EVALUATING THE EXTENT OF ILL-STRUCTURED PROBLEM SOLVING PROCESS AMONG PRE-SERVICE TEACHERS IN AN ASYNCHRONOUS ONLINE DISCUSSION AND REFLECTION LOG LEARNING ENVIRONMENT

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ABSTRACT
Most educators increasingly regard ill-structured problem solving as an important objective of learning and have sought various means to achieve it. In this article, we describe a learning environment to help pre-service teachers in Singapore solve ill-structured problems. There are four key dimensions in our learning environment: tutor-led face-to-face tutorial, face-to-face discussion among participants, asynchronous online discussion, and a reflection log. The goal of this study was to investigate the roles of asynchronous online discussion and reflection logs in supporting ill-structured problem solving. Findings indicated that the use of asynchronous online discussion in an Asian context appears to mainly support two types of ill-structured problem solving processes, “Articulate the problem space” and “Generate possible problem solutions,” while the reflection log seems to facilitate the processes of “Assessing the viability of alternative solutions” and “Monitor the problem space and solution options.” The pre-service teachers’ perceptions on using the asynchronous online discussion and reflection log were also reported.

INTRODUCTION
Problem solving can be viewed as a skill of finding appropriate ways to achieve a goal that is not immediately attainable (Holyoak, 1991; Mayer, 1992). It is
generally regarded as one of the most important activities in everyday and professional lives (Jonassen, 2000; Phye, 2001), one that is essential in helping teachers handle the complex problems commonly encountered in their everyday professional life. Many of the complex problems faced by teachers are ill-defined or ill-structured; that is, problems that are “situated in and emergent from a specific content” (Jonassen, 1997, p. 68) and “lacking solutions that are indisputably correct” (Kagan, 1993, p. 715). Examples of some of the ill-structured problems that are commonly faced by teachers include decision-making problems (e.g., what is the best teaching approach to use with this class?), trouble-shooting problems (e.g., how am I going to get this equipment to work?), and design problems (e.g., how do I design an engaging learning material that can help my students learn this stuff well?). Because teachers are expected to solve ill-structured problems in their daily professional lives, it is thus important that teacher education programs in universities and colleges focus on instruction on how to help the pre-service teachers solve problems. We believe that such an instruction, among other things, should provide learners with the opportunity in solving problems, as well as the necessary support to help them solve the problems.

According to Jonassen (2002), problem solving has two critical attributes. First, problem solving involves the mental representation of a situation in the world, also known as the problem space (Newell & Simon, 1972). Second, problem solving involves some active manipulation of the problem space. As Jonassen remarked, “When we manipulate the problem space, we represent the components and dimensions of the problem, generate hypotheses about how to find the unknown, test those possible solutions, and draw conclusions” (p. 2).

In addition to having the aforementioned two critical attributes, problem solving is also determined by the types of problems that are being solved. This is because different types of problems engage different problem solving processes (Jonassen, 2002). Jonassen (1997) distinguished between well-structured and ill-structured problems. Well-structured problems, which are commonly found at the end of textbook chapters, have single solutions, optimal solution paths, and structured goals (Sinnott, 1989).

Ill-structured problems, on the other hand, often have the following characteristics: they do not present one or more of the problem elements (Shin, Jonassen, & McGee, 2003); they have vaguely defined or unclear goals and unstated statements (Jonassen, 1997; Voss, 1988; Voss & Post, 1988); they possess multiple solutions, solution paths, or no solutions at all (Kitchner, 1983); they possess multiple criteria for evaluating solutions (Shin et al., 2003); they represent uncertainty about which concepts, rules, and principles are necessary for the solution or how they are organized (Shin et al., 2003); they require learners to express their personal opinions or beliefs about the problem (Meacham & Emont, 1989); and they require learners to make judgments about the problem and defend them (Jonassen, 1997). Because of the difference in nature between the
two types of problems, the process for solving well-structured problems will probably not work for ill-structured problems (Shin et al., 2003).

In this study, we focused on an ill-structured problem. More specifically, we used the ill-structured problem as a stimulus for authentic activity (Duffy & Cunningham, 1996). In other words, our focus was on developing the pre-service teachers’ problem solving skills related to solving ill-structured problems through working on an authentic activity, rather than directly telling or teaching them the skills. The authentic activity that we chose for this study was a design problem (a hypermedia design project). Our reasons for choosing a design problem were as follows:

1. Design problems are regarded as one of the most ill-structured kinds of problems and the most common in professional practice (Jonassen, 2002).
2. Design problems, particularly hypermedia design projects, can help make the learners’ understanding and thinking explicit (Dede, 1992; McFarlane, Williams, & Bonnett, 2000), and thus better open to critical examination of their ill-structured problem solving processes.
3. Moreover, hypermedia design, when employed as a tool to link together conceptual elements, allows many ways of organizing information, looking at the content, and representing knowledge structures and conceptual relationships (Jonassen 1998, cited in Chen & McGrath, 2003).

