996)), personal agents (e.g. Remembrance Agent (Rhodes and Starner, 1996)) and more recently, the interactive assistance agents (e.g. Microsoft Agent). Most of these web agents have been embedded into different web applications to perform various tasks on behalf of their users.

Information filtering agents such as NewsWeeder and Webhound, as they are named, are performing the tasks of filtering information from the Web and presenting only the information that the users selected or the information that may of interest to the users. NewsWeeder enables the users to personalized list of article summaries from selected group of articles while Webhound recommends new documents to the users based on observation and employs documents to a user by comparing materials deemed to be of interest to one user with database of other user preferences.

Information search assistant agents such as WebWatcher, LAW & ELVIS and Syskill & Webert normally attempt to recommend links that a user should follow, help a user to find new and interesting information on the Web or deciding what pages might be an interest to the user. WebWatcher recommends links to its user, observes user's reactions towards its advice so that it could eventually predicts a user's action. LAW interactively suggests links to the user as they browse the Web and uses a separate Web robot that attempts to find pages that might be an interest for the users while Syskill & Webert learns a user profile by analyzing information on a page. It uses the user profile to suggest links and construct a query to find pages that the user would be interested to explore.

Other agents carry out their tasks based on their roles. Information clustering agents like CUSTARD groups similar documents together and presents the user with clusters of documents, rather than a flat list. MAVA, an information-advising agent, employs a number of agents to mediate access to a collection of databases. Do-I-Care is an innovative WWW agent that collaborates with both users and their peers to identify potential interesting changes. It works by soliciting user opinions about changes it finds to train a user model. Recently, Microsoft has developed interactive assistant agents named Microsoft agents, which is a set of programmable software services that supports a presentation of interactive animated characters within the Microsoft Windows interface. These agents work as interactive assistants to introduce, guide, and entertain or enhance Web pages or applications. They enable the incorporation of conversational interfaces, which leverages natural aspects of human social communication. In addition, Microsoft agents support speech recognition, hence an application will have the capability to respond to voice commands.

Based on information gathered above, the author formulates a diagram to illustrate various types of web agents with different roles on the Internet as shown in Figure 4-3.
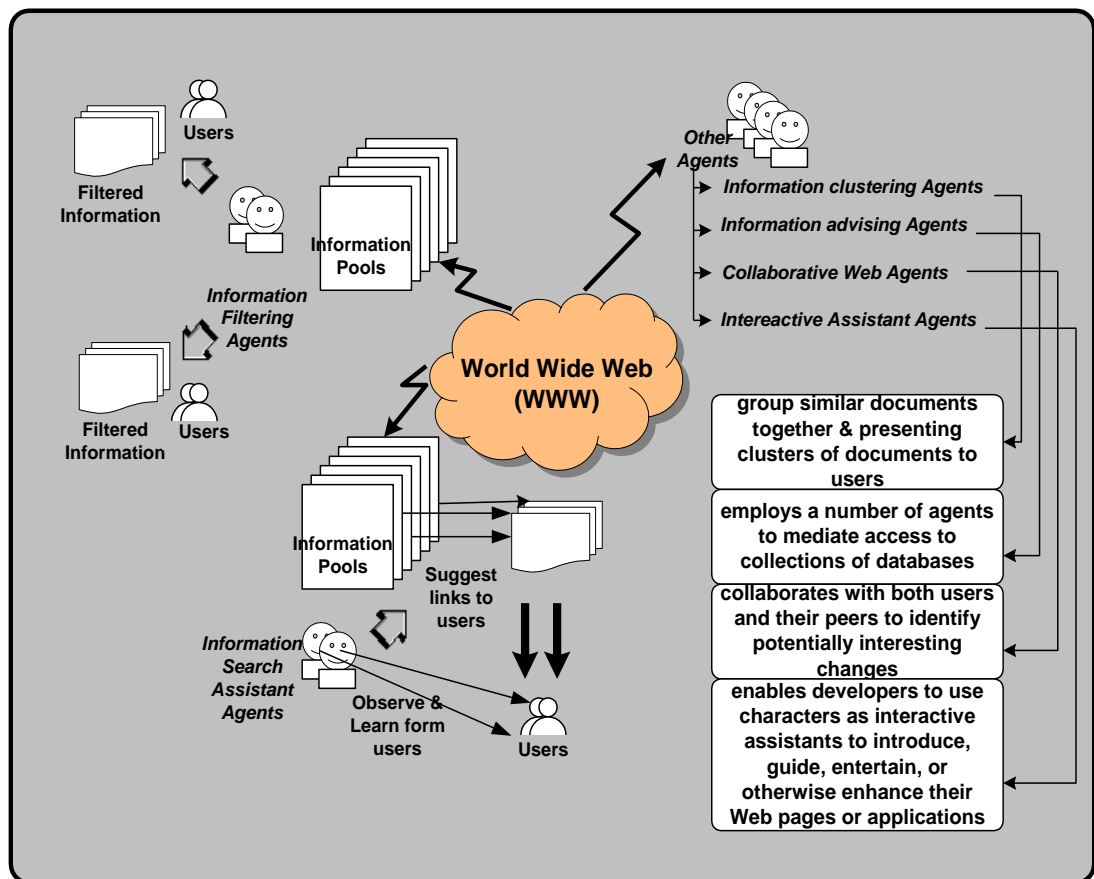


**Figure 4-3 Various Types of Web Agents with Different Roles on the Internet**

## 4.4 Agent Architectures for Educational Applications

Even though the implementation of web agents in educational applications is currently not a norm yet, however, there are indications that most future educational applications would implement various web agents to accomplish complicated tasks. At the time of writing, the author does not found any collaborative learning applications that implemented web agents in supporting the collaborative learning process. As a result, section 4.4.1 reviews four agent architectures that implemented web agents in their educational applications. Three of these agent architectures have been implemented in

the existing applications namely EduBots (Andoh et. al., 2001), CALM (Olguin et. al. 2000)and ANGEL (Jafari, 1999). The remaining agent architecture (Fenton-Kerr et. al., 1998) is a proposal of an architectural scheme for distributed collaborative learning environment. The reviews intentionally emphasize on how these agent architectures are implemented to support the learning activities. Thus, issues such as intelligent agents will not be considered in detail.

### 4.4.1 Existing Educational Applications with Agent Architectures

**EduBots (Educational Robots)**

EduBots serves as a major system component in an Intelligent Educational System model proposed by (Andoh et. al., 2001). This model consists of five basic components, which are student, teacher, repositories, EduBots and communication system. In order for EduBots to perform its functions, it must be trained by the users (student and teacher) to ensure it can understand tasks according to the knowledge provided. The EduBots will store and keep provided knowledge into its knowledge base. Once these Edubots are trained, student and teacher can request Edubots to perform tasks such as analysis courseware, library and assessment repositories and providing responses according to its knowledge base. The responses can be sent through communication system or displayed on web browser.

To support the educational system, EduBots applies multi-agents which are interface agent, assessment agent, email agent and sharing agent. Interface agent is a web-based graphical interface where it enables users to interact with Edubots. The primary functions of the interface agent are to execute the assessment and the sharing agent, to display information to the users and to communicate with other agents and with the

knowledge base. Email agent is responsible for generating, composing, organizing and sending emails to both students and teachers. The assessment agent analyzes assessment repository and determines which part of learning materials should be re-learned. The sharing agent is responsible for checking library repository for users where it can determine which articles or documents in the library repository are useful for its users based on the pre-defined user's requirements knowledge. The internal architecture of EduBots is depicted in figure 4-4.

Andoh and his colleagues stated several potential advantages of EduBots in educational system. These include sharing knowledge effectively, enabling cooperative task resolution among users, providing dynamic and personalized interface, improving the distribution of modules as well as communication among users.
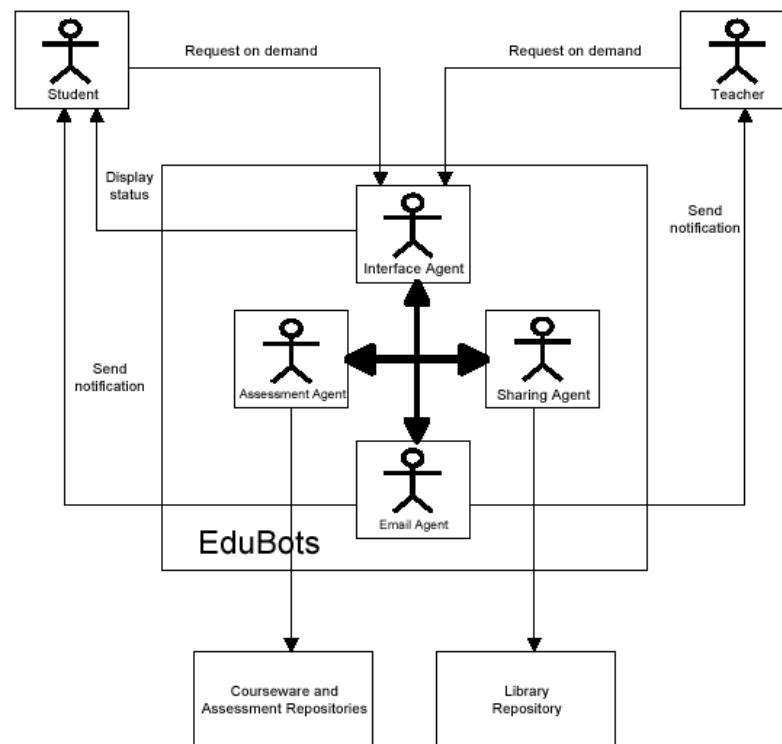


**Figure 4-4 EduBots' Internal Architecture (Adapted from Andoh et. al., 2001)**

**CALM (Computer Aided Learning Material)**

CALM is an on-line learning environment which is developed at UNICAMP. It is developed to recommend lessons regarding a student's learning objective and profile and to support interaction among actors and a learning material (Adriano et. al., 1999). CALM can be viewed as a kind of recommender system that work on sets of texts to assist and augment the social process of recommendation. In such process, a set of recommendations on a given subject (e.g., URL's in a newsgroup) is aggregated and delivered to an appropriate destination (a person or a repository). The main characteristic of these systems is the ability to choose and classify recommendations from input, based on weighted voting and content analysis. CALM differs from the traditional recommender systems that it regards to subjects already done by students, learning materials available, and the subjects that aimed to be learned. CALM recommendation is a composition that comprise of the desired subjects and a set of recommended subjects that are supposed to be known.

Olguin and colleagues proposed an Agent-based Architecture for group study in 1999. There are four agency working together in this architecture namely Group Agency, User Agency, Activities Agency and Advisory Agency. Figure 4-5 shows the Agent Architecture proposed by Olguin. In this architecture, the Group Agency performs tasks related to search and invitation processes. The User agency is associated with any user in the learning environment, group owner or not. This agency is responsible to interact with search agents sent by Group agencies.
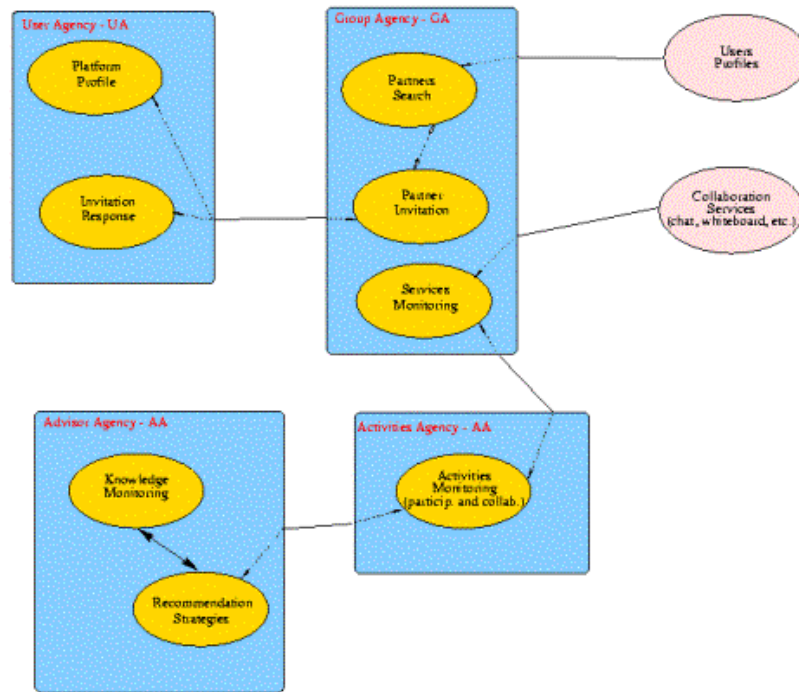
**Figure 4-5 Agent Architecture (Adapted from Olguin et. al. 2000)**

The Activity Agency uses the information collected by Group Agency to generate more information that is important for reasoning group members' activity and participation levels, and evaluating the effectiveness of a group. The Advisor agency performs most of the tasks related to group and members knowledge monitoring. It enables the customization of generated recommendations send by the group advisor based on the members profile and information related to the group activities. This agent-based architecture is implemented as a service of CALM system. It only implements the Group and User Agencies, which using CALM as a test-bed.

**ANGEL (A New Global Environment for Learning)**

ANGEL, A New Global Environment for Learning, is a web-based enterprise course management system, which is a further enhancement of the Oncourse project (Jafari, 1999). With the successful achievement of Oncourse, CyberLearningLabs of Indiana

University continued their Oncourse research and development project in the direction of developing a new global environment for learning. The objectives of ANGLE include the conceptual design, system design, prototype development and system development of a new intelligent web-based environment for teaching and learning needs. ANGEL project's major features include intelligent agents, enterprise framework and distributed authentication. Additionally, ANGEL focuses on theoretical research in the area of cognitive science, web usability and assessment.

The goals of ANGEL software development are focused on applying the research findings into the development of a complete software enterprise system. ANGEL's goals are broader than the developed Web-based "courseware" solutions. ANGEL supports standards for interoperability which is currently in development by the Internet Engineering Task Force and IMS EDUCAUSE and creating global solutions for teaching and learning. These software solutions are developed as modules, making the environment adaptable to the needs of educators of various resources. Utilizing IMS Metadata protocols, the objects in ANGLE environments (which may consist of software resources, course content, video or audio resources, etc.) are readily searchable and accessible through traditional search engines, but with more concise query methods. This global access is managed by the authentication system, allowing resources to be made private, local or global depend on the author's preferences.

Moreover, the ANGEL environment includes a series of intelligent agents to provide a more effective, interactive and dynamic environment for teaching and learning. ANGLE's architecture is designed in a way that it can be modified and extended since e-learning strategies change and grow. Intelligent agents are one type of the extension.

Generally, there are five intelligent agents developed in ANGLE, namely Who Dun It Agent, What's New Agent, Learner Profile Agent, PDA Agent and Ungraded Items Agent. The Who Dun It agent is responsible to generate course mail to specific users based on their activity. For instance, it can be used to find students who scored above 75% on a quiz and send an email to each of them. The What's New agent searches items that have not been visited or completed by the user and brings them to the user's attention. This may helps the user to catch up quickly. The Learner Profile Agent enables the assessment of every student's total performance. It reduces the time spent in assessing student performance and participation, provides information on every aspect of each student's performance and relates each student's performance to his/her class. The PDA Agent provides access to ANGLE at any time and place. It enables user to download news, calendar and unread course item into the PDA (Personal Digital Assistant). The Ungraded Items Agent plays the role of finding and listing all items with one or more ungraded submission to ensure action can be carried out accordingly.

**Architectural Scheme for Distributed Collaborative Learning Environment**

Fenton-Kerr's architectural scheme is proposed for supporting the distributed collaborative learning environment (Fenton-Kerr et. al., 1998). Past multi-agent schemes are usually implemented in a situation where net-based transactions will occur. The typically agents in such multi-agent schemes include interface agents, informational agents and coordinating or planning agents (Fenton-Kerr et. al., 1998). To extend this concept, Fenton-Kerr proposed 3 additional entities specifically designed for a distributed collaborative learning environment. The 3 extended entities are LOCAL agent, TRACKER agent and DICTIONARY agent.

The LOCAL agent has local knowledge, but not specialized knowledge. It acts as a guide to modules, explaining the actions of various screen objects such as input and result fields and buttons. The TRACKER agent tracks a user's passage through the program, makes inferences on the user's current level of understanding (i.e. basic user modeling) and keeps a record of the user's subject-specific input. It may also maintain a log of user's previous sessions within-course assessment. Finally, the DICTIONARY agent offers contextual explanations or definitions. It may make use of alternative input modes such as audio-based requests, or gestural (deictic) responses (such as circling a word). In the proposed approach, a variation on the federated system (Genesereth and Ketchpel, 1994), detailed in figure 4-6, the coordinating agent plays the role of a facilitator.
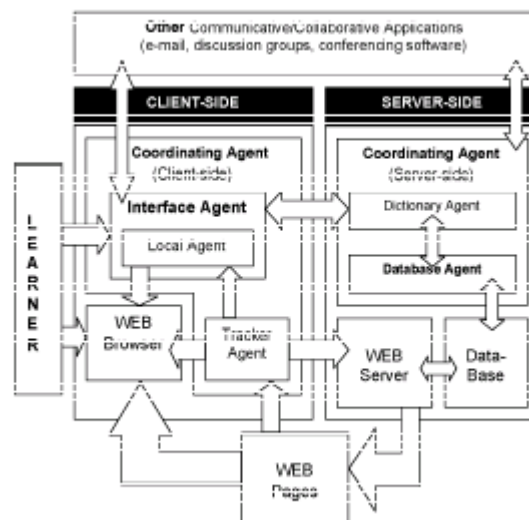


**Figure 4-6 A Proposed Architectural Scheme of a Multi-Agent System (Adapted from Fenton-Kerr et. al., 1998)**

As shown in figure 4-6, the Database Agent retrieves database information by developing appropriate structured query statements. As the only agent with knowledge of database and its contents, it mediates requests from other agents such as Dictionary

Agent and system-level requests from the web server. The Tracker Agent has two tasks. It keeps track of the current page contents and logs a user's entire session, including visited pages, test results or other interactions.

**4.4.2 Summary on reviewed Agent Architectures**

Table 4-1 provides a summary of web agents' implementation in education applications based on the web agents involved, their roles and characteristics, as well as its applied architecture in each application.

**Table 4-1 Summary of Web Agents' Implementation in Educational Applications**

| Application | Agents Involved | Roles & Characteristics | Architecture |
|---|---|---|---|
| Edubots (web-based), 2001 | Interface Agent | - To executive the assessment agent & sharing agent<br>- To display information to users<br>- To communicate with other agents and with knowledge based | Collaborative Agents Architecture (Multi-Agent System) |
| | Sharing Agent | - To determine user's interested articles or documents based on pre-defined user's knowledge requirements | |
| | Assessment Agent | - To analyze assessment repository<br>- To determine which part of material should be re-learned | |

| | | | |
|---|---|---|---|
| | Email Agent | - To be responsible in generating, composing, organizing and sending emails to both the students and teachers | |
| CALM (web-based) 2000 | Group Agency | - To perform the tasks related to search and invitation processes | Agent-based Architecture (Multi-Agent System) |
| | User Agency | - To interact with search agents sent by Group agencies | |
| | Activity Agency | - To generate more information for reasoning about activity and participation levels of group members | |
| | Advisory Agency | - To perform most of the tasks related to group and members knowledge monitoring | |
| ANGLE (web-based) 2000 | Who Dun It Agent | - To generate course mail to specific users based on their activity | ANGLE System Architecture |
| | What's New Agent | - To search items that have not been visited or completed by the user<br>- To bring these items to the user's attention | |

| | Learner Profile Agent | - To monitor every student's performance and participation<br>- To maintain every student's activity log<br>- To reduce the assessment time of students' performance | |
|---|---|---|---|
| | PDA Agent | - To provide access to ANGLE anytime, anyplace | |
| | Ungraded Items Agent | - To find and list all items with one or more ungraded submission | |
| Fenton-Kerr's architectural scheme | Local Agent | - To explain the actions of various screen objects to the modules | Proposed Architectural Scheme (Multi-agent System) |
| | Tracker Agent | - To track a user's passage through the program<br>- To make inferences about a user's current level of understanding<br>- To keep a record of a user's subject-specific input<br>- To maintain a log of user's previous sessions | |
| | Dictionary Agent | - To offer contextual explanations/definitions | |
| | Database Agent | - To retrieve database information by developing appropriately structured query statements | |

| | Coordinating Agent | - To transform the application-level messages and route them to the appropriate places | |
|---|---|---|---|

## 4.5 Web Agents in Supporting Collaborative Learning

The advancement of Internet and WWW has significant impact on education. The Internet provides an environment where everyone can teach and learn collaboratively. With the WWW, worldwide information and global dimensions of education interaction become feasible. These changes have direct impact on collaborative learning activities. They provide network infrastructures and knowledge sharing spaces for collaborative learning. Under such circumstances, the web agents have great potentials in supporting the collaborative learning as well.

According to Kristensen (2001), one of the major challenges in the field of CSCL is to provide the learners with an environment that helps them relate new knowledge to knowledge they already have internalized, and to integrate this knowledge with knowledge from different information technology tools. Web agents, particularly information agents can be used to perform these tasks by providing the learner access to larger knowledge resources through the WWW, searching and filtering related information on behalf of the learners.

Besides, web agents also can be used to support the students in learning process. Normally, in a collaborative learning environment, the students have access to other students' and teachers' ideas and concepts. Web agents can be used to enable the students to exchange and synthesize viewpoints with many students and teachers. To

promote more effective collaboration, web agents such as personal assistant agents can be used to help a student to obtain assistance from other students while he/she performs a task. This surely simplifies the student's learning process.

In addition, collaborative learning requires organization and coordination of people and resources within the distributed environments. Web agents can play a crucial role in the coordination processes. Moreover, some of the collaborative process involved several stages with different activities at each stage. Under such circumstances, web agents can be used to automate the complicated collaboration processes in simplifying the collaborative learning. This can be achieved by controlling the flows of the activities and guiding the students' navigation.

Besides, knowledge sharing is a major requirement in a collaborative learning environment. Creating a shared repository which can be publicly accessed and easily reused normally requires great efforts and time. In this context, web agents are best to be used to administer and maintain the shared repository. These tasks include searching, categorizing and storing the information, and enabling the retrieval of these information in an easy manner.

From the discussion in section 4.5, many potential roles of web agents in supporting collaborative learning are identified. These roles are summarized in table 4-2 below:

**Table 4-2 Web Agents Roles in Supporting Collaborative Learning Activities**

| Types of possible web agents | Major roles | Examples |
|---|---|---|
| Information Agents | Provide access to worldwide knowledge resources, search, filter and integrate related information for its users. | Search Agent, Filtering Agent, Integration Agent, etc. |
| Personal Assistant Agents | Assist users to get help while they are performing a learning task by enabling the communication among the students | Mentor Agent, Interactive Assistant Agent, Personal Agent, |

| | and teachers. | etc. |
|---|---|---|
| Coordinating and Autonomous Agents | Coordinating the flows of collaborative process and automating some complicated processes. | Navigation Agent, Tracker Agent, Information Advising Agent etc. |
| Repository or Database Agents | Administer and maintain the large volume of information in the shared repository or database. | Sharing Agent, Filtering Agent, Clustering Agent, Profile Agent, etc. |

## 4.6 Web Agents in supporting G-Jigsaw Collaborative Learning

Form the discussion in this chapter, there are many potentials to deploy web agents to support collaborative learning activities. The author attempts to utilize web agents to automate and simplify the G-Jigsaw activities. Based on the web agent roles identified in section 4.5 and the drawbacks of G-Jigsaw prototype discussed in section 3.8, the following are the potential roles of web agents in supporting G-Jigsaw:

- Sharing Agent – to enable teachers to retrieve and use existing questions for creating a jigsaw task, to enable students to retrieve the responses and summaries for the jigsaw task, as well as to filter, categorize and save new questions in a shared repository automatically.

- Integration Agent – to enable the students to perform the report integration automatically.

- Navigation Agent – to control and automate the flows of G-Jigsaw activities by keeping track of every student's jigsaw task profiles.

The next two chapters will discuss the design and implementation of G-Jigsaw which utilizes the web agents to support jigsaw collaborative learning activity. Chapter 5 will discuss the analysis and design of G-Jigsaw while chapter 6 will describe its web agents' implementation.

## 4.7 Review Summary

This chapter has presented a thorough literature review on web agents. The fundamental theoretical aspects of software agent such as agent definitions and classifications are discussed. The web agent definition, the potentials of its deployment and the various types of web agents are investigated. Three existing educational applications that implement web agents and an architectural scheme for distributed collaborative learning environment are reviewed. As a result, web agents' potentials in supporting collaborative learning activities are identified. Finally, web agents to support G-Jigsaw collaborative learning are discussed.

# Chapter 5 – G-Jigsaw Analysis and Design

This chapter presents the analysis and design of G-Jigsaw. The first part depicts the requirements analysis and object-oriented analysis of G-Jigsaw. G-Jigsaw architecture, design specification and user interface design are presented in the second part.

## 5.1 G-Jigsaw Analysis

Analysis is the process of extracting the needs of a system and what the system must do to satisfy the user's requirements (Bahrami, 1999). It is a very important phase to ensure the developed system will function according to users' needs. G-Jigsaw analysis includes both requirement analysis and object-oriented analysis.

### 5.1.1 Requirement Analysis

Requirement analysis is a process of discovery, refinement, modeling and specification (Pressman, 1992). It bridges the gap between system level software allocation and software design, enables software functions and performance to be specified, indicates software's interface with other system components and establishes design constraints that the software must meet.

Requirement analysis always encompasses functional requirements and non-functional requirements. Functional requirements describe how the system should behave given certain stimuli (Pfleeger, 1998). They illustrate interactions between the system and their environment. Conversely, non-functional requirements do not specifically focused on the system functionality. They place restrictions on the development process of the product being and specify external constraints that the product must meet. Non-

functional requirements include safety, security, usability, reliability and performance requirements (Kotonya and Sommerville, 1998).

### 5.1.1.1 G-Jigsaw Functional Requirements

G-Jigsaw functional requirements are based on the group jigsaw process model discussed in chapter 3. The process model is supported by G-Jigsaw modules named Jigsaw Task, Initial Group, Expert Group and Jigsaw Group. Besides that, G-Jigsaw supports two types of users with different responsibilities, which are teachers and students. Teachers are responsible for preparing the jigsaw tasks and evaluating students' answers. Students are engaged in three continuously stages of jigsaw collaborations, which are inter-member (group level) in Initial Group, inter-group (group level) in Expert Group and inter-member (group, classroom level) in Jigsaw Group.

**Functional Requirements for Jigsaw Task Module**

The Jigsaw Task Module supports both teachers and students. The functional requirements for these users are listed accordingly below:

1. Teachers are able to:
   i. create new jigsaw tasks for students' participation.
   ii. retrieve and use existing questions through question templates for the jigsaw task.
   iii. upload graphics for the jigsaw task.
   iv. modify created jigsaw task.
   v. extend jigsaw task submission date.
   vi. delete expired or unwanted jigsaw task.

2. Students are able to:
    i. view jigsaw tasks prepared by teachers.
    ii. participate in jigsaw tasks.
    iii. resume their uncompleted jigsaw task.

This module will automatically filter, categorize and save new questions in a shared repository.

**Functional Requirements for Initial Group Module**

The Initial Group Module supports student's inter-member (group level) collaboration.

The functional requirements for this module are depicted below:

1. Students are allowed to:
    i. select their group and question assigned by their teacher.
    ii. view their selected question and other group members' questions.
    iii. respond to all group members.
    iv. view group members' responses towards their responsible question.
    v. create a summary for their responsible question.
    vi. retrieve and modify group members' responses into their summary.

2. Besides that, it is able to:
    i. create a profile for each student who starts a new jigsaw session.
    ii. keep track on the number of questions that students have responded.
    iii. inform students when there are no more questions to be responded.
    iv. control and automate the jigsaw activity.

3. Explicit controls are implemented for students to:
    i. respond to all their group members in any sequence.
    ii. create a summary only when they have read all their group members' responses.
    iii. proceed to the next stage (i.e. Expert Group) only when they have

submitted their summary.

**Functional Requirements for Expert Group Module**

The Expert Group Module supports student's inter-group (group level) collaboration.

The functional requirements for this module are as follows:

1. Students are able to:
    i. view summaries of other groups.
    ii. respond to other groups members' summaries.
    iii. receive comments and feedback towards their own summary.
    iv. respond to feedbacks they received in order to discuss or clarify issues raised by other groups' members.
    v. create a report for their responsible question.
    vi. retrieve their summary as a part of their report answer.
    vii. view responses received towards their summary.
    viii. modify and improve their responsible question report.

2. Explicit controls are implemented for students to:
    i. create a report only when they have read all other groups members' summaries.
    ii. proceed to the next stage (i.e. Jigsaw Group) only when they have submitted their report.

3. Besides that, this module is able to control and automate the jigsaw activity.

**Functional Requirements for Jigsaw Group Module**

The Jigsaw Group Module supports student's inter-member (group, classroom level) collaboration. The functional requirements for this module include:

1. Students are able to:
    i. view all their group members' reports.
    ii. modify their own report if necessary.
    iii. create an integrated report (only by the group leader).
    iv. view their group and other groups' individual and integrated reports.

2. Besides that, it is able to perform the integration process automatically.

3. The explicit control implemented in this module is only the group leader is allowed to perform the integration report process.

### 5.1.1.2 G-Jigsaw Non-functional requirements

Non-functional requirements restrict how the functional requirements should be implemented. The non-functional requirements for G-Jigsaw include:

1. The system should provide an easy user interface for users to understand how to use the system.

2. The system should be expendable for future enhancement.

3. The system should be able to provide good security control for all documents and pages in the database.

These non-functional requirements define the overall qualities of G-Jigsaw.

### 5.1.2 Object-Oriented Analysis

"Object-oriented Analysis (OOA) is a method of analysis that examines requirements from the perspective of the classes and objects found in the vocabulary of the problem domain." - Grady Booch (Verma, 2000). Unified Modeling Language (UML) is one of the modeling languages used in OOA and it is selected to produce the G-Jigsaw analysis

model. Use Case Diagrams and Class Diagrams are used in the analysis process.

### 5.1.2.1 G-Jigsaw's Use Case Diagrams

A use case is a typical interaction between user and the system in order to achieve some goals (Verma, 2000). It provides a communication basis between users and developers in planning a project. Use case diagrams are used to visualize use cases as primary elements in software development. These diagrams consist of actors, a set of use cases enclosed by a system boundary and relationship among the use cases. An actor is a role of an external object or a user plays with respect to the system. There are two types of relationships (i.e. uses and extends) among use case diagrams. The 'uses' relationship is used to avoid repetition when there are some general behavior that are similar across more than one use case while the 'extends' relationship is used to describe a variation on a normal behavior.

There are 26 use cases in the G-Jigsaw analysis model. These use cases are identified and categorized into 5 modules. All use cases in a module can be represented in one use case diagram. Each of these use case can be described by using a scenario. Interaction diagrams illustrate the details of these scenarios in the object-oriented design (OOD) phase. Only two actors (i.e. teacher and student) are involved throughout the entire process. This chapter only shows 3 use case diagrams and the other use case diagrams are attached in Appendix A-1.

**Jigsaw Task Module**

There are 8 use cases in the Jigsaw Task module. Figure 5-1 shows the use case diagram for this module. In this module, only teacher can create new jigsaw task for

students' participation. Teachers can retrieve existing questions from a shared repository using available task templates. Teacher can edit or delete the questions if necessary. After the jigsaw task is created, both teachers and students can view it. They can also navigate other modules.
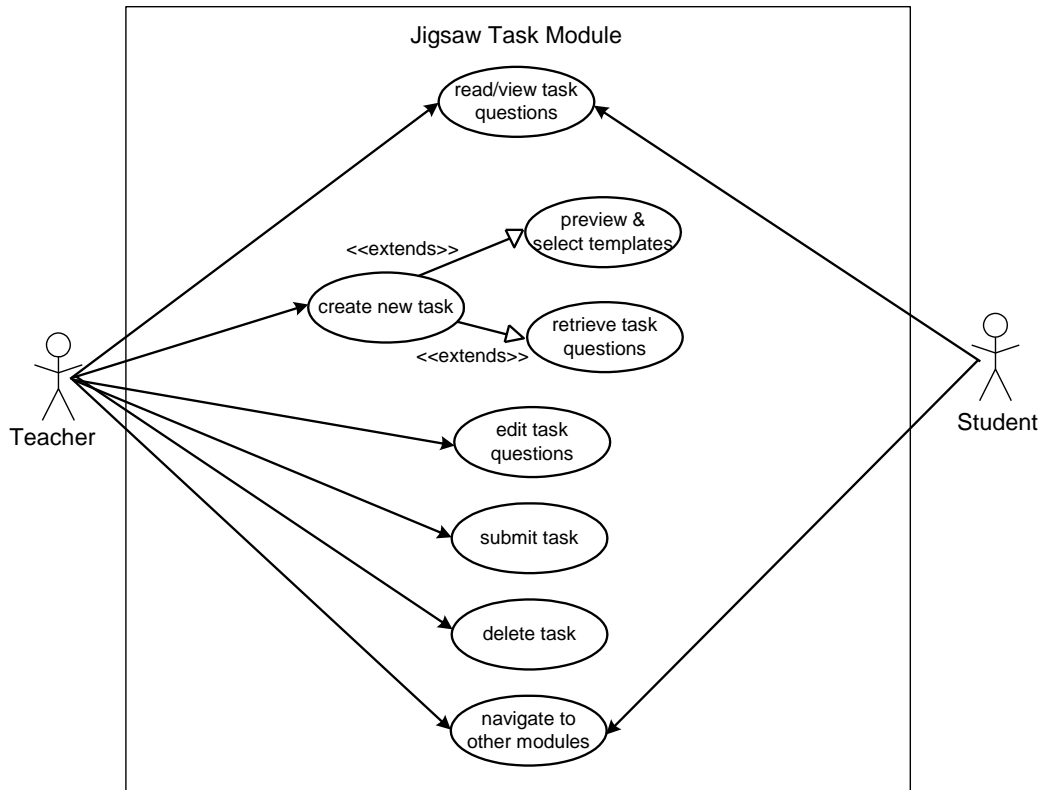


**Figure 5-1 Use Case Diagram For Jigsaw Task Module**

**Initial Group Module**

There are 7 use cases in the Initial Group module as shown in figure 5-2. In this module, only students are involved. When they start to participate in the jigsaw activity, students set their own profile, post responses to their group members, read responses from their group members and compose a summary for their selected question to be used in the Expert Group discussion. Students can retrieve and use their group members' responses as part of their summary.
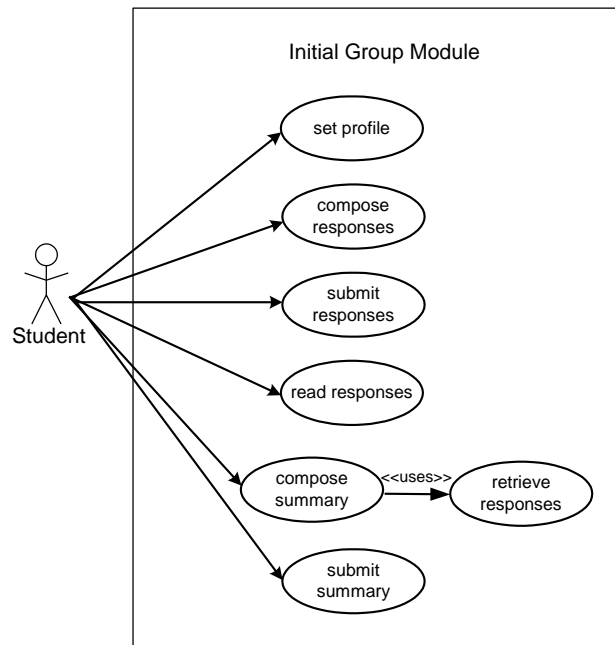
**Figure 5-2 Use Cases Diagram For Initial Group Module**

**Expert Group Module**

Figure 5-3 presents the Expert Group module's use case diagram. There are 5 use cases in this module. Similar to the Initial Group module, this module involves only the students. Students can read other groups' summaries and post and receive comments from other groups members. After the expert group discussion, students need to create a report. Their can retrieve and use their previous summary to be apart of their report. These individual reports will be integrated later in the Jigsaw Group.
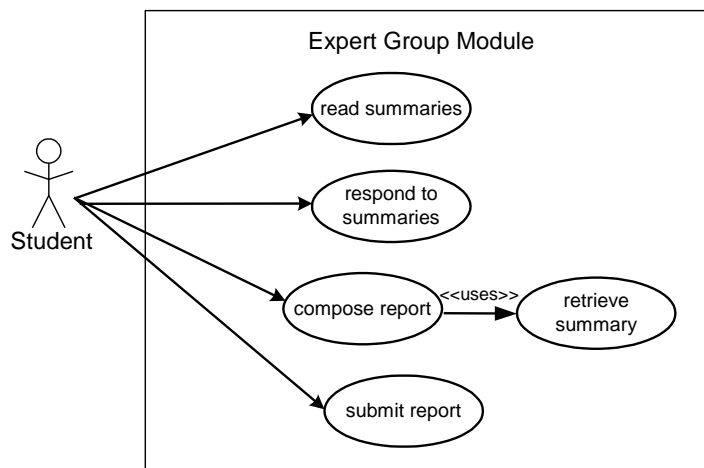


**Figure 5-3 Use Cases Diagram For Expert Group Module**

### 5.1.2.2 G-Jigsaw Class Modeling

UML class diagrams show the classes of the system, their inter-relationships, the operations and attributes of the classes (Ambler, 2003). In this section, class diagrams are used to analyze requirements in the form of an analysis model. Thus, the focus is to identify the classes' responsibilities instead of focusing on specific attributes or operations. A class model comprised one or more class diagrams and the supporting specifications that describe the model elements include classes, relationships between classes and interfaces (Ambler, 2003). The G-Jigsaw class model is depicted in figure 5-4. This model serves as an analysis model that shows a general view on how various classes in the system collaborate with each other. The design details for G-Jigsaw are discussed in the OOD section.
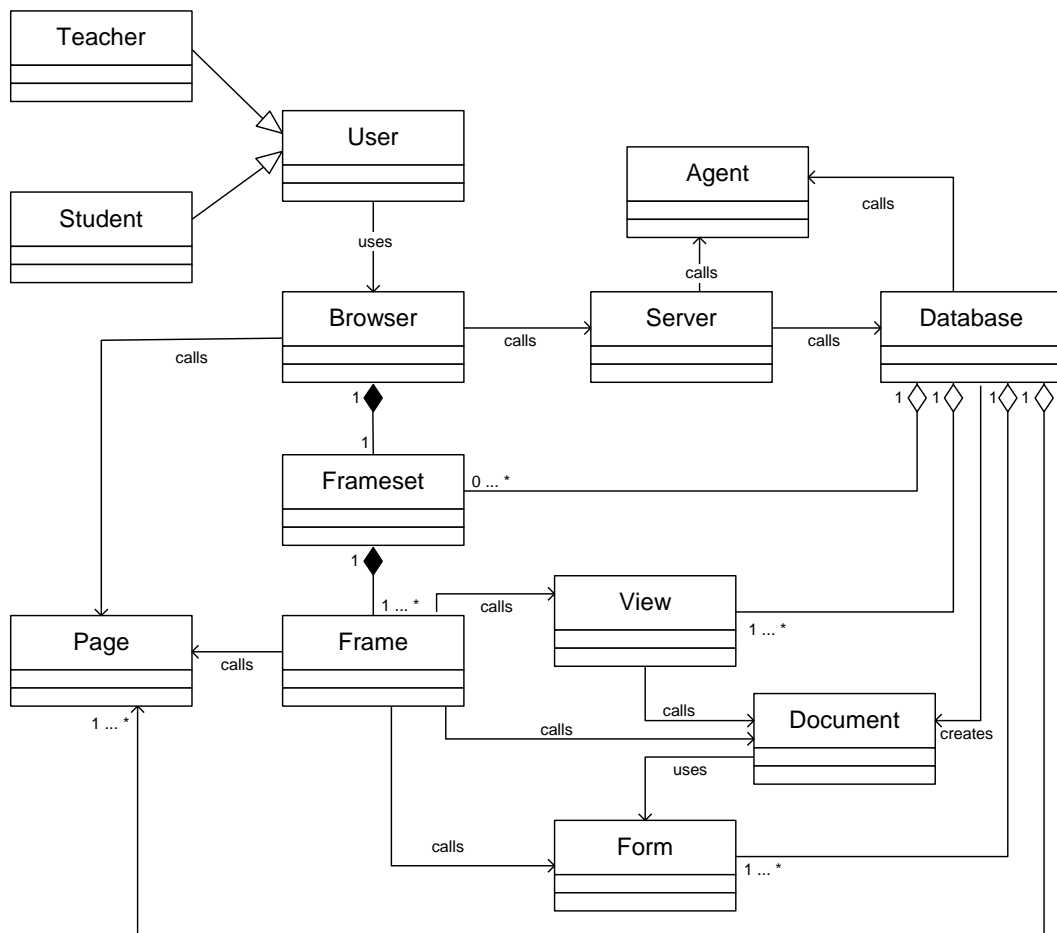


**Figure 5-4 G-Jigsaw Class Model**

### 5.1.3 Summary of Web Agents Requirements in G-Jigsaw

This section summarizes the functional requirements in G-Jigsaw that involve web agents.

