A JXTA-based System for Adaptive and Collaborative Learning

Hyosook Jung, Jinhyun Ahn, Seongbin Park*

Department of Computer Science Education
Korea University, Seoul, Korea
{est0718, budongsim, psb}@comedu.korea.ac.kr

Abstract: In this paper, we present an adaptive and collaborative learning system that is based on JXTA technology [jx205, Gon01]. JXTA enables any connected devices in a network to participate in communication and collaboration as peers and our system supports additional functionalities such as adaptive navigation, adaptive group formation, and instant messaging. We tested our system against undergraduate students who took a data structure class. The experimental results indicate that our JXTA-based learning system helped students learn effectively.

1 Introduction

In this paper, we present a JXTA-based learning system which supports various types of adaptive features by utilizing user models that reflect user behaviors during learning. The system also provides collaborative functionalities such as instant messaging that allow users to communicate and collaborate with their peers in real time [Tra05, Mah04]. In order to complement the weak points of collaborative learning in P2P networks such as a free rider [BV03] and differences between learners, it also supports adaptive functionalities such as adaptive navigation and dynamic group formation depending on the learning context of a student, where a learning context refers to various properties about the student such as whether the student has sufficient knowledge on the problems that are to be learned or not.

This paper is organized as follows. In section 2, related works are described. In section 3, the adaptive and collaborative learning system is explained. In section 4, we describe the experimental results in detail and the paper concludes in section 5.
2 Related works

There are three areas that are related to our work and figure 1 depicts the relationship between our work and related fields.

Collaborative learning is an education method that motivates students, promotes critical thinking, and develops social behavior for working together. In order to produce good outcomes, the learning method must be well prepared [Bis05].

JXTA technology allows any connected device on a network, ranging from cell phones and wireless PDAs to PCs and servers, to communicate and collaborate. JXTA peers create and join a virtual network where they can interact with their peers and resources directly [jx205, Gon01].

While general P2P systems such as Napster and Gnutella can be used for collaborative learning, these do not have enough tools for small groups to interact strongly [EL04]. EDUCOSM [MNF+03] focuses on the collaborative learning in Web-based courses and supports a shared document pool to collect Web resources, collaborative annotation of the documents, and publication of the student’s own work. COMTELLA [Vas04] is a P2P system that can be used for sharing files, mainly papers, and retrieving files among those that are shared by their colleagues. EDUTELLA [NWQ+02] is an educational P2P service for exchanging educational resources in the W3C metadata standard RDF. GROOVE [EL04] is a P2P software designed to facilitate collaboration and communication among small groups. It focuses on the shared workspace that users create and provides many tools that can be used in the workspaces such as calendar, discussion, file sharing, outliner, pictures, notepad, sketchpad, Web browser, etc.

*To whom correspondence should be addressed.
In a complex hyperspace, learners may experience the problems of disorientation and cognitive overload [Con87]. For overcoming these problems, adaptive hypermedia presents personalized contents and link structures based on a user model. The adaptation is described as adaptive presentation and adaptive navigation. Adaptive presentation provides information on a topic in different methods according to the user’s knowledge, goals, preferences and so on. Adaptive navigation changes the link structure so that a user is guided toward interesting or relevant information [BHW99]. AHA! is one of adaptive hypermedia systems which supports adaptive presentation by the conditional inclusion of fragments and adaptive navigation by the link annotation or hiding [BAB+03].

3 JXTA-based learning system

Figure 2 shows the architecture of our system and a typical usage scenario is as follows:

1. A user runs a student program at a client peer, joins in a JXTA network, and logs in the manager peer.
2. The updating module in the manager peer finds user’s attributes and their values in the user database.
3. The manager peer sends both user’s learning context (i.e., low-level or high-level knowledge) and the information about user’s group (i.e., basic or superior group) to the client peer.
4. The updating module updates the user model of the client peer whenever the student solves a problem.