We do realize, however, that the mere provision of an ill-structured problem as a stimulus for authentic activity is probably insufficient for individuals to fully engage in the problem solving processes. The learning environment itself must also be able to support problem solving. In this vein, we believe that the current traditional classroom environment is limited in its ability to fully provide a suitable learning environment for individuals to solve an ill-structured problem such as designing a hypermedia project due to the following two reasons:

1. First, there may be a limited amount of time for the pre-service teachers to be fully involved in the ill-structured problem solving process in class. We believe that ill-structured problem solving processes require time to execute and are often not addressed fully during the standard class period. What about out of class time then? Although it is possible for the pre-service teachers to continue their discussion after class, it is difficult to get all to stay back on a regular basis. As a result, the discussion would be confined to a small group of people only, thus eliciting only a limited amount of interaction, collaboration, and sharing of ideas.
2. Second, although the pre-service teachers may get feedback about their ill-structured problem solving processes from their instructors in class, such feedback is usually limited in terms of their scope and depth (due to time constraints). The pre-service teachers can ask for feedback from their peers. However, there may be some pre-service teachers who are shy to voice their opinions in class for fear they may be laughed at if their opinions are faulty. This is especially so in the Asian culture where the fear of losing “face” is taken
very seriously. As a result of the pre-service teachers’ reticence, there is a lack of widespread peer-to-peer interaction, which can easily lead to a dearth of peer feedback and comments. Without regular feedback, the pre-service teachers will not know if they are progressing on the right track in their ill-structured problem solving processes.

It is thus evident that solving an ill-structured problem, such as designing hypermedia educational software in traditional classroom environments can be a challenging task. This therefore raises an important concern:

What then can we do to enhance the existing learning environment in order to give the pre-service teachers more time and opportunity to engage in the ill-structured problem solving processes, and without the fear of being laughed at?

We believe that the use of asynchronous online discussion and reflection log can address the aforementioned concern. Asynchronous online discussion, for instance, has many qualities that may be useful in facilitating ill-structured problem solving. These include time and place-independence, multi-participant capacity, message storage/retrievability, and the text orientation of the medium (Hawkes & Dennis, 2003). Subsequent paragraphs in this article will describe in greater detail what an asynchronous online discussion and reflection log are and our rationale for using them as part of the design of our learning environment to help the pre-service teachers solve ill-structured problems. In the following sections, we will briefly discuss the ill-structured problem solving processes, as well as the theoretical framework of our study.

ILL-STRUCTURED PROBLEM SOLVING PROCESSES

According to Schön (1990), ill-structured problem solving may be conceptually considered as a design process. Jonassen (1997) argued that the process of solving an ill-structured problem is “a frame experiment in which the problem solver engages in a reflective conversation with the elements of the problem situation” (p. 79). Jonassen (1997) elaborated the following processes for solving ill-structured problems: 1) articulating problem space and contextual constraints; 2) identifying and clarify alternative opinions, positions, and perspectives; 3) generating possible problem solutions; 4) assessing the viability of alternative solutions by constructing arguments and articulating personal beliefs; 5) monitoring the problem space and solution options; 6) implementing and monitoring the solution; and 7) adapting the solution.

So, when learners encounter an ill-structured problem, they must first decide if there is a problem, because the ill-structured problem may not directly be visible (Jonassen, 1997). If the problem exists, learners then construct a representation of the problem which contains all the possible states of the problem based on the
possible causes and contextual constraints of the problem (Sinnott, 1989; Voss & Post, 1988). In other words, problem solvers need to identify the “appropriate problem space from among the competing options” (Jonassen, 1997, p. 79). Learners will also attempt to identify, describe, and understand the various perspectives, views, and opinions of others so as to obtain a better representation of the problem. When learners collaborate and interpret conflicting views, they are essentially constructing multiple smaller problem spaces (Etheris & Tan, 2004).

In addition, learners will also try to locate and select critical information from their memory, which fits the context in the course of constructing the problem space (Voss & Post, 1988). Based on the information selected, learners then suggest possible solutions to the problem and also “develop a justification or an argument for supporting their selection of a particular cause and solution because ill-structured problems usually have divergent or alternative solutions” (Shin et al., 2003, p. 8). Learners should also define the limits of any solution to the problem. Finally, the solution is implemented. If the solution does not solve the problem, learners can either adapt the existing solution based on the feedback gathered, or revisit the problem to determine alternative solution and test that solution (Voss & Means, 1989). Table 1 summarizes the ill-structured problem solving processes.