In Jigsaw Task Module:

1. The Sharing Agent enables the teachers to retrieve and use existing questions through question templates for the jigsaw task.
2. The Sharing Agent will automatically filter, categorize and save new questions in a shared repository.
3. The Navigation Agent enables the students to resume their uncompleted jigsaw task.

In Initial Group Module:

1. The Sharing Agent enables the students to retrieve and modify group members' responses into their summary.
2. The Navigation Agent:
    i. creates a profile for each student who starts a new jigsaw session.
    ii. keeps track on the number of questions that students have responded.
    iii. informs students when there are no more questions to be responded.
    iv. controls and automate the jigsaw activity.
3. The Navigation Agent enforces some explicit controls for students to:
    i. create a summary only when they have read all their group members' responses.
    ii. proceed to the next stage (i.e. Expert Group) only when they have submitted their summary.

In Expert Group Module:

1. The Sharing Agent enables the students to retrieve their summary as a part of their report answer.
2. The Navigation Agent enforces some explicit controls for students to:
    i. create a report only when they have read all other groups members' summaries.
    ii. proceed to the next stage (i.e. Jigsaw Group) only when they have submitted their report.

In Jigsaw Group Module:

1. The Integration Agent enables the students to perform the report integration automatically.

2. The Navigation Agent allows only the group leader to perform the integration report process.

## 5.2 G-Jigsaw Design

Design is a creative process of transforming a problem into a solution; the description of a solution is also called design (Pfleeger, 1998). It is a phase that emphasizes on how the system should perform in order to fulfill the requirements identified in the analysis phase. G-Jigsaw Design includes the Architecture Design, Object-oriented Design as well as Interface Design.

### 5.2.1 Architecture Design

G-Jigsaw is a web-based application that resided on the Lotus Domino platform. Figure 5-5 depicts the G-Jigsaw's environment that comprises of both hardware and software components. The hardware components of G-Jigsaw consist of client computers, a domino server computer and a network that connects them. The software components of G-Jigsaw reside on the client and server computers. There are three-levels of software architecture for its client and server, which are the client/server level, Notes Object Services (NOS) level and Database/File level.

The client and server programs are located in the client/server level of the software architecture. The Domino Server program supports the connection between clients and server and manages a set of server tasks.
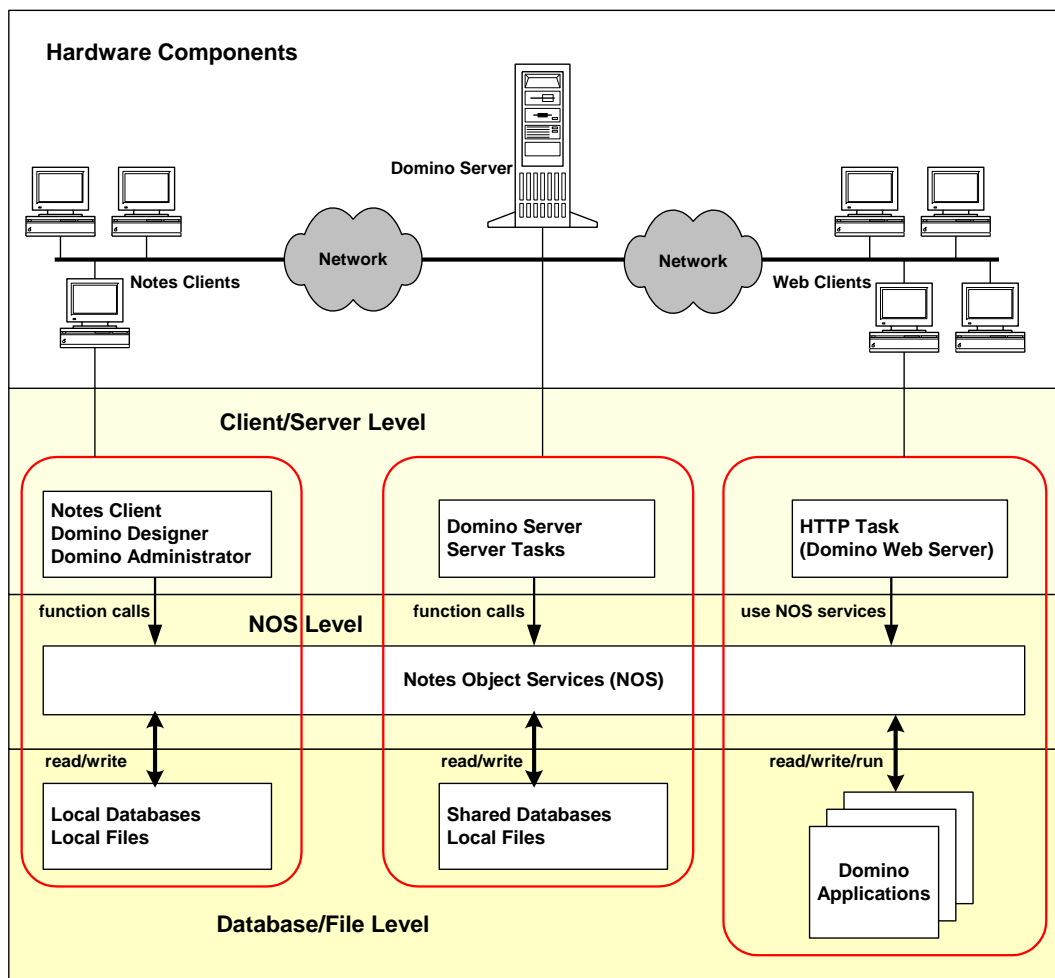
**Figure 5-5 G-Jigsaw Environment**

G-Jigsaw supports two types of clients, the Notes Clients and Web Clients. The Notes Clients comprises of Lotus Notes Client, Domino Designer and Domino Administrator. The Notes Clients are mainly restricted to the developers and administrators only. Developers use Domino Designer to modify and customize G-Jigsaw design elements and to control users' access to the G-Jigsaw database. Administrators use Domino Administrator to register new users into the Domino server and manage the Domino Web Server configuration. On the other hand, the G-jigsaw Web Clients are the Internet Browser that connects to the Domino server. Teacher and students can use the Web Clients to carry out various collaborative learning activities supported by G-Jigsaw.

The second level in G-Jigsaw architecture is the NOS level. The NOS is a set of portable C/C++ functions that create and access information in databases and files, compile and interpret formulas and scripts and as an interface for the operating system services. The client and server programs use NOS to create, modify, read and maintain databases and files. The third level of G-Jigsaw architecture is the database/file level. This level serves as repositories for all the data stored in databases or files. G-Jigsaw is a shared database that can be access over the network.

Since G-Jigsaw is designed as a web application, therefore, it is important to know the architecture of the Domino Web server. Lotus Domino Server can be a Web application server that provides an integrated set of services to create more secure interactive Internet and Intranet applications. In this context, the HTTP (Hyper Text Transfer Protocol) server task of the Domino Server plays an important role in handling requests from web clients. Figure 5-6 illustrates the Domino Web Server architecture.

As shown in figure 5-6, the heart of the Domino Web application server is the HTTP server task. Requests from Web clients go directly to the HTTP task to be processed. When the HTTP task receives a request from a Web browser, a connection is made to the HTTP stack. The HTTP stack includes all codes that deal with both inbound and outbound HTTP communications. It manages the connection between Web clients and server. The default action for HTTP stack is to send the request directly to the URL (Uniform Resource Locater) parser. The URL parser handles incoming Domino URL calls. It determines if it is a standard URL or a special Domino URL.
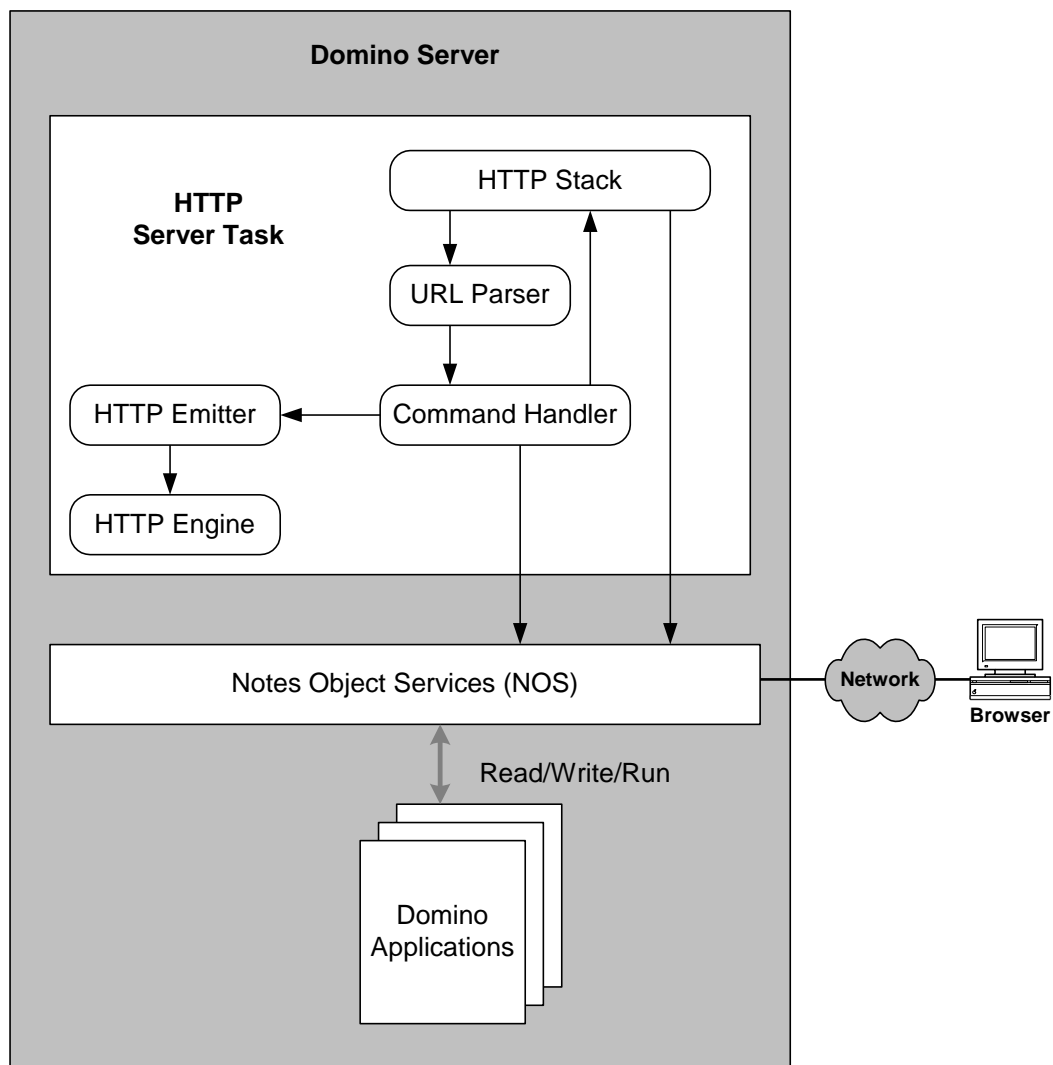
**Figure 5-6 Domino Web Server Architecture**

If it is a standard URL, the parser sends the information to the HTTP stack, which processes it as simple HTTP commands. If it is a Domino URL, the parser breaks the URL into different parts, performs a series of checks, provides implicit commands if necessary and invokes appropriate command handlers. These command handlers are direct links between HTTP task and NOS. They manage all details associated to each command by establishing the correct identity for security purposes, accessing NOS, executing formulas and scripts and retrieving information.

The result is sent back to the HTTP server through the command handlers and then passed to the HTML emitter. The HTML emitter prepares the outgoing flow of information based on the URL calls results. It uses HTML engine to translate the information into HTML pages. The HTML engine acts as a standards source that defines the proper format of any information translated into HTML. Finally, the pages are sent to HTTP stack, which establishes a connection to the client and display the data correctly.

G-Jigsaw implements multi-tier client/server architecture as shown in figure 5-7.
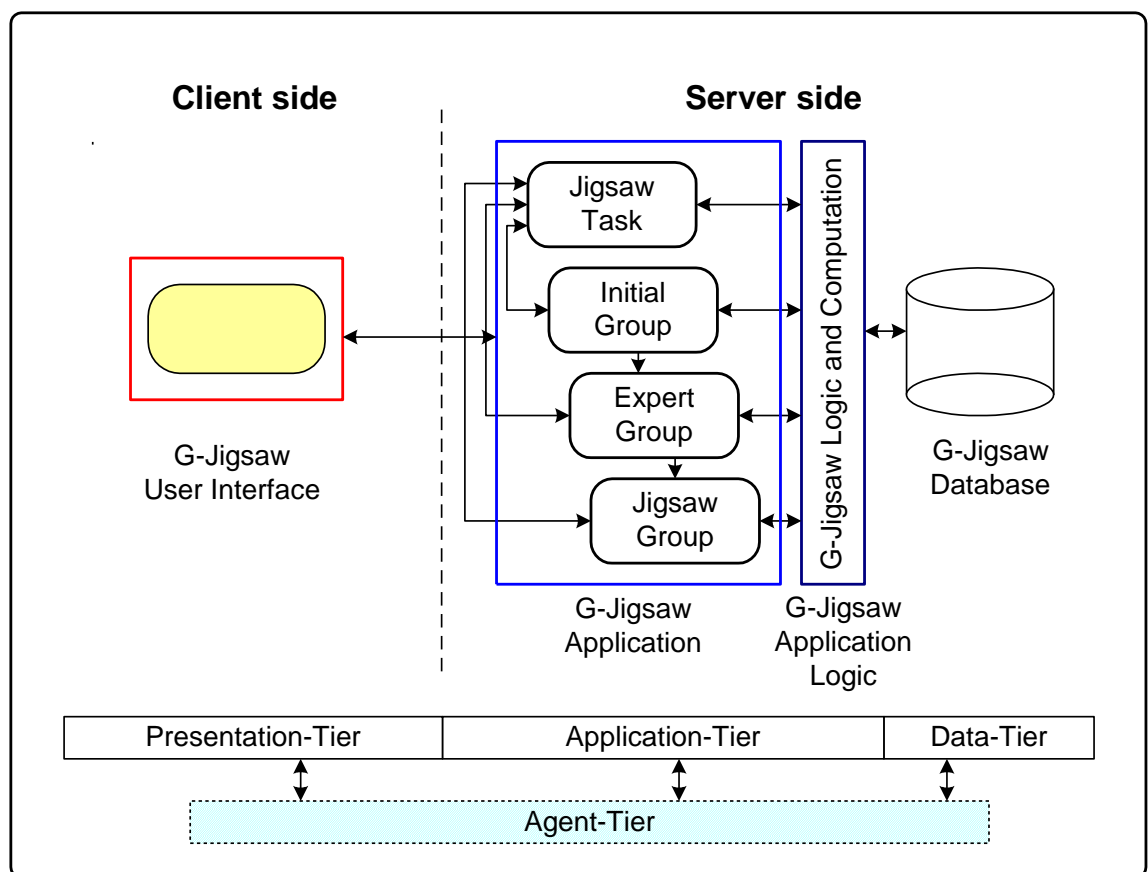


**Figure 5-7 G-Jigsaw's Multi-tier Client/Server Architecture**

In this architecture, G-Jigsaw's user interface is located in the presentation-tier at the client side, which receives users' inputs and display information to users through a web browser. G-Jigsaw's modules and its application logic reside on the application-tier at

the server side. The application-tier is the core component that supports the jigsaw activities. The data-tier provides access to G-Jigsaw database. The database can only be accessed through the application-tier. In addition, an agent-tier is embedded in this architecture to support the deployment of web agents. The agent-tier has its own unique internal multi-agent architecture that enables the communication within the web agents as well as its external entities located in other tiers. This internal multi-agent architecture will be discussed in more details in chapter 6.

### 5.2.2 Object-Oriented Design

"OOD is a method of design encompassing the process of object-oriented decomposition and a notation for depicting both logical and physical as well as static and dynamic models of the system under design" - Grady Booch (Verma, 2000). The analysis model presented in section 5.1.2 serves as a core basis for the design models, while a mature design model provides better guidelines for programming activities. Sequential Diagrams and Activity Diagrams are used in the design process.

### 5.2.2.1 G-Jigsaw's Sequential Diagrams

A Sequence Diagram provides a diagrammatic representation of a specific instance of a use case (a scenario) (Verma, 2000). It provides a way to visually step through invocation of the operations defined by the classes. The G-Jigsaw design model uses sequential diagrams to validate and flesh out the logic of a usage scenario. A usage scenario is the description of a potential way that the system is used (Ambler, 2003). This chapter shows only 5 sequential diagrams and the other diagrams are enclosed in Appendix A-3.

**Successful Login Scenario**

User (student or teacher) opens a web browser

User enters homepage URL

Browser connects to web server

Browser requests homepage from server

Server requests username and password from user

User enters correct username and password

Server verifies username and password

Server accepts username and password

Server retrieves homepage from server database

Server database sends the required page to browser

Browser displays homepage on the screen
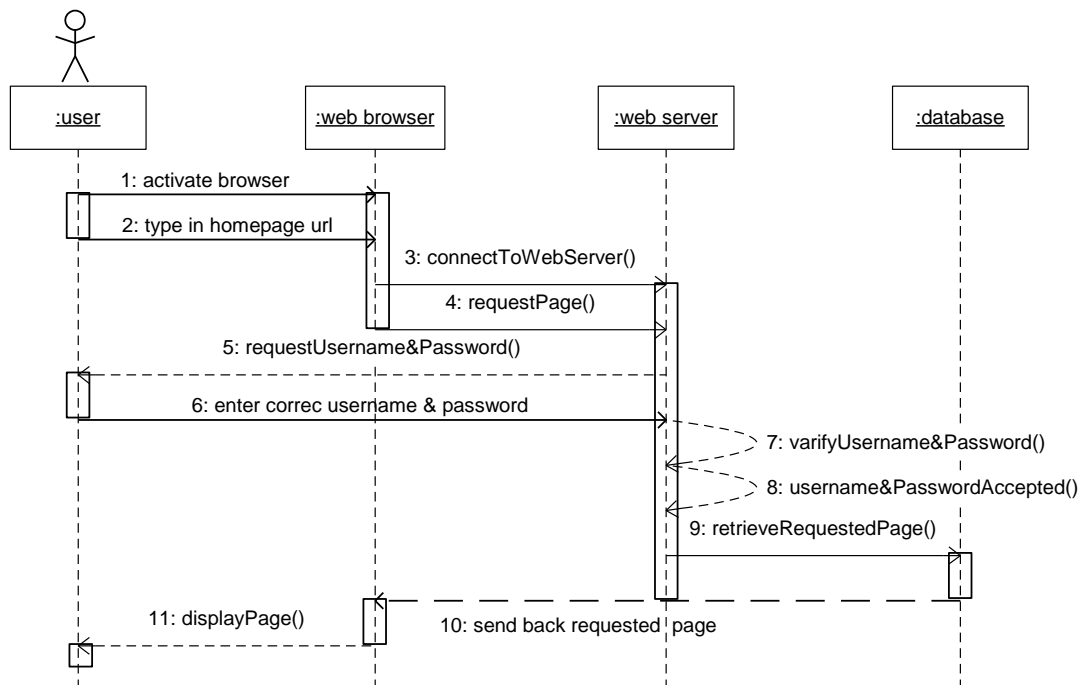


**Figure 5-8 G-Jigsaw Successful Login Scenario**

**Create New Jigsaw Task Scenario**

Teacher clicks on the create new task link

Browser requests question template form from server

Server retrieves template form from server database

Server database searches for requested template form

Template form is sent to browser

Browser displays template form to teacher

Teacher previews and selects template

Teacher set questions

Teacher retrieves questions

Teacher modifies questions

Teacher submits task questions to server database

Server database activates the web agent

Web agent filters the submitted questions

Web agent categorizes the task questions

Web agent updates the server database

Server database sends confirmation message to browser

Browser displays message to teacher
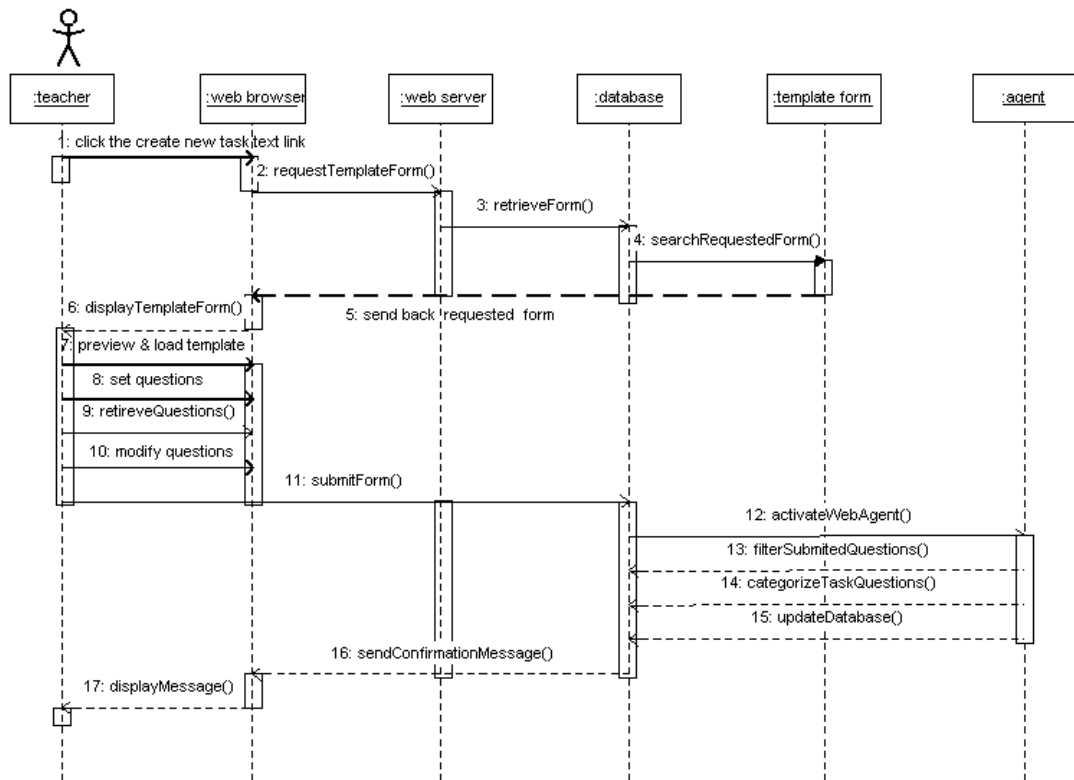
**Figure 5-9 Jigsaw Task Module's Create New Jigsaw Task Scenario**

**Compose Response Scenario**

Student clicks the Post Response button

Browser requests the response form

Server retrieves the requested form from server database

Server database searches for the requested form

Response form is sent to the browser

Browser displays response form to the student
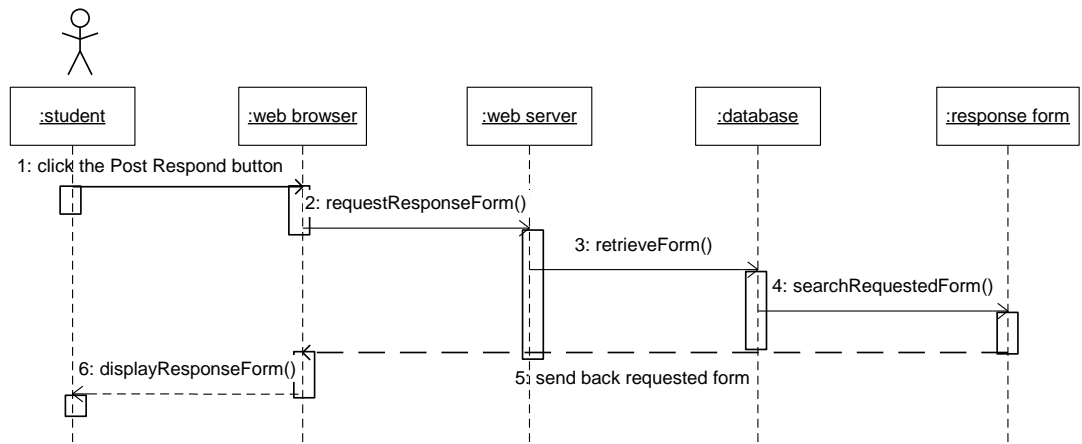
**Figure 5-10 Initial Group Module's Compose Response Scenario**

## Read or View Summaries Scenario

Student clicks the link to read or view summaries

Browser requests for the required document from server

Server retrieves requested document from server database

Server database sends the requested document to browser

Browser displays the requested document to user
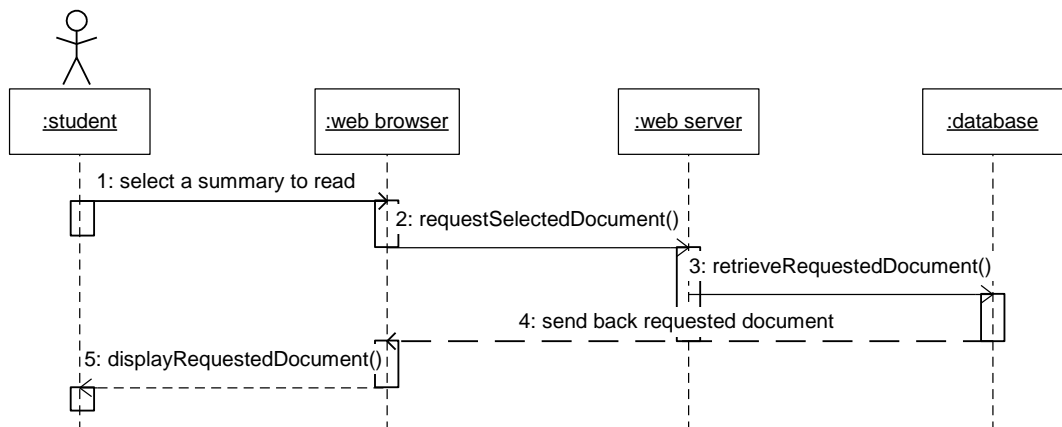


**Figure 5-11 Expert Group Module's View Summaries Scenario**

**Integrate All Reports Scenario**

Student clicks the Create Integrated Report button

Browser requests for report integration from server

Server activates web agent (integration agent)

Web agent integrates all related reports in server database

Server database sends integrated report to browser

Browser displays the integrated report to student
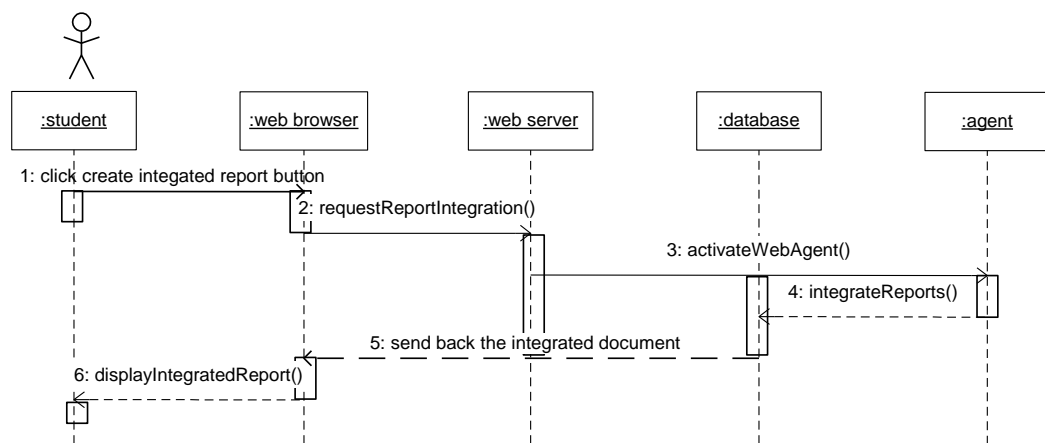


**Figure 5.12 Jigsaw Group Module's Integrate All Reports Scenario**

**5.2.2.2 G-Jigsaw's Activity Diagrams**

An Activity Diagram shows the flow from an activity to an activity within a system. It shows a set of activities, the sequential or branching flow from an activity to an activity and objects that act and acted upon (Booch et. al., 1999). The G-Jigsaw design model uses activity diagrams to illustrate the system dynamic view. This chapter only shows one activity diagram in figure 5-13 which emphasize on the control flow of students' participation in G-Jigsaw activities. The complete activity diagrams for each module are depicted in Appendix A-4.
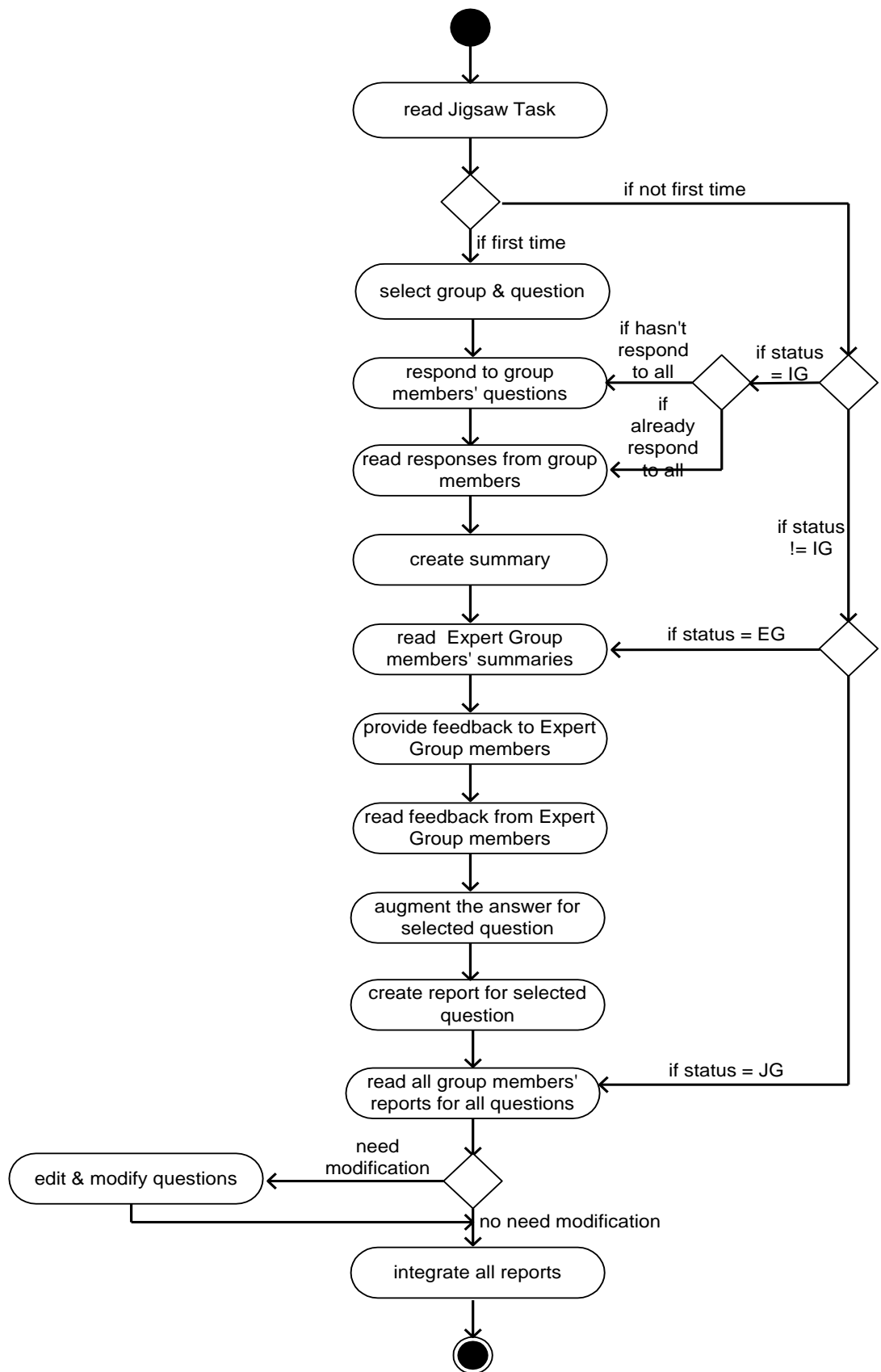
**Figure 5-13 Activity Diagram Showing Students' Jigsaw Activity Process**

### 5.2.3 G-Jigsaw Graphical User Interface Design

G-Jigsaw is implemented as one of WebCL modules to support the jigsaw-type collaborative learning. Therefore, Graphical User Interface (GUI) designs of G-Jigsaw are consistent with WebCL GUI. Figure 5-14 presents the common layout for WebCL GUI design for its homepage module.
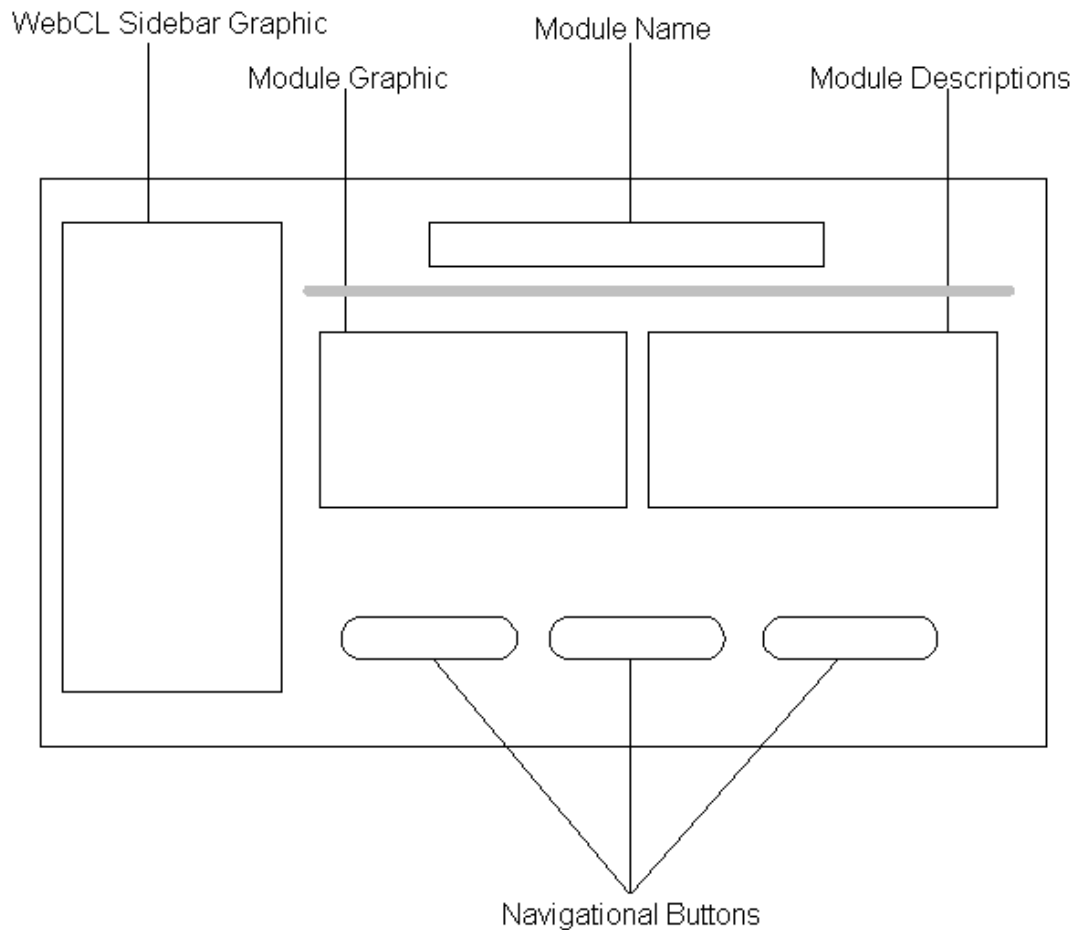


**Figure 5-14 G-Jigsaw's Homepage GUI Design**

Based on the GUI layout shown in figure 5-14, G-Jigsaw homepage generally consists of five major sections. The WebCL Sidebar Graphic section on the left side is the same for all WebCL modules. This GUI graphic is obtained directly from the WebCL. The G-Jigsaw name, graphic and descriptions sections make it differ from WebCL homepage module. The navigational buttons are placed at the bottom of the homepage. G-Jigsaw

homepage comprises of 3 navigational buttons that provides access to the WebCL homepage, Jigsaw Task and Completed Task. Figure 5-15 displays other G-Jigsaw pages layouts. These pages are also designed to be consistent with WebCL.
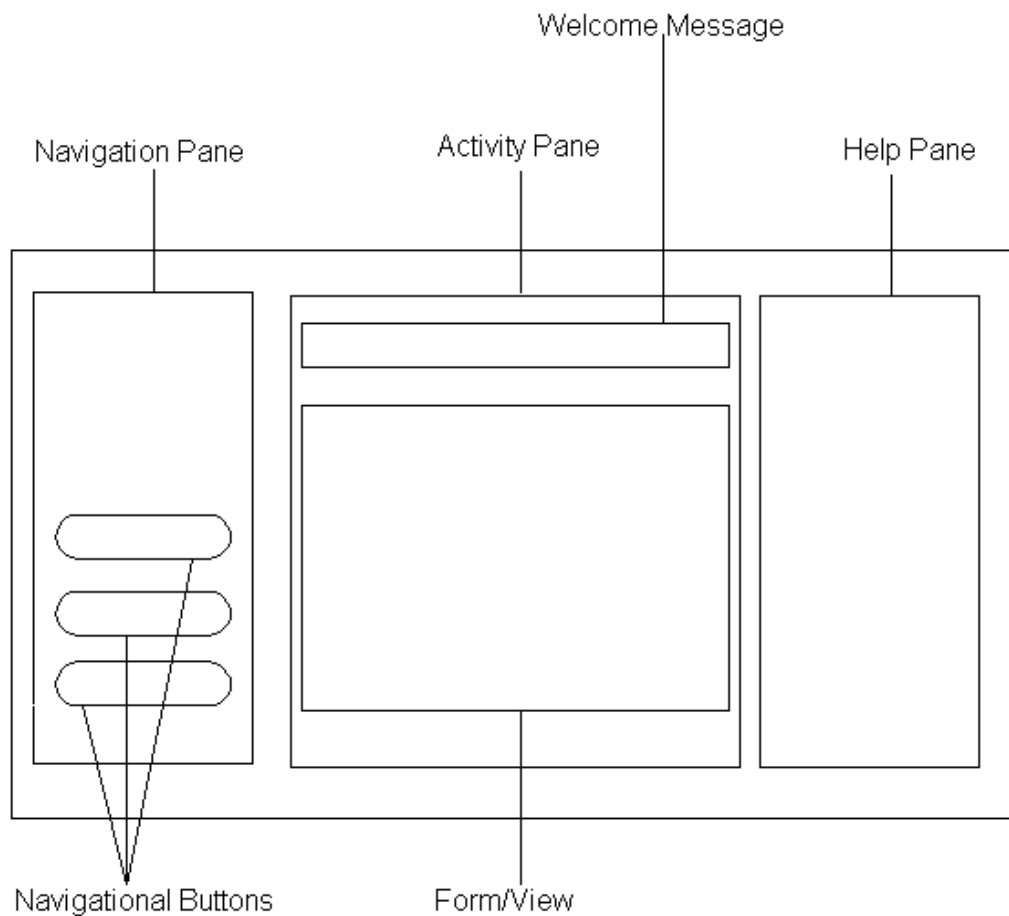


**Figure 5-15 G-Jigsaw's Page GUI Design**

As illustrated in figure 5-15, all G-Jigsaw pages consist of 3 panes namely Navigational Pane, Activity Pane and Help Pane. The Navigational Pane provides access to G-Jigsaw internal modules, which are Jigsaw Task and Completed Task. This pane is always placed on the left side of the page. The Activity Pane is located at the center. This is where different jigsaw activities are carried out. This pane always has a welcome message on top of it and it embeds forms and views that support the jigsaw activities. On the right hand side is the Help pane. This pane displays Quick Helps for user to

perform various tasks and operations. The G-Jigsaw's GUI design screenshots will be depicted in the next chapter.