5. The manager peer informs all peers in a peer group that a new client peer participates in the group.

6. The client peer can see connected members in its own group, their learning contexts, and a list of learning problems.

7. The client peer requests a problem by clicking a link anchor in order to learn.

8. The managing content module in the manager peer finds the requested problem in the content database.

9. The manager peer sends the requested problem to the client peer.

10. The client peer uploads a result file to the manager peer after the user solves the problem.

11. The updating module in the manager peer updates the knowledge of the student and the level of the group.

12. The annotating/hiding link module changes the colors of link anchors of the problems depending on the updated user model.

13. The adaptive grouping module in the manager peer switches the existing group to a new group.

Table 1 shows the types of adaptative functions that our system provides. The attributes and adaptation rules are defined according to how often values of attributes are updated. The more dynamic attributes are updated frequently while the less dynamic attributes are updated infrequently.

Figure 3 shows a student program. A student logs in the manager program with ID and password. The student can see a list of problems that are selected based on the user model of the student. The learning context is updated dynamically according to the knowledge of the student that is changed whenever the student submits a result file. The titles of the problems (i.e., link anchor) are colored based on the learning context of the student such as not enough (black), available (blue), or completed (purple). The colors guide the student to navigate the content adaptively (i.e., link annotation).

The student can also see the information of the assigned group such as the number of connected peers, their status (i.e., name, major, and programming skill), or shared files. The student can exchange messages and share files with the members in the group. (See figure 4.) These behaviors are informed to the manager program to update the user model and can be used to support dynamic adaptation such as rearranging the groups and giving appropriate problems.

Figure 5 shows a manager program. It stores the user models of all students in a user database and the contents to be learned in a content database. It also stores the submitted
result file in a result database. The user model is a file that contains the attributes and their values such as the latest login date, the number of login times, the score of each problem, the time to solve a problem, the type of the assigned group as well as the personal information (i.e., ID, password, programming skill, major). The attributes are used to determine which problems to provide for the student.

Each student can belong to exactly one group and the manager program assigns a student to a certain group that is suited to the knowledge of the student. It always monitors the behaviors of the student and updates the user model of the student. It rearranges the student to another group and provides appropriate problems based on the updated user model.

### Table 1: The type of adaptation

<table>
<thead>
<tr>
<th>attribute</th>
<th>adaptation rule</th>
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</thead>
<tbody>
<tr>
<td>knowledge level of a student</td>
<td>System increases the knowledge level when a student submits a solution</td>
</tr>
<tr>
<td>group index for a student</td>
<td>System changes a current group into a new one which is appropriate for the new knowledge level when the knowledge level increases</td>
</tr>
<tr>
<td>the number of file uploading</td>
<td>Students should upload their files at least once to download other files</td>
</tr>
<tr>
<td>the color of each problem</td>
<td>System presents the titles of the problems in different colors depending on whether the problem is solved or not</td>
</tr>
<tr>
<td>difficulty level of a problem</td>
<td>Author defines the difficulty level of all problems</td>
</tr>
<tr>
<td>personal features (name, password, grade, major, programming skill, etc.)</td>
<td>When a students updates the values of attributes, the values are changed</td>
</tr>
<tr>
<td>a list of problems for a group</td>
<td>The difficulty level of the problem is the same as the level of the group</td>
</tr>
</tbody>
</table>

### 4 Experimental results

We experimented our system against thirty eight undergraduate students at the department of computer science education of Korea university. The students were skilled in C language and had been taking a Java language class that consisted of lectures in a classroom and practices in a laboratory. In our experiment, a professor gave a lecture about the concept of recursion and students solved three simple problems about recursion as a pretest. We divided the students into four groups as follows.

- **Group A**: it is a control group and students learn individually.
• Group B: students learn individually and use an adaptive navigation function which guides learning process using three colors such as black (not enough), blue (available), and purple (completed). It represents student’s current learning context.

• Group C: students learn collaboratively and use collaborative functions such as instant messaging and file sharing in a static group which does not change.

• Group D: students learn collaboratively in a group which changes depending on their current learning contexts. (i.e., dynamic grouping). In addition, it supports a ban of free-riding (i.e., students must upload their files at least once in order to share the results with others) as well as adaptive navigation and collaborative functions.