### THEORETICAL FRAMEWORK

In this research, social constructivism theory forms the key theoretical foundation of our study.

**Social Constructivism**

The general tenet of social constructivism is that knowledge is constructed by people through social interaction and collaboration with others—generated, established, and maintained by a community of knowledgeable peers (Bruffee, 1993; Duffy & Jonassen, 1991). Social constructivism is commonly linked to Vygotsky because he emphasized the critical importance of interaction with people, such as other children, parents, and teachers, in cognitive development (Hung, 2001). Through the process of negotiating meaning, learners broaden their own understanding, which is then individually reconstructed using prior knowledge and experience (Wu, 2003). Thus, an important inference of social constructivism is that learning is collaborative and best situated within a problem solving framework (Hung, 2001).

One of the key concepts in social constructivism is the Zone of Proximal Development or ZPD (Hew & Cheung, 2003). ZPD is typically regarded as the distance between the actual development level, as determined by the ability to engage in problem solving independently, and the level of potential development,
Table 1. Ill-Structured Problem-Solving Processes\textsuperscript{a}

<table>
<thead>
<tr>
<th>No.</th>
<th>Ill-structured process</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Articulate problem space and contextual constraints</td>
</tr>
<tr>
<td></td>
<td>– Statements that decide if a problem really exist.</td>
</tr>
<tr>
<td></td>
<td>– Statements that determine the nature and contextual constraints of the problem.</td>
</tr>
<tr>
<td>2</td>
<td>Identify and clarify alternative opinions, positions, and perspectives</td>
</tr>
<tr>
<td></td>
<td>– Statements that describe various perspectives, views and opinions on a problem.</td>
</tr>
<tr>
<td></td>
<td>– Statements that attempt to seek understanding of the various perspectives, views, and opinions on a problem.</td>
</tr>
<tr>
<td>3</td>
<td>Generate possible problem solutions</td>
</tr>
<tr>
<td></td>
<td>– Statements that describe solutions to a problem.</td>
</tr>
<tr>
<td>4</td>
<td>Assess the viability of alternative solutions by constructing arguments and articulating personal beliefs</td>
</tr>
<tr>
<td></td>
<td>– Statements that evaluate the alternative solutions and give reasons for rejecting or accepting any of the solutions.</td>
</tr>
<tr>
<td>5</td>
<td>Monitor the problem space and solution options</td>
</tr>
<tr>
<td></td>
<td>– Statements that show, explicitly or implicitly, the problem solver’s metacognitive process of deciding if a problem is solvable, whether there exist strategies for solving it, and defining the limits of any strategy to solving the problem.</td>
</tr>
<tr>
<td>6</td>
<td>Implement and monitor the solution</td>
</tr>
<tr>
<td></td>
<td>– Statements that describe how a solution is implemented to solve a problem.</td>
</tr>
<tr>
<td></td>
<td>– Statements that describe whether the solution is able to overcome the problem.</td>
</tr>
<tr>
<td></td>
<td>– Statements that describe whether the solution is acceptable to all involved parties.</td>
</tr>
<tr>
<td>7</td>
<td>Adapt the solution</td>
</tr>
<tr>
<td></td>
<td>– Statements that describe how the solution is tried out in actual settings and how it is adjusted based on users’ feedback.</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Adapted from Jonassen, 1997.
determined through problem solving under an adult guidance (Vygotsky, 1978) or in collaboration with more capable peers (Hung, 1998). So as the pre-service teachers interact with one another via an asynchronous online discussion environment, those who are less skilled in ill-structured problem solving skills will be able to learn from their more competent peers. The whole aim is to help those pre-service teachers who are less competent in ill-structured problem solving to internalize the necessary skills in order to become more competent and independent problem solvers.

DESIGN OF THE LEARNING ENVIRONMENT

There were four dimensions in our learning environment: tutor-led face-to-face tutorial; face-to-face discussion among group members; asynchronous online discussion; and reflection log. The purpose of the tutor-led face-to-face tutorial was to provide the pre-service teachers with core knowledge and concepts of good hypermedia design. During the tutorial, the tutor would also ask the pre-service teachers to apply what they had learned by commenting on some good and bad hypermedia projects. The pre-service teachers would also be guided to produce drafts of their own hypermedia projects.

The face-to-face discussion among group members allowed the pre-service teachers, working in pairs, to: identify the design problems of the group’s own hypermedia project; identify and clarify alternative opinions about the group’s own project; generate possible solutions to the design problems; assess the viability of possible solutions to the design problems; and produce a simple storyboard about their own hypermedia projects.