## 5.3 Chapter Summary

This chapter has presented G-Jigsaw analysis and design. Both of the requirements and object-oriented analysis are identified in the first part of this chapter. G-Jigsaw architecture design, object-oriented design and GUI design are also discussed in this chapter. Most of the UML diagrams such as use case diagrams, interaction diagrams, activities diagrams and class diagrams are used in G-Jigsaw object-oriented analysis and design process. Chapter 6 will discuss the implementation of G-Jigsaw agents, its internal multi-agent architecture and the execution aspects of G-Jigsaw.

# Chapter 6 – G-Jigsaw Implementation and Execution

This chapter describes the implementation and execution of G-Jigsaw. The first part discusses the implementation of G-Jigsaw, which covers the implementation of agents, its internal multi-agent architecture, communication that exist within the architecture and G-Jigsaw security features. The second part presents some scenarios of G-Jigsaw execution that cover all four modules of G-Jigsaw named Jigsaw Task, Initial Group, Expert Group and Jigsaw Group.

## 6.1 The implementation of G-Jigsaw's Agents

Collaboration always involves the process of sharing ideas and opinions. All these data are normally recorded separately either as files or documents and are stored in various repositories. When a group of users need to integrate their collaborative deliverables, they need to retrieve data and recompile them into the final outcome (e.g. copying the required data, pasting and modify them as a new document and save it) manually. This will definitely affect the collaborative learning process due to the time spent in searching and copying the required data. In order to overcome this limitation, G-Jigsaw deploys an Integration Agent to automatically obtain the information required for the integration and performs it on behalf of the users. By implementing this agent, the integration process can be done with a single mouse click. It certainly will save a lot of users' time and makes the integration process simpler and less troublesome.

In addition, knowledge sharing is a key requirement for an effective collaborative learning environment. To create a shared repository, users are usually required to explicitly provide such valuable data into the system. However, this process normally will consume a lot of time and efforts. Therefore, not many users are willing to spend

the extra time for such data entries task. G-Jigsaw attempts to create a knowledge shared repository without consuming a lot of the users' time. To achieve this, a Sharing Agent is developed to perform tasks such as such as data extraction, filtering and categorizing transparently without the user's knowledge. This agent also enables users to retrieve tasks from the shared repository. Therefore, the task questions are reusable and time spent to set new questions are minimize.

Although the jigsaw technique greatly promotes students' collaborative learning activities, however, its complex activity flows and processes are major drawbacks. The challenge became more demanding because G-Jigsaw activities are carried out via a computer-supported system. As a result, a Navigation Agent is implemented to control the flows, rules and processes of jigsaw activities automatically. This will not only help to simplify the user's participation, moreover, it also impacts user's learning experience. It assists user's learning materials navigation effectively, keeps track of user's status and prompts users into effective action. With the deployment of this agent, users will understand the concepts of jigsaw much easier and realize the benefits of collaborative learning.

Three agents were implemented in G-Jigsaw, which are named Integration Agent, Sharing Agent and Navigation Agent to support the jigsaw activities and processes. However, the execution of these agents needs to be monitored in a systematic manner. From the review carried out in chapter 4, Olguin and his colleagues proposed an Agent-based Architecture for group study (Olguin, 2000). In this architecture, each user of the Collaboration Framework has an associated agency. This agency is responsible for receiving requests and returning responses from and to its owner. The architecture consists of 4 agencies that interact together to support the collaborative learning

environment. Among the four agencies is the Activity Agency that is responsible to monitor activities of tasks and generates more information such as student's participation and collaboration levels using the information collected by Group Agency. This information is very important to evaluate the effectiveness of a group. Olguin and his colleagues have not implemented this agency, but the concept of an Activity Agency that monitors the participation and collaboration in this architecture can be applied in G-Jigsaw. It can serves as the agent manager to coordinate and monitor the execution of the three agents mentioned. Hence, the Activity Agency is used to manage agents of G-Jigsaw to achieve the following major objectives:

1. To speed up and simplify the integrating process in a group.

2. To simplify the process of jigsaw activities by automating the complex activity flows and processes of G-Jigsaw to ensure that students focus only on their learning process not the jigsaw process.

3. To perform back-end processing such as filtering, categorizing and extracting information transparently without the users' knowledge

In order for the agents to interact with each other to carry out specific tasks that support the jigsaw activity processes, a multi-agent architecture is required. Section 6.2 will describe further about the internal multi-agent architecture.

## 6.2 The Implementation of G-Jigsaw's Internal Multi-Agent Architecture

According to Fenton-Kerr and his colleagues (1998), although multiple agent tasks could be programmed into a single entity, but such multi-faceted agent would be difficult to construct and maintain. Moreover, due to its complexity, it would likely

affect the response time, especially if it is implemented across a busy network. To prevent this from occurring, an alternative approach is to implement a multi-agent system as described by (Bigus and Bugus, 1998) where each modular agent could almost carry out a specific task automatically. In this approach, a coordinating agent is responsible to manage various agents in its care.

Thus, this multi-agent approach is implemented in G-Jigsaw as its internal agent architecture. This architecture adopts the multi-agent architectural scheme system proposed by (Fenton-Kerr, et. al., 1998) as discussed in chapter 3, section 3.5.2. In G-Jigsaw, the Activity Agency fulfills the role of a coordinating agent. Fundamentally, Activity Agency monitors 3 web agents called Sharing Agent, Integration Agent and Navigation Agent.

Sharing Agent is responsible to extract, filter, categorize accordingly and store teachers' submitted jigsaw task questions in a shared repository. This is carried out to avoid redundancy questions in the shared repository. Other teachers will be able to retrieve these questions via the Sharing Agent. The Integration Agent enables students to integrate their group reports automatically. Upon activation, this agent will search the student group's information from the group profile. Based on the information gained, it will then search for the related group's reports and integrates all the individual report as one final report.

Navigation Agent is accountable to automate the complex flows and processes of jigsaw activity. Therefore, it will play the role of the tracker agent proposed by Fenton-Kerr, et. al.. This agent will keep track of every login user's profile. Based on the user's current status, it will automatically place the user in the right stage. Every user's action is traced

and the profile is updated accordingly. Figure 6-1 depicts the internal multi-agent architecture of G-Jigsaw which is implemented in the agent-tier of G-Jigsaw architecture as shown in figure 5-7 in chapter 5.
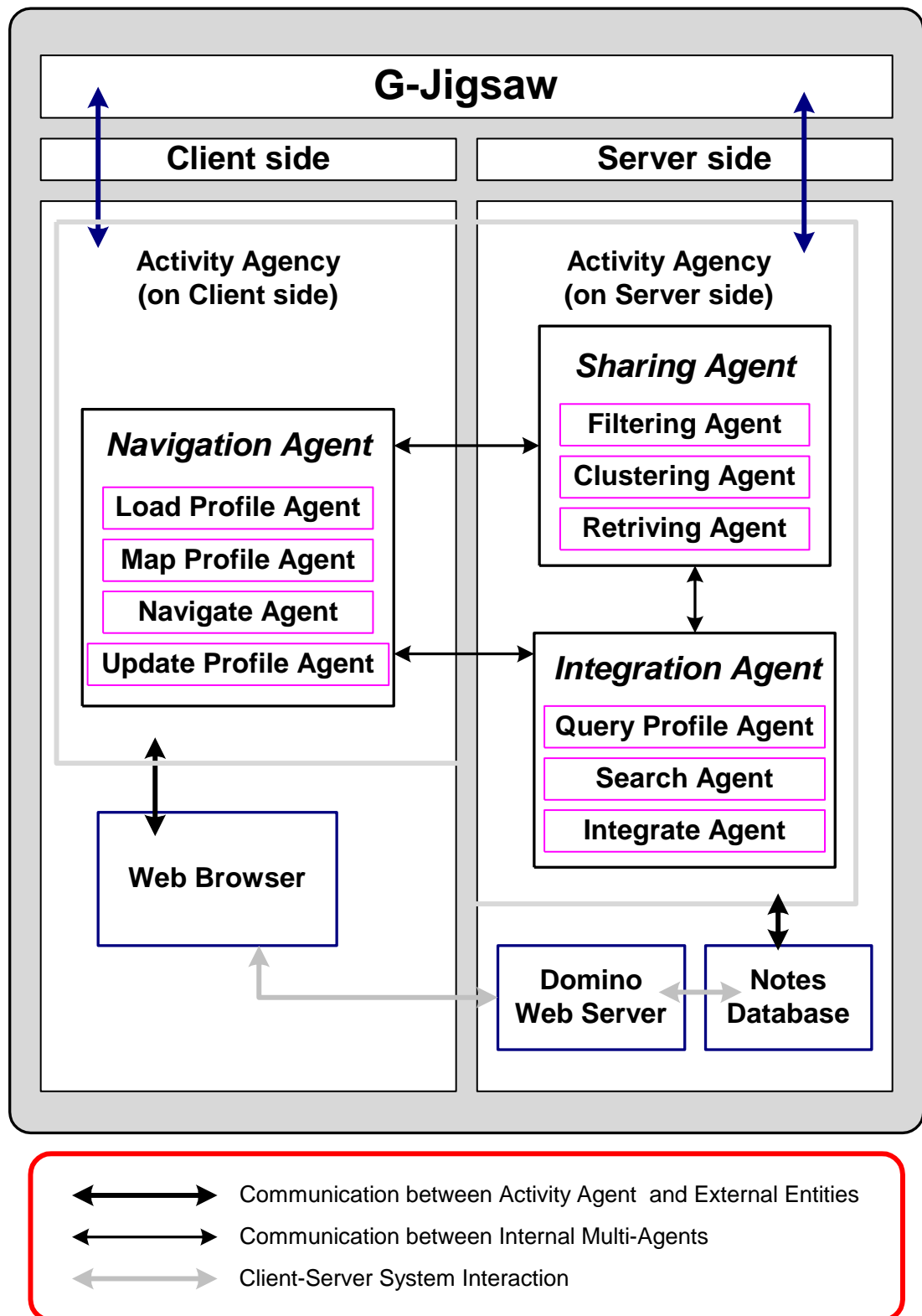


**Figure 6-1 G-Jigsaw Internal Agent Architecture**

Figure 6-2 further illustrates how the web agents work together in automating and simplifying the jigsaw session.
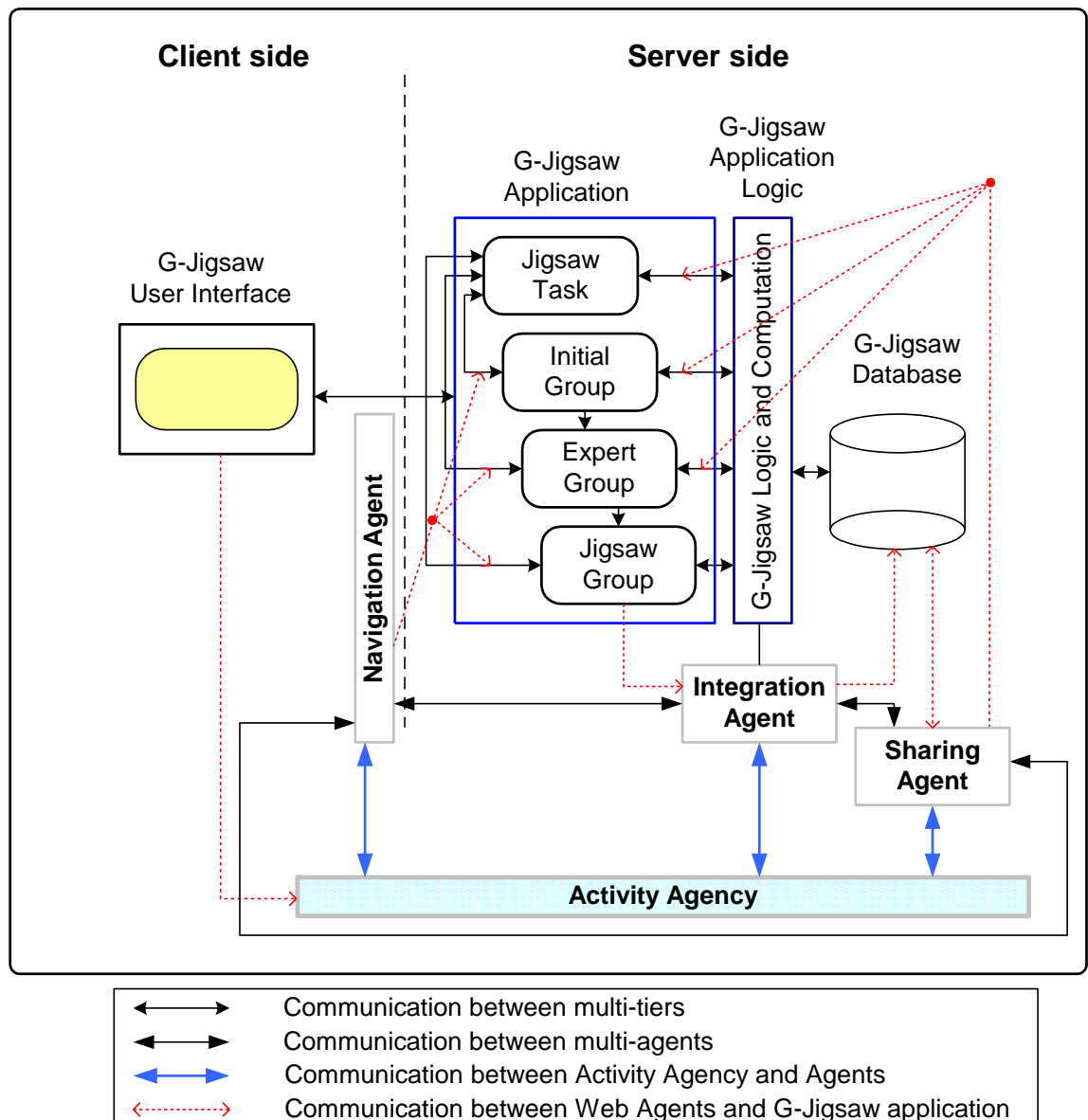


**Figure 6-2 The Multi-agent Internal Architecture's Communication in G-Jigsaw**

As of figure 6-2, the Activity Agency is responsible to monitor the user's action throughout the jigsaw session and identified the user's requests. Then, it activates the appropriate web agents and sends messages to the agents in carrying out the user's requests respectively. Based on the messages received, the web agents activate the internal agents under their supervision in turns to perform a more specific task. The

subsequent section discusses these communications, which includes the external communication of Activity Agent with its external entities (e.g. web server, web browser and applications) as well as its internal multi-agents communication in detail.

### 6.2.1 G-Jigsaw's Multi-Agent Communication

As shown in figure 6-1 and figure 6-2, the architecture of G-Jigsaw internal agent serves as an additional layer for G-Jigsaw client-server architecture. Besides the common client-server interactions that occur between the client (browser), server and databases, this internal agent architecture enables agents to communicate internally with other agents and externally with other external entities.

Activity Agency communicates externally with the clients (browsers), server and application (G-Jigsaw). It receives requests from users via the web browser and triggers the appropriate agents to perform the user's requests. Therefore, it is responsible for the execution of internal agents. Activity Agency acts as an agent manager that forward information from one agent to another agent, from user to agents and from agents to user. Table 6-1 depicts all the possible user's requests throughout the entire jigsaw session as well as the messages and actions performed by the Activity Agency upon the user's requests.

**Table 6-1 Activity Agency's Reactions Towards User's Requests**

| User's Requests (User's Actions) | Messages Sent | Actions Performed |
|---|---|---|
| Retrieve jigsaw questions | 1 | Activate Sharing Agent |
| Submit jigsaw task | 2 | Activate Sharing Agent |
| Start answering new task | 3 | Activate Navigation Agent |
| Submit a profile | 4 | Activate Navigation Agent |
| Resume previous task session | 5 | Activate Navigation Agent |
| Compose response | 6 | Activate Navigation Agent |
| Submit Response | 7 | Activate Navigation Agent |
| Read Response | 8 | Activate Navigation Agent |
| Compose Summary | 9 | Activate Navigation Agent |
| Retrieve Responses | 10 | Activate Sharing Agent |
| Submit Summary | 11 | Activate Navigation Agent |

| Read Summary | 12 | Activate Navigation Agent |
|---|---|---|
| Compose Report | 13 | Activate Navigation Agent |
| Retrieve previous summary | 14 | Activate Sharing Agent |
| Submit Report | 15 | Activate Navigation Agent |
| Read Report | 16 | Activate Navigation Agent |
| Integrate Group Reports | 17 | Activate Integration Agent |
| Read Integrated Report | 18 | Activate Navigation Agent |

There are 3 web agents modular included in the Activity Agency. Each modular is responsible to invoke, monitor and control a set of more specific agents that will perform specific tasks. In a multi-agent structure, the communication within each agent is very important to ensure the success of the system. This can be achieved through the internal agent communication. Table 6-2 shows the communication of Sharing Agent with Activity Agency as well as its internal agents.

**Table 6-2 Sharing Agent's Communication**

| Messages Received | Messages Sent | Actions Performed |
|---|---|---|
| 1, 10, 14 | 1 – Retrieve Document [Username, task_id] | Activate Retrieving Agent |
| 19 | 2 – Retrieving task completed | Report task completion to Activity Agency |
| 2 | 3 – New Task Submission | Activate Filtering Agent |
| 20 | 4 – Cluster Questions | Activate Clustering Agent |
| 21 | 5 – Submission process completed | Report task completion to Activity Agency |
| **Note:**<br>19 = Message from Retrieving Agent indicating the completion of retrieving task<br>20 = Message from Filtering Agent indicating the completion of filtering task<br>21 = Message from Clustering Agent indicating the completion of clustering task<br>For messages 1, 2, 10 and 14, refer to table 6-1 | | |

Based on table 6-2, the sharing agent will perform its tasks accordingly. Table 6-3 depicts the pseudo-codes for the agents' algorithms to describe the mechanisms on how each agents work and communicate with one another. The algorithms are attached in Appendix D.
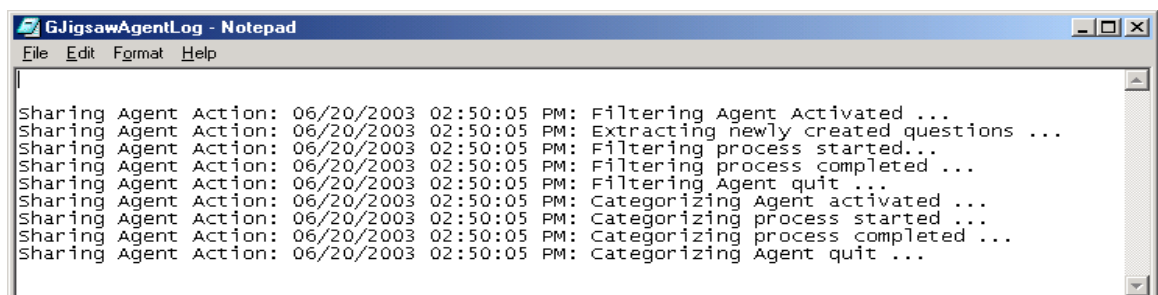
**Table 6-3 Pseudo-codes for Sharing Agent's Algorithm**

**For Sharing Agent:**

When activated by Activity Agency,
        Check the message received
        If message = 1 or message = 10 or message = 14 Then
                Activate Retrieving Agent [message, type, username, task id]
        Else If message = 2 Then
                Activate Filtering Agent [message]
        Else If message = 20 Then
                Activate Clustering Agent [message]
        Else
                If message = 19 Then
                        Send message 2 to Activity Agency
                Else If message = 21 Then
                        Send message 5 to Activity Agency
                End If
        End If
Sharing Agent Quit

---

**For Retrieving Agent:**

When activated by Sharing Agent,
        Check the message received
        Based on the type received
        Use the arguments (username, task id) as keys
        Search through the shared repository for documents that math the keys
        Retrieving the related documents accordingly
        Report the task completion message 19 to Sharing Agent
Retrieving Agent Quit

---

**For Filtering Agent:**

When activated by Sharing Agent,
        Check the message received
        Extract submitted new questions into an array
        For each question in the array
                Loop through the share repository's questions
                        If question already exists Then
                                Delete question in array
                        Else
                                Continue
                        End If
                End Loop
                Increase array index by 1
        End For
        Report the task completion message 20 to Sharing Agent
Filtering Agent Quit

```
For Clustering Agent:

When activated by Sharing Agent,
        Check the message received
        Extract task title from submission task and make it as new category
        Loop through the share repository's categories
                If category already exists Then
                        Save the filtered questions in the array in this category
                        Sort the question collection in ascending order
                Else
                        Create a new category
                        Save the filtered questions in the array in this category
                        Sort the question collection in ascending order
                End If
        End Loop
        Report the task completion message 21 to Sharing Agent
Clustering Agent Quit
```

Interactions among teachers, Activity Agency and Sharing Agent are best described using a scenario where a teacher is creating a new jigsaw task for student's participation. When a teacher submits a jigsaw task, the Activity Agency will invoke the Sharing Agent to call the Filtering Agent. The Filtering Agent will extract the submitted questions and filter the existing questions in the shared repository. Upon completion, the Filtering Agent will report back to the Sharing Agent. The Sharing Agent then invokes the Categorizing Agent to categorize and sort the questions into respective categories. Then, it reports back to the Sharing Agent. All these tasks are performed transparently without the teacher's knowledge. The teacher will only be notified that his/her submission is successfully entered in the shared repository. Figure 6-3 shows the execution log of Sharing Agent. Similarly, when a teacher intends to retrieve questions from the shared repository, the Activity Agency will notify the Sharing Agent to activate the Retrieving Agent in order to perform the retrieving task.



**Figure 6-3 The Sharing Agent Execution**

Table 6-4 shows the communication of Navigation Agent with Activity Agency as well as its internal agents. Table 6-5 lists the locations returned by the Map Profile agent based on the current user's level and task status in the user profile. The location returned is then passed to Navigate agent in order to automate the entire jigsaw session.

**Table 6-4 Navigation Agent's Communication**

| Messages Received | Messages Sent | Actions Performed |
|---|---|---|
| 5, 25 | 1 – Load user's profile | Activate Load Profile Agent |
| 22 | 2 – Map profile values [username, level, status] | Activate Map Profile Agent |
| 23 | 3 – Navigate to current location [location] | Activate Navigate Agent |
| 24 | 4 – Navigation completed | none |
| 3, 4, 6, 7, 8, 9, 11, 12, 13, 15, 16, 18 | 5 – Update user's profile [username] | Activate Update Profile Agent |
| **Note:**<br>22 = Message from Load Profile Agent indicating the completion of loading task<br>23 = Message from Map Profile Agent indicating the completion of mapping task<br>24 = Message from Navigate Agent indicating the completion of navigation task<br>25 = Message from Update Profile Agent indicating the completion of updating task<br>For messages 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 15, 16 and 18, refer to table 6-1 | | |

**Table 6-5 Map Profile Agent's mapping table**

| Level | Status | Location Returned |
|---|---|---|
| 0 – Jigsaw Task module | 0 – new task | Jigsaw Task |
| 0 | 1 – create profile | Profile Form |
| 1 – Initial Group module | 2 – view questions | Questions View |
| 1 | 3 – create response | Response Form |
| 1 | 4 – read responses | Responses View |
| 1 | 5 – continue to create summary | Responses View |
| 1 | 6 – create summary | Summary Form |
| 2 – Expert Group module | 7 – read summaries | Summaries View |
| 2 | 8 – continue to create report | Summaries View |
| 2 | 9 – create report | Report Form |
| 3 – Jigsaw Group module | 10 – read reports | Report View |
| 3 | 11 – integrate report | Report View |
| 3 | 12 – read integrated report | Integrated Report View |

Table 6-6 depicts the pseudo-codes for the agents' algorithms in Navigation to describe the mechanisms on how each agents work and communicate with one another. The algorithms are attached in Appendix D.

**Table 6-6 Pseudo-codes for Navigation Agent's Algorithm**

**For Navigation Agent:**

When activated by Activity Agency,
       Check the message received
       If message = 5 Or 25 Then
              Activate Load Profile Agent
       Else If message = 22 Then
              Activate Map Profile Agent [username, level, status]
       Else If message = 23 Then
              Activate Navigate Agent [location]
       Else If message = 3 Or message = 4 Or message = 6 Or message = 7 Or message = 8
            Or message = 9 Or message = 11 Or message = 12 Or message = 13 Or message = 15
            Or message = 16 Or message = 18 Then
              Activate Update Profile Agent [username]
       Else If message = 24 Then
              Send message 4 to Activity Agency
       End If
Navigation Agent Quit

**For Load Profile Agent:**

When activated by Navigation Agent,
       Check the message received
       Extract the current user's username as a key
       Search through the database for user profile document that matches the key
       Load the values from the profile document to the memory
       Report the task completion message 22 to Navigation Agent
Load Profile Agent Quit

**For Map Profile Agent:**

When activated by Navigation Agent,
       Check the message received
       Based on the user's current level and status received
       Map them to the mapping table
       Return mapped location
       Report the task completion message 23 to Navigation Agent
Map Profile Agent Quit

**For Navigate Agent:**

When activated by Navigation Agent,
       Check the message received
       Based on the location received
       Redirect the user to the location accordingly
       Display the instructions and enables the functions accordingly
       Report the task completion message 24 to Navigation Agent
Navigate Agent Quit

```
For Update Profile Agent:

When activated by Navigation Agent,
        Check the message received
        Extract the current user's username as a key
        Loop through the database for user profile document that match the key
                If profile document exists Then
                        Update the status in profile document
                        Exit Loop
                Else
                        Create a profile document for the user
                        Insert and save the values in the profile document
                End If
        End Loop
        Report the task completion message 25 to Navigation Agent
Update Profile agent quit
```

The second scenario illustrates interaction between the students, the Activity Agency and the Navigation Agent. When a student joint a jigsaw session, the Activity Agency will activates the Navigation Agent. First, the Navigation Agent checks the student's profile based on the login information. If there is no profile available, a new profile will be generated otherwise, the Navigation Agent will load the student's profile via the Load Profile Agent. Based on this information, the Navigation Agent calls the Map Profile Agent to perform the mapping process. The Map Profile Agent will map the student's current level and status with its mapping table as shown in table 6-5. Then, it will return the mapped location and report back to the Navigation Agent. This immediately followed by the activation of Navigate Agent to position the student in the proper stage to continue with his/her jigsaw session.

Each time a student completed an activity (e.g. post a response, compose a summary or create a report), the Activity Agent will notify the Navigation Agent. Based on the types of activity, the Navigation Agent will update the student's profile through the Update Profile Agent. The Update Profile Agent is responsible to update the student's profile status. Once the profile is updated, the Navigation Agent will redirect the student to the proper stage to continue with his/her jigsaw session through its Load Profile Agent,

Map Profile Agent and Navigate Agent. Figure 6-4 shows the execution log of the

Navigation Agent.
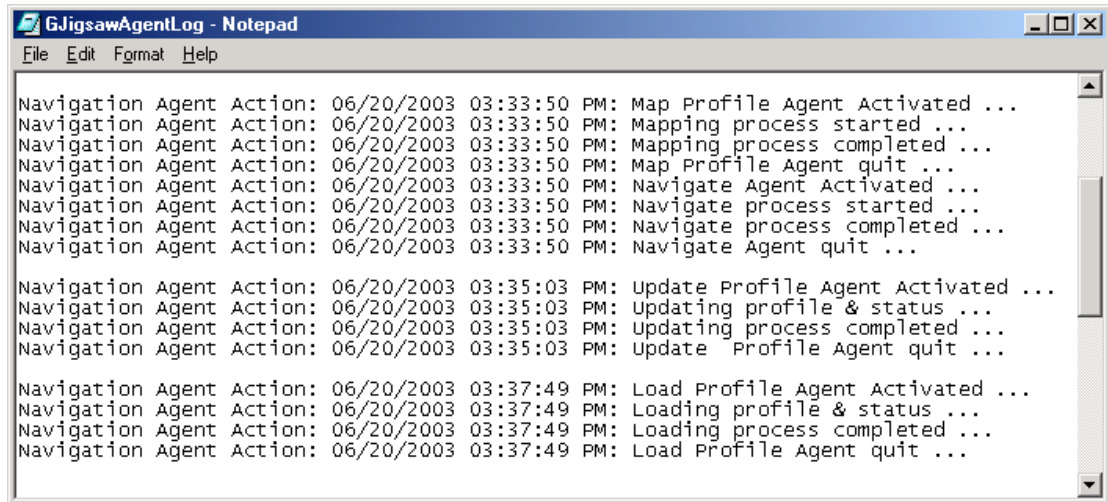


**Figure 6-4 The Navigation Agent Execution**

Table 6-7 shows the communication of Integration Agent with Activity Agency as well

as its internal agents.

**Table 6-7 Integration Agent's Communication**

| Messages Received | Messages Sent | Actions Performed |
|---|---|---|
| 17 | 1 – Get profile values [username] | Activate Query Profile Agent |
| 26 | 2 – Create integrated report form | Activate Integrate Agent |
| 27 | 3 – Search and retrieve documents | Suspend Integrate Agent, Activate Search Agent |
| 28 | 4 – Integrate group reports | Resume Integrate Agent |
| 29 | 5 – Integration completed | Report task completion to Activity Agency |
| **Note:** <br> 26 = Message from Query Profile Agent indicating the completion of querying task <br> 27 = Message from Integrate Agent indicating the completion of form creation <br> 28 = Message from Search Agent indicating the completion of searching task <br> 29 = Message from Integrate Agent indication the completion of integrating task <br> For message 17, refer to table 6-1 | | |

Table 6-8 presents the pseudo-code for the agents' algorithms to show the mechanisms

on how the agents work and communicate with each another in Integration Agent. . The

algorithms are attached in Appendix D.

**Table 6-8 Pseudo-codes for Integration Agent's Algorithm**

**For Integration Agent:**

When activated by Activity Agency,
      Check the message received
      If message = 17 Then
            Activate Query Profile Agent [username]
      Else If message = 26 Then
            Activate Integrate Agent [group, document]
      Else If message = 27 Then
            Suspend Integrate Agent
            Activate Search Agent [group, task id]
      Else If message = 28 Then
            Resume Integrate Agent
      Else If message = 29 Then
            Send message 5 to Activity Agency
      End If
Integrating Agent Quit

**For Query Profile Agent:**

When activated by Integration Agent,
      Check the message received
      Extract username as a key
      Loop through the user profile documents
            If profile document exists Then
                 Get the values of task id and user's group name
                 Exit Loop
            End If
      End Loop
      Return the values to Integration Agent
      Report the task completion message 26 to Integration Agent
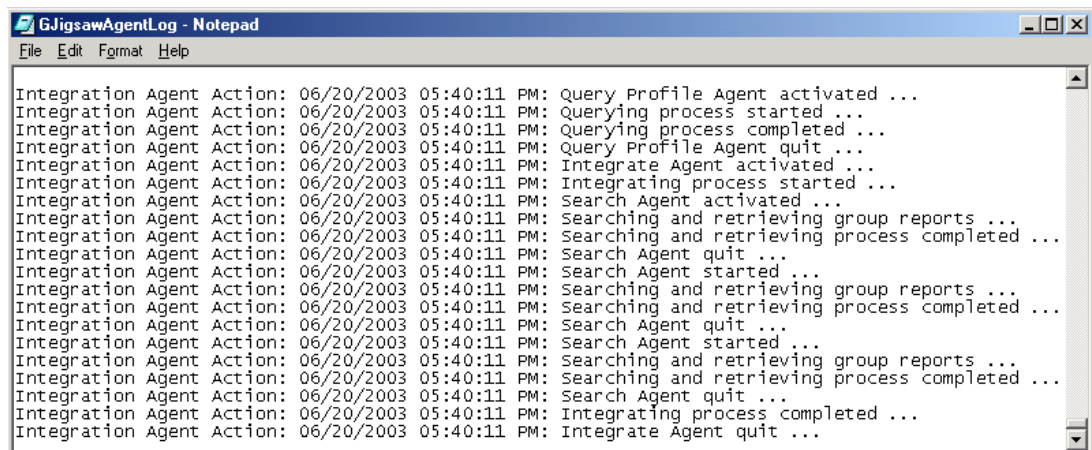Query Profile Agent Quit

**For Integrate Agent:**

When activated by Integration Agent,
      Check message received
      If message = 2 Then
            Create a new Integrated Report Form
            Extract the report's task title value and insert to the task title field
            Insert the group name field with the provided value
            Report form created message 27 to Integration Agent
            Integrate Agent Wait
      Else If message = 4 Then
            Loop through the document collection
               Extract the task question, report content field values from the document collection
               Insert the values to the Integrated Report form
            End loop
            Save the integrated report document in repository
       End If
      Report the task completion message 29 to Integration Agent
Integrate Agent Quit

```
For Search Agent:

When activated by Integration Agent,
        Using the arguments (group, task id) passed by Integration Agent as keys
        Loop through the report documents
                If document exists then
                        Assign the document in a document collection
                Else
                        Continue
                End If
        End Loop
        Return the document collection to Integration Agent
        Report the task completion message 28 to Integration Agent
Search Agent Quit
```

When all the group members of a group completed their report in the Jigsaw Stage, the group leader is required to integrate all the individual reports. This integration process will be carried out by the Activity Agency through the Integration Agent that will coordinate the entire integration process as described in table 6-8. First, The Integration Agent activates the Query Profile Agent to obtain the group's information. Then, it will invoke the Integration Agent to create a new document to place the integrated report. Once the document is created, Search Agent is called. The Search Agent will use information from the Query Profile Agent to repeatedly search and retrieve the correct group reports. Upon completion, the Integration Agent will integrate all these reports into an integrated report. Figure 6-5 shows the execution log of the Integration Agent.



**Figure 6-5 The Integration Agent Execution**

## 6.3 The Implementation of G-Jigsaw Security Aspects

Generally, the entire process of G-Jigsaw is supported by Activity Agency through its multi agents. Besides the execution of agents, the security aspects are also very important to ensure the success of G-Jigsaw. Since G-Jigsaw is implemented using Lotus Notes, therefore it will inherit the Notes database security features, which includes Manager, Designer, Editor, Author, Reader, Depositor and No Access.

Lotus Notes Domino server will handle the security of the G-Jigsaw database efficiently if the access control is assigned properly. Therefore, G-Jigsaw has 4 different user roles for different group of user. Users with Administrator role are assigned with Manager Access. This group of users is responsible to administer and maintain the database of G-Jigsaw. Users with the role of Teacher are assigned with the Designer Access. They are able to create new tasks, delete existing task in the database or modify the Lotus Notes formula of G-Jigsaw.

The third group of users is the Students, which are assigned with Editor Access. They are able to create new documents such as summary and reports and delete only their own documents. However, they are not allowed to modify the Lotus Notes formula of G-Jigsaw. The default access control of G-Jigsaw is set to No Access, which prevents the public users from accessing G-Jigsaw.