<table>
<thead>
<tr>
<th></th>
<th>adaptive function</th>
<th>collaborative function</th>
<th>learning type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>X</td>
<td>X</td>
<td>individual learning</td>
</tr>
<tr>
<td>Group B</td>
<td>adaptive navigation</td>
<td>X</td>
<td>individual learning</td>
</tr>
<tr>
<td>Group C</td>
<td>X</td>
<td>instant messaging, file sharing in a static group</td>
<td>collaborative learning</td>
</tr>
<tr>
<td>Group D</td>
<td>adaptive navigation learning and grouping</td>
<td>instant messaging, file sharing, and a ban of free-riding in a dynamic group</td>
<td>collaborative learning</td>
</tr>
</tbody>
</table>

Table 2: The differences of function and learning style between four groups

Table 2 outlines the differences between four groups defined by three properties such as adaptive and collaborative function and learning style for the evaluation of our system.
Table 3 outlines the differences of learning activity between three subject groups defined by three properties for the evaluation of our system. Students in the control group (i.e., group A) read an examination paper, learned individually, and wrote the solutions of the problems on the paper. Students in the subject groups used their own systems; they joined a JXTA network and solved the problems individually or collaboratively, using their JXTA applications. Students solved three intermediate level problems and two difficult level problems as a posttest.

To evaluate the efficiency of each system, we measured average scores of the pretest and posttest for each group after grading the final results. Table 4 shows the results for the pretest and posttest of each group. There was score improvement at the subject groups (Group B, C, D), but not at the control group (Group A).

From the experimental results, we conclude that the adaptive navigation and collaborative
functions could have a good effect on learning. However, unlike our prediction that the students in group D would achieve better improvement of score than other groups because both adaptive navigation and collaborative functions were provided, group C achieved better scores than group D where only collaborative functions were supported. Our interpretation of this result is as follows. Thirty eight students took part in the experiment and they were randomly assigned to one of four groups. Twelve students in group D were too small to form different level groups by dynamic grouping. Therefore, it was difficult to communicate between the students actively during relatively short period of time. On the other hand, students in group C could communicate with their group members steadily since the group did not change. So with only collaborative functions, group C would be able to obtain better achievement than group D.

5 Conclusions and Future Works

In this paper, we presented a JXTA-based adaptive learning system. The system provides functionalities such as dynamic group formation, adaptive navigation, and instant messaging. We tested our system against undergraduate students for a data structure class and the experimental results were promising. We are currently extending the system so
Step | Group B | Group C | Group D
---|---|---|---
1 | registration | registration | registration
2 | join a static group which does not change | join a dynamic group which changes according to student’s knowledge level | join a dynamic group which changes according to student’s knowledge level
3 | use an adaptive navigation function which changes the title color of a problem according to student’s knowledge level | upload the result of the problem | use an adaptive navigation function which changes the title color of a problem according to student’s knowledge level, upload the result of the problem
4 | download member’s results of the group, discuss if the solutions are appropriate for the problems | use adaptive grouping according to their knowledge level, download member’s results of the group when uploading their own results, discuss if the solutions are appropriate for the problems | use adaptive grouping according to their knowledge level, download member’s results of the group when uploading their own results, discuss if the solutions are appropriate for the problems
5 | submission of the results | submission of the results | submission of the results

Table 3: The differences of learning activity between three subject groups.

<table>
<thead>
<tr>
<th></th>
<th>pretest</th>
<th>posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>95</td>
<td>90</td>
</tr>
<tr>
<td>Group B</td>
<td>80</td>
<td>85</td>
</tr>
<tr>
<td>Group C</td>
<td>83</td>
<td>93</td>
</tr>
<tr>
<td>Group D</td>
<td>83</td>
<td>90</td>
</tr>
</tbody>
</table>

Table 4: The average scores for the pretest and posttest of each group

that learners can use handheld devices such as PDAs as well as desktop computers in the JXTA network. We also plan to implement more adaptive functionalities (either, finer, or coarser, or both) than are provided currently.

References