In addition to the above, the pre-service teachers also participated in an asynchronous online discussion session and completed their reflection logs. The following sections will briefly describe the concepts of asynchronous online discussion and reflection logs.

Asynchronous Online Discussion

Romiszowski and Mason (1996) defined asynchronous communication as one where participants are not online at one and the same time, as in the case of correspondence by letter or fax. In other words, asynchronous communication is not real time or instantaneous (Williams, Watkinds, Daley, Courtenay, Davis, & Dymock, 2001). In an asynchronous online discussion forum, the participants type in their messages and send them to a central database; there is no lost of data as the discussion forum allows records of a participant’s written messages to be kept in the virtual electronic “space” for long periods of time (Ganeva, 1999). Participants can thus respond to the messages posted at any time they prefer and view the messages many times and long after the messages have been posted. In this way,
asynchronous online discussion can resemble written communication (Ganeva, 1999).

Most of the current asynchronous online discussion forums automatically sequences and arranges the messages into various discussion threads sorted according to the time of contribution, the author, or clustered according to topical links (Ganeva, 1999). A discussion thread is usually listed on the left margin of the screen and is the initial message. Follow-up messages to the initial message are typically indented under the original message. A single simple discussion thread may remain a straight line or turn into a tree as participants post follow-up messages to replies. The visual display of the threads allows participants to easily view the desired message and post their replies.

Asynchronous online discussion has the potential to improve the teaching and learning experiences in traditional classroom settings. As Groeling (1999, p. 1) wrote, “With it, scholars and educators have the potential to vastly expand the opportunities for students to interact outside the classroom.” In brief, the literature has argued that asynchronous online discussion has the following desirable characteristics: asynchronicity, reduced social barriers, and increased reflection (Groeling, 1999). Asynchronous online discussion forums are generally available 24 hours a day and 7 days a week. This is especially useful, as they allow student-to-student and student-to-tutor interactions and collaborations to occur at any time and at any distance. Participants can therefore choose to join in the discussions at a time and place most convenient and suitable to them.

Asynchronous online discussion can also be seen as a means to enhance student control over learning and make the educational experience “more democratic” (Harasim, 1989). Researchers also argue that such discussion can also help enhance the participation of students who might be less willing to participate in traditional face-to-face classroom settings due to shyness, language problems, or gender (Groeling, 1999). This is because communicating through a computer can take away many of the normal social cues associated with face-to-face interaction.

Since the messages in an asynchronous online discussion are exchanged over an extended length of time rather than back and forth simultaneously, participants can take their own time ordering and composing their thoughts (Groeling, 1999). Research has highlighted that participants have become better at critiquing, questioning, analyzing, making connections, and extending the content beyond the classroom through the use of asynchronous online discussion forums (Williams et al., 2001).

There are now many software packages that offer platforms for asynchronous online discussions. These include BlackBoard, an off-the-shelf, integrated online delivery and management system for faculty members and students to use, and Knowledge Forum. In this study, the pre-service teachers made use of the Communication Centre of the BlackBoard software for the asynchronous online discussion activities.
The online discussion in our study ran for two weeks. During the discussion, the pre-service teachers posted their hypermedia design projects onto the Web and gave constructive comments, suggestions, or questions about each other’s project. They also posted their subsequent responses to these comments. The purpose for the online discussion was thus twofold:

1. To provide each pre-service teacher an opportunity to identify design problems of their classmates’ projects and give suggestions to solve the problems. Each group would therefore receive feedback about their own projects.
2. To give each group of pre-service teachers the opportunity to evaluate the comments and suggestions they received and respond to these.

Whenever a pre-service teacher posted a message, the new message would be added to the discussion in a manner which showed the relationship of the new response to the existing online discussion messages. This helped the pre-service teachers to follow the threads of discussion easily. The criteria on which the pre-service teachers’ participation in the asynchronous online discussion would be judged, which were 10% of their final grade in the course, were discussed in class prior to the commencement of the actual discussion. The criteria were as follows: post at least one comment, suggestion, or question about someone else’s hypermedia project; incorporate ideas or concepts gathered from the face-to-face tutorials and assigned readings; and articulate well-reasoned positions.

Since the omnipresence of the tutor or instructor’s continual monitoring of message postings can be inherently oppressive to certain students and ideas, and yet to remove oneself completely may abdicate responsibility for overseeing a required learning activity (Fauske & Wade, 2003-2004), the tutor in our study only participated in the following manner: answered any pre-service teachers’ questions that were specifically directed to the tutor and posted instructions at the very onset of the online discussion to help the pre-service teachers remember the specific tasks they had to do. Hence, the entire online discussion was very much controlled by the pre-service teachers. Questions, prompts, comments, and suggestions were generated freely by the participants.