## 6.4 Scenarios of G-Jigsaw Execution

Group Jigsaw aims to enhance student's skills and capabilities in contributing valuable ideas and opinions collaboratively in groups. It also supports an integration feature for students to produce a complete group outcome. These can be achieved through modules

of G-Jigsaw that are named Jigsaw Task, Initial Group, Expert Group and Jigsaw Group. Each of these modules supports different roles of users in different ways. Figure 6-6 presents the homepage of G-Jigsaw.
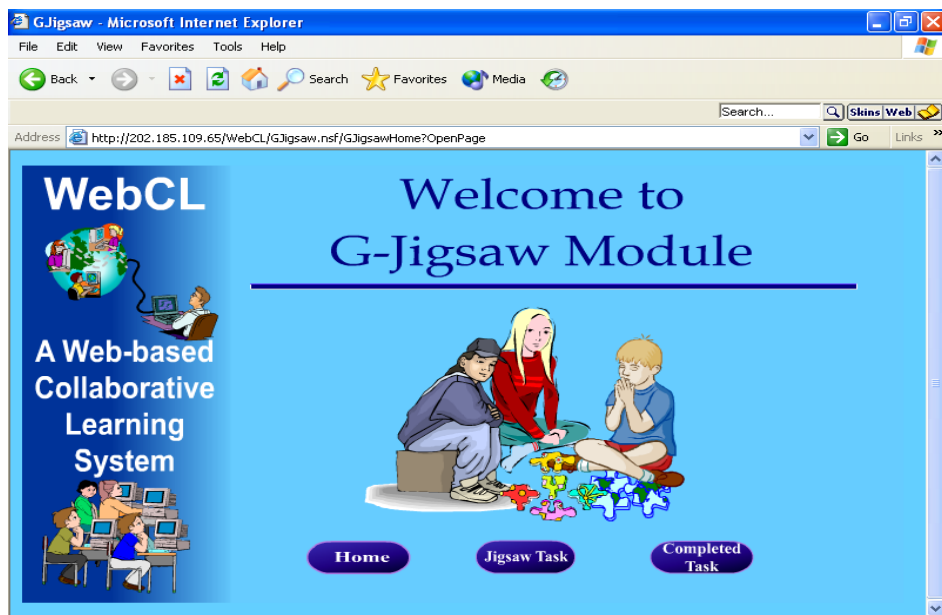


**Figure 6-6 G-Jigsaw Homepage**

### 6.4.1 Jigsaw Task Module

The Jigsaw Task module is meant for teachers to create jigsaw task questions for the students' participation. When a teacher creates a new jigsaw task, he/she is provided with 4 different question templates. Figure 6-7 depicts the preview of Template 1.
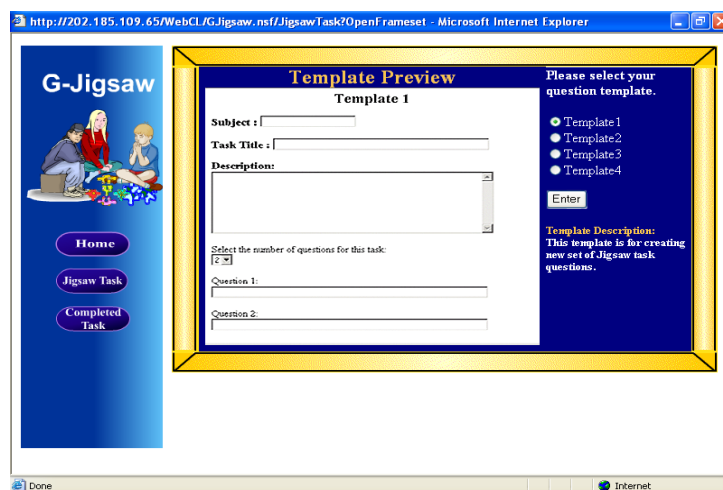


**Figure 6-7 G-Jigsaw's Question Templates**

Template 1 enables teachers to create a new set of jigsaw task questions and in Template 2 teachers are able to retrieve existing questions from the shared repository as their new jigsaw task questions without any modifications. However, in Template 3 and Template 4 teachers are allowed to modify the retrieved questions. Template 3 is used for short questions while Template 4 is more suitable for long questions.

Once a template is selected, a form is displayed for the teacher to enter the jigsaw task questions. Figure 6-8 presents a sample of a science subject jigsaw task entitled "The Food Chain" for standard 5 students.
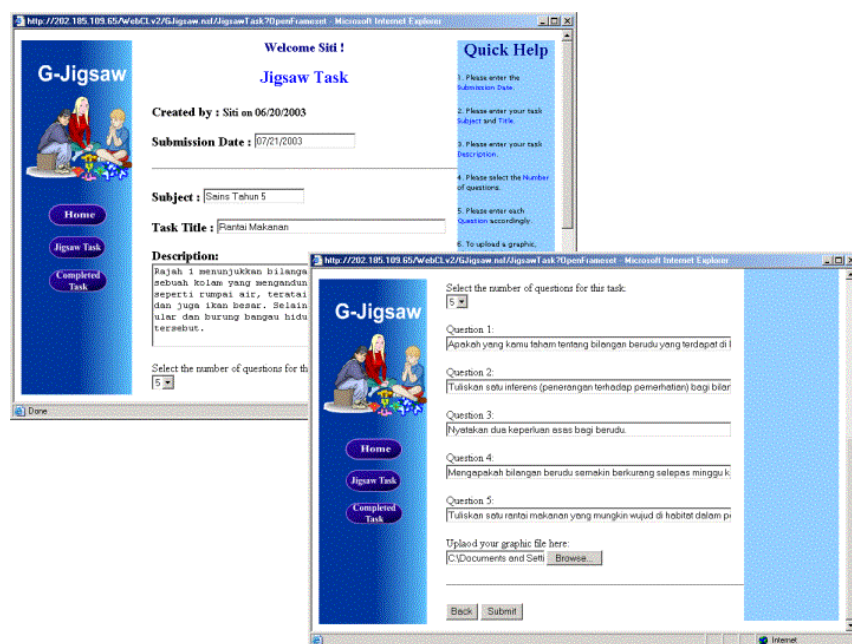


**Figure 6-8 Creating a Jigsaw Task**

As of figure 6-8, a teacher is required to set submission date, subject, task title and description of the jigsaw task. Then, the teacher must enter the number of questions he/she requires, enter the details for each question and submit the jigsaw task questions. Upon completion, the new jigsaw task will be displayed in the Jigsaw Task view as shown in figure 6-9. Here, students are able to read and start to participate in the new jigsaw task.

**Figure 6-9 Jigsaw Tasks View**

### 6.4.2 Initial Group Module

When a student starts to participate in a new jigsaw session, first he/she is required to select his/her group then select his/her responsible question assigned by the teacher. These selections will generate the student's profile and the student is now in the Initial Group, which is the first level of the jigsaw collaboration. In Initial Group, the student is required to give responses to his/her group members' responsible questions. Figure 6-10 illustrates an example of questions that the student needs to respond.
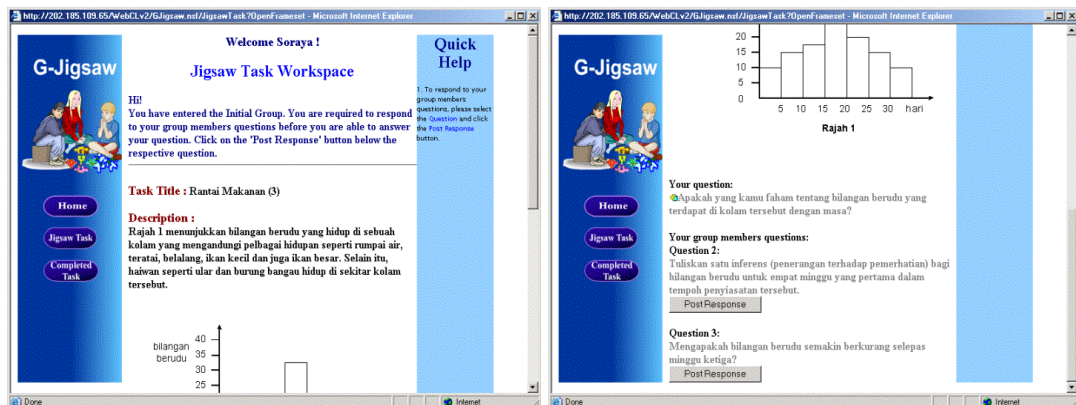


**Figure 6-10 Questions to be responded in Initial Group**

Figure 6-11 below shows a student response towards his/her member's question. G-Jigsaw keep tracks the number of questions that have been responded and how many are left. Once the student has responded to all his/her group member's questions, he/she can now read their responses towards his/her question and then, create a summary (answer). This summary will be used during the discussion in the Expert Group.
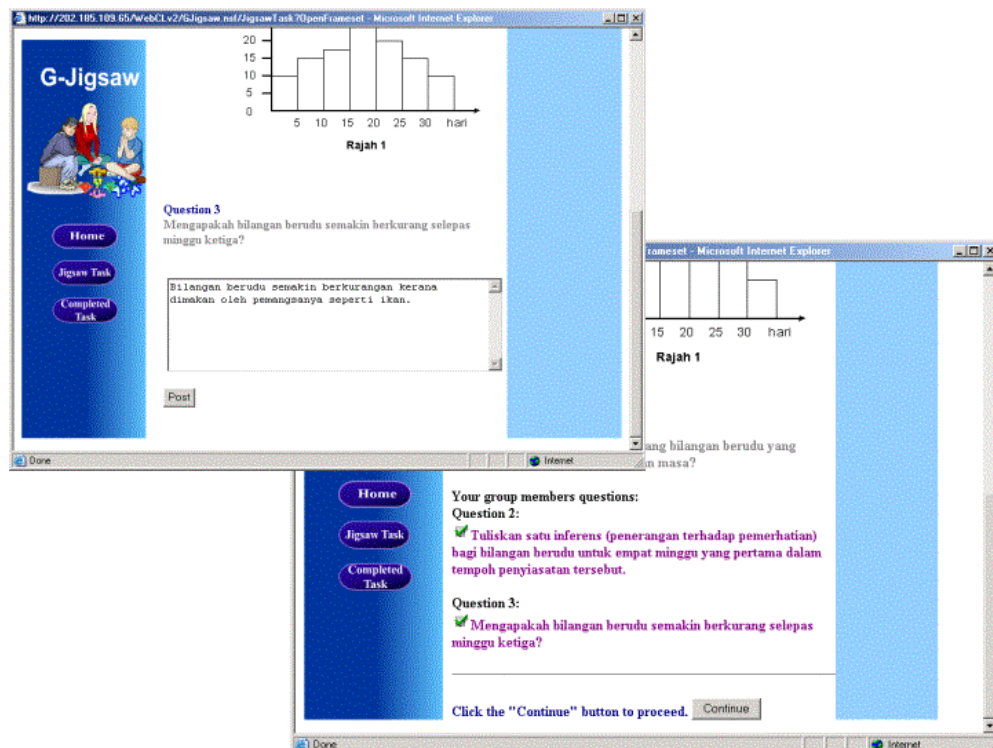


**Figure 6-11 Giving Responses in Initial Group**
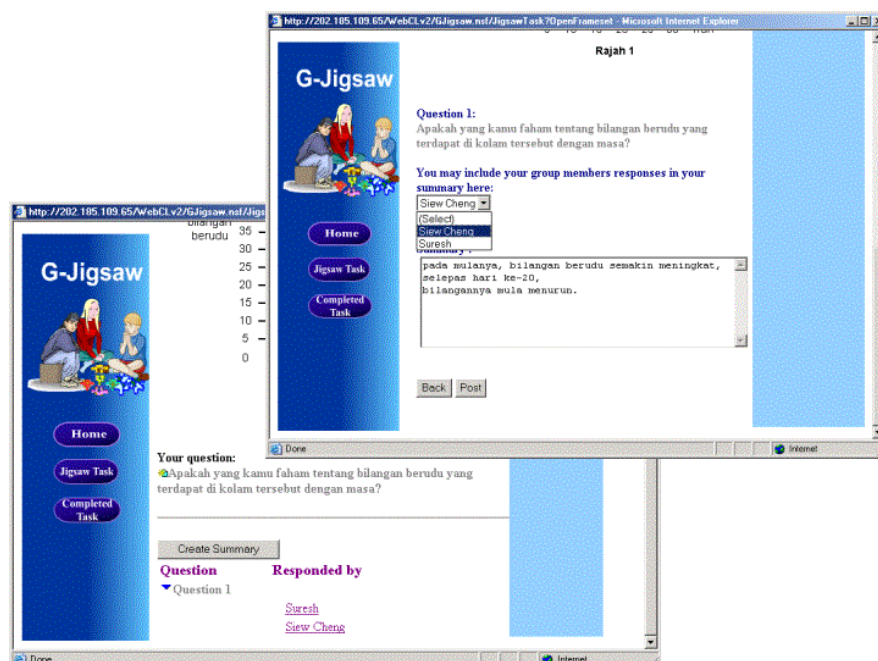


**Figure 6-12 The Summary View and Form**

Figure 6-12 shows the view and form that will be used by the students to compose their summary. In the Summary form, students are able to retrieve and modify his/her group member's responses as part of their summary. This is the last step in the Initial stage collaboration and the student will now proceed to the Expert Group.

### 6.4.3 Expert Group Module

The Expert Group comprises of members from different groups whom are responsible for the same question. Figure 6-13 depicts the Expert Group View where students are able to read their new group member's summary.
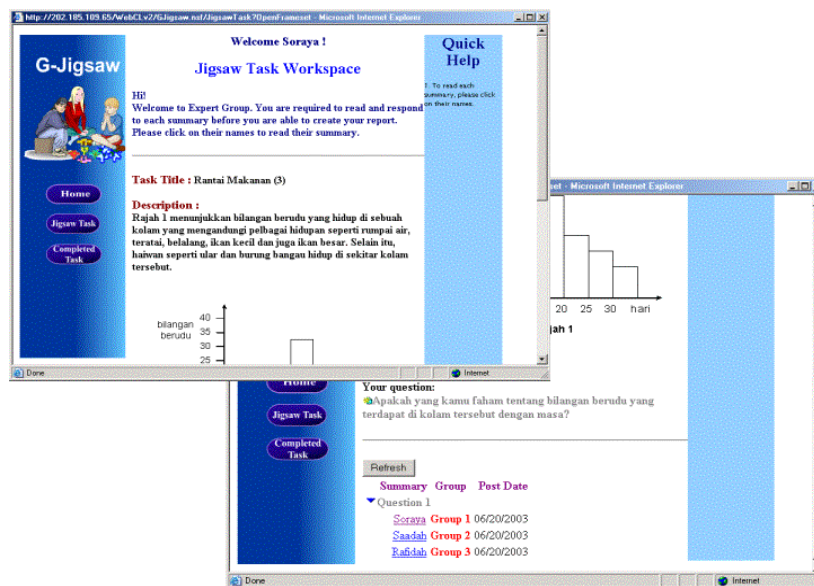


**Figure 6-13 Expert Group View**

In Expert Group, students are required to read and comments on their new group member's summaries. Students will also receive comments from their new group member's towards their summary. This is shown in figure 6-14.
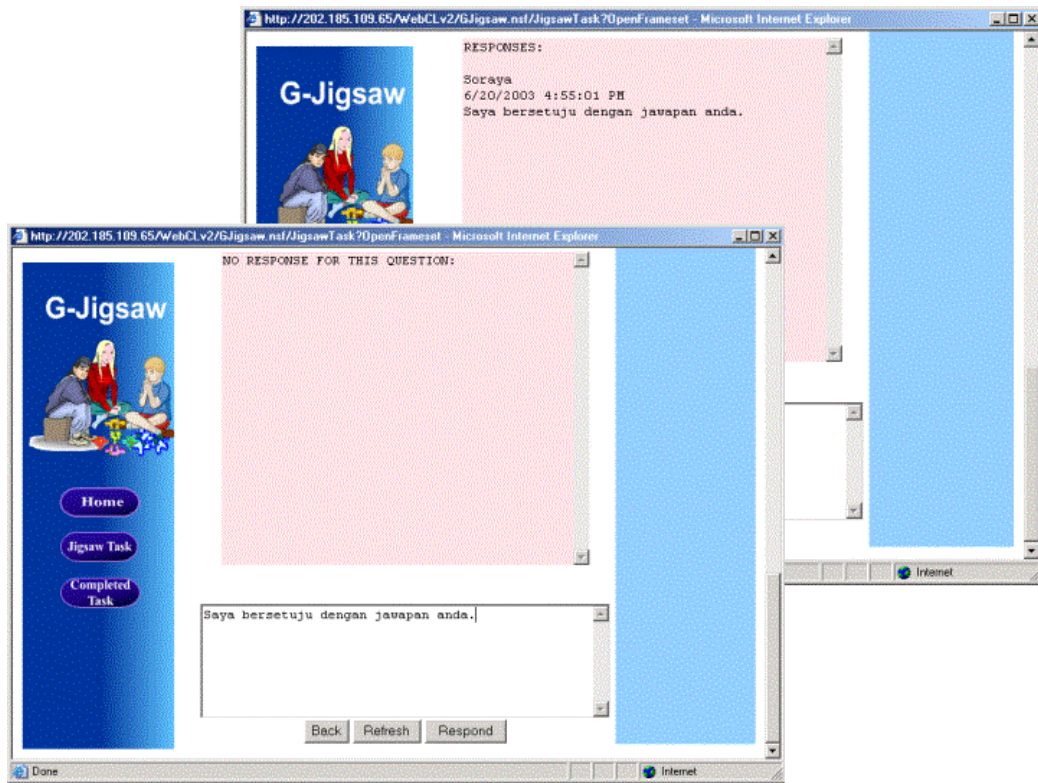
**Figure 6-14 Providing comments and feedback to the Summary**

Based on these comments, the students need to compose a new improved report. Figure 6-15 displays the Report View with the create report feature. Figure 6-16 shows the Report Form where students are able to retrieve and modify their previous summary as part of their report. This is the last step of Expert Group collaboration and the students will now proceed to the Jigsaw Group.
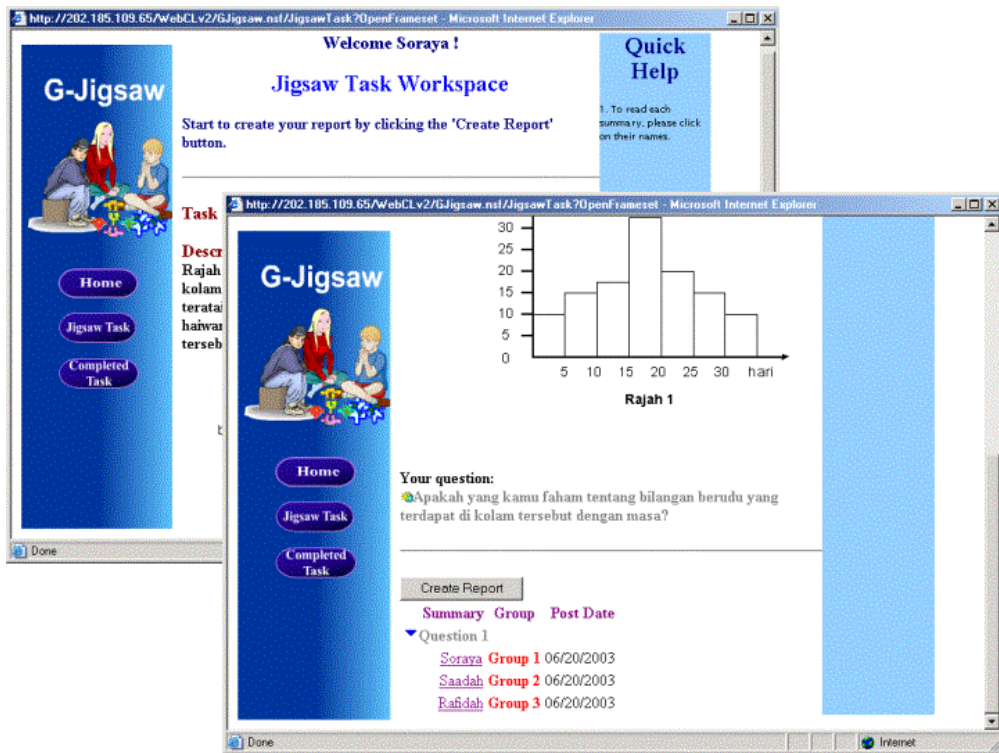
**Figure 6-15 The Report View**



**Figure 6-16 The Report Form**

### 6.4.4 Jigsaw Group Module

Students will be grouped back to their original group to form the Jigsaw Group. In Jigsaw Group students are able to view their group member's report as shown in figure 6-17.
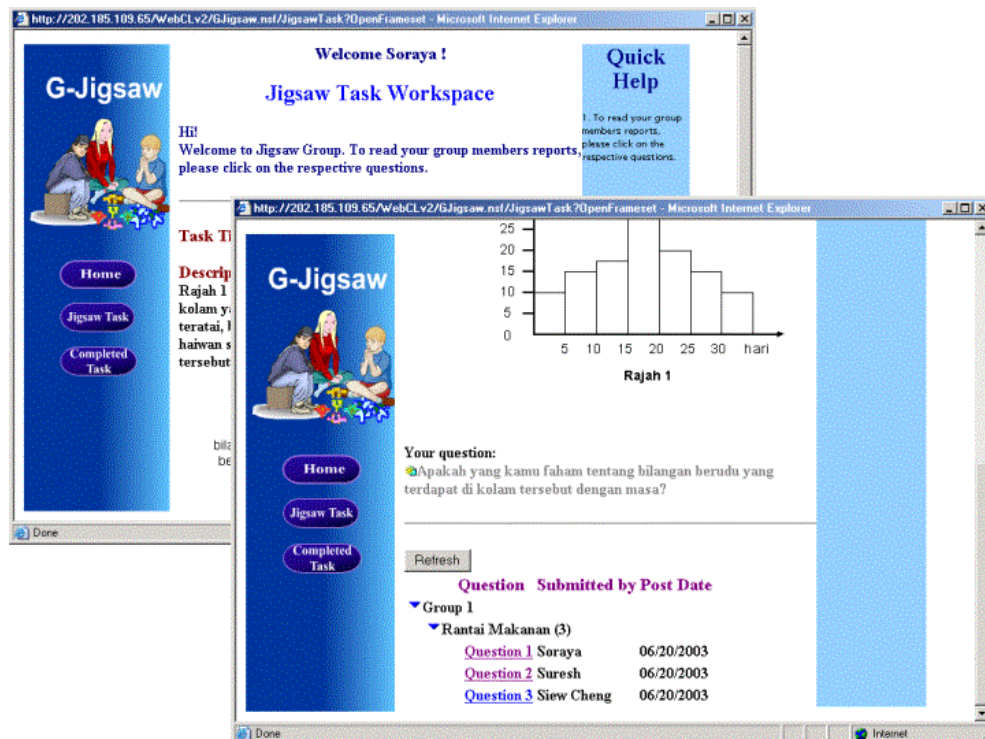


**Figure 6-17 Jigsaw Group Report View**

By reading their group member's report, they are equipped with all the answers for the jigsaw task questions and not only their responsible question. The group leader is responsible to integrate his/her group members' reports by clicking the Create Integrated Report button as depicted in figure 6-18. The integration process is automatically managed by G-Jigsaw. Students' integrated reports can be viewed in the Completed Task view as shown in figure 6-19.
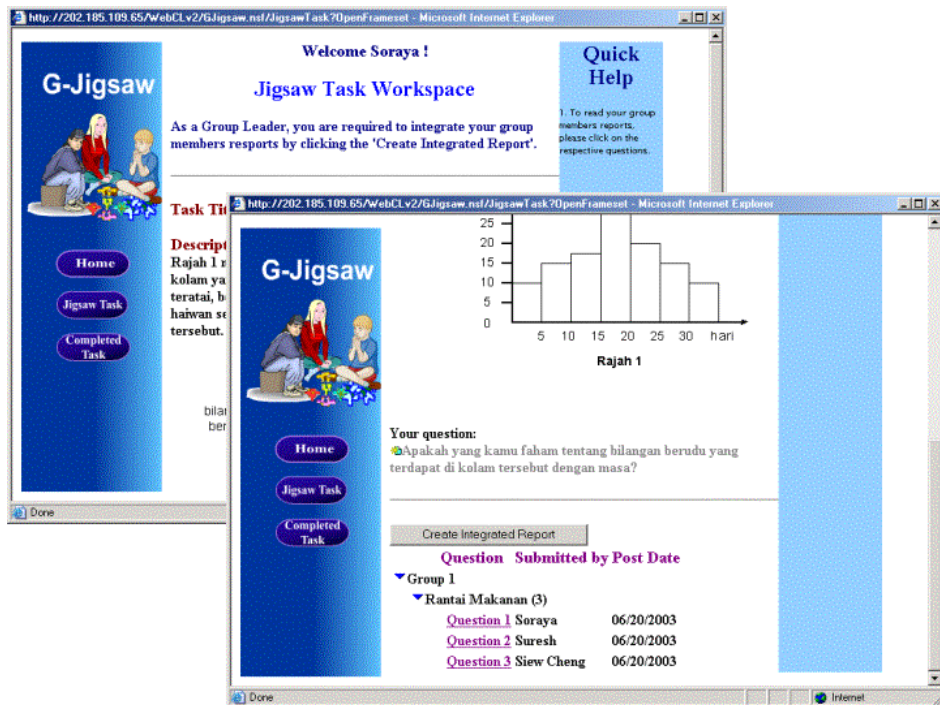
**Figure 6-18 Integrate Report View**



**Figure 6-19 Completed Task View**

## 6.5 Chapter Summary

This chapter has presented the implementation and execution of G-Jigsaw. The web agents that are essential for G-Jigsaw have been identified and the implementation of Activity Agency that coordinates these agents in a multi-agent architecture was discussed. In addition, the communication and the interaction of these agents are also described. Furthermore, this chapter presented the security features of G-Jigsaw that are inherited from the Lotus Notes and the scenarios of G-Jigsaw execution.

# Chapter 7 – G-Jigsaw Evaluation and Result

This chapter reveals the evaluation of G-Jigsaw. The first part discusses the evaluation methodologies, designed questionnaires and analysis results. The second part discusses the objectives that have been achieved by G-Jigsaw.

## 7.1 G-Jigsaw Evaluation

The evaluation of G-Jigsaw comprises of two stages. The first stage is a pilot test carried out by primary schools teachers and the second stage is a hands-on testing by primary school students. The following sections further describe the evaluations carried out in more detail.

## 7.2 Pilot Test for Primary Schools Teachers

The pilot test consists of three sections. Section A consists of two parts. The first part is an experiment that compares two versions of G-Jigsaw, where one version does not implements web agents and the other version with web agents. The former version of G-Jigsaw is developed using a fast prototyping method to incorporate the Group Jigsaw process model into a computer supported web-based environment. The purpose of this experiment is to determine the significant difference in performance and simplicity of the web agents' deployment in supporting the jigsaw activities. The second part of section A evaluates the effectiveness of G-Jigsaw's features and functionalities. Section B is a usability test with an attempt to determine G-Jigsaw's usability aspects such as the readability of information, users satisfactory towards the system and the ease of use of the system. Section C collects teachers' opinions and feedback on possible enhancements towards the G-Jigsaw.

The pilot test was conducted through a workshop by a group of 10 primary schools teachers selected by the Selangor State Department of Education. These teachers are teaching various subjects such as Science, Mathematic, Bahasa Melayu and English. They are computer literates and do not have much difficulty in using web-based application. Furthermore, most of these teachers have attended several computer courses especially in preparing teaching and learning materials using computers.

### 7.2.1 Experimental Material

For this pilot test, a Jigsaw task sample suitable for standard 5 English titled "The Nipah Palm" is used in both versions of G-Jigsaw. In order to measure the successfulness of web agents in supporting the jigsaw activities, the task questions and activities that need to be performed for both versions are identical. However, the steps to perform each activity are different for both versions.

### 7.2.2 Environment

The WebCL server is located in the CNT Room of Faculty of Computer Science and Information Technology, University of Malaya. The server is equipped with Intel Pentium III processor for server and 256 Megabyte of RAM. It runs on a Lotus Domino platform with Windows 2000 server as its operating system.

The teachers involved in this pilot test accessed the G-Jigsaw from the Djikstra Lab at Faculty of Computer Science and Information Technology, University of Malaya. The computers used by these teachers are equipped with Intel Pentium IV processor with 256 Megabyte of RAM and run on Windows XP operating system. The teachers used Internet Explorer 5.0 as the web client to connect to the WebCL server via the faculty's

Local Area Network.

### 7.2.3 Methodology

Before the pilot test begins, every teacher is briefed on the concept of collaborative jigsaw and the objectives of the G-Jigsaw evaluation. Then, a demonstration is performed to introduce G-Jigsaw's flow and functionalities. Task scenarios for the pilot test were distributed to each teacher which provides step-by-step instructions on how to perform each activity as attached in Appendix B. The teachers are required to perform each activity listed in the task scenarios for both versions of G-Jigsaw. The time spent in performing each activity is recorded for comparison. These activities will be discussed in more detail in section 7.2.4. Upon completing the activities, the teachers are required to answer a questionnaire.

### 7.2.4 Activities Performed in the Task Scenarios

Based to the task scenarios, the teachers are required to perform 5 similar activities in both versions of G-Jigsaw. These activities include:

- Activity 1:     Setting a new jigsaw task

- Activity 2:     Responding to all their group members

- Activity 3:     Composing a summary

- Activity 4:     Composing a report

- Activity 5:     Integrating a group report

Activity 1: Setting new jigsaw task

For G-Jigsaw without web agents, teachers need to enter new jigsaw task using a blank jigsaw task form. For G-Jigsaw with web agents, teachers are provided with 4 templates

to choose from. The default template is similar to the blank jigsaw task form in G-Jigsaw without web agents. The second template allows teachers to reuse questions in the shared repository but without any modifications. The third and fourth templates allow teachers to reuse shared questions and perform modifications. The third template is suitable for short questions and the later template is suitable for lengthy questions.

Activity 2: Responding to all their group members

In this activity, the teachers are required to give responses toward their group members' responsible question. For G-Jigsaw without agents, the teachers need to have a clear understanding of the jigsaw concept and its activity flows. At the same time, they need to remember how many questions they have responded and how many questions left. In contras, the entire jigsaw session in the G-Jigsaw with web agents is automated. The teachers only need to concentrate on giving responses to their group members. The web agents will keep track and inform the teachers on questions that have been responded as well as questions need to be responded.

Activity 3 and 4: Composing a summary and report

These activities require the teachers to compose a summary to advance to the Expert Group and a report to advance to the Jigsaw Group. The steps for both versions are almost the same except that the navigation for G-Jigsaw with web agent is automated. In G-Jigsaw without agents, need to manually advance to the Expert Group or the Jigsaw Group.

Activity 5: Integrating a group report

This activity involves integrating group members report into one complete integrated report. For G-Jigsaw without web agents, teachers are required to perform "copy and

paste" task. First, they need to open every group members report then copy it into an integrated report. Conversely, for G-Jigsaw with web agents, the agent will performs the integration task on behalf of the teachers through a single click.

### 7.2.5 Designed Questionnaire

The questionnaire is divided into three sections (A, B and C). The first part of section A contains a table for the teachers to record the time they spent for each activity in the experiment. The second part of section A compares the significant differences of web agents in simplifying the complicated process of jigsaw activity. There are two questions available. Question 1 compares the level of difficulty in carrying out each of these activities while question 2 compares the easy of use of the system. The rating scales for these questions are from 1 (very difficult) to 5 (very easy). The 5 remaining questions in the second part of section A are evaluated solely on G-Jigsaw with web agents to determine the effectiveness of G-Jigsaw's features and functionalities. These questions measure the sufficiency of web agents in achieving the following aspects:

- The usefulness of the facilities provided in G-Jigsaw

- The collaboration among the teachers and students

- The effectiveness of quick helps and instructions in G-Jigsaw

- The performance of G-Jigsaw

- The easy-of-use of G-Jigsaw

Section B of the questionnaire consists of 10 questions extracted from SUMI's usability test. The objective of this section is to evaluate G-Jigsaw's usability. The following usability aspects are evaluated in the questionnaire:

- The readability and usefulness of the G-Jigsaw information (quick help and

instructions)

- The user's satisfaction in using G-Jigsaw

- The ease-of-use of G-Jigsaw

- The presentation of G-Jigsaw

- The navigation of G-Jigsaw

Section C consists of 3 teachers comments and opinions towards the tested G-Jigsaw. Table 7-1 shows the summary of the designed questionnaire's various evaluation categories. The questionnaire is attached in Appendix C-1.

**Table 7-1 Summary of Pilot Test Designed Questionnaire**

| Questionnaire Section | Question's Number | Evaluation Category |
|---|---|---|
| Section A Part I (a): Experiment | – | The significant difference of average time spent to perform jigsaw activities between web agents |
| Section A Part I (b): | 1, 2 | The significant differences of web agents in simplifying the complicated process of jigsaw activities |
| Section A Part II: | 3a, 5a, 6a | The usefulness of G-Jigsaw facilities |
|  | 3c, 4c, 6b | The collaboration among the teachers and students |
|  | 4b | The quick help and instructions of G-Jigsaw |
|  | 3b, 5b, 7b | The performance of G-Jigsaw |
|  | 4a, 7a | The ease-of-use of  G-Jigsaw |
| Section B | 8, 11, 12 | The readability and usefulness of G-Jigsaw information |
|  | 9, 10 | The users' satisfaction in using G-Jigsaw |
|  | 13, 14, 15 | The ease-of-use of G-Jigsaw |
|  | 16 | The presentation of G-Jigsaw |
|  | 17 | The navigation of G-Jigsaw |
| Section C | 18, 19, 20 | General comments and opinions |

### 7.2.6 Pilot Test Results

**Part I of Section A - The Comparison Results**

Table 7-2 shows the comparison results of the average time spent for each activity by both versions of G-Jigsaw during the pilot test experiment.

**Table 7-2 The Average Time Spent in Performing Each Jigsaw Activity**

| Task Scenario Activity | 1. Set a new jigsaw task | 2. Respond to all group members | 3. Compose a summary | 4. Compose a report | 5. Integrate group members report |
|---|---|---|---|---|---|
| **Average time spent (minutes)** | G-Jigsaw (without web agents) | | | | |
| | 18 | 19 | 18 | 18 | 15 |
| | G-Jigsaw (with web agents) | | | | |
| | 8 | 9 | 8 | 8 | 1 |

From the table 7-2, it is very apparent that the G-Jigsaw with web agents greatly shows significant improvement in each activity performance. It enhanced more than 100% compare to the G-Jigsaw without web agents.

G-Jigsaw with web agents that provide templates (i.e. 2, 3 and 4) managed to reduce the time spent in creating new jigsaw tasks up to 2.25 times. This is because the templates enable the teachers to retrieve existing questions from the shared repository and use them with or without modifications. In this context, the web agents are responsible to administer the shared repository by performing tasks such as filtering and categorizing new questions as well as saving and retrieving existing questions transparently. Thus, these templates save a lot of the teachers' time in creating a jigsaw task for their students.

G-Jigsaw supports jigsaw activity which has complex flows in order to achieve thorough collaboration. The results show that the time spent by the teachers to respond

to all group members, to compose a summary and to compose a report in the G-Jigsaw without web agents are 2 times slower compared to the G-Jigsaw with web agents. This is due to the reason that in G-Jigsaw without web agents the teachers need to keep track of their task's status and navigate to the appropriate module manually.

For the last activity, the performance for integrating group members report in the G-jigsaw with web agent increase up to 15 times (1500 %). The core reason for this significant improvement is due to automation of report integration supported by the web agents. Rather than opening every group report to carry out the "copy and paste" task as in the G-Jigsaw without web agents, the teachers only need to click on a single button. Then, the web agent will automatically retrieve the related reports and integrate them into a full report. The integration time is usually less than a minute.

From the experiment carried out, most of the teachers found it difficult to perform the task scenario activities for the first time. However, the web agents' automation greatly simplified the jigsaw activity and able to reduce the time required to perform the jigsaw activities as shown in table 7-2. This can be shown in table 7-3, which compares the steps required for the integration process manually without web agents as well as the automatic integration process with Integrate Agent. As of table 7-3, it is obviously that if the students need to perform the integration process manually, they need to switch views back and forth, open and copy the group reports one by one, and past them to the integrated report form respectively. The more questions in the jigsaw tasks, the longer time and more steps are required. On the other hand, when the students utilize web agent to perform the integration process, then the steps have been significant simplified. Regardless how many questions are involved in a particular task, students just need to perform two steps for the integration.

**Table 7-3 Group Report Integration Steps (with and without web agents) Comparison**

| Steps for integrating group reports manually without any agent | Steps for integrating group reports with Integration Agent |
|---|---|
| 1. From the report view, click the Create Integrated Report button. <br> 2. When the form is opened, fill in the details such as Task Title, Task Description, Task Questions, Group etc. <br> 3. Switch to the Report view to open the first group report. <br> 4. Copy the first report's content and switch back to the integrated report form to paste them in the appropriate area. <br> 5. Edit the content if necessarily. <br> 6. Repeat the steps 3 to 5 for the rest of the questions until all questions are copied into the integrated report form area. <br> 7. Submit the integrated report. <br> 8. Switch to the Integrated Report View to view the integrated report. | 1. From the Report View, click the Create Integrated Report button. <br> 2. The Integration Agent performs the integration automatically and redirect user to Integrated Report View upon completion. |

Figure 7-1 presents the mean values of each activities in both versions of G-Jigsaw in a bar chat.



