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 grou members repo
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. 2. When the form is opened, fill in the details such as Task Title, Task Description, Task Questions, Group etc. 3. Switch to the Report view to open the first group report. 4. Copy the first report's content and switch back to the integrated report form to paste them in the appropriate area. 5. Edit the content if necessarily. 6. Repeat the steps 3 to 5 for the rest of the questions until all questions are copied into the integrated report form area. 7. Submit the integrated report. 8. Switch to the Integrated Report View to view the integrated report.	1. From the Report View, click the Create Integrated Report button. 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.

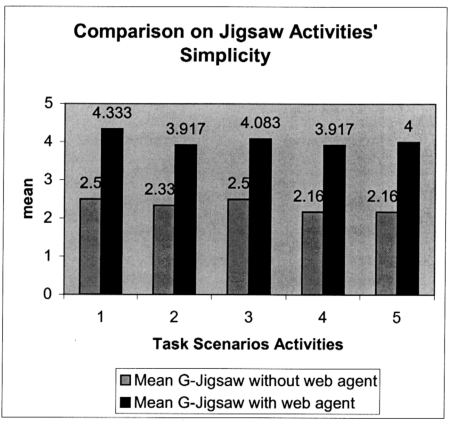

Figure 7-1 Comparison Results on the significant differences of web agents in simplifying the jigsaw activities

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.

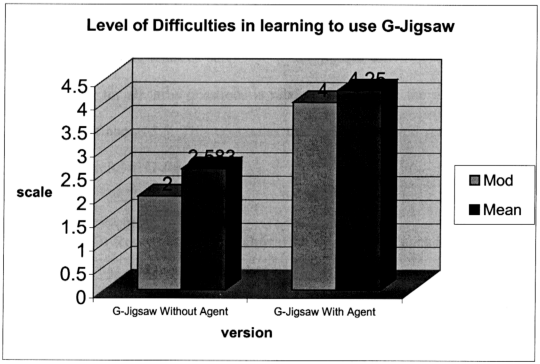

Figure 7-2 Comparison Results on the level of difficulties in learning to use G-Jigsaw

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.

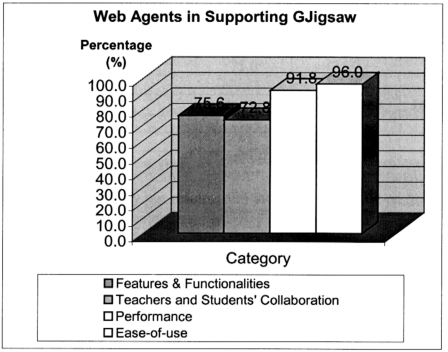

Figure 7-3 Web Agents in supporting G-Jigsaw Activities

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.