**Reflection Log**

The main purpose of the reflection log was to have the pre-service teachers think about the suggestions or comments that they received from their peers with regards to the pre-service teachers’ own hypermedia design projects. The pre-service teachers would then give their reasons for accepting or rejecting the suggestions or comments. We believe that the reflection log served four objectives:
1. It helped to make the pre-service teachers’ tacit perspectives about hypermedia design concepts more explicit. This would enable the tutor to address any misconceptions that the pre-service teachers might have in their design.

2. The very process of writing in a reflection log itself encourages higher-level cognition such as analysis, synthesis, evaluation as well as clear and precise thinking (Garrison, 1993).

3. It gave the pre-service teachers time to think about the suggestions they received and to consider whether it would be appropriate to incorporate these suggestions into their projects.

4. It provided an avenue for shy pre-service teachers to voice their disagreements without the fear of being seen as argumentative or being laughed/ridiculed at.

We summarize the activities and objectives of the four different dimensions in Table 2.

We conjecture that each of the dimensions can facilitate certain ill-structured problem solving process. Table 3 shows the mapping between the ill-structured problem solving process and our learning environment.

For the purpose of this article, we examined only the use of asynchronous online discussion and reflections log, and investigated in detail their roles in supporting ill-structured problem solving.

**RESEARCH QUESTIONS**

The following four research questions were the focus of this study:

1. What types of ill-structured problem solving process did the pre-service teachers exhibit during the asynchronous online discussion?
2. What types of ill-structured problem solving process did the pre-service teachers exhibit in their reflection log?
3. How did the pre-service teachers perceive the use of asynchronous online discussion in solving an ill-structured problem?
4. How did the pre-service teachers perceive the use of reflection log in solving an ill-structured problem?

**METHOD**

**Subjects**

The subjects for this research were 47 pre-service teachers (17 male, 30 female), enrolled in a diploma in education program. This gender mix is normal for education majors at the National Institute of Education (NIE), Singapore. We acknowledge that any results cannot be generalized to other pre-service teacher populations. Of those pre-service teachers completing an evaluation
survey, 4.3% responded that they *seldom* participated (i.e., 1–2 times) in asynchronous online discussions, 40.4% said they used it *sometimes* only (3–5 times), while 54.2% said they used it *often* (more than 5 times).

**Instrumentation**

The main instrument used in this study was the ill-structured problem solving processes articulated by Jonassen (1997) (see Table 1). In addition to that, we also made use of the following instruments—a questionnaire survey for all the pre-service teachers ($N=47$), open-ended questions, and focus group interviews to

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<table>
<thead>
<tr>
<th>Dimension</th>
<th>Activity and objective</th>
</tr>
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<tbody>
<tr>
<td>Tutor-led face-to-face tutorial</td>
<td>• Direct instruction—to provide core concepts and principles of good hypermedia design.</td>
</tr>
<tr>
<td></td>
<td>• Instructor-led discussions on the characteristics of good and bad hypermedia projects.</td>
</tr>
<tr>
<td></td>
<td>• Instructor assisted the pre-service teachers to produce drafts of their hypermedia projects.</td>
</tr>
<tr>
<td>Face-to-face discussion among group members</td>
<td>• Identify the design problems of the group’s <em>own</em> hypermedia project.</td>
</tr>
<tr>
<td></td>
<td>• Identify and clarify alternative opinions about the group’s <em>own</em> project.</td>
</tr>
<tr>
<td></td>
<td>• Generate possible solutions to the design problems.</td>
</tr>
<tr>
<td></td>
<td>• Assess the viability of possible solutions to the design problems.</td>
</tr>
<tr>
<td></td>
<td>• Each group to produce a simple storyboard about their hypermedia projects.</td>
</tr>
<tr>
<td>Asynchronous online discussion</td>
<td>• Identify the design problems of <em>other</em> groups’ hypermedia projects.</td>
</tr>
<tr>
<td></td>
<td>• Identify and clarify alternative opinions about other groups’ projects.</td>
</tr>
<tr>
<td></td>
<td>• Generate possible solutions to the design problems.</td>
</tr>
<tr>
<td></td>
<td>• Assess the viability of possible solutions to the design problems.</td>
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<tr>
<td>Reflection log</td>
<td>• Enable the pre-service teachers to reflect upon the different suggestions and comments they received about their own hypermedia design projects.</td>
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<tr>
<td></td>
<td>• The pre-service teachers will give their reasons whether to accept or reject the received suggestions.</td>
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</table>
help ensure accuracy of the conclusions drawn and hence enhance the reliability and validity of the study.