**Comparison on Jigsaw Activities' Simplicity**
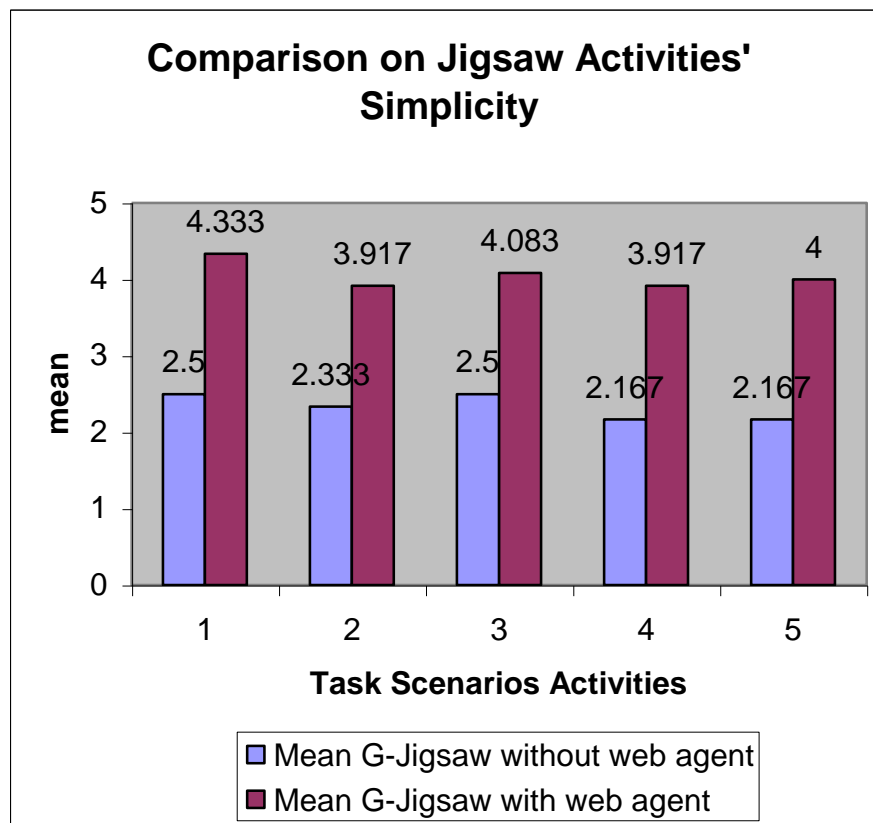
**Figure 7-1 Comparison Results on the significant differences of web agents in simplifying the jigsaw activities**

The results in figure 7-1 shows that web agents managed to simplify the complex jigsaw process to a great extend. From the bar chat above, it is concluded that most of the teachers found it quite difficult to perform activities in the G-Jigsaw without web agents (with mod value 2) whereas they found it quite easy to carry out the same activities in the G-Jigsaw with web agents (with mod value 4). This shows that the deployment of web agents simplifies the complex process of jigsaw activity. Through the automation process, almost all activities in the G-Jigsaw with web agents are almost the mean value of 4 or more. Therefore, the web agents enable the teachers to carry out their activities much more easier.
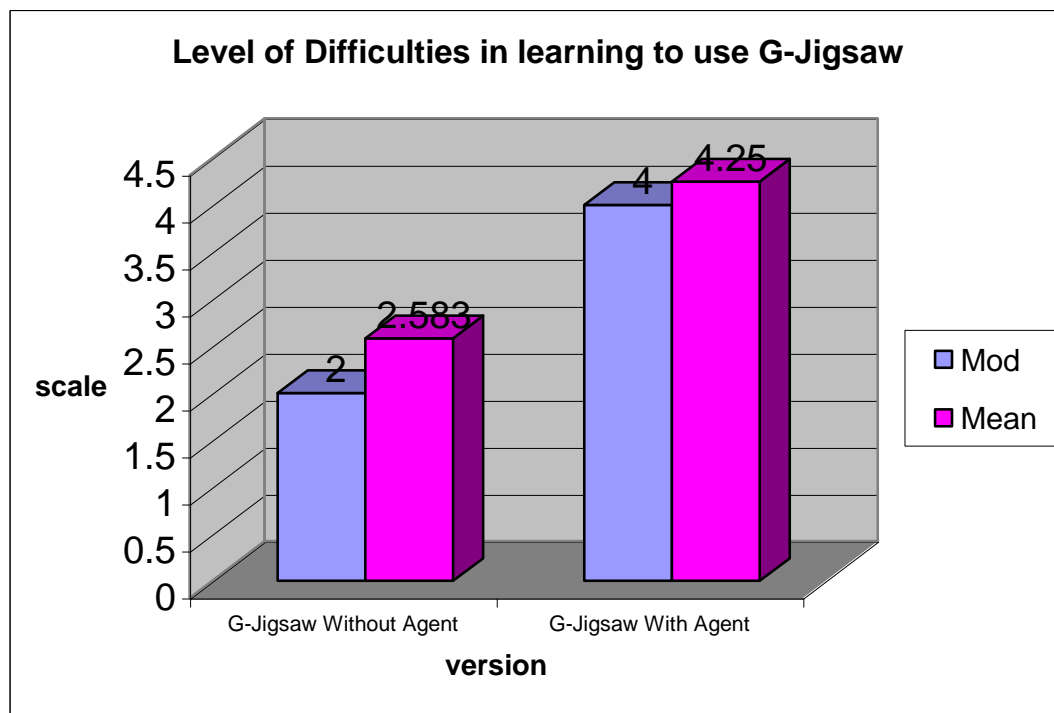
Figure 7-2 presents the mean values of each activities in both versions of G-Jigsaw in a bar chat.



**Figure 7-2 Comparison Results on the level of difficulties in learning to use G-Jigsaw**

Similarly, results from figure 7-2 indicate that the G-Jigsaw with web agents scores the mean value of 4.25 and mod value of 4 whereas the mean value for the G-Jigsaw without web agents is 2.583 with its mod value of 2. The results verify that the web agents make the process of learning how to use the system easier.

**Part II of Section A – System Features and Functionalities Evaluation Results**

**Table 7-4 (a) Results on the Usefulness of G-Jigsaw's Facilities**

| Question Number | Mod | Mean |
|---|---|---|
| 3a. The usefulness of the templates facility which supports the sharing and retrieving of existing questions in shared repository) | 4 | 4.000 |
| 5a. The usefulness of the retrieval function that retrieves group members' responses | 4 | 3.583 |
| 6a. The usefulness of the retrieval function that retrieves the student's previous summary | 4 | 3.750 |

Table 7-4 (a) presents the results of the usefulness of the facilities provided in G-Jigsaw. As shown in table 7-4 (a), Question 3a, 5a and 6a evaluate the usefulness of the sharing and retrieving features supported in the jigsaw activity. The results show that the mod rating for all three questions is relatively high with the mod values of 4 and mean values of above 3.5. This concludes that the sharing and retrieving features are essential and useful in G-Jigsaw.

**Table 7-4 (b) Results on the Collaboration among the Teachers and Students**

| Question Number | Mod | Mean |
|---|---|---|
| 3c. The shared repository use to retrieving existing question created by other teachers promotes the teacher's collaboration | 4 | 3.833 |
| 4c. Responding to group member's questions promotes students' collaboration. | 3 | 3.250 |
| 6b. The jigsaw activities (e.g. giving responses, commenting on the summaries and receiving feedback) promote students' collaboration | 4 | 3.833 |

Table 7-4 (b) presents the results of collaboration among the teachers and students. The

second category of questions attempts to assess the effectiveness of web agents in supporting the collaboration among teachers and students during the jigsaw activity. The results obtained from table 7-4 (b) indicate that the sharing of existing jigsaw task questions promotes teachers' collaboration with the average mod value of 4 and average mean value of 3.833 respectively.

Besides, the results show that the activity of responding to group members' questions encourages the students' collaboration with the mod value of 3 and mean value of 3.25. Other activities in G-Jigsaw such as commenting other group's summaries and receiving feedback from other group members scored 4 in mod and 3.833 in mean. Therefore, these activities helped to promote students collaboration. As a result, web agents in G-Jigsaw encourage the collaboration among teachers and students with the average mod of 4 and the mean score of above 3.0.

**Table 7-4 (c) Results on the helpfulness of G-Jigsaw's Quick Helps and Instructions**

| Question Number | Mod | Mean |
|---|---|---|
| 4b. The quick helps and instructions | 4 | 3.667 |

As shown in the table 7-4 (c), the third category attempts to determine the usefulness of the quick helps and instructions provided in G-Jigsaw The results show that the quick helps and instructions in G-Jigsaw are helpful and scored mean value of 3.667 and mod value of 4.

**Table 7-4 (d) G-Jigsaw's Performance Evaluation Results**

| Question Number | No (%) | Undecided (%) | Yes (%) |
|---|---|---|---|
| 3b. The sharing facility reduces the time required in creating a jigsaw task | 0.0 % | 8.0 % | 92.0 % |

| | | | |
|---|---|---|---|
| 5b. The retrieving facility speeds up the time of composing a summary | 8.3 % | 8.3 % | 83.3 % |
| 7b. The integration facility shorten the report integration time | 0.0 % | 0.0 % | 100.0 % |

The next category of questions presented in table 7-4 (d) intends to measure the G-Jigsaw performance. Based on the results, 92% of the teachers agreed that the sharing facility speeds up their time in preparing the jigsaw task, 83% consented that the retrieving facility speeds up their time in composing a summary and all the teachers agreed that the integration facility speeds up their time in integrating all group members report. These results verified that the facilities provided greatly enhanced G-Jigsaw performance. Since these facilities are the responsibility of web agents, hence web agents enhanced the performance of G-Jigsaw significantly.

**Table 7-4 (e) G-Jigsaw Ease-of-use Results**

| Question Number | No (%) | Undecided (%) | Yes (%) |
|---|---|---|---|
| 4a. The automation process simplifies the activity of responding to group members | 0.0 % | 8.0 % | 92.0 % |
| 7a. The integration process makes the group reports integration easier | 0.0 % | 0.0 % | 100.0 % |

The last category of questions measured the ease-of-use of G-Jigsaw. Based on the result, 92% of the teachers found it is easy to respond to other group members. All of the teachers agreed that the integration facility makes the integration process easier. As a result, web agents greatly simplified the process of jigsaw activities.

In order to have a clearer picture on how web agents supports each category mentioned above, the results shown in table 7-4 are recompile into a bar chart. The average min score for each category are taken for the chart. Figure 7-3 shows the overall results on

how the web agents support various categories in G-Jigsaw.
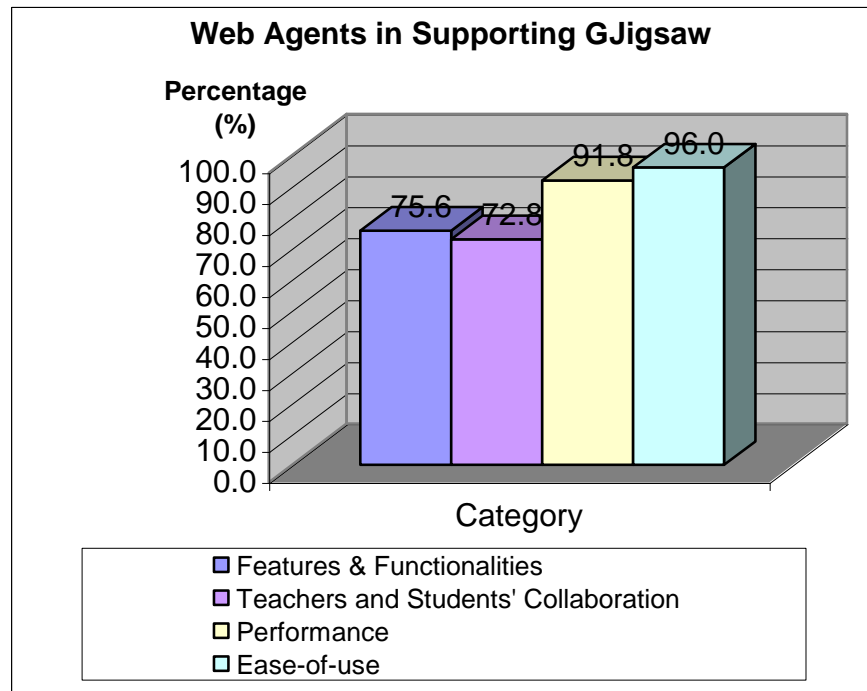


**Figure 7-3 Web Agents in supporting G-Jigsaw Activities**

## Section B – Usability Test Results

**Table 7-5 G-Jigsaw's Usability Test Results**

| G-Jigsaw's information readability and usefulness | | | |
|---|---|---|---|
| **Question Number** | **Agree (%)** | **Undecided (%)** | **Disagree (%)** |
| 8. Instructions are helpful | 92.0 | 8.0 | 0.0 |
| 11. Information are clear and understandable | 58.0 | 42.0 | 0.0 |
| 12. Can understand and act with provided information | 83.0 | 17.0 | 0.0 |
| **User's satisfaction of using G-Jigsaw** | | | |
| **Question Number** | **Agree (%)** | **Undecided (%)** | **Disagree (%)** |
| 9. Enjoy the jigsaw session | 100.0 | 0.0 | 0.0 |
| 10. Satisfy with the software | 67.0 | 33.0 | 0.0 |
| **Ease-of-use of G-Jigsaw** | | | |
| **Question Number** | **Agree (%)** | **Undecided (%)** | **Disagree (%)** |
| 13. Task performed in a straightforward manner | 58.0 | 42.0 | 0.0 |
| 14. Keep going back to look at guides | 33.0 | 42.0 | 25.0 |

| 15. Difficult to learn to use new function | 17.0 | 33.0 | 50.0 |
|---|---|---|---|
| **G-Jigsaw's presentation** | | | |
| **Question Number** | **Agree (%)** | **Undecided (%)** | **Disagree (%)** |
| 16. Attractive Presentation | 75.0 | 25.0 | 0.0 |
| **G-Jigsaw's navigation** | | | |
| **Question Number** | **Agree (%)** | **Undecided (%)** | **Disagree (%)** |
| 17. Easy Navigation | 67.0 | 33.0 | 0.0 |

Table 7-5 depicted the usability test results from the pilot test. Based on this table, 92 % of the teachers agreed that the instructions are useful in assisting them while they are carrying out the jigsaw activities. 83% of the teachers consented that they can understand and follow the information provided by G-Jigsaw. However, only 58% of teachers considered the information provided is clear and understandable while the remaining 42% cannot decide. These results show that G-Jigsaw's instructions are very helpful. Although its information's readability score relatively low, but it is generally acceptable since none of the teachers disagreed on its readability. This implies that the presentation of the information should be improved.

In terms of user's satisfaction, all teachers enjoyed the jigsaw activities session. Up to 67% of them express that they are satisfied with G-Jigsaw while 33% remain undecided. As a result, G-Jigsaw scored quite high in achieving the user's satisfaction.

In the ease-of-use aspect, the results show that most of the teachers are undecided. 58% of the teachers agreed that the tasks can be performed directly. 50% of them agreed that learning how to use new functions is easy. Only 25% of the teachers do not need to refer the quick help frequently. This result shows that G-Jigsaw only achieved its ease-of-use aspect moderately. These indicate that even though the web agents greatly simplify the jigsaw activities, however there is still room to improve G-Jigsaw usability.

Besides, 75% of the teachers agreed that the presentation (user interface) of G-Jigsaw is very attractive. This means G-Jigsaw's has successfully provided an attractive appearance and presentation for its users. In terms of G-Jigsaw navigation aspects, 67% of the teachers consented that it is relatively easy to move from one place to another.

**Section C – Teachers comments and opinions**

Teachers comments and opinions towards the tested G-Jigsaw are extracted from section C of the questionnaire as depicted below:

- G-Jigsaw activities promote students' creative and critical thinking (KBKK – Kemahiran Berfikir secara Kreatif and Kritis).

- G-Jigsaw is a good tool for teaching and it is practical for teachers and students.

- G-Jigsaw enables students to learn collaboratively and support each other with their summaries and reports.

- G-Jigsaw promotes ideas generation.

## 7.3 Hands-On Testing for Primary School Students

The hands-on testing is divided into two sections. The first section relates to the ease-of-use in carrying out activities in G-Jigsaw. It evaluates the effectiveness of web agents in supporting the complex jigsaw activities. The second section focuses on the effectiveness of the jigsaw concepts that have been incorporated in G-Jigsaw as well as its suitability to be used by primary school students.

The hands-on testing was conducted in Sekolah Kebangsaan Putrajaya 2 by a group of 27 year 5 Zuhal students. These students are computer literate and familiar with various teaching and learning materials using computers and web-based applications.

### 7.3.1 Experimental Material

For the purpose of this testing, a sample Jigsaw task for year 5 Science subject titled "Rantai Makanan" (The Food Chain) has been prepared for the students to participate using G-Jigsaw. The sample task comprises of 5 distinct yet interrelated questions.

### 7.3.2 Environment

The WebCL server is located in the Computer Lab 2 of Sekolah Kebangsaan Putrajaya 2 with the specifications of Intel Pentium III processor for server with 256 Megabyte of RAM. The server runs on a Lotus Domino platform with Windows 2000 Server operating system. The students access the G-Jigsaw in the same computer lab. All the computers used by the students are with the specifications of Intel Pentium II processor with 64 Megabyte of RAM and Windows NT operating system. The students use the Internet Explorer 5.0 as the web client to connect to the server via the school's Local Area Network.

### 7.3.3 Methodology

Before the hands-on testing begins, the students were briefed about collaborative jigsaw concept and the objectives of the G-Jigsaw evaluation. Then, the students carry out each activity based on the step-by-step instructions provided. There were 5 facilitators in the lab to monitor and assist the students during the testing session. Questionnaire was distributed to each student before the testing begins. Each time the students completed an activity, they were required to answer related questions in the questionnaire.

**7.3.4 Designed Questionnaire**

The purposes of this student hands-on testing were described in section 7.3. Thus, the questionnaire was designed into two sections. The questionnaire is based on yes or no answer. There are all together 9 questions in the first section. These questions focus on the ease-of-use and the effectiveness of G-Jigsaw. The second section consists of 5 questions. The first 3 questions measure how the jigsaw concept in G-Jigsaw supports the primary schools collaborative learning. The last two questions are for the students' general to provide their feedback and opinion towards G-Jigsaw. Table 7-6 shows the categories of this evaluation. The complete questionnaire is attached in Appendix C.

**Table 7-6 Summary of Questionnaire Evaluation Categories**

| Question Number | Evaluation Category |
|---|---|
| Section A: 1, 2, 4, 6, 9 | The ease-of-use of G-Jigsaw |
| Section A: 3, 5, 7, 8 | The effectiveness of the jigsaw method |
| Section B: 1, 2, 3 | The efficiency of collaborative learning |
| Section B: 4, 5 | General feedback and opinions on G-Jigsaw |

**7.3.5 Student Hands On Testing Results**

The results of the hands-on testing are displayed in table 7-7.

**Table 7-7 Student Hands-On Testing Results**

| G-Jigsaw's Ease-of-Use | Yes (%) | No (%) |
|---|---|---|
| Easy to start the jigsaw activity | 74.1 | 25.9 |
| Easy to respond to group members | 88.9 | 11.1 |
| Easy to read group members' responses | 100.0 | 0.0 |
| Easy to give comments to expert group members | 96.3 | 3.7 |
| Easy to integrate group members' report | 100.0 | 0.0 |
| **G-Jigsaw's Effectiveness** | **Yes** | **No** |
| Find the jigsaw session enjoyable | 100.0 | 0.0 |
| Find the responses useful | 100.0 | 0.0 |
| Managed to gain a better understanding from the summaries | 96.3 | 3.7 |
| Find the comments helped them to improve their answers | 92.6 | 7.4 |

| G-Jigsaw in Supporting Collaborative Learning | Yes | No |
| --- | --- | --- |
| Promotes knowledge sharing | 100.0 | 0.0 |
| Promotes collaborative learning | 88.9 | 11.1 |
| Suitable for primary schools learning activities | 92.6 | 7.4 |

Based on table 7-7, the results show that 74.1% of the students agreed that the jigsaw activity is easy to start, 88.9% among them managed to respond to their group members without much difficulties and 96.3 % of them are able to provide comments to their expert group members. Moreover, all the students agreed that they can easily read their group members' responses and all the group leaders managed to integrate the group reports easily. These results prove that G-Jigsaw has improved significantly in term of its ease-of-use aspect compared to the pilot testing conducted previously.

The second category of the questionnaire evaluates the effectiveness of the jigsaw method that had been incorporated in G-Jigsaw. Based on the results, all the students involved found the jigsaw session enjoyable and they expressed that the responses from their group members are very helpful in their learning process. In addition, up to 96.3% of the students managed to gain a better understanding after reading summaries from other group members during the Expert Group. 92.6 % of the students felt that the comments toward their summary greatly helped them to improve their answers. Thus, these results concluded that G-Jigsaw have successfully incorporated the jigsaw method in promoting student collaborative learning.

The third category further evaluates the achievement of G-Jigsaw in supporting students' collaborative learning activities. As shown in table 7-7, all the students agreed that G-Jigsaw promotes the knowledge sharing and 88.9% of them said that G-Jigsaw supports them to learn collaboratively. Besides, 92.6% of the students agreed that G-Jigsaw is suitable for primary school collaborative learning activities. These results

summarized that G-Jigsaw supports student's collaborative learning activities in primary school efficiently.

Last but not least, some of the most essential opinions from the students towards the evaluated G-Jigsaw are extracted from the questionnaire and as shown below:

- The jigsaw activities are very challenging and interesting.

- The jigsaw activities improved the understanding towards a particular question.

- The jigsaw activities enable students to work together collaboratively.

- The jigsaw activities assist students to learn a particular subject more effectively.

- The jigsaw activities enable students to exchange their ideas easily.

- The jigsaw activities improve the students learning performance.


## 7.4 Discussion on G-Jigsaw's Achievement

In conjunction with the two evaluations above, this section discusses the objectives that had been achieved by G-Jigsaw. Based on the two evaluations, G-Jigsaw has achieved the following:

1. The deployment of web agents in G-Jigsaw provided significant improvement in the performance of G-Jigsaw. Results from the evaluations verified that the web agents enhanced and simplified the performance of jigsaw activities in the following aspects:

    i. The average time spent for each activity has been reduced more than 50%.

    ii. The complex processes and flows of jigsaw have been simplified through automation.

    iii. The integration time is increased up to 15 times.

iv. The curve of learning how to use G-Jigsaw has improved significantly.

v. The features and functionalities of G-Jigsaw have been well supported.

vi. The collaboration among teachers and students has been achieved.

2. The facilities of G-Jigsaw are very useful in supporting the jigsaw-type collaborative learning in the following ways:

   i. The shared repository promotes the sharing and reuse of teaching materials.

   ii. The retrieval facilities simplified the jigsaw activities.

   iii. The quick helps and instructions provided are helpful.

3. The results concluded that G-Jigsaw have successfully incorporated the jigsaw method in promoting students collaborative learning activities in the following ways:

   i. 100% of the participants agree that G-Jigsaw promotes knowledge sharing.

   ii. 89% of the students consent that G-Jigsaw promotes collaborative learning.

   iii. All students (100%) involved find that the jigsaw session is enjoyable.

   iv. All the activities provided in G-Jigsaw achieved 90% and above on its effectiveness and usefulness.

4. In addition, G-Jigsaw's usability achieves great success in the following aspects:

   i. The information readability is generally acceptable.

   ii. The instructions and quick helps provided are adequate.

   iii. The users are satisfied working with G-Jigsaw.

   iv. G-Jigsaw is easy to learn and use.

   v. The presentations in G-Jigsaw are attractive.

   vi. The navigations in G-jigsaw are simple.

5. G-Jigsaw is suitable to be used in supporting primary schools students'

collaborative learning activities.

Based on the summary results above, it is very obvious that the objectives listed in chapter 1 have been achieved. With the deployment of web agents in the development of G-Jigsaw, it has successfully serves as a web-based tool that incorporates jigsaw technique to support students' collaborative learning. The functionalities evaluation in part II of section A of the pilot test shows satisfactory results. In addition, many benefits of collaborative learning and advantages of the Jigsaw technique have been successfully incorporated in G-Jigsaw. This can be seen from both the pilot testing and the students hands-on testing. The former achieved 92% in term of teachers and students collaboration whereas the later shows good results in the collaborative aspects (i.e. knowledge sharing, collaborative learning) with the score of 100%, 88.9% respectively. Furthermore, the effectiveness of G-Jigsaw category in student hands-on testing concluded that G-Jigsaw managed to incorporate the group jigsaw process model very successfully with the score of 90% and above for each evaluated aspects.

Besides, web agents that simplified and enhanced the jigsaw activity process have been identified and implemented successfully. Results from section A of the pilot testing show the significant improvement with the deployment of web agents. In term of ease-of-use, even though the results from the pilot test were not very satisfactory, however it has been greatly improved based on the results shown in the student hands on testing.

Out of the back-end database processing tasks, the automated integration task received the best feedback from both testing. Other facilities such as retrieving, categorizing and filtering proved their usefulness in this context. This draws to the conclusion that the deployment of web agents greatly enhanced the G-Jigsaw performance in supporting

jigsaw collaborative learning activities.

## 7.5 Chapter Summary

This chapter has evaluated G-Jigsaw against its objectives and requirements. The evaluations for two categories of users (teachers and students) have been conducted via the pilot testing and student hands-on testing respectively. Results from the evaluations are investigated and conclusions on G-Jigsaw's achievement have been made.

# Chapter 8 – Conclusion and Future Enhancements

This chapter provides the research summary, its contributions and future enhancements. The research summary is discussed in Section 8.1 and the research contributions are discussed in section 8.2. The suggestions and recommendations obtained from the evaluations carried out are discussed in Section 8.3.

## 8.1 Research Summary

This thesis presents the efforts made to develop a web-based tool that utilizes the web agents in supporting primary schools jigsaw collaborative learning. The theoretical aspects of collaborative learning, especially the Jigsaw technique created by Aronson have been reviewed. The jigsaw collaborative learning activity proposed by a group of teachers in a workshop which serves as the core foundations for the construction of the G-Jigsaw process model are presented. A G-Jigsaw prototype is developed to incorporate the G-Jigsaw process model into a web-based environment. Reviews on the software agent literature specializing in the web agent are carried out. How a multi-agent architecture is formulated to enable the web agents to communicate with each other in simplifying and automating the jigsaw activities is described. The development and implementation of G-Jigsaw that incorporates both the process model and the multi-agent architecture in supporting the jigsaw collaborative learning with the deployment of web agents is presented. The teachers (pilot testing) and students (hands-on testing) evaluations are carried out and the results that indicate that web agents greatly simplifying the complex jigsaw processes are highlighted.

## 8.2 Research Contributions

The research contributions are as follows:

1. It introduces a G-Jigsaw process model to support the primary schools jigsaw collaborative learning. The proposed G-Jigsaw process model introduces three levels of students' collaboration (i.e. Initial Level, Expert Level and Jigsaw Level) to support the students' collaborative learning activities. This process model is then incorporated into a web-based tool called G-Jigsaw. From the evaluation carried out on the G-Jigsaw, it indicates that students find the G-Jigsaw very interesting and challenging.

2. It discovers the potential of agent technology in supporting collaborative learning and proves its usefulness through the development of G-Jigsaw that implements the web agents. From the thorough review carried out on the software agents, it is discovered that the agent technology has great potential in supporting collaborative learning application. However, not many current collaborative learning applications are implementing agent technology in their applications. During G-Jigsaw development, web agents are implemented in the following ways:

   i. To automate the complex jigsaw flows so that the jigsaw activity can be simplified.

   ii. To provide retrieving and integrating facilities in order to speed and smoothen the collaboration process.

   iii. To create a profile for each user to assist the jigsaw navigation.

   iv. To administer the database back-end processing such as filtering and categorizing.

3. It formulates a multi-agent architecture in supporting the collaborative learning which can be applied to other collaborative learning applications. The multi-agent architecture supports the deployment of web agents. The implementation of web-agents in G-Jigsaw has made an impact on the jigsaw activity process. Based on the evaluation carried out, G-Jigsaw with web-agents performed more effectively and this shows that web-agents can be used successfully in supporting collaborative learning activities.

4. It simplifies the complex jigsaw process and brings the jigsaw technique into a web-based computer supported collaborative learning environment. Although the Jigsaw technique has achieved great success for the past few decades, however, its complicated structure and flows makes it difficult to be incorporated in a computer supported collaborative learning environment. Many of the primary and secondary school teachers carry out their Jigsaw lesson manually. The development of G-Jigsaw has successfully simplified the Jigsaw activities through its computer supported collaborative environment. G-Jigsaw even enables students to participate in Jigsaw activities at a distance. This greatly enhanced the levels of collaboration.

5. It serves as one of the WebCL module, which supports the Jigsaw-type collaborative learning activity in schools. WebCL is a collaborative learning system that supports various types of collaborative learning activities. G-Jigsaw serves as a module that highly demonstrates the concepts of collaborative learning. Students who participate in this module can easily understand the concepts of collaborative learning and will be able to experience its benefits. Hence, this is G-Jigsaw vast contribution to the WebCL system.

## 8.3 Future Enhancements

Although this research has achieved most of its objectives and provides contributions particularly in supporting jigsaw collaborative learning technique, however it still has several aspects that can be improved.

G-Jigsaw current version restrictions are:

1. The G-Jigsaw only supports a maximum of 25 students in 5 different groups per jigsaw session. In a standard classroom, the number of students is normally more than 25 people. Therefore, for the remaining students to participate in a jigsaw session, they have to share with other students. For this reason, G-Jigsaw should be improved so that it can dynamically support any number of students and groups.

2. The automation process of G-Jigsaw is not robust enough. The numbers of questions that can be set are based on the number of students. The numbers of students that can participate for each jigsaw session are 4, 9, 16 or 25 only. Therefore, this restriction should be modified in order for it to supports any number of students per session. In order to overcome this problem, web agents can be used as students' dummies. The role of these dummies is to stimulate students' participation. For instance, if a class has only 23 students, therefore the new version of G-Jigsaw will still be able to support 5 groups by using 2 dummies for the last 2 groups.

3. The G-Jigsaw navigation can also be enhanced by implementing exceptions handling functions to make it more robust and reliable. To achieve these objectives, more longer period testing and evaluation session should be carried out. This is to ensure that all the errors are detected and enhancement possibilities are identified.

4. Although G-Jigsaw interfaces are quite well established, however many students who have used G-Jigsaw suggested that there should be more multimedia elements embedded into G-Jigsaw. The students say that by incorporating these multimedia elements in G-Jigsaw, the learning process will be more interesting. This enhancement requires further research efforts to ensure that it will not violate with the students' learning.

5. G-Jigsaw is currently designed for primary school students to carry out their jigsaw collaborative learning. Further studies and evaluations should be carried out to expand its scope so that it can be used to support secondary schools, colleges and universities as well.

6. The evaluations of this research are mainly focus on how potential web agents can be used to support the jigsaw collaborative learning successfully. However, it is very important to carry out further testing on how well the advantages of Aronson's Jigsaw Classroom are supported in G-Jigsaw.

Besides all the recommendations suggested, there is another further investigation that could be carried out. The investigation is to compare the augmented G-Jigsaw process with other types of collaborative learning such as Circle of Learning, Student Teams-Achievement Division (STAD) and Teams-Games-Tournament (TGT). This research will provide great contributions towards the determination of the best approach to support students' collaborative learning activities effectively.

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# Appendix A: G-Jigsaw Object-Oriented Analysis and Design

This appendix depicts all the UML diagrams used for G-Jigsaw's object-oriented analysis and design. These diagrams include Use Case Diagrams, Class Diagrams, Sequential Diagrams and Activity Diagrams.

## A-1 G-Jigsaw Use Cases and Use Case Diagrams

This section shows the use cases for G-Jigsaw in both teacher mode and student mode. Generally, 15 common use cases are identified throughout the jigsaw process. Most of these use cases interact with different objects in different stages. For instance, the read/view use case is applied to read or view a jigsaw task in teacher mode, while the same use case also apply to read or view responses, summaries or reports in student mode. As a result, there are all together 26 specific use cases derived from the common use cases. Besides, there are two actors involved in G-Jigsaw, teacher and student. The common use cases are listed below:

1. Login [success/failure]
2. Navigate [Jigsaw Task, Completed Task, G-jigsaw Homepage]
3. Read/View [Jigsaw Tasks, Responses, Summaries, Reports and Final Reports]
4. Compose [Jigsaw Tasks, Responses, Summaries, Reports and Final Reports]
5. Preview & Load Templates [Template1, Template2, Template3, Template4]
6. Upload Graphic [Jigsaw Tasks]
7. Submit/Post [Jigsaw Tasks, Profiles, Responses, Summaries, Reports]
8. Edit [Jigsaw Tasks, Reports]
9. Delete [Jigsaw Tasks, Reports]
10. Retrieve [Jigsaw Tasks Questions, Responses, Summaries]
11. Start/Continue [Jigsaw Tasks]
12. Set profile
13. Respond [Responses, Summaries]
14. Integrate [Reports]
15. Switch [Groups]

The following use case diagrams demonstrate all the use cases in G-Jigsaw:
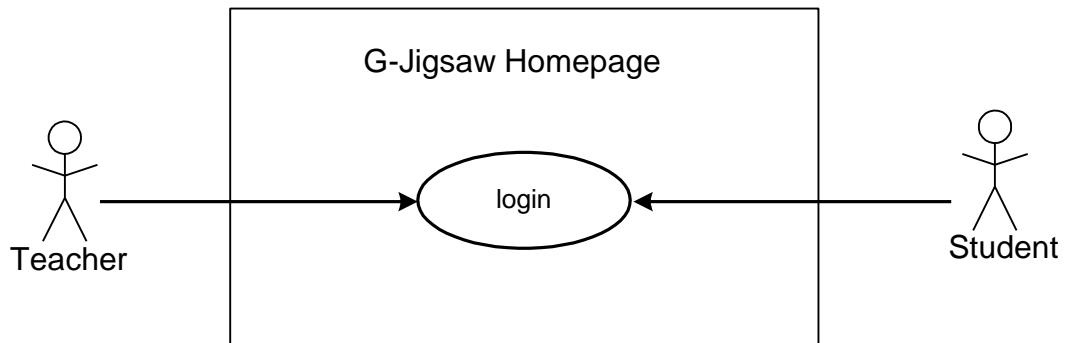
**A-1-1 Accessing G-Jigsaw**



**Figure A-1-1 Accessing G-Jigsaw Use Case Diagram**

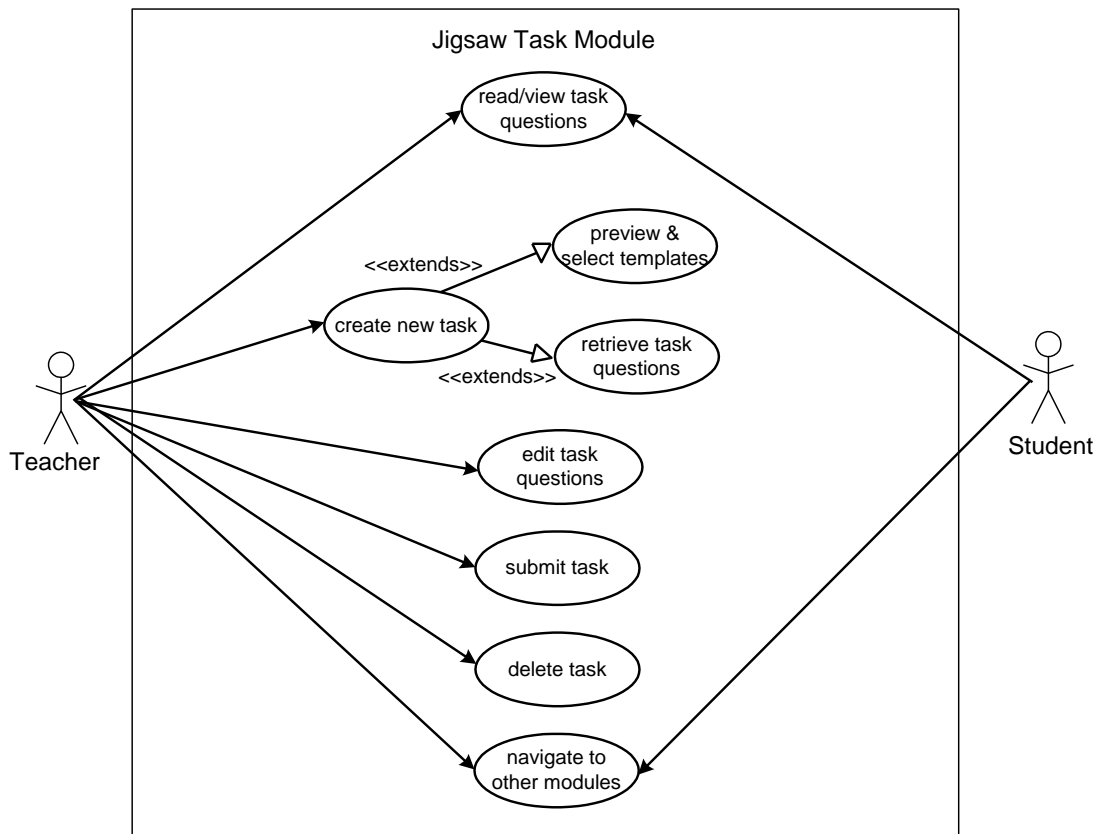**A-1-2 Accessing Jigsaw Task Module**



**Figure A-1-2 Accessing Jigsaw Task Module Use Case Diagram**
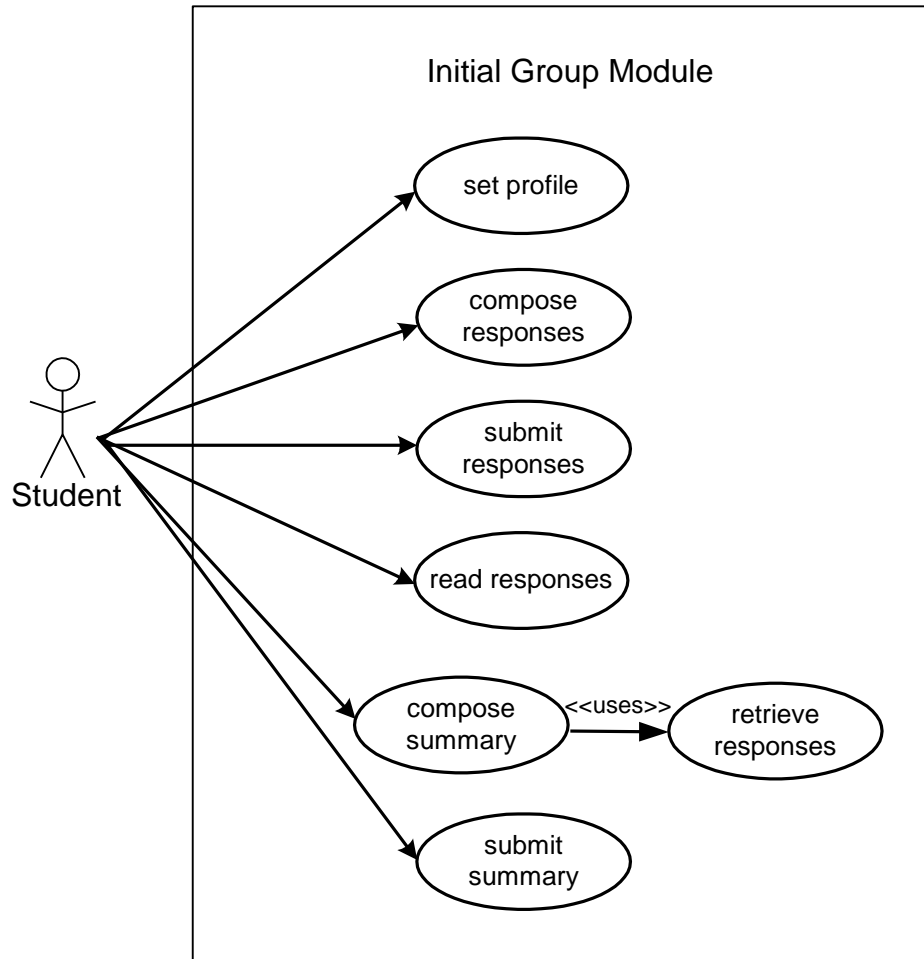
**A-1-3 Accessing Initial Group Module**



**Figure A-1-3 Accessing Initial Group Module Use Case Diagram**
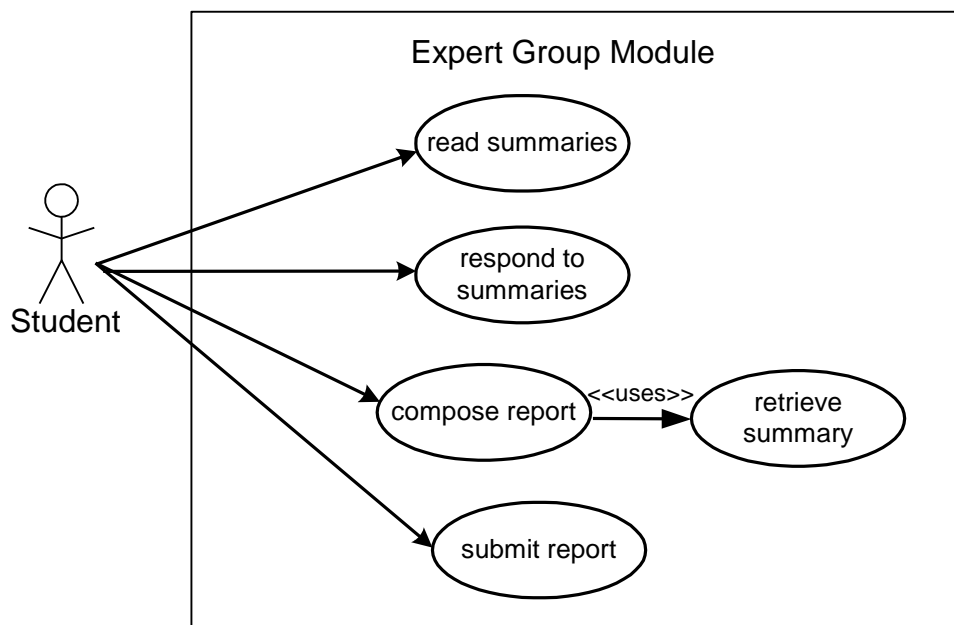
**A-1-4 Accessing Expert Group Module**



**Figure A-1-4 Accessing Expert Group Module Use Case Diagram**

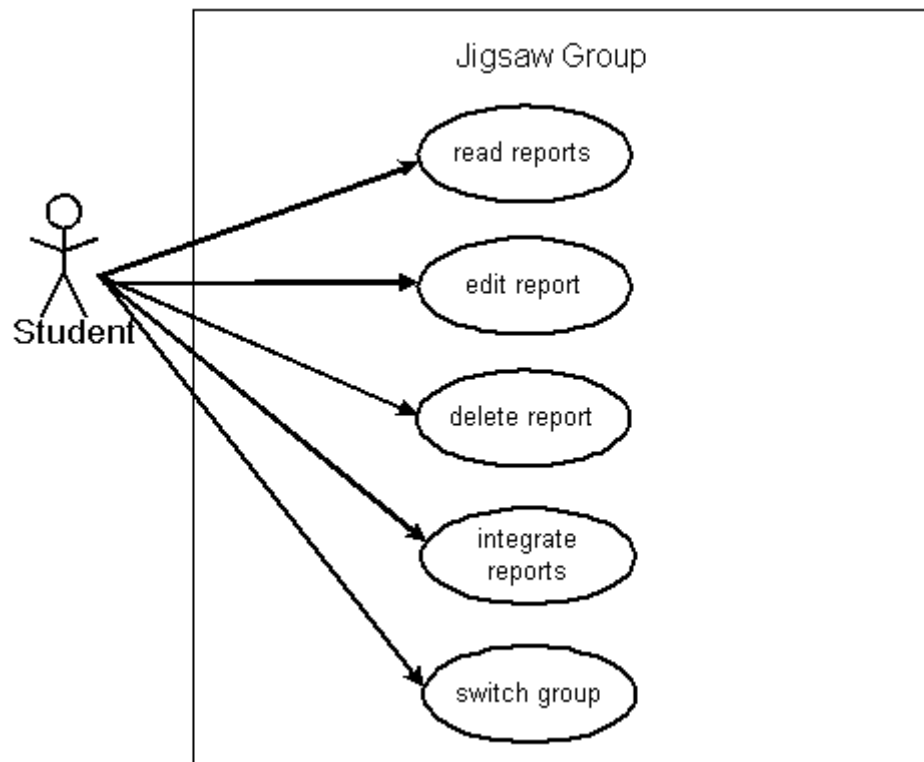### A.1.5 Accessing Jigsaw Group Module



**Figure A-1-5 Accessing Jigsaw Group Module Use Case Diagram**

## A-2 G-Jigsaw Class Diagram

This section shows the class diagram of G-Jigsaw. Generally, there are 4 major classes in G-Jigsaw namely User, Browser (Client), Server (Server) and Database. Teacher and Student are two subclass derived from User to represent two types of user. The Database class consists of 7 design elements classes. How each of these classes connect to each other are shown in figure A-2-1 below:
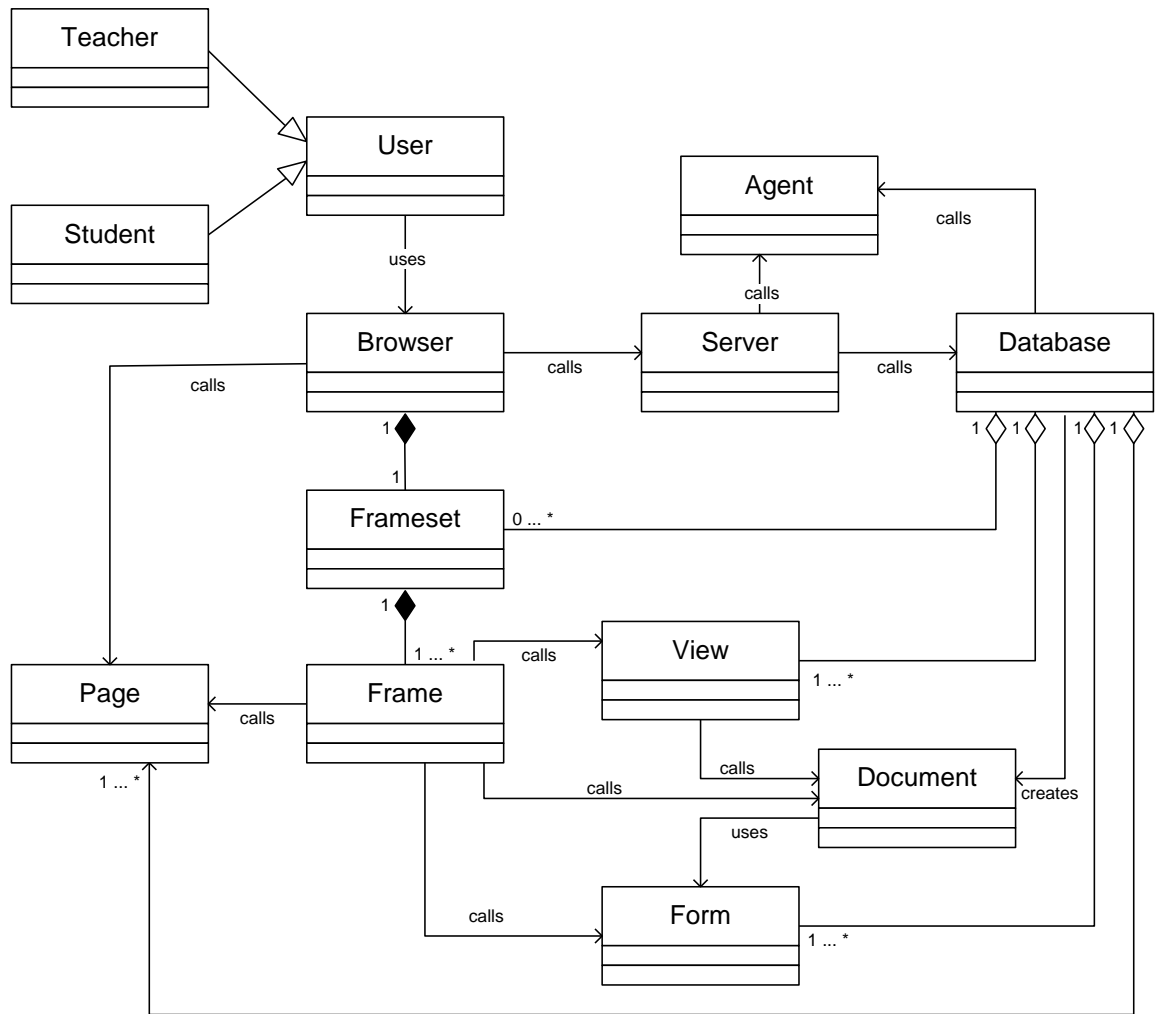
**Figure A-2-1 G-Jigsaw Class Diagram**

## A-3 G-Jigsaw Scenarios and Sequential Diagrams

This section describes the detailed interaction of each use case depicted in section A-1. Sequential diagrams are used together with its scenario descriptions to illustrate each use case's interaction.

### A-3-1 Scenario 1: Successful Login

1. User (student or teacher) opens a web browser
2. User enters homepage URL
3. Browser connects to web server
4. Browser requests homepage from server
5. Server requests username and password from user
6. User enters correct username and password
7. Server verifies username and password
8. Server accepts username and password

9.  Server retrieves homepage from server database
10. Server database sends the required page to browser
11. Browser displays homepage on the screen
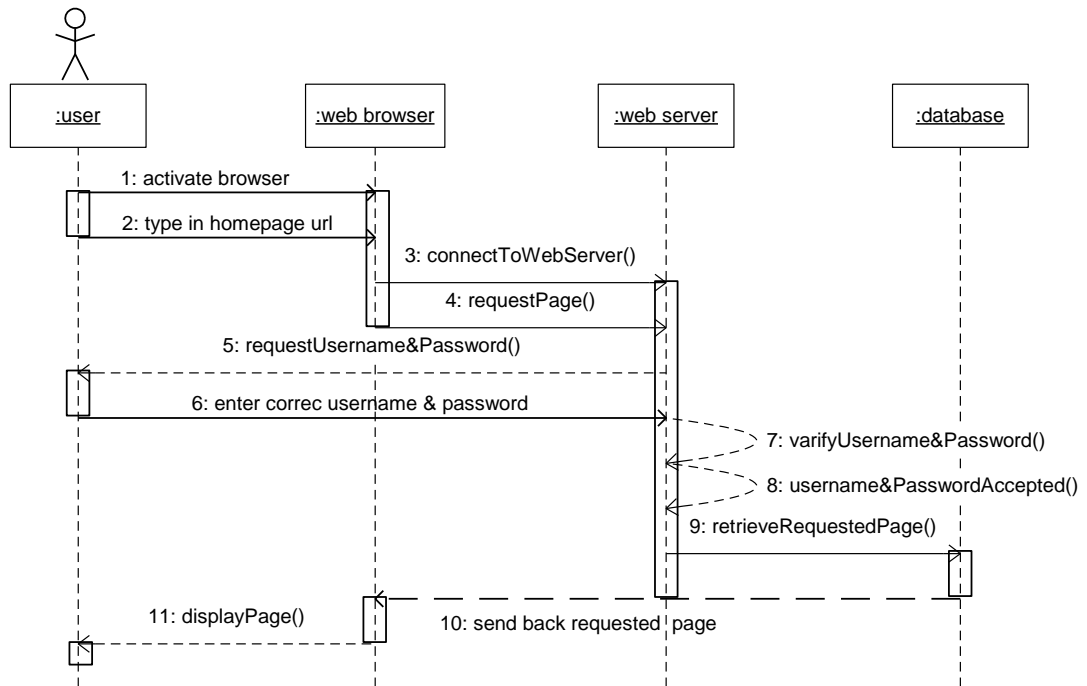


**Figure A-3-1 Successful Login Sequential Diagram**

**A-3-2 Scenario 2: Login Failure - Invalid username/password**

1.  User (student or teacher) opens a web browser
2.  User enters homepage URL
3.  Browser connects to web server
4.  Browser requests homepage from server
5.  Server requests username and password from user
6.  User enters invalid username and password
7.  Server verifies username and password
8.  Server rejects username and password
9.  Server prompts user for reentering username and password
10. User cancels the request
11. Server sends unauthorized error message to browser
12. Browser displays error message on the screen to user
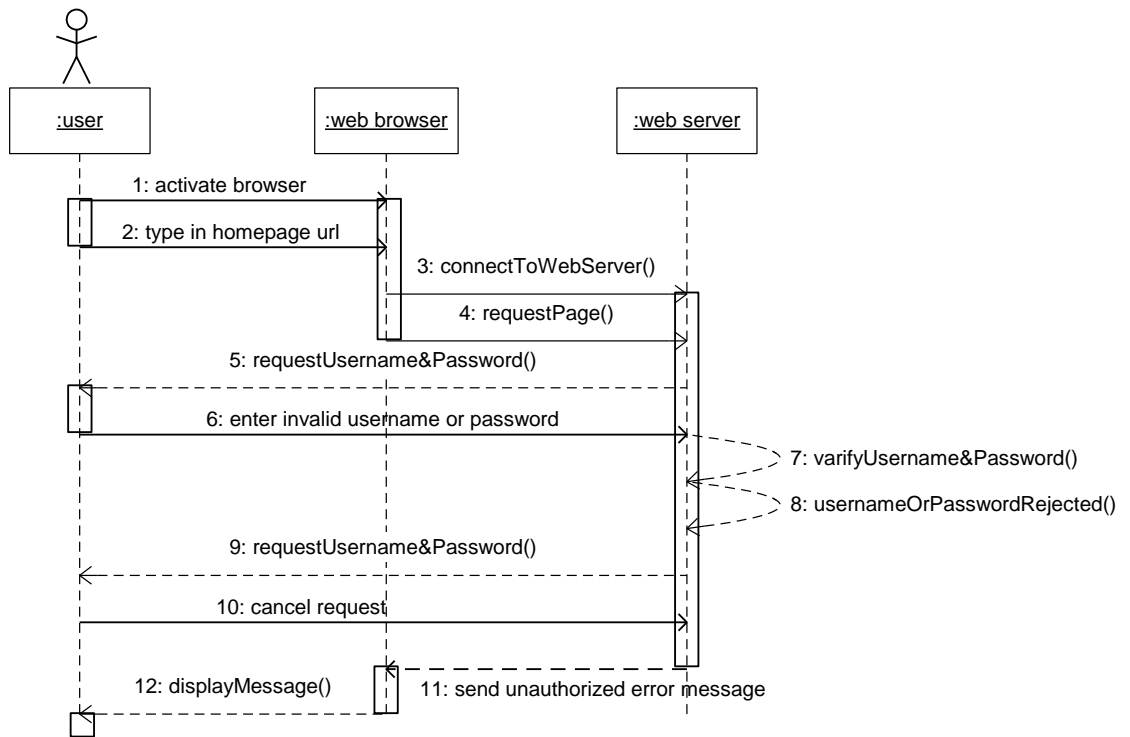
**Figure A-3-2 Login Failure Sequential Diagram**

## A-3-3 Scenario 3: Navigate to other task modules

1. User (student or teacher) selects a task module
2. Browser requests for the selected page from server
3. Server retrieves the page from server database
4. Server database sends the requested page to browser
5. Browser displays the selected page to user
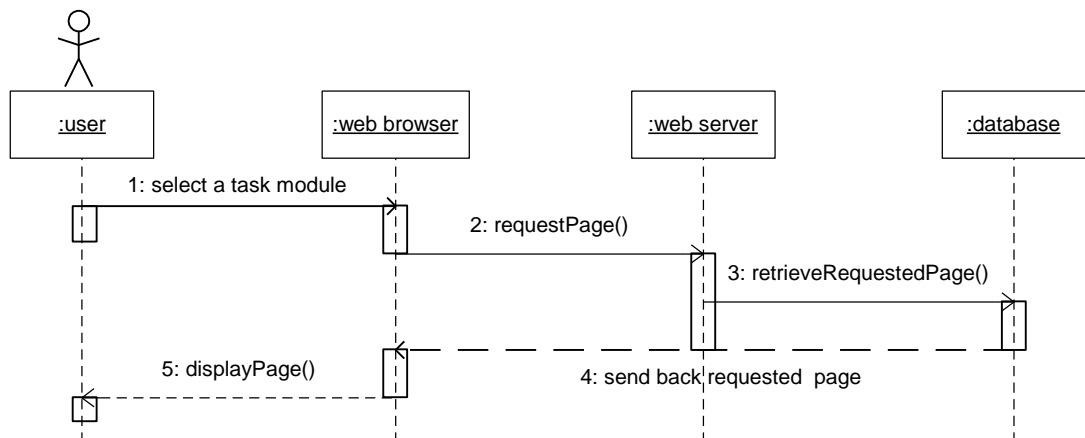


**Figure A-3-3 Navigate to other Task Modules Sequential Diagram**

**A-3-4 Scenario 4: Read/View Jigsaw Tasks**

1. User (student or teacher) clicks on the link to read or view the jigsaw task questions
2. Browser requests for the required document from server
3. Server retrieves requested document from server database
4. Server database sends the requested document to browser
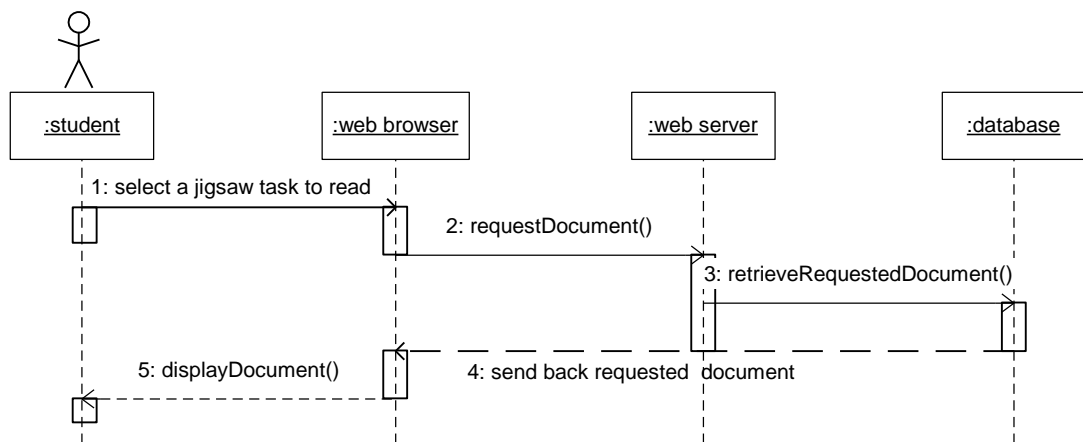5. Browser displays the requested document to user



**Figure A-3-4 Read/View Jigsaw Tasks Sequential Diagram**

**A-3-5 Scenario 5: Compose New Jigsaw Task**

1. Teacher clicks on the create new task link
2. Browser requests question template form from server
3. Server retrieves template form from server database
4. Server database searches for requested template form
5. Template form is sent to browser
6. Browser displays template form to teacher
7. Teacher previews and selects template
8. Teacher set questions
9. Teacher retrieves questions
10. Teacher modifies questions
11. Teacher submits task questions to server database
12. Server database activates the web agent
13. Web agent filters the submitted questions
14. Web agent categorizes the task questions
15. Web agent updates the server database
16. Server database sends confirmation message to browser
17. Browser displays message to teacher
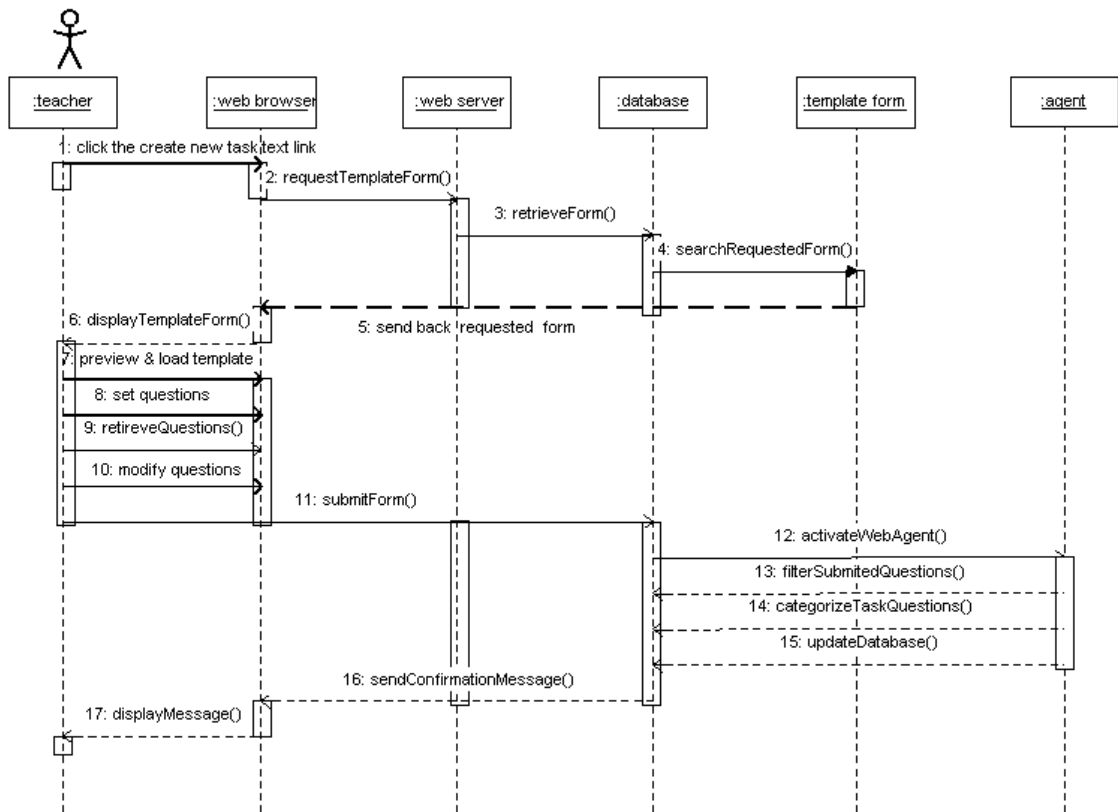
**Figure A-3-5 Compose New Jigsaw Task Sequential Diagram**

## A-3-6 Scenario 6: Preview and Select Templates

1. Teacher browses the template options from browser
2. Browser requests selected template's layout and description from server for teacher to preview
3. Server retrieves the requested information from server database
4. Server database search the requested layout from template forms collection
5. Template form collection sends the template layout and its description to browser
6. Browser displays the layout and description to teacher
7. Teacher selects a template
8. Browser requests the selected template from server
9. Server retrieves the requested template from server database
10. Server database creates new task form
11. Server database embeds the selected template in the newly created form
12. Task form with the requested template is sent to browser
13. Browser displays task form with selected template to teacher
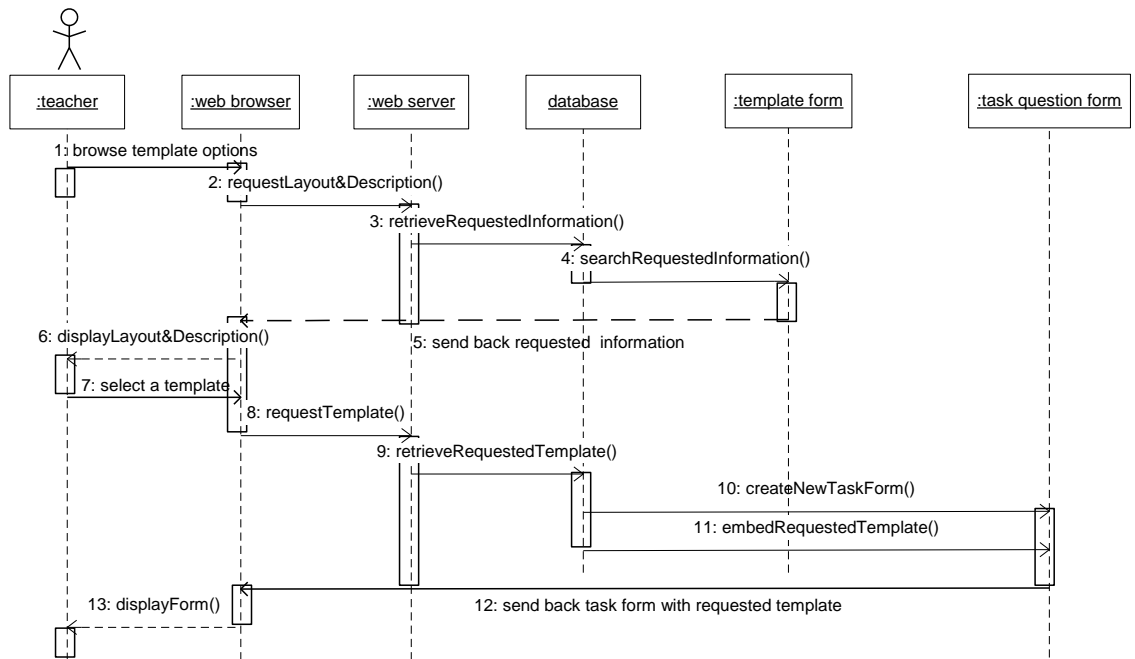
**Figure A-3-6 Preview and Select Templates Sequential Diagram**

### A-3-7 Scenario 7: Retrieve Jigsaw Task Questions

1. Teacher clicks the retrieve button
2. Browser requests questions available for retrieval form server
3. Server activates web agent to retrieve related questions
4. Web agent retrieves available questions from server database
5. Web agent sends a list of all available questions to browser
6. Browser displays a pop up window with a list of questions for retrieval
7. Teacher browses to select questions to be retrieved
8. Teacher retrieves the question.
9. Browser closes the pop up window after the retrieval
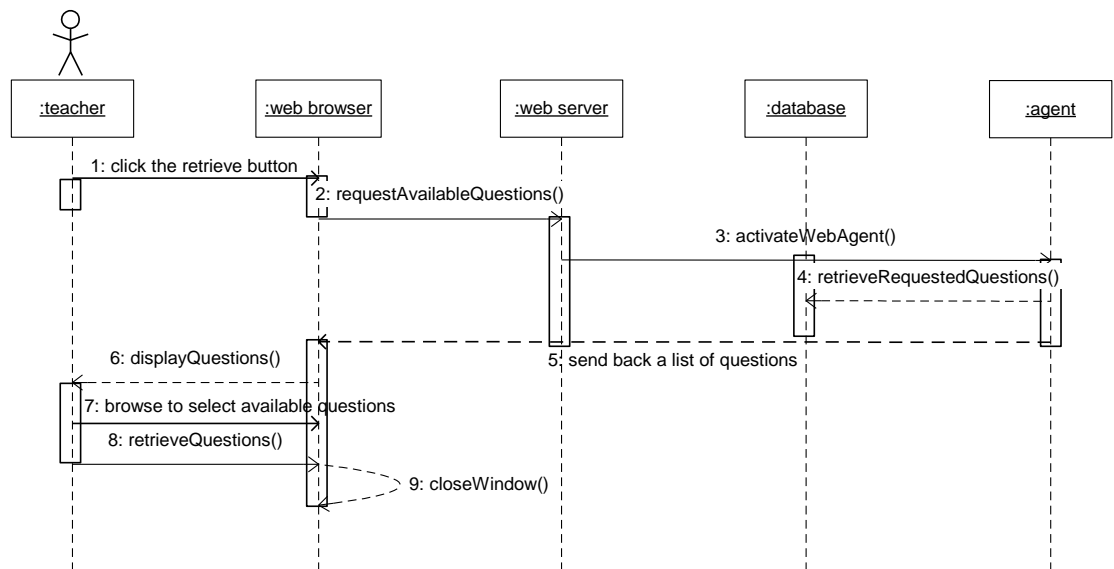


**Figure A-3-7 Retrieve Jigsaw Task Questions Sequential Diagram**

**A-3-8 Scenario 8: Edit Jigsaw Task**

1. Teacher clicks on the jigsaw task to be edited
2. Browser requests for the required document from server
3. Server retrieves requested document from server database
4. Server database sends the requested document to browser
5. Browser displays the requested document to teacher in read mode
6. Teacher clicks on the edit button
7. Browser requests server database to open document in edit mode
8. Server database changes the document to edit mode
9. Teacher edits the jigsaw task in browser
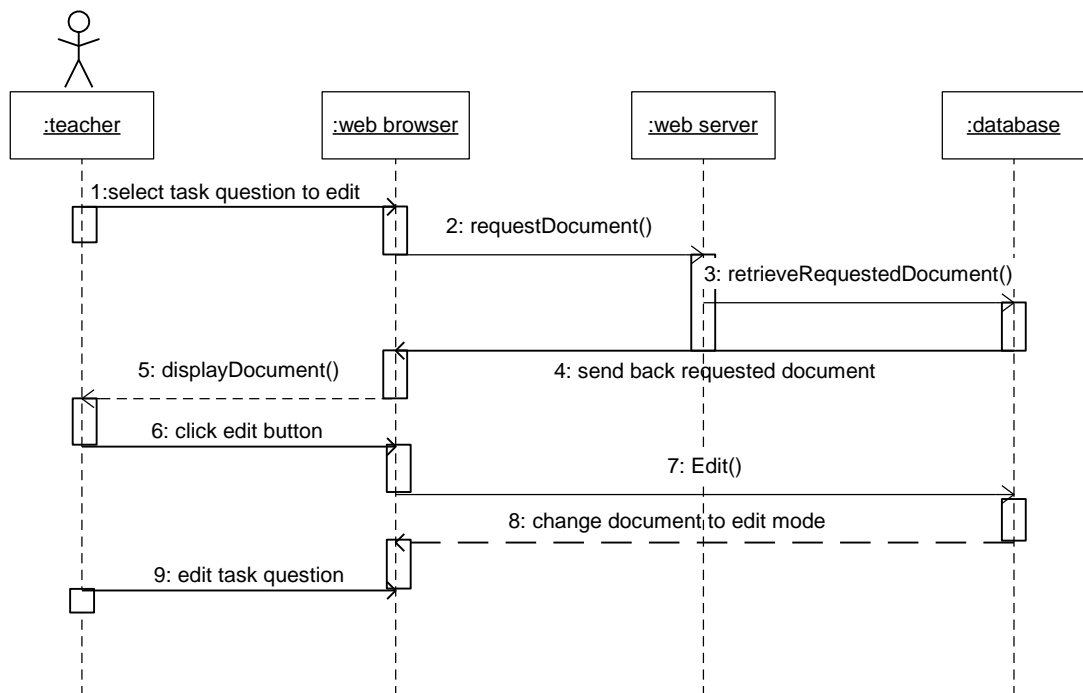


**Figure A-3-8 Edit Jigsaw Task Sequential Diagram**

**A-3-9 Scenario 9: Delete Jigsaw Task**

1. Teacher clicks on the jigsaw task to be deleted
2. Browser requests for the required document from server
3. Server retrieves requested document from server database
4. Server database sends the requested document to browser
5. Browser displays the requested document to teacher in read mode
6. Teacher clicks on the delete button
7. Browser requests server database to delete the document
8. Server database deletes the document
9. Server database sends deleted message to browser
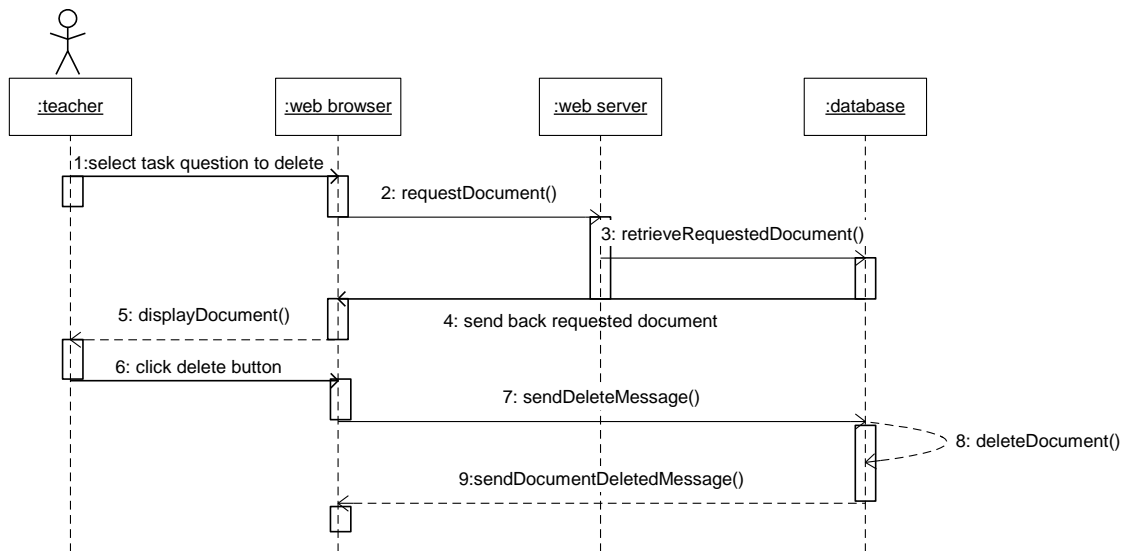
**Figure A-3-9 Delete Jigsaw Task Sequential Diagram**

### A-3-10 Scenario 10: Submit Jigsaw Task

1. Teacher clicks the submit button
2. Browser sends submitted information to server
3. Server saves the information in server database
4. Server database returns confirmation message to browser
5. Browser displays confirmation message to teacher
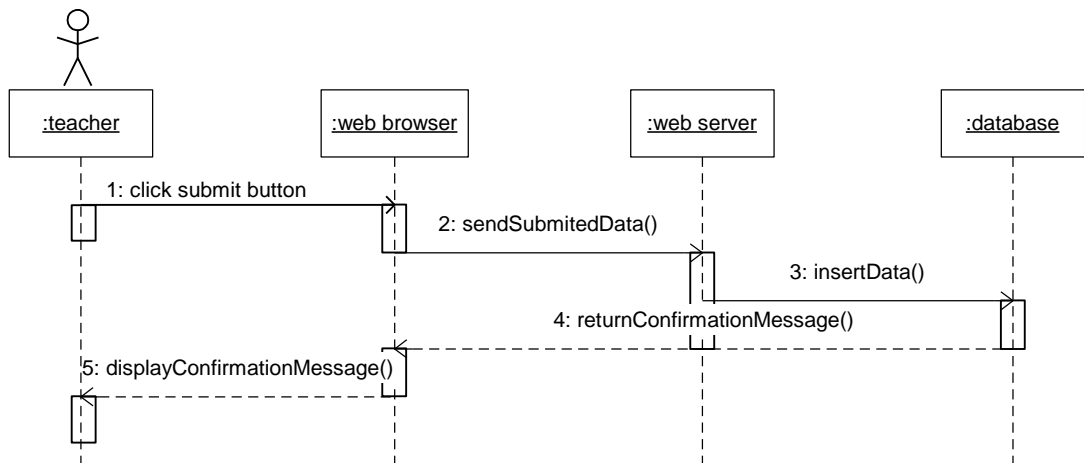


**Figure A-3-10 Submit Jigsaw Task Sequential Diagram**

## A-3-11 Scenario 11: Set Profile

1. Student selects group and task question
2. Student clicks the continue button
3. Browser sends student profile to server
4. Server activates web agent (profile agent)
5. Web agent creates a profile document
6. Web agent saves the profile document in server database



**Figure A-3-11 Set Profile Sequential Diagram**
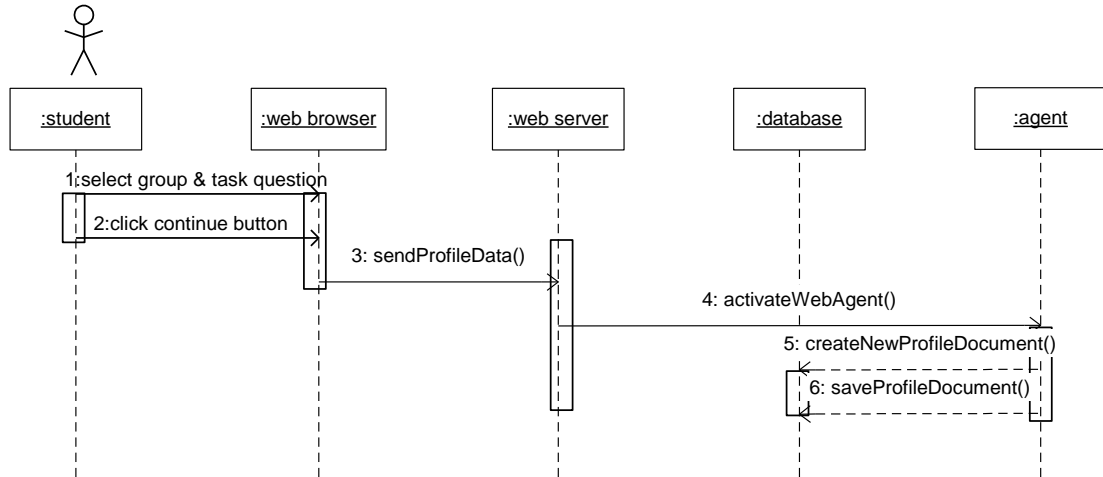
## A-3-12 Scenario 12: Compose Response

1. Student clicks the Post Response button
2. Browser requests the response form
3. Server retrieves the requested form from server database
4. Server database searches for the requested form
5. Response form is sent to the browser
6. Browser displays response form to the student
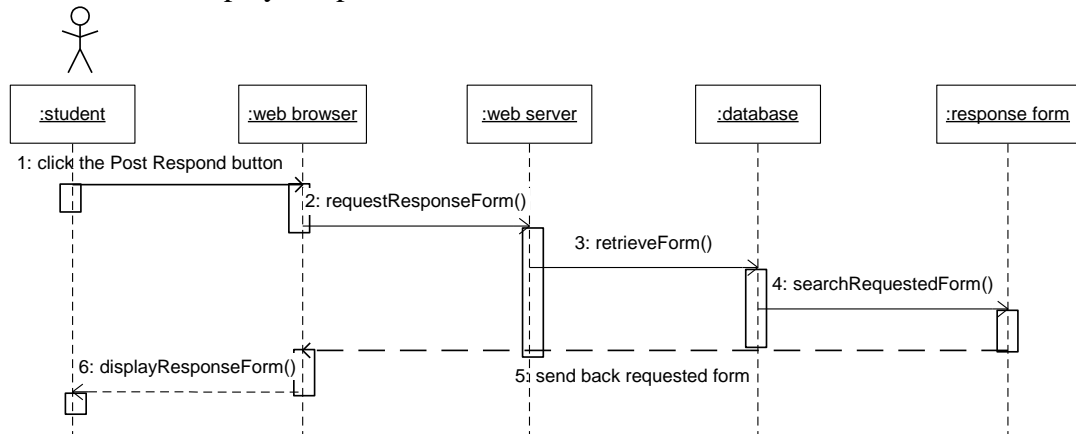


**Figure A-3-12 Compose Response Sequential Diagram**

## A-3-13 Scenario 13: Submit Response

1. Student clicks the post button
2. Browser sends submitted information to server
3. Server saves the information in server database
4. Server database returns confirmation message to browser
5. Browser displays confirmation message to student
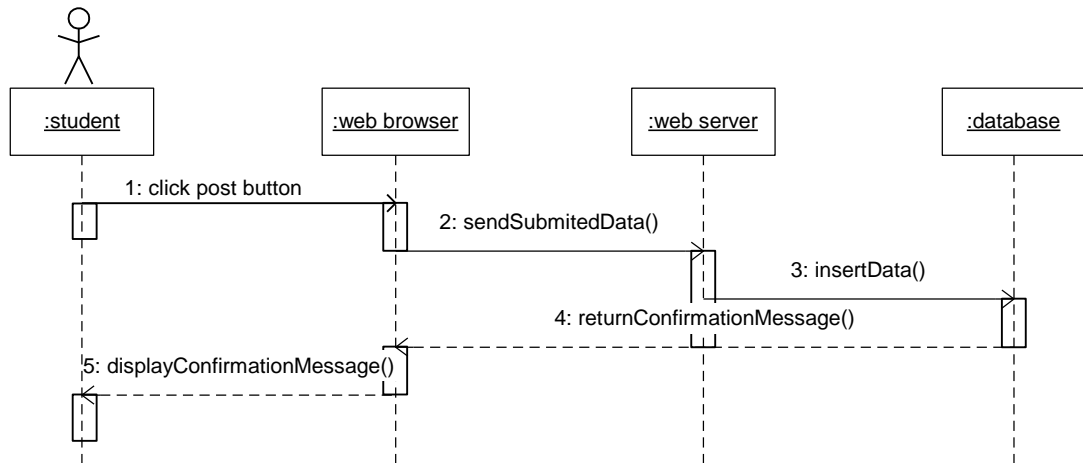