Questionnaire

Each pre-service teacher completed a questionnaire with 29 5-point Likert-scale items (1 = almost never, 2 = seldom, 3 = sometimes, 4 = often, 5 = almost always). The questionnaire was used to assess the pre-service teachers’ perceptions about their accessibility, participation, reflection, and satisfaction of using asynchronous online discussion in designing hypermedia projects. Sample questions include:

Table 3. Mapping between Ill-Structured Problem Solving Processes and the Learning Environment

<table>
<thead>
<tr>
<th>Ill-structured problem solving process</th>
<th>Learning environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify the design problem</td>
<td>• Tutor-led face-to-face tutorial</td>
</tr>
<tr>
<td></td>
<td>• Face-to-face discussion among group members</td>
</tr>
<tr>
<td></td>
<td>• Asynchronous online discussion</td>
</tr>
<tr>
<td>Identify and clarify alternative opinions</td>
<td>• Tutor-led face-to-face tutorial</td>
</tr>
<tr>
<td></td>
<td>• Face-to-face discussion among group members</td>
</tr>
<tr>
<td></td>
<td>• Asynchronous online discussion</td>
</tr>
<tr>
<td>Generate possible problem solutions</td>
<td>• Tutor-led face-to-face tutorial</td>
</tr>
<tr>
<td></td>
<td>• Face-to-face discussion among group members</td>
</tr>
<tr>
<td></td>
<td>• Asynchronous online discussion</td>
</tr>
<tr>
<td>Access the viability of alternative solutions</td>
<td>• Tutor-led face-to-face tutorial</td>
</tr>
<tr>
<td></td>
<td>• Face-to-face discussion among group members</td>
</tr>
<tr>
<td></td>
<td>• Asynchronous online discussion</td>
</tr>
<tr>
<td></td>
<td>• Reflection log</td>
</tr>
<tr>
<td>Monitor the problem space and solution options</td>
<td>• Reflection log</td>
</tr>
<tr>
<td></td>
<td>• Asynchronous online discussion</td>
</tr>
<tr>
<td>Implement the solution</td>
<td>• Creating the hypermedia projects</td>
</tr>
<tr>
<td>Adapt the solution</td>
<td>• Feedback from actual intended users</td>
</tr>
</tbody>
</table>
• The discussion forum is easy for me to use.
• The fact that I cannot see my fellow participants encourages me to post my ideas or opinions more freely.
• I reflect more when I am in the online discussion than when I am in class.
• Going to the online discussion forum is worth my time and effort.

The initial version of the questionnaire was piloted prior to its use in this study. Online tutors and students were asked to comment on the preliminary version for content and face validity. Some of the survey items were changed or reworded based on these comments. The final modified version was then administered to the entire sample.

We also assessed the internal consistency reliability of each multi-item scale by using Cronbach’s alpha coefficient. The results are: accessibility (0.78), participation (0.83), reflection (0.74), and satisfaction (0.88). The figures indicate that the items on the survey are satisfactory in terms of their consistency in measuring each of the scales.

**Open-Ended Questions and Focus Group Interviews**

Open-ended questions were used in the study to allow the pre-service teachers to elaborate on their opinions about the factors that affect their satisfaction in using asynchronous online discussion in the context of solving an ill-structured problem. Sample questions include:

• What are the advantages of participating in an online discussion forum when designing a hypermedia project?
• What about the disadvantages of participating in an online discussion forum when designing a hypermedia project?

Focus group interviews were also conducted to elicit in-depth information about the pre-service teachers’ perceptions on the factors that may affect their satisfaction in using asynchronous online discussion and reflection log. We chose focus group interviews over individual interviews because we believe the interaction between the participating pre-service teachers in focus groups elicits more of the students’ point of view by allowing a struggle of understanding of how others interpret key terms or ideas and a debate of issues raised (Morgan, 1993). Table 4 summarizes the instruments, data collection sources, and research questions of this study.