**Figure A-3-13 Submit Response Sequential Diagram**

## A-3-14 Scenario 14: Read/View Responses

1. Student clicks on the link to read or view the responses
2. Browser requests for the required document from server
3. Server retrieves requested document from server database
4. Server database sends the requested document to browser
5. Browser displays the requested document to student
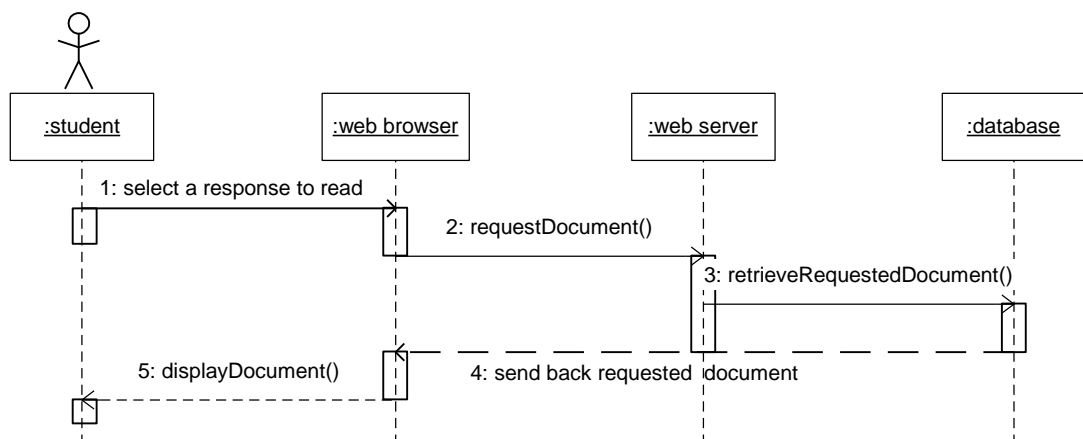


**Figure A-3-14 Read/View Responses Sequential Diagram**

**A-3-15 Scenario 15: Compose Summary**

1. Student clicks the summary button
2. Browser requests for the summary form
3. Server retrieves the requested form from server database
4. Server database searches for the requested form
5. Summary form is sent to the browser
6. Browser displays summary form to the student
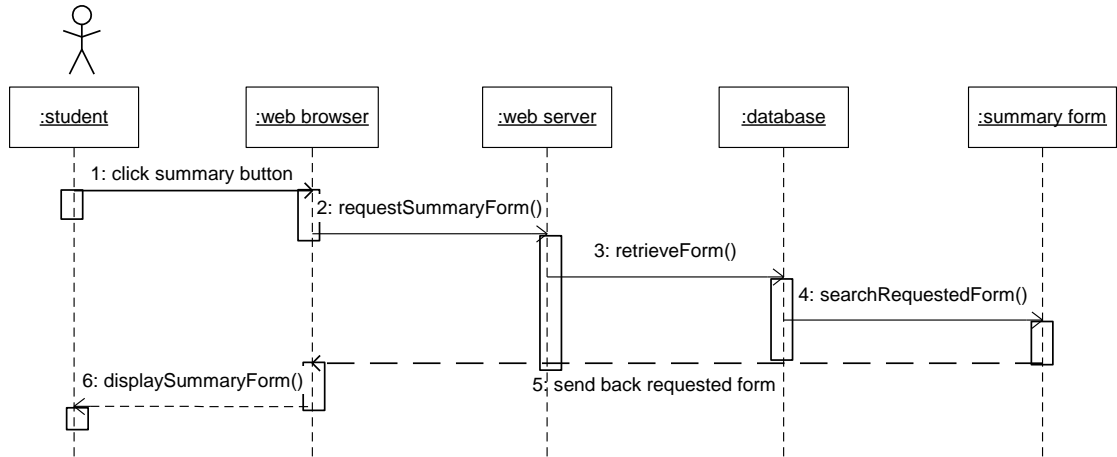


**Figure A-3-15 Compose Summary Sequential Diagram**

**A-3-16 Scenario 16: Retrieve Responses**

1. Student selects the author of the response in a dropdown list
2. Browser requests a search on server
3. Server runs a search in server database based on the keyword received
4. Server database returns the search results to browser
5. Browser extracts the data sent by server and set the data in the form's field
6. Browsers display the retrieved data for student
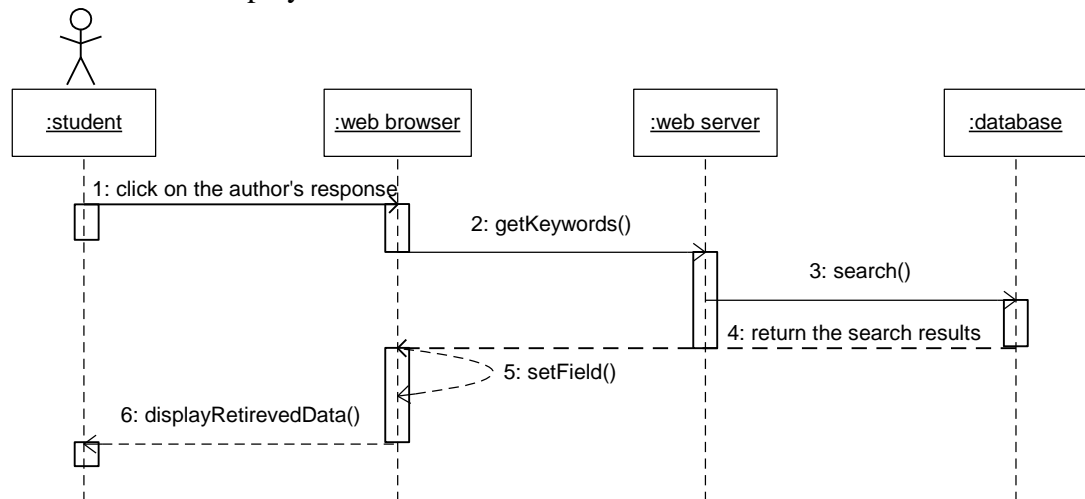


**Figure A-3-16 Retrieve Responses Sequential Diagram**

## A-3-17 Scenario 17: Submit Summary

1. Student clicks the post button
2. Browser sends submitted information to server
3. Server saves the information in server database
4. Server database returns confirmation message to browser
5. Browser displays confirmation message to student
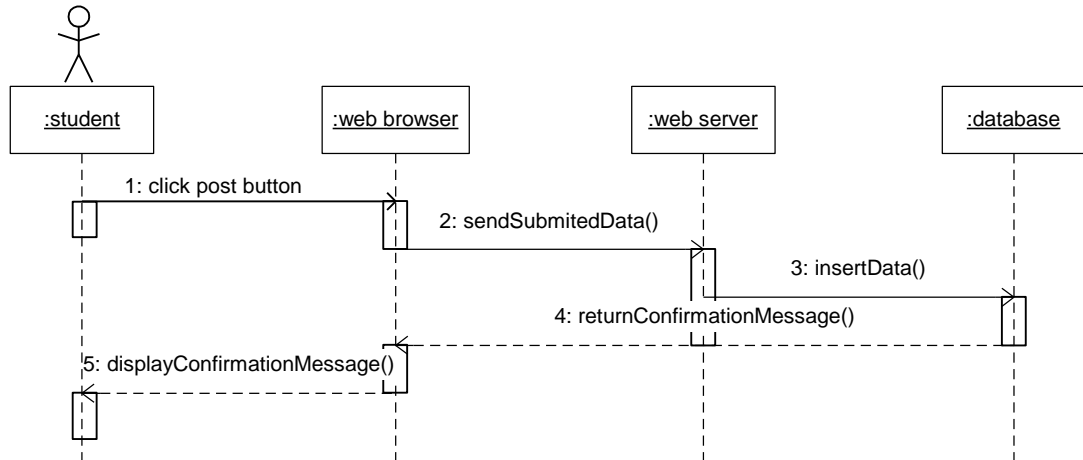


**Figure A-3-17 Submit Summary Sequential Diagram**

## A-3-18 Scenario 18: Read/View Summaries

1. Student clicks on the link to read or view the summaries
2. Browser requests for the required document from server
3. Server retrieves requested document from server database
4. Server database sends the requested document to browser
5. Browser displays the requested document to user
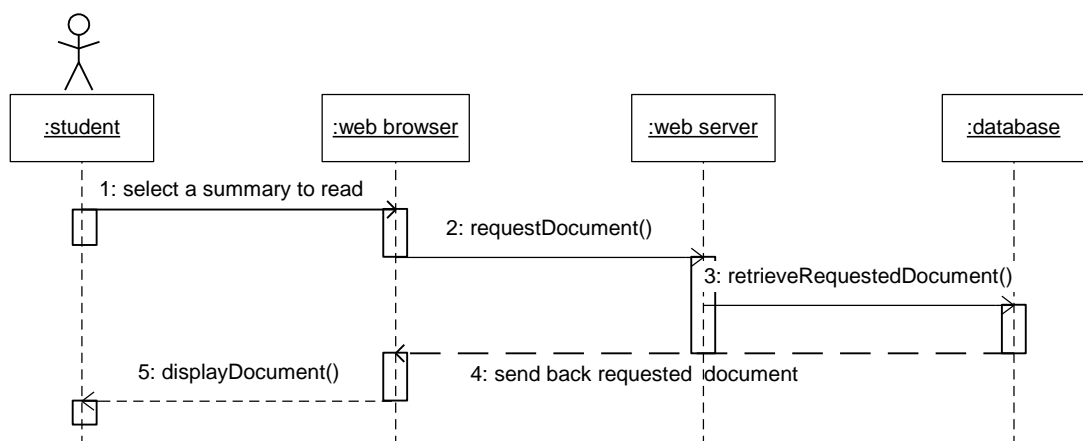


**Figure A-3-18 Read/View Summaries Sequential Diagram**

## A-3-19 Scenario 19: Respond to Summaries

1. Student types in the comments/feedback
2. Student clicks the response button
3. Browser sends the information to server
4. Server updates the document in server database
5. Server database returns the updated document to browser
6. Browser displays the summary with updated response for student
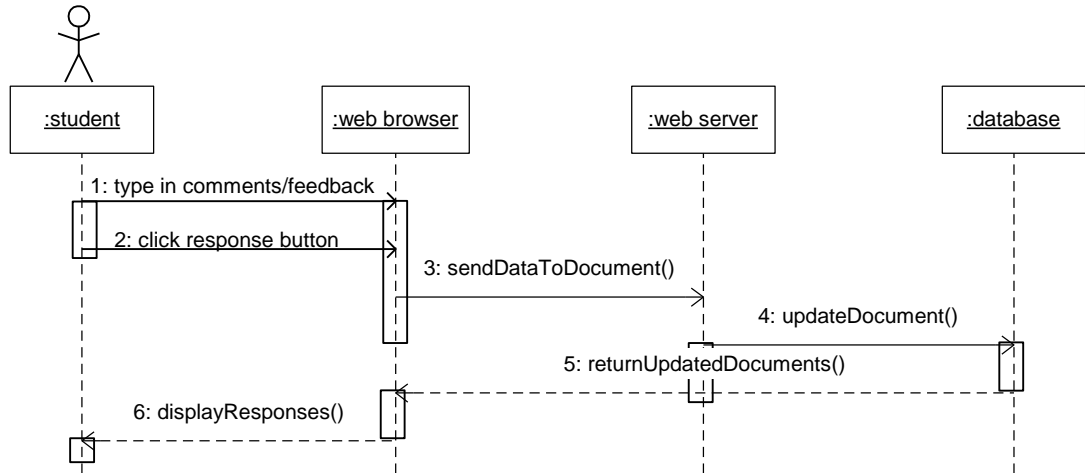


**Figure A-3-19 Respond to Summaries Sequential Diagram**

## A-3-20 Scenario 20: Compose Report

1. Student clicks the create report button
2. Browser requests for the report form
3. Server retrieves the requested form from server database
4. Server database searches for the requested form
5. Report form is sent to the browser
6. Browser displays report form to the student
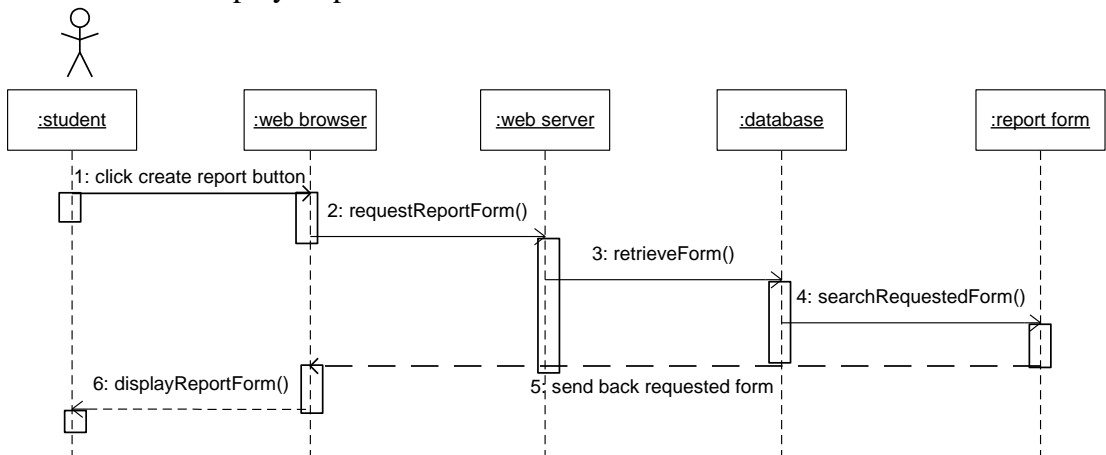


**Figure A-3-20 Compose Report Sequential Diagram**

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**A-3-21 Scenario 21: Retrieve Summary**

1. Student clicks the copy button
2. Browser a requests a search on server
3. Server runs a search in server database based on the student's profile
4. Server database returns the search document to browser
5. Browser extracts the data sent by server and set the data in the form's field
6. Browsers display the retrieved data for student
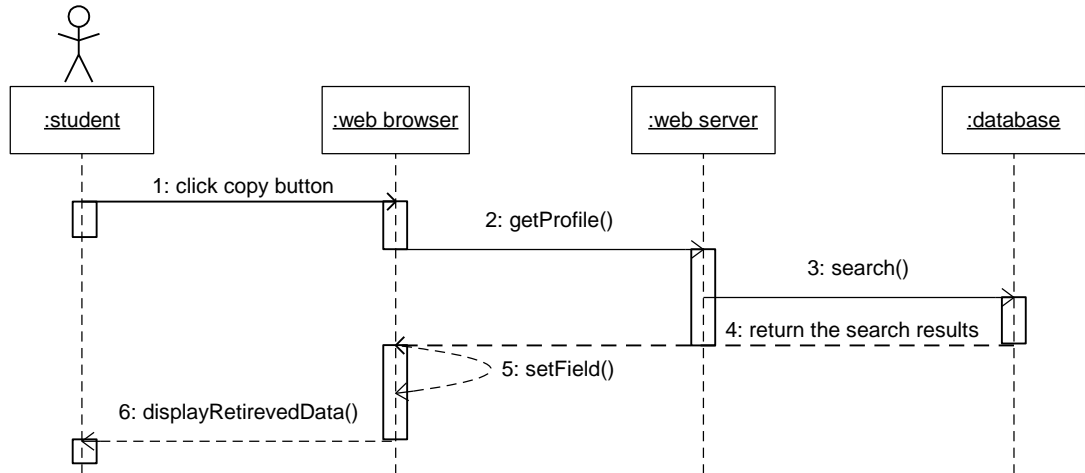


**Figure A-3-21 Retrieve Summary Sequential Diagram**

**A-3-22 Scenario 22: Submit Report**

1. Student clicks the post button
2. Browser sends submitted information to server
3. Server saves the information in server database
4. Server database returns confirmation message to browser
5. Browser displays confirmation message to student
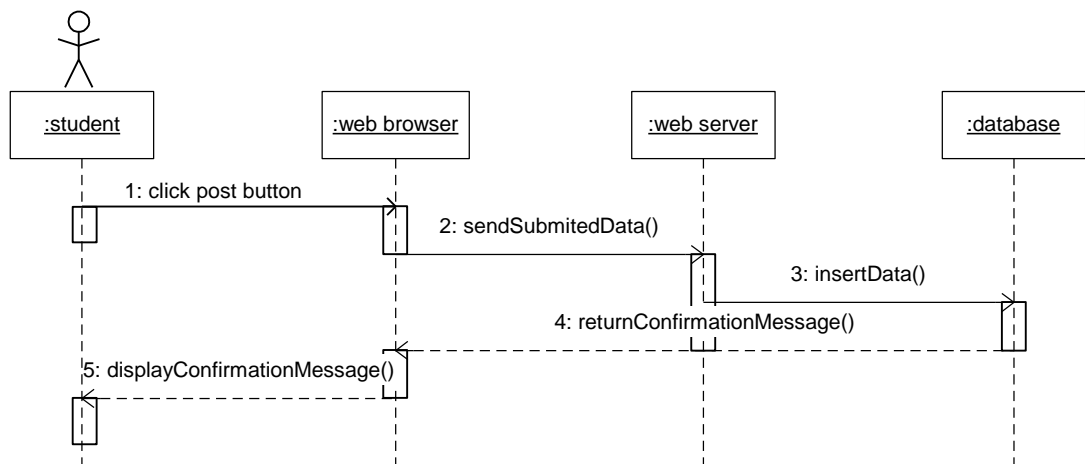


**Figure A-3-22 Submit Report Sequential Diagram**

### A-3-23 Scenario 23: Read/View Reports

1. Student clicks on the link to read or view the reports
2. Browser requests for the required document from server
3. Server retrieves requested document from server database
4. Server database sends the requested document to browser
5. Browser displays the requested document to student
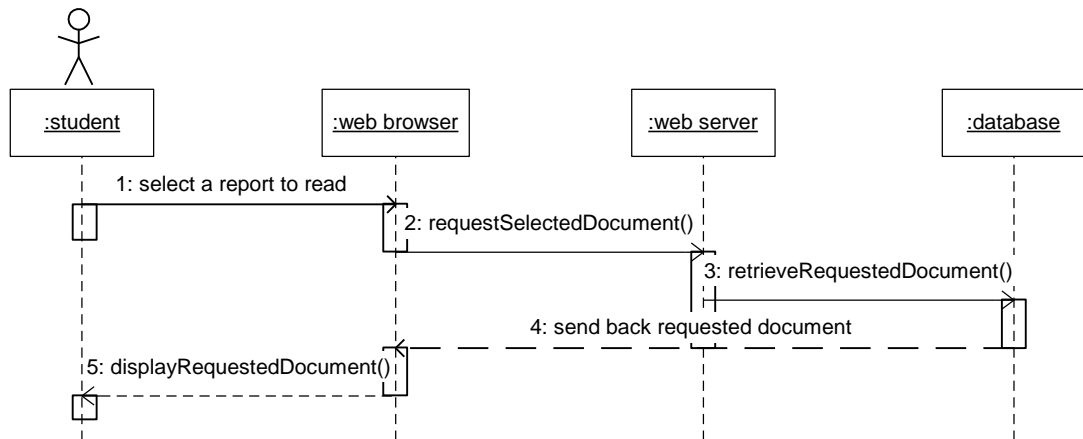


**Figure A-3-23 Read/View Reports Sequential Diagram**

### A-3-24 Scenario 24: Edit Report

1. Student clicks on the report to be edited
2. Browser requests for the required document from server
3. Server retrieves requested document from server database
4. Server database sends the requested document to browser
5. Browser displays the requested document to student in read mode
6. Student clicks on the edit button
7. Browser requests server database to open document in edit mode
8. Server database changes the document to edit mode
9. Student edits the jigsaw task in browser
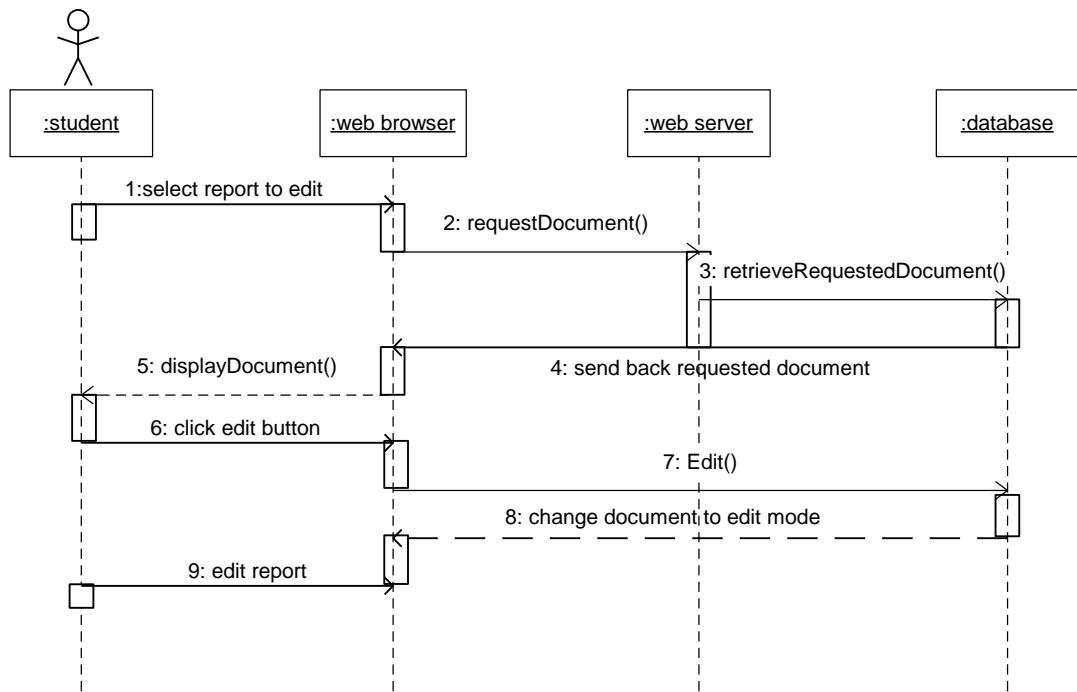
**Figure A-3-24 Edit Report Sequential Diagram**

## A-3-25 Scenario 25: Delete Report

1. Student clicks on the report to be deleted
2. Browser requests for the required document from server
3. Server retrieves requested document from server database
4. Server database sends the requested document to browser
5. Browser displays the requested document to student in read mode
6. Teacher clicks on the delete button
7. Browser requests server database to delete the document
8. Server database deletes the document
9. Server database sends deleted message to browser
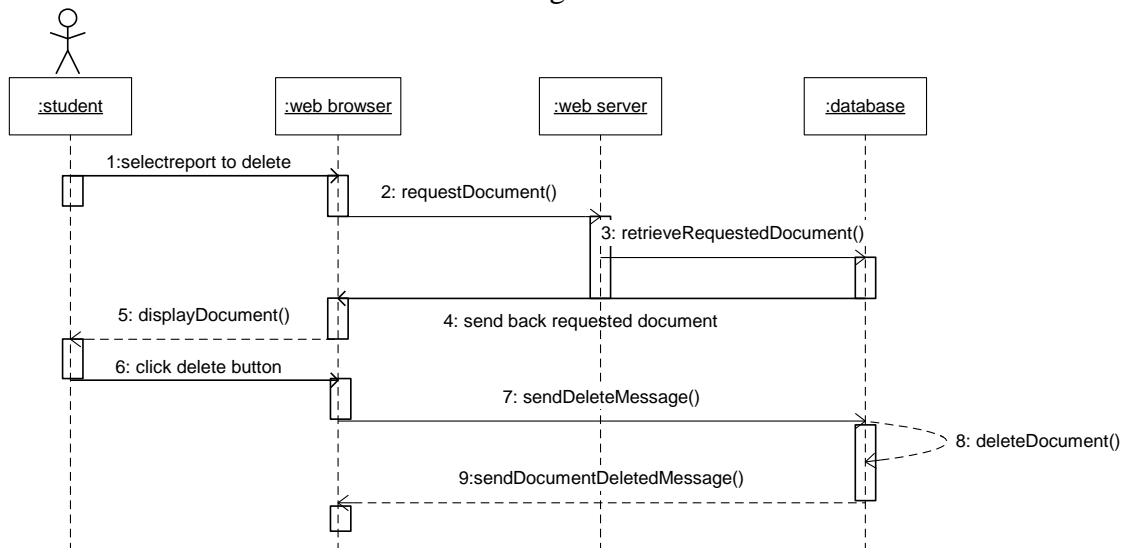


**Figure A-3-25 Delete Report Sequential Diagram**

## A-3-26 Scenario 26: Integrate Reports

1. Student clicks the integrate reports button
2. Browser requests for report integration from server
3. Server activates web agent (integration agent)
4. Web agent integrates all related reports in server database
5. Server database sends integrated report to browser
6. Browser displays the integrated report to student
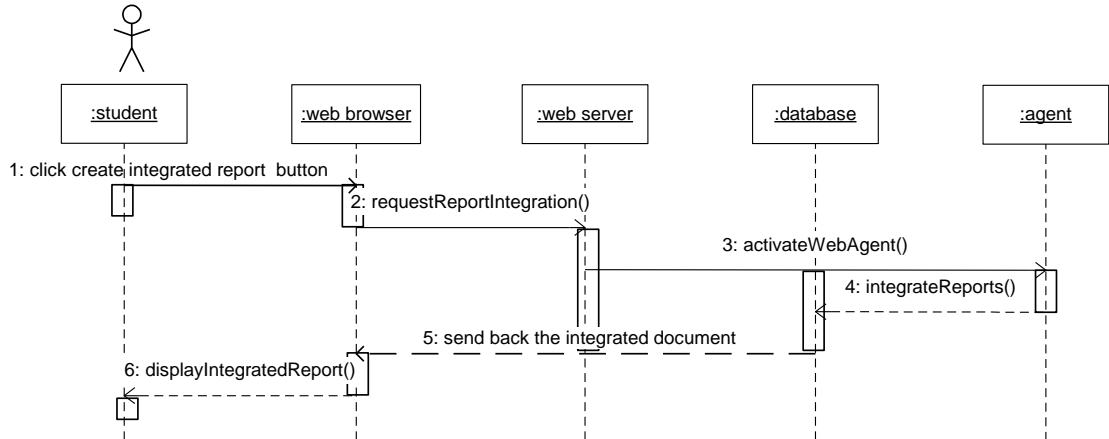


**Figure A-3-26 Integrate Reports Sequential Diagram**

## A-3-27 Scenario 27: Switch Group

1. Student places the cursor over the Switch Group link
2. Browser displays a dropdown list with available groups to student
3. Student selects and clicks on the group to be switched
4. Browser requests the page from server
5. Server retrieves the page from server database
6. Server database sends the requested page to browser
7. Browser displays the selected page to student
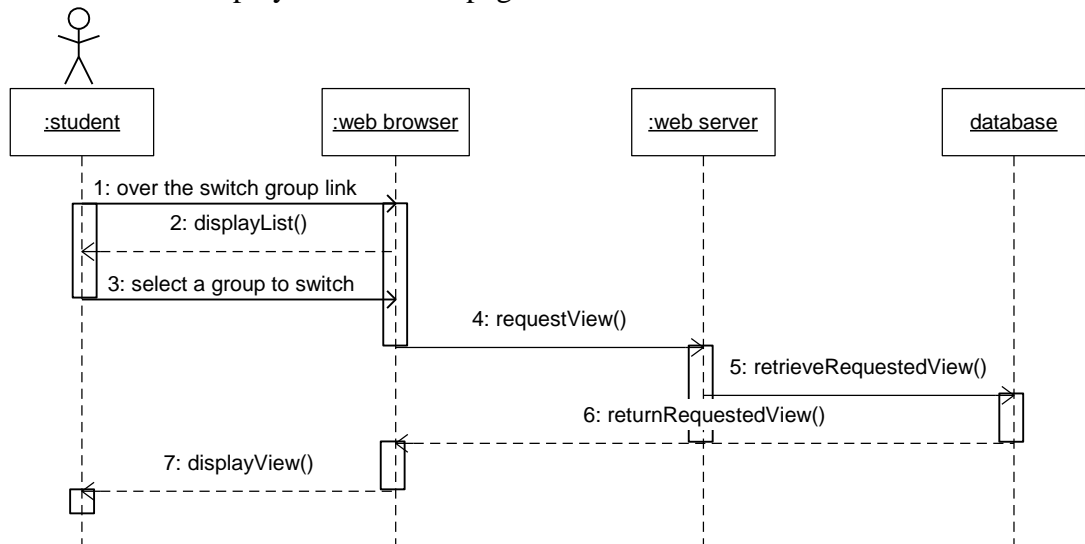


**Figure A-3-27 Switch Group Sequential Diagram**

# A-4 G-Jigsaw Activities Diagrams

This section depicts the jigsaw processes using the Activity Diagram. There are 7 Activity Diagrams for illustrating each level of jigsaw activity's processes.

## A-4-1 Create New Jigsaw Task
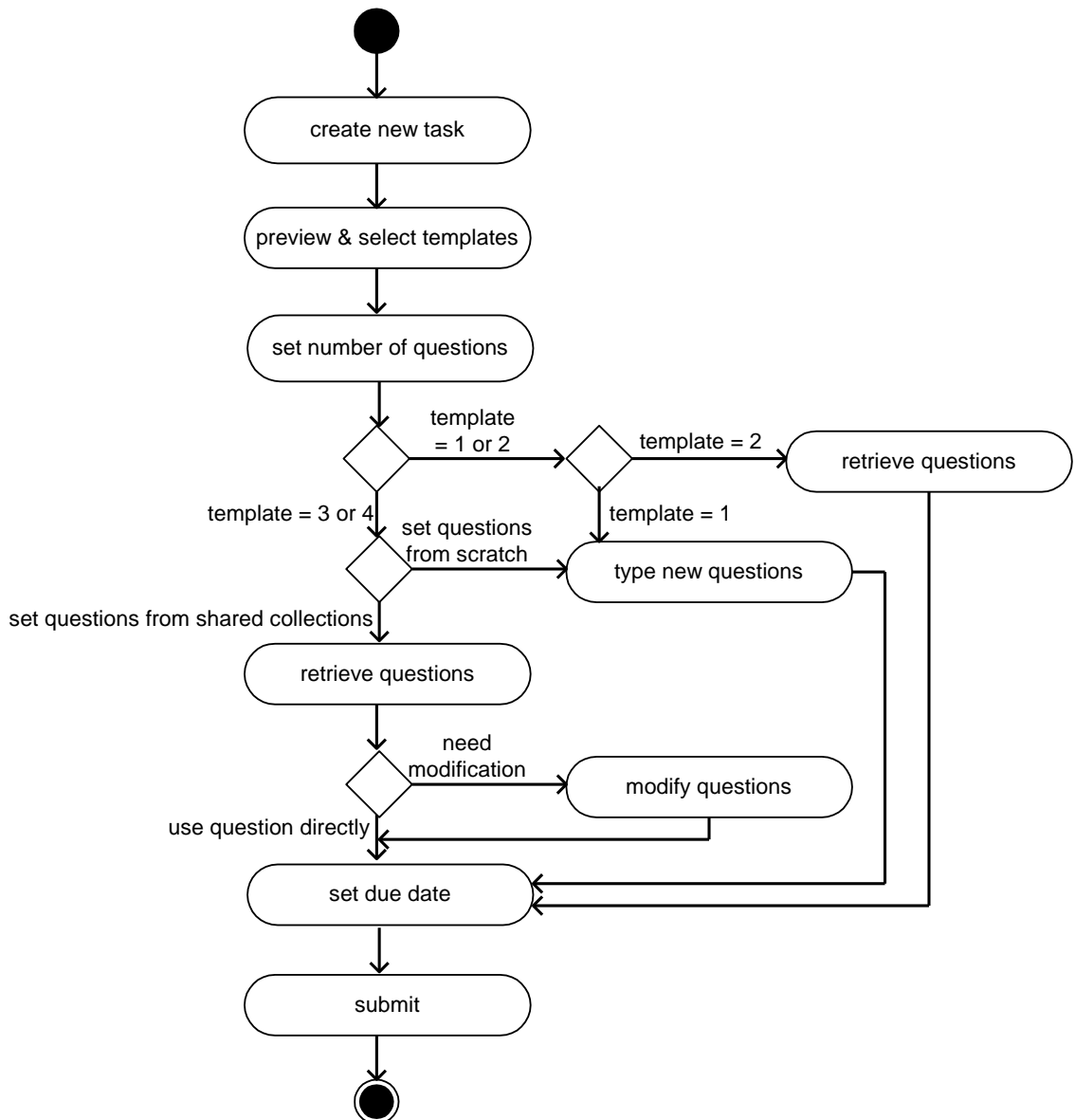


**Figure A-4-1 Create New Jigsaw Task Activity Diagram**

**A-4-2 Read and/or Edit Jigsaw Task**
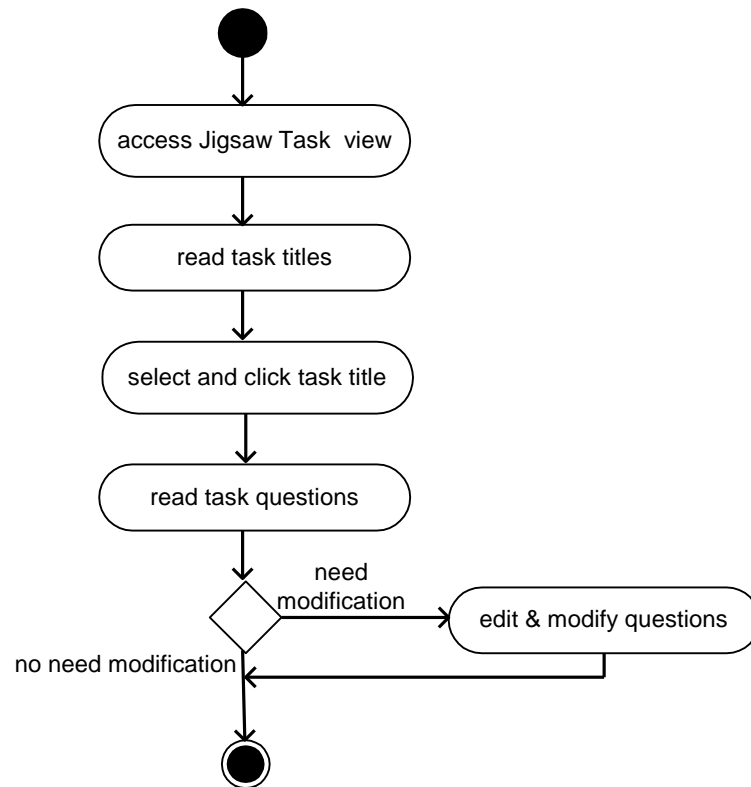


**Figure A-4-2 Read and/or Edit Jigsaw Task Activity Diagram**

**A-4-3 Respond to Group Members in Initial Group**
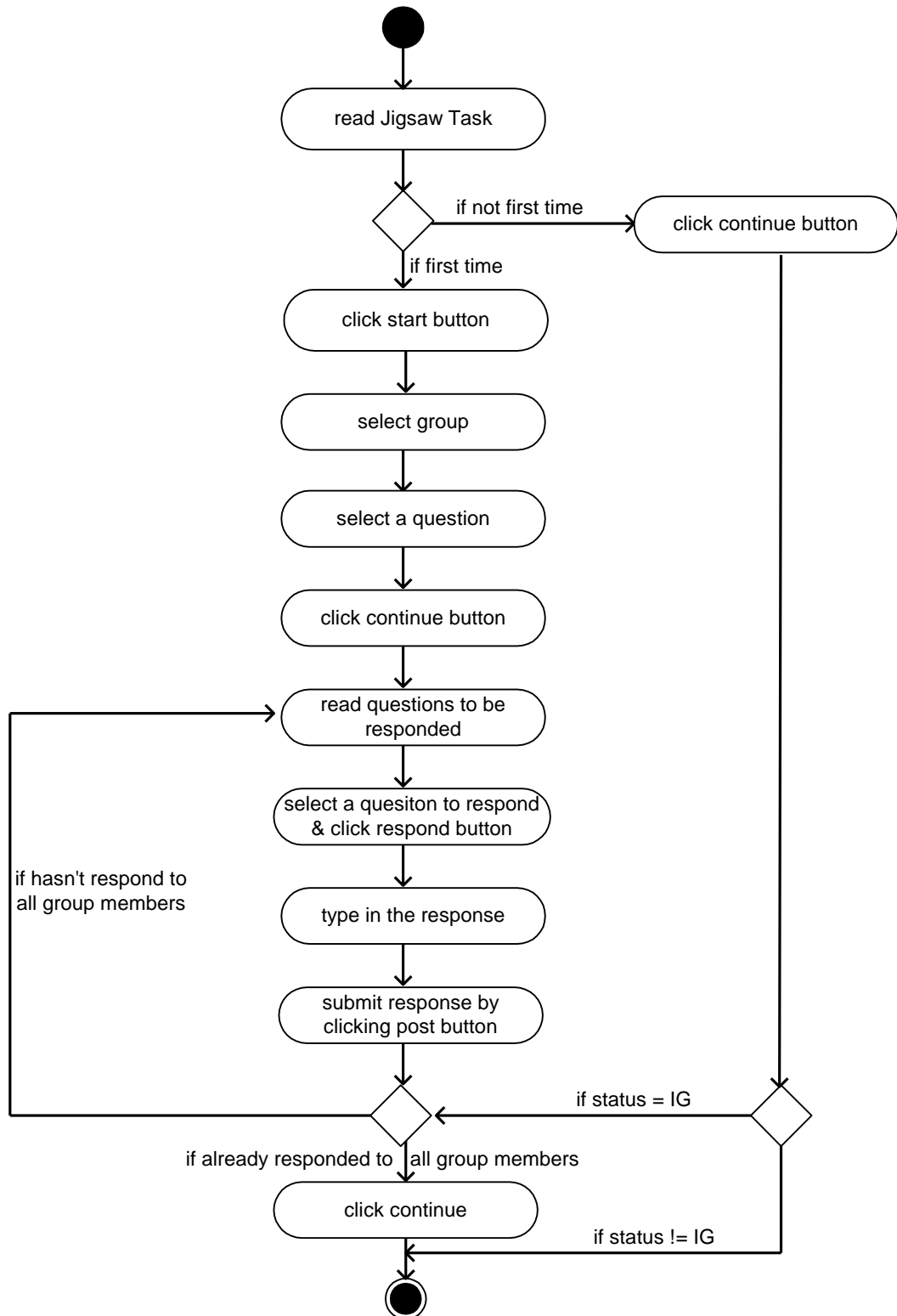


**Figure A-4-3 Respond to Group Members Activity Diagram**

**A-4-4 Compose Summary in Initial Group**
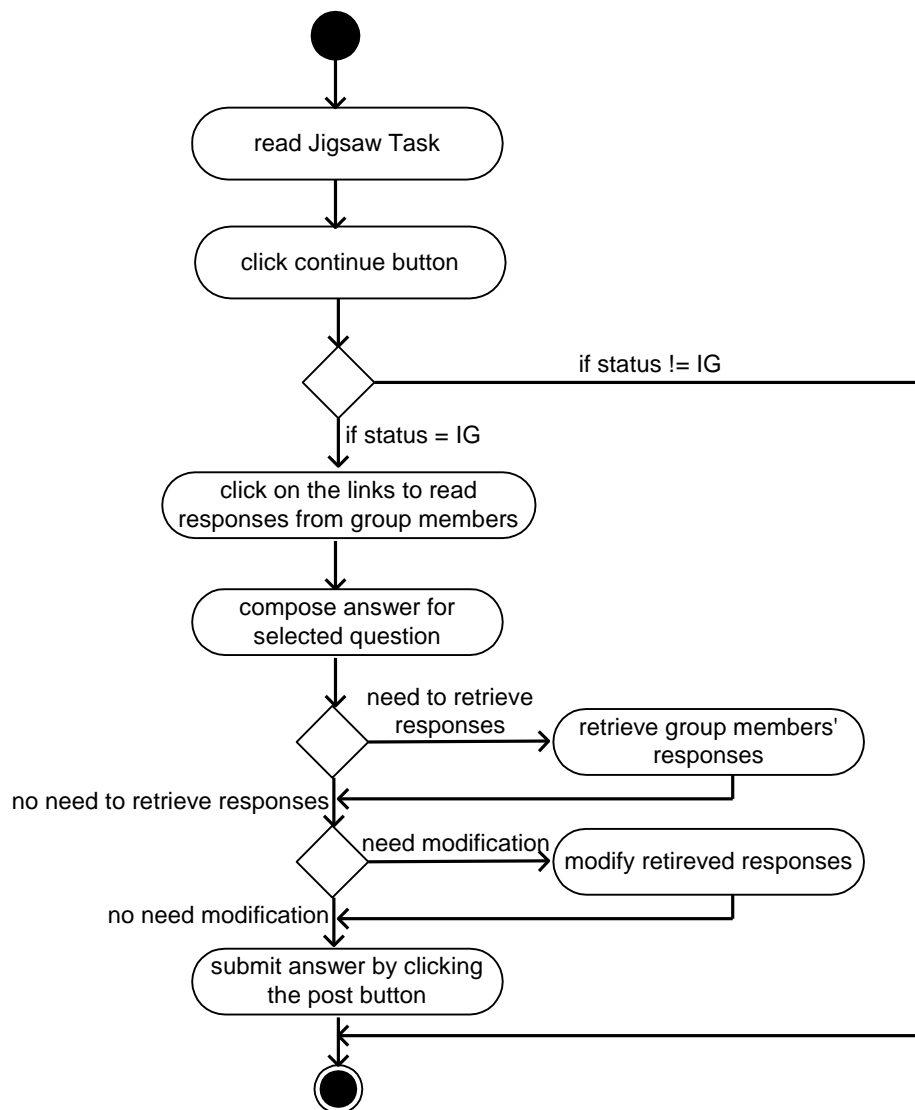


**Figure A-4-4 Compose Summary Activity Diagram**

**A-4-5 Provide Comments and Compose Report in Expert Group**
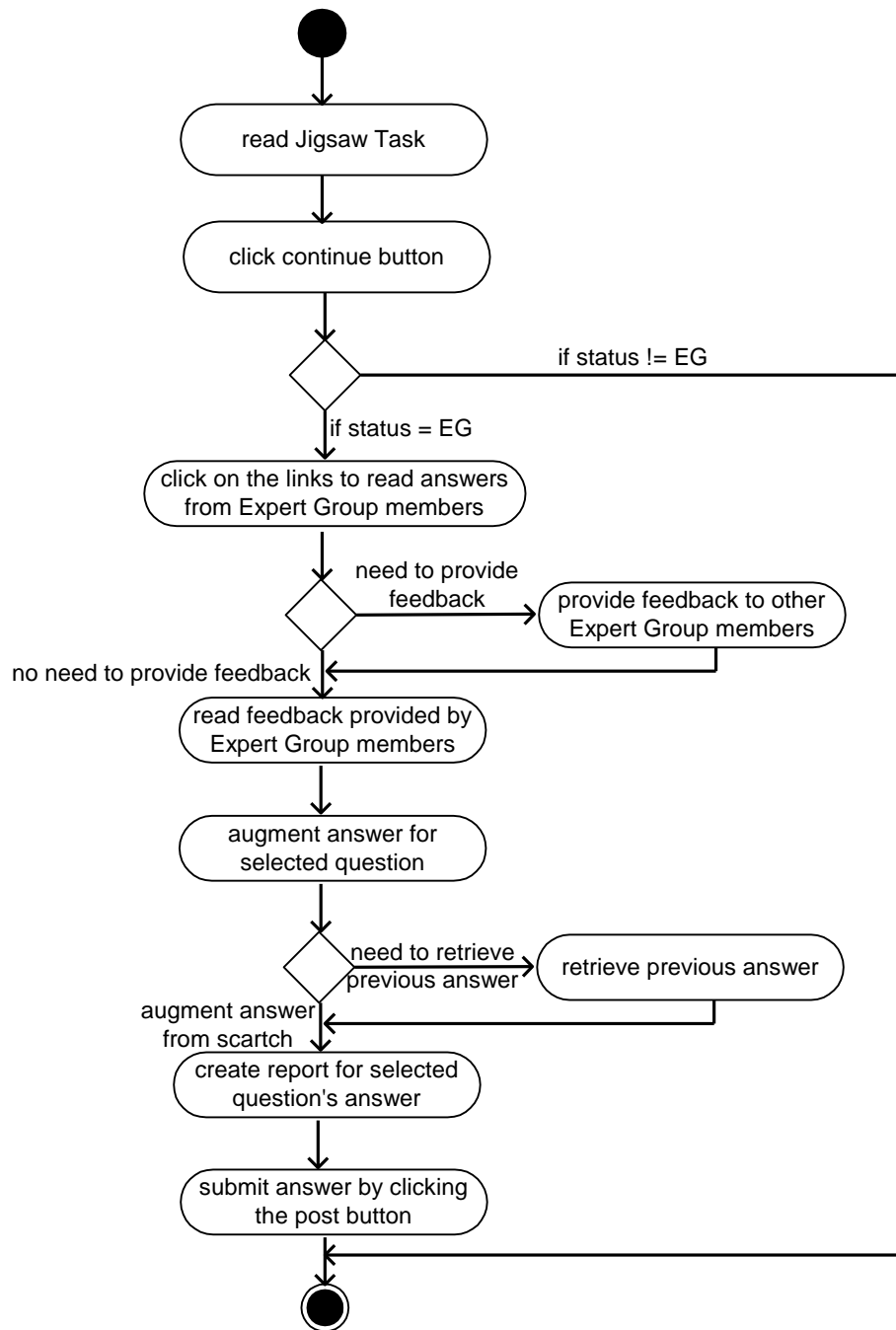


**Figure A-4-5 Provide Comments and Compose Report Activity Diagram**

**A-4-6 Read, Edit and Integrate Group Reports in Jigsaw Group**
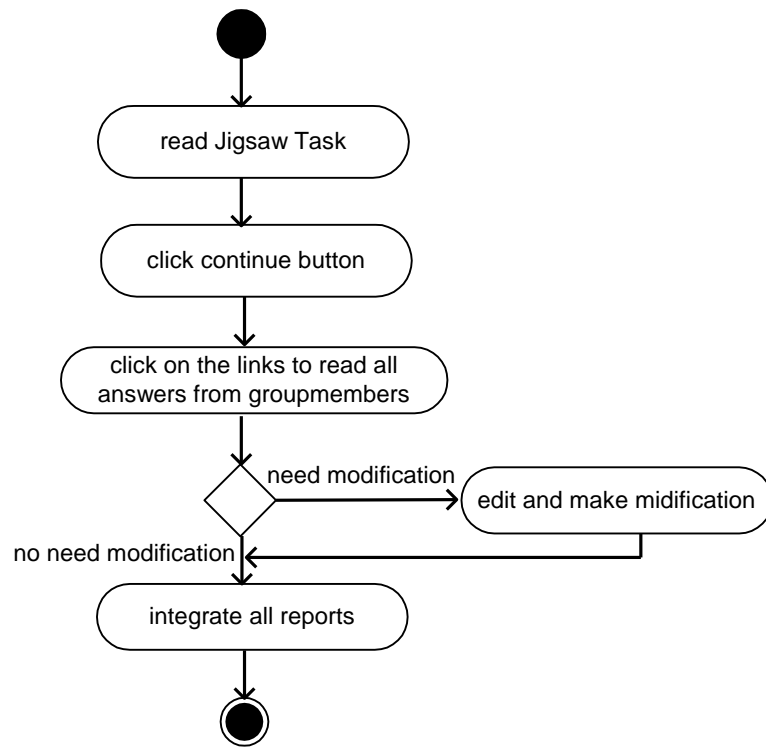


**Figure A-4-6 Read, Edit and Integrate Group Reports Activity Diagram**

**A-4-7 The Entire Session of Jigsaw Activity**
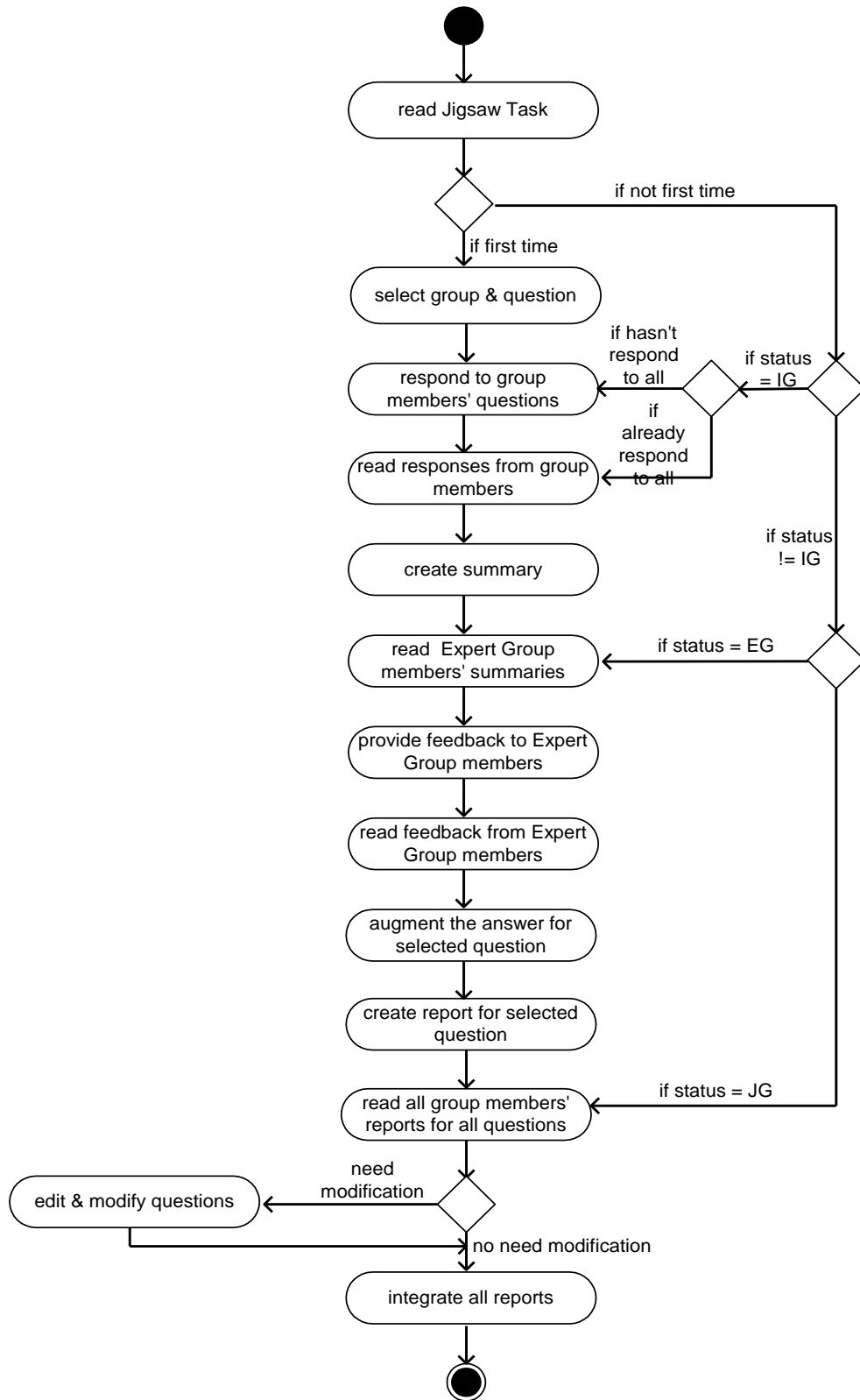


**Figure A-4-7 The Entire Jigsaw Session Activity Diagram**

# Appendix B: G-Jigsaw Evaluation Task Scenarios

## B-1 Pilot Test Task Scenarios

*Instructions: Follow the test scenario instructions for each module. Upon completion, please fill up the questionnaire provided. Thank you for your participation.*

**Section A:**

**I. Test Scenario For Jigsaw Task module (without agent)**

Activity 1: Setting a new jigsaw task

1. Open the Internet Explorer browser in your Desktop.
2. On the Browser's Address bar, type in the following URL and press enter.
   http://202.185.109.65/Hybrid/GTSimulate.nsf/
3. When the dialog box prompt for username and password, fill in the correct username and password and click ok.
4. Now, you are at the Group Task Simulation's homepage.
5. Click on the Tasks button to proceed.
6. Now, you are able to view the list of Simulation Tasks and the Quick Help. Click on the New Simulation Task text link at the 3$^{rd}$ bullet of Quick Help to create a new task for your students.
7. Set your question by following the instructions displayed in Quick Help.
8. Upon completion, click the submit button.
9. Click OK to go back to Simulation Task View.

Activity 2: Responding to all group members

1. From the Simulation Task View, select the Simulation Task title and click on its link.
2. Read the task questions carefully.
3. Click the Response button (which is at the bottom-right of the page) to start responding to your group members' questions.
4. Select the question to be responded and fill in your group. (You must remember questions that you must respond, questions to be responded, and questions that already responded in order to participate this task. You also need to understand the concept of Jigsaw method in order to know how and which to respond.)
5. Type your response in the text area.
6. Upon completion, click the Post button.
7. Click Continue to response to other questions. (Repeat steps 3 to 6)
8. Upon completion, click the OK button.

Activity 3: Composing a summary

1. When you have responded to all your group members, click on the Simulation Group button.
2. Move your mouse's cursor over to "Switch SubQuestion". Then, a dropdown menu will appear.
3. Select your own question by clicking on the dropdown menu item. (you have to remember your own question.)
4. Now, you should be able to see your group members and their responses. (Responses of other group member are there too.)
5. Click on your group members' name to view their responses.
6. After reading the response, use the browser's back button to view other members' responses and repeat steps 5 and 6.
7. When you have finished reading all your group members' responses, click on the Summary button to compose a summary.
8. Type your summary in the provided text area.
9. Upon completion, click the Post button.
10. Click the OK button to proceed to Expert Group.

Activity 4: Composing a report

1. Move your mouse's cursor over to "Switch SubQuestion". Then, a dropdown menu will appear.
2. Select your own question by clicking on the dropdown menu item. (you have to remember your own question)
3. Now, you should be able to see your own summary and your group members' summary.
4. Click on your group member's name to view their summary.
5. Type in your comments and feedback. Upon completion, click the "Response" button.
6. After reading the summary, use the browser's back button to view other members' summary and repeat steps 5 and 6.
7. When you have finished reading all your group members' summary, click on the 'Create Report' button to compose a report.
8. Type your report in the provided text area.
9. Upon completion, click the Post button.
10. Click the OK button to proceed to Jigsaw Group.

Activity 5: Integrating a group report

1. Move your mouse's cursor over to "Switch Group". Then, a dropdown menu will appear.
2. Select your own group by clicking on the dropdown menu item. (You have to remember your own group)
3. Now, you should be able to see your group members' report.
4. To integrate all reports, you must be the group leader.
5. Click on one of the reports and click the 'Integrate Reports' button. Then, an integrated report form is opened.
6. Copy each of your group members' report into the integrated report form one by one.
7. Upon completion, click the Post button.
8. Click on the integrated report to view the final outcome.

## II. Test Scenario For Jigsaw Task module (with agent)

Activity 1: Setting a new jigsaw task

1. Open the Internet Explorer browser in your Desktop.
2. On the Browser's Address bar, type in the following URL and press enter.
   http://202.185.109.65/Hybrid/GJigsaw.nsf/GJigsawHome?OpenPage
3. When the dialog box prompt for username and password, fill in the correct username and password and click ok.
4. Now you are at the G-Jigsaw's homepage.
5. Click on the Jigsaw Task button to proceed.
6. Now, you are able to view the list of Jigsaw Tasks and the Quick Help. Click on the New Jigsaw Task text link at the 3$^{rd}$ bullet of Quick help to create a new task for your students.
7. There are four template options available to set a task question.


Using Template 2:

1. Select Template 2 and view its template description. Then, click the Enter button.
2. Set your questions by following the instructions displayed in Quick Help.
3. Upon completion, click the submit button.
4. Click OK to go back to Jigsaw Task View.

Using Template 3 or 4

1. Click on the New Jigsaw Task text link at the 3$^{rd}$ bullet of Quick help to create a new task for your students.
2. Select template 4 and view its description. Then, click the Enter button.
3. Set your question by following the instructions (steps 5 to 11) displayed in Quick Help.
5. Upon completion, click the submit button.
6. Click OK to go back to Jigsaw Task View.

Activity 2: Responding to all group members

1. At the Jigsaw Task View, select the Jigsaw Task title and click on its link.
2. Read the task questions carefully.
3. Click the Start button (found on the bottom-right of the page) to start the Jigsaw Task session.
4. Fill in your group and select a question. Then, click the Continue button. (Once you have clicked the Continue button, agent will automate the entire session for this task).
5. Then, the system will display the questions that you need to respond.
6. Select a question and click its Post Response button.
7. Type your response in the provided text area.
8. Upon completion, click the Post button.
9. Repeat steps 6 to 8 until you have finished responding to all the questions.

Activity 3: Composing a summary

1. Once you have responded to all your group members, the system will inform you that there are no more responses. (Controlled by agent)
2. Click the Continue button to proceed.
3. If your group members have finished their responses, you should be able to view their responses at the bottom of the page automatically. (If they have not finished, you have to wait for them in order to see their responses towards your question. This is controlled by agent).
4. Click on each of the link to read their responses.
5. When finished reading each of the responses, use the back button to read other responses.
6. When you have read all your group members' responses, click on the Summary button to compose a summary.
7. Follow the instructions displayed in Quick Help to compose a summary.
8. Upon completion, click the Post button.
9. Now, you should be able to see your own summary and your group members' summary. (If you can only see your own summary that means other group members have not completed their summaries. Wait until they finished composing a summary. This is controlled by agent).

Activity 4: Composing a report

1. Click on the links to view other group members' summary.
2. Type in your comments and feedback. Then, click the "Response" button.
3. To read another summary, use the 'back' button to go back to the Expert Group view.
4. Repeat steps 1, 2 and 3 until you have view all your group members' summaries.
5. Click on the 'Create Report' button to compose a report.
6. Follow the instructions displayed in Quick Help to compose a report.
7. Upon completion, click the Post button.
8. Now, you should be able to see your own report and your group members' report. (If you can only see your own report that means other group members have completed their reports. Wait until they finished composing a report. This is controlled by agent).

Activity 5: Integrating a group report

1. To integrate all group members' reports, you must be the group leader.
2. Click on the 'Create Integrated Report' button.
3. The system's agent will perform the integration.
4. Click on the integrated report link to view the final group report.

**Thank you for your participation. Please answer the following Questionnaire to complete the testing.**

## B-2 Hands-on Testing Task Scenarios

**Kumpulan:** _____          **Nombor Soalan:** _____

**Username:** _____          **Katalaluan:** _____

## Aktiviti Group Jigsaw

Pelajar diminta untuk melaksanakan aktiviti Group Jigsaw mengikut langkah-langkah yang disenaraikan di bawah. Pelajar juga diminta untuk menjawab beberapa soalan bagi setiap aktiviti (bila perlu).

## A. Masuk ke halaman utama Group Jigsaw

Langkah-langkahnya:

1. Sila klik pada Group Jigsaw.
2. Sila masukkan "username" dan katalaluan anda seperti di atas.
3. Kini anda berada di halaman utama Group Jigsaw.

## B. Memulakan aktiviti Jigsaw

Langkah-langkahnya:

1. Sila klik pada "Jigsaw Task" untuk membaca soalan yang disediakan oleh guru anda.
2. Sila klik pada tajuk soalan.
3. Sila klik pada "Start" untuk memulakan aktiviti Jigsaw.
4. Sila pilih kumpulan dan nombor soalan seperti yang diberikan di atas.
5. Sila klik pada "Continue".
6. Kini anda berada di halaman soalan yang perlu dijawab.

## C. Memberi maklumat kepada ahli kumpulan anda

Langkah-Langkahnya:

1. Sila klik pada "Post response" di bawah soalan yang anda ingin jawab.
2. Sila beri maklumat anda dalam tempat yang disediakan dan klik pada "Post" apabila selesai.
3. Perhatikan bahawa soalan yang telah anda jawab akan ditanda (√).
4. Ulangi langkah-langkah 1 dan 2 untuk memberi maklumat pada soalan-soalan yang seterusnya.

5. Apabila semua soalan telah dijawab, mesej "No more responses" akan dipaparkan di bawah halaman soalan.
6. Sila klik pada "Continue".
7. Kini, anda dapat melihat maklumat-maklumat yang diberikan oleh ahli kumpulan anda.
8. Sekiranya anda terlihat mesej "No document found", ini bermaksud ahli kumpulan anda belum lagi menyiapkan maklumat mereka.
9. Sila tunggu sehingga mereka selesai.
10. Sila klik pada "Refresh" untuk mengemaskini halaman maklumat anda.

## D. Membaca maklumat-maklumat yang diberikan oleh ahli kumpulan anda.

Langkah-langkahnya:

1. Sila klik pada nama ahli kumpulan anda untuk membaca maklumat mereka.
2. Sila klik pada "Back" untuk kembali ke halaman maklumat.
3. Ulangi langkah 1 and 2 untuk membaca maklumat yang seterusnya sehingga semua maklumat telah dibaca.

## E. Menyediakan ringkasan bagi soalan anda

Langkah-langkahnya:

1. Sila klik pada "Summary" untuk menjawab soalan anda.
2. Anda boleh menaip jawapan anda pada tempat yang disediakan
   ATAU
   menggunakan maklumat dari ahli kumpulan anda dengan memilih nama mereka dan mengubahsuainya.
3. Klik pada "Post" setelah selesai membuat ringkasan bagi soalan anda.
4. Kini, anda dapat melihat ringkasan anda dan juga ringkasan daripada ahli kumpulan lain yang menjawab soalan yang sama dengan anda.
5. Sekiranya anda hanya dapat melihat ringkasan sendiri, ini bermaksud ahli kumpulan lain belum lagi menyiapkan ringkasan mereka.
6. Sila tunggu sehingga mereka selesai.
7. Sila klik pada "Refresh" untuk mengemaskini halaman anda.

## F. Membaca ringkasan dan memberi komen

**Langkah-langkahnya:**

1. Sila klik pada nama ahli kumpulan lain untuk membaca ringkasan mereka.
2. Sila taipkan komen anda di tempat yang disediakan.
3. Sila klik pada "Respond" setelah selesai.

4. Anda dapat melihat komen anda wujud di bawah ringkasan yang sedang dibaca.
5. Sila gunakan "Back" untuk membaca ringkasan yang seterusnya.
6. Ulangi langkah-langkah 1 hingga 5 sehingga semua ringkasan telah dibaca dan dikomen.

## G. Menyediakan laporan anda

Langkah-langkahnya:

1. Sila klik pada "Create Report" untuk membuat laporan bagi soalan anda.
2. Anda boleh meniap jawapan anda pada tempat yang disediakan
   ATAU
   menggunakan semula ringkasan anda dengan klik pada "Copy" dan mengubahsuainya.
3. Klik pada "Post" setelah laporan disiapkan.
4. Kini, anda dapat melihat laporan anda sendiri dan juga laporan daripada ahli kumpulan anda.
5. Sekiranya anda hanya dapat melihat laporan sendiri, ini bermaksud ahli kumpulan anda belum lagi menyiapkan laporan mereka.
6. Sila tunggu sehingga mereka selesai.
7. Sila klik pada "Refresh" untuk mengemaskini halaman anda.

## H. Menggabungkan semua laporan Jigsaw (Untuk Ketua Kumpulan sahaja)

Langkah-langkahnya:

1. Sila klik pada "Create Integrated Report".
2. Untuk membaca laporan lengkap tersebut, klik pada tajuk "View Full Report".

**Terima kasih atas penyertaan anda dalam aktiviti ini.**

# Appendix C: G-Jigsaw Questionnaires

## C-1 Pilot Testing Questionnaire (for Teachers)

**Research Question:**

Will there be a significant difference of performance and achievement in implementing Web Agents to support collaborative learning activities.

**Section A: Experiment**

*Instructions: This section consists of 7 questions. The first 2 questions compare two modules, one without web agents and the other one with web agents. The following 5 questions are based on the activity below. You are required to carry out the activities below before you can proceed to answer question 1. To carry out the activities, please follow instructions provided in Task Scenarios.*

| Activity | Time spent in G-Jigsaw module (without web agents) | Time spent in G-Jigsaw module (with web agents) | |
|---|---|---|---|
| | Using Default Template | Using Template 2 | Using Template 3/4 |
| 1. Enter questions for new task | | | |
| 2. Respond to all group members | | | |
| 3. Compose a summary | | | |
| 4. Compose a report | | | |
| 5. Integrate all reports | | 1 minute | |

1. Rate the difficulty level of the 5 activity you carried out.

   For G-Jigsaw without web agents
       (Difficult)                                    (Easy)

   | | | | | |
   |---|---|---|---|---|
   | Activity 1: | 1 | 2 | 3 | 4 | 5 |
   | Activity 2: | 1 | 2 | 3 | 4 | 5 |
   | Activity 3: | 1 | 2 | 3 | 4 | 5 |
   | Activity 4: | 1 | 2 | 3 | 4 | 5 |
   | Activity 5: | 1 | 2 | 3 | 4 | 5 |

For G-Jigsaw with web agents
        (Difficult)                                                        (Easy)

| | | | | | |
|---|---|---|---|---|---|
| Activity 1: | 1 | 2 | 3 | 4 | 5 |
| Activity 2: | 1 | 2 | 3 | 4 | 5 |
| Activity 3: | 1 | 2 | 3 | 4 | 5 |
| Activity 4: | 1 | 2 | 3 | 4 | 5 |
| Activity 5: | 1 | 2 | 3 | 4 | 5 |

2. How easy was it for you to learn to use the system for this testing?

For G-Jigsaw without web agents

  (Difficult)                                 (Easy)
    1              2            3            4          5

For G-Jigsaw with web agents

  (Difficult)                                 (Easy)
    1              2            3            4          5

3. For activity 1 : G-Jigsaw with web agents

    a. How the shared questions helped you in setting new questions?

      (Not helpful)                              (Very helpful)
        1              2            3            4          5

    b. Are the shared questions reducing your time in setting new questions?

        ☐ No                ☐ Undecided            ☐ Yes

    c. How effective is the sharing facility in promoting collaboration among teachers?

      (Not effective)                          (Very effective)
        1              2            3            4          5

4. For activity 2 : G-Jigsaw with web agents

    a. Did you find it easy to respond to all your members?

        ☐ No                ☐ Undecided            ☐ Yes

    b. Are the instructions provided helping you to know where you are and how you should proceed?

      (Not helpful)                              (Very helpful)
        1              2            3            4          5

c.  Is sharing responses effective to promote students collaboration before they start to compose their summary?

(Not effective)                                        (Very effective)
    1          2          3          4          5

5.  For activity 3 : G-Jigsaw with web agents

a.  Did you find the retrieving responses facility helped you to compose your summary better?

(Not helpful)                                        (Very helpful)
    1          2          3          4          5

b.  Did the retrieving responses facility minimize your time in writing a summary?

☐ No                 ☐ Undecided                 ☐ Yes

6.  For activity 4 : G-Jigsaw with web agents

a.  Did you find the retrieving summary facility helped you to compose your report?

(Not helpful)                                        (Very helpful)
    1          2          3          4          5

b.  Do you agree that being able to view other members' summary, give comments and receive feedback before composing the final report helped to promote collaboration among students?

(Strongly disagree)                                        (Strongly agree)
    1          2          3          4          5

7.  For activity 5 : G-Jigsaw with web agents

a.  Is the integration facility very useful to integrate students' final reports?

☐ No                 ☐ Undecided                 ☐ Yes

b.  Did the integration facility minimize the integration process time?

☐ No                 ☐ Undecided                 ☐ Yes

**Section B: Usability Test**

Instructions: This section consists of 10 statement based on the module with web agents. Please answer each question carefully and tick your answers accordingly.

8.  The instructions are helpful

   ☐ Agree          ☐ Undecided          ☐ Disagree

9.  I enjoy my session on this software

   ☐ Agree          ☐ Undecided          ☐ Disagree

10. Working with this software is satisfying

   ☐ Agree          ☐ Undecided          ☐ Disagree

11. The information provided in this software is clear and easy to understand

   ☐ Agree          ☐ Undecided          ☐ Disagree

12. The instructions provided in this software is easy to follow

   ☐ Agree          ☐ Undecided          ☐ Disagree

13. Tasks can be easily performed in this software

   ☐ Agree          ☐ Undecided          ☐ Disagree

14. I need to go back and forth to look at the instructions

   ☐ Agree          ☐ Undecided          ☐ Disagree

15. It is difficult to learn how to use new functions

   ☐ Agree          ☐ Undecided          ☐ Disagree

16. This software has a very attractive presentation

   ☐ Agree          ☐ Undecided          ☐ Disagree

17. It is relatively easy to move from one part of a task to another

   ☐ Agree          ☐ Undecided          ☐ Disagree

**Section C: Opinions and Feedback**

18. List out the most negative aspect(s) you found in this system (if any)

_____

_____

_____

19. List out the most positive aspect(s) you found in this system (if any)

_____

_____

_____

20. General comments and opinions:

_____

_____

_____

_____

_____

_____

**Thank you very much for your participation in this testing. All the information given is solely for research purposes only.**

## C-2 Hands-On Testing Questionnaire (for Students)

**Kumpulan:** _____        **Nombor Soalan:** _____

**Username:** _____        **Katalaluan:** _____

## Soal selidik Aktiviti Group Jigsaw

**Soalab-soalan mengenai activiti Jigsaw yang telah dijalankan:**

1. Saya dapat memulakan aktiviti jigsaw dengan mudah.
   Ya                              Tidak

2. Saya dapat memberikan maklumat kepada ahli kumpulan dengan mudah.
   Ya                              Tidak

3. Saya berasa gembira kerana dapat menyumbangkan maklumat kepada ahli kumpulan saya.
   Ya                              Tidak

4. Saya dapat membaca maklumat yang diberikan dengan mudah.
   Ya                              Tidak

5. Maklumat yang diberikan oleh ahli sekumpulan dapat membantu saya menjawab soalan.

   Ya, kerana _____

   Tidak, kerana _____

6. Saya dapat memberi komen kepada "Expert Group" dengan mudah.
   Ya                              Tidak

7. Saya dapat lebih maklumat dengan membaca jawapan dari "Expert Group".

   Ya, kerana _____

   Tidak, kerana _____

8. Komen yang diterima membantu saya memperbaiki jawapan.

   Ya, kerana _____

   Tidak, kerana _____

9. Saya dapat menggabungkan semua jawapan dengan mudah. (Untuk Ketua Kumpulam sahaja)
   Ya                              Tidak

### Soalan-soalan Umun

1. Aktiviti Jigsaw membantu saya berkongsi maklumat dengan rakan-rakan.
   Ya                                    Tidak

2. Saya memahami jawapan bagi semua soalan yang disediakan oleh guru.
   Ya                                    Tidak

3. Sistem ini sesuai untuk digunakan dalam aktiviti pembelajaran di sekolah.
   Ya                                    Tidak

4. Saya suka menggunakan system Jigsaw kerana

_____

_____

_____

_____

5. Sila berikan komen dan pandangan lain tentang system ini:

_____

_____

_____

_____

_____

_____

**Terima kasih atas penyertaan anda dalam aktiviti ini.**

# Appendix D: G-Jigsaw Web Agents' Algorithm

## Sharing Agent Algorithms:

```
SharingAgent (message As Integer)
{
    If message = 1 Or message = 10 Or message = 14 Then
        Call RetrievingAgent (1, message, username, task_id)
    ElseIf message = 2 Then
        Call FilteringAgent (3)
    ElseIf message = 20 Then
        Call ClusteringAgent (4)
    Else
        If message = 19 Then
            report (2)
        Else
            report (5)
        End If
    End If
}

RetrievingAgent (message As Integer, type As Integer, name As String, id As Integer)
{
    If message = 1 Then
        If type = 1 Then
            retrieve ("question", name, id)
        ElseIf type = 10 Then
            retrieve ("response", name, id)
        Else
            retrieve ("summary", name, id)
        End If

        report (19)
    End If
}

FilteringAgent (message As Integer)
{
    If message = 3 Then
        Dim aryQuestion As Variant
        aryQuestion = getNewQuestion ()    'Extract new Questions into an array
        ' Loop through the questions and filter existing questions
        ForAll question In aryQuestion
            filter (question)
        End ForAll

        report (20)
    End If
}

ClusteringAgent (message As Integer)
{
    If message = 4 Then
        Dim category As String
        Dim categories As Variant
        Dim isExist As Integer

        isExist = False
        category = getTitle ()    'Extract submitted task title as category
        categories = getCategories () 'Extract all existing categories in the database
        ' Loop through the categrories in database to perform clustering
```

```
            ForAll item In categroeis
                If item = category Then
                    isExist = True
                    insertQuestions ()
                    sort ()
                    exit ()
                End If
            End ForAll

        If Not isExist Then
            createNewCategory ()
            insertQuestions ()
            sort ()
        End If


        report (21)
    End If
}


Navigation Agent:

NavigationAgent (message As Integer)
{
    If message = 5 Or message = 25 Then
        Call LoadProfileAgent (1)
    ElseIf message = 22 Then
        Call MapProfileAgent (2, message, username, level, status)
    ElseIf message = 23 Then
        Call NavigateAgent (3, location)
    ElseIf message = 3 Or message = 4 Or message = 6 Or message = 7 Or message = 8
                    Or message = 9 Or message = 11 Or message = 12 Or message = 13
                    Or message = 15 Or message = 16 Or message = 18 Then
        Call UpdateProfileAgent (5, message, username)
    ElseIf message = 24 Then
        report (4)
    End If
}

LoadProfileAgent (message As Integer)
{
    Dim key As String
    Dim profile As NotesDocument
    If  message = 1 Then
        key = getUserName ()
        Set profile = getProfile ()
        setStatus ()

        report (22)
    End If
}

MapProfileAgent (message As Integer, name As String, level As Integer, status As Integer)
{
    Dim location As String
    If message = 2 Then
        getProfile (name)
        If level = 0 Then
            If status = 0 Then
                location = "Jigsaw Task"
            ElseIf status = 1 Then
                location = "Profile Form"
            End If
        ElseIf level = 1 Then
```

```
                If status = 2 Then
                    location = "Question View"
                ElseIf status = 3 Then
                    location = "Response Form"
                ElseIf status = 4 Or status = 5 Then
                    location = "Responses  View"
                ElseIf status = 6 Then
                    location = "Summary Form"
                End If
            ElseIf level = 2 Then
                If status = 7 Or status = 8 Then
                    location = "Summaries View"
                ElseIf status = 9 Then
                    location = "Report Form"
                End If
            ElseIf level = 3 Then
                If status = 10 Or status = 11 Then
                    location = "Report View"
                ElseIf status = 12 Then
                    location = "Integrated Report View"
                End If
            End If
            return (location)
            report (23)
        End If
}

NavigateAgent (message As Integer, location As String)
{
    If message = 3 Then
        redirect (location);
        displayInstructions (location)
        report (23)
    End If
}

UpdateProfileAgent (message As Integer, type As Integer, name As String)
{
    Dim profile As NotesDocument
    If  message = 5 Then
        Set profile = getProfile (name)
        If isProfileExist (profile) Then
            If type = 3 Then
                status = 1
            ElseIf type = 4 Then
                status = 2
                level = 1
            ElseIf type = 6 Then
                status = 3
            ElseIf type = 7 Then
                If isRespondDone() Then
                    status = 4
                Else
                    status = 2
                End If
            ElseIf type = 8 Then
                If isReadDone() Then
                    status = 5
                End If
            ElseIf type = 9 Then
                status = 6
            ElseIf type = 11 Then
                status = 7
```

```
                level = 2
            ElseIf type = 12 Then
                If isReadDone() Then
                    status = 8
                End If
            ElseIf type = 13 Then
                status = 9
            ElseIf type = 15 Then
                status = 10
                level = 3
            ElseIf type = 16 Then
                If isReadDone() And isLeader(name) Then
                    status = 11
                End If
            ElseIf type = 18 Then
                status = 12
            End If
            saveProfile ()
        End If

        report (25)
    End If
}
```

**Integration Agent:**

```
IntegrationAgent (message As Integer)
{
    If message = 17 Then
        Call QueryProfileAgent (1, username)
    ElseIf message = 26 Then
        Call IntegrateAgent (2, group, NULL)
    ElseIf message = 27 Then
        suspendIntegrateAgent (3)
        Call SearchAgent (3, group, task id)
    ElseIf message = 28 Then
        Call IntegrateAgent (4, group, document)
    ElseIf message = 29 Then
        report (5)
    End If
}

QueryProfileAgent (message As Integer, name As String)
{
    Dim profile As NotesDocument
    If message = 1 Then
        Set profile = getProfile (name)
        return (getGroup (), getTaskid ())

        report (26)
    End If
}

IntegrateAgent (message As Integer, group As String, document As Variant)
{
    If message = 2 Then
        createNew ()
        taskTitle = getTaskTitle ()
        groupName = getGroup ()
        report (27)
        suspend ()
    ElseIf message = 4 Then
        resume ()
```

```
        ForAll doc In document
            TaskQuestion = document.getItemValue("TaskQuestion")
            TaskAnswer = document.getItemValue ("ReportContent")
        End ForAll
        save ()
        report (29)
    End If
}

SearchAgent (message As Integer, group As String, id As String)
{
    Dim document As NotesDocumentCollection

    If message = 3 Then
        Set document = getGroupReports (group, id)
        return (document)
        report (28)
    End If
}
```