**Procedure and Data Analysis**

Prior to the commencement of the asynchronous online discussion session, all the pre-service teachers were first briefed in a face-to-face session, about the task they were to do as well as the objectives of the online discussion and reflection log. At the end of the whole course, the pre-service teachers completed the
<table>
<thead>
<tr>
<th>Research questions</th>
<th>Instruments</th>
<th>Data sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>What types of ill-structured problem solving process did the pre-service teachers exhibit during the asynchronous online discussion?</td>
<td>• Indicators of ill-structured problem solving processes (see Table 1)</td>
<td>• Transcripts of the asynchronous online discussion</td>
</tr>
<tr>
<td>What types of ill-structured problem solving process did the pre-service teachers exhibit in their reflection log?</td>
<td>• Indicators of ill-structured problem solving processes (see Table 1)</td>
<td>• Reflection logs</td>
</tr>
<tr>
<td>How did the pre-service teachers perceive the use of asynchronous online discussion in solving an ill-structured problem?</td>
<td>• Questionnaire • Open-ended questions • Focus group interviews</td>
<td>• Responses to the questionnaire • Responses to the open-ended questions • Interview transcripts</td>
</tr>
<tr>
<td>How did the pre-service teachers perceive the use of reflection log in solving an ill-structured problem?</td>
<td>• Focus group interviews</td>
<td>• Interview transcripts</td>
</tr>
</tbody>
</table>
questionnaire, the open-ended questions, and the focus-group interviews. The focus group interviews were about 45 minutes long and, with the permission of the pre-service teachers, these interviews were audio taped to assist in accurately capturing all responses. All online discussion transcripts and reflection logs were also collected for analysis at the conclusion of the course.

The analysis of all the pre-service teachers’ online transcripts and reflection logs were carried out in two parts. In the first part, the transcripts and logs were read and divided into message ideas. A message idea was the unit of measure used in this study. Once the message ideas were identified, the analysis then moved into the second part where the ill-structured problem solving processes (shown in Table 1) were used to identify the various such processes evident in both the online transcripts and reflection logs.

One main concern in the content analysis of the reflection logs and online transcripts is the high degree of subjectivity involved in putting the various ill-structured problem solving processes into their correct categories. Therefore, to minimize this high degree of subjectivity, the definitions of the various ill-structured problem solving processes were carefully studied. We then discussed any ambiguities of the definitions that arose until a mutual agreement was reached. We also got ourselves familiar with the seven steps by doing a “sample exercise” independently on some transcripts and compared the results. Once we became familiar with the seven steps, we then coded and categorized the transcripts independently. Any uncertainties of the coding and categorization faced were discussed and negotiated until a mutual agreement was reached.

In order to investigate the pre-service teachers’ perceptions on the use of asynchronous online discussion and reflection log in solving an ill-structured problem, we analyzed the students’ responses to the questionnaire, open-ended questions, and focus-group interviews. From these various sources of data, units of information were coded and sorted according to recurring themes or categories.

RESULTS

This section looks at the results and discusses its relevance in terms of the four research questions raised earlier.

1. **What types of ill-structured problem solving processes did the pre-service teachers exhibit during the asynchronous online discussion?**

A total of 516 ill-structured problem solving processes were found in the asynchronous online discussion transcripts. On average, each pre-service teacher thus exhibited 11 problem solving processes. The data in Table 5 reveal that the majority of the ill-structured problem solving process was “Articulate problem space and contextual constraints” (i.e., N = 197), followed by “Generate possible
problem solutions” \((N = 148)\). However, there were relatively few “Identify and clarify alternative opinions” \((N = 93)\), “Assess the viability of alternative solutions” \((N = 27)\), and “Monitor the problem space and solution options” \((N = 41)\).

Table 6 provides a summary of instances from the asynchronous online discussion that represent the different types of ill-structured problem solving processes. The names of the participants have been changed to ensure anonymity.

Table 5. Types of Ill-Structured Problem Solving Processes Exhbitied by the Pre-Service Teachers in Their Online Discussion Transcripts

<table>
<thead>
<tr>
<th>Ill-structured problem solving process</th>
<th>Number of times occurred</th>
</tr>
</thead>
<tbody>
<tr>
<td>Articulate problem space and contextual constraints</td>
<td>197</td>
</tr>
<tr>
<td>Identify and clarify alternative opinions, positions, and perspectives</td>
<td>93</td>
</tr>
<tr>
<td>Generate possible problem solutions</td>
<td>143</td>
</tr>
<tr>
<td>Assess the viability of alternative solutions by constructing arguments and articulating personal beliefs</td>
<td>27</td>
</tr>
<tr>
<td>Monitor the problem space and solution options</td>
<td>41</td>
</tr>
<tr>
<td>Implement and monitor the solution</td>
<td>10</td>
</tr>
<tr>
<td>Adapt the solution</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 7 shows the types of ill-structured problem solving processes exhibited by the pre-service teachers in their reflection logs. The data in Table 7 reveal that the majority of the ill-structured problem solving processes found in the reflection log was “Assess the viability of alternative solutions” \((i.e., \(N = 183\))\), followed by “Monitor the problem space and solution options” \((N = 108)\) and “Implement the solution” \((N = 102)\). There was no “Articulate problem space,” “Identify and clarify alternative opinions,” “Generate possible problem solutions,” or “Adapt the solution” process found.

2. What types of ill-structured problem solving processes did the pre-service teachers exhibit in their reflection logs?

Table 7 shows the types of ill-structured problem solving processes exhibited by the pre-service teachers in their reflection logs. The data in Table 7 reveal that the majority of the ill-structured problem solving processes found in the reflection log was “Assess the viability of alternative solutions” \((i.e., \(N = 183\))\), followed by “Monitor the problem space and solution options” \((N = 108)\) and “Implement the solution” \((N = 102)\). There was no “Articulate problem space,” “Identify and clarify alternative opinions,” “Generate possible problem solutions,” or “Adapt the solution” process found.
Table 8 shows some actual examples of the ill-structured problem solving processes found in the pre-service teachers’ reflection logs.

3. **How did the pre-service teachers perceive the use of asynchronous online discussion in solving an ill-structured problem?**

The data from the pre-service teachers’ responses to the questionnaire, open-ended questions, and focus-group interviews can be roughly classified into two themes: 1) the benefits and 2) the limitations of using asynchronous online discussion in solving an ill-structured problem. Each will be elaborated in the following section.

**Benefits of Using Asynchronous Online Discussion in Solving Ill-Structured Problem**

*Flexibility and convenience*—First of all, a majority of pre-service teachers (93.6%) perceived that the online discussion provided a flexible and convenient way for them to interact with one another to solve problems related to their hypermedia projects. The pre-service teachers indicated in the questionnaire that they often accessed the online discussion at places and times convenient to them. Thus, the availability of the discussion forum for 24 hours a day and 7 days a week enabled the pre-service teachers to continue their discussions at their own pace outside the classroom without the constraints of specific allotments of time and place.

*Increased reflection*—Another benefit noted by the pre-service teachers was the increased time to reflect upon the various hypermedia projects in the asynchronous online discussion. In fact, 63.8% of the pre-service teachers responded in the questionnaire that they reflected more during the asynchronous online discussion than when they were in class. The pre-service teachers indicated that they were able to think more critically about each other’s projects and give more thoughtful feedback in the online discussion due to the larger amount of time they had. The participants felt that there is often very little time for in-depth thinking in a normal classroom because of the spontaneity of face-to-face interactions.

*Opportunity to express thoughts more freely and descriptively*—Since ill-structured problems are dialectical in nature, requiring the problem solver to identify all the various perspectives, views, and opinions on a problem (Jonassen, 1997), it is essential that a learning environment be provided that allows participants to voice their opinions freely and without being impeded by the behavior of others. Since physical bodies are absent in electronic space, asynchronous online discussion has the potential to eliminate inequities associated with gender, race, or class and thus give a voice to all groups (Fauske &
### Table 6. Evidence of Ill-Structured Problem Solving Processes in the Asynchronous Online Discussion

<table>
<thead>
<tr>
<th>Name</th>
<th>Examples from the asynchronous online discussion</th>
<th>Ill-structured problem solving processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alex</td>
<td>&quot;I can understand you choose red as background because the topic is on Chinese New Year, but I feel that if learners have to go through all slides with background red, by the time they finish reading, it may be too tiring for the eyes.&quot;</td>
<td>Student identifies a possible design problem in one of the hypermedia projects. (Articulate the problem space)</td>
</tr>
<tr>
<td>John</td>
<td>&quot;I find the background color too strong for the eyes.&quot;</td>
<td>Student agrees with Alex on the color problem. (Articulate the problem space)</td>
</tr>
<tr>
<td>Jane</td>
<td>&quot;Hi, I’m kind of impressed with the red that was used. It does not fail to capture learner’s interest.&quot;</td>
<td>However, another student gives an alternative opinion about the choice of red. She feels that the use of red is able to capture the learner’s interest. (Identify alternative opinions)</td>
</tr>
<tr>
<td>Ben</td>
<td>&quot;I agreed with Jane that it’s appropriate to use red for the background as it creates the Chinese New Year atmosphere, however, in order not to have it too eye-tiring, you may actually blurred-off the background (water-marked it).&quot;</td>
<td>This student also gives an alternative opinion that is in line with Jane’s views but poses a possible solution that could address Alex’s and John’s concern. (Identify alternative opinions and generate possible solutions)</td>
</tr>
<tr>
<td>Mariam</td>
<td>&quot;I agree that you should watermark your strong red background or perhaps choose a lighter shade of red.&quot;</td>
<td>Student posts a similar suggestion to Ben’s. (Generate possible solutions)</td>
</tr>
</tbody>
</table>
Jenny

“Yep. Using red as the background is appropriated for the topic. Very cheery and giving the feeling of “Chinese new year.” As for the changing of the bright red to light red, as mentioned in some other threads, I think that it is not necessary. It may lose the feeling of being in the Chinese new year.”

This student, however, thinks that there is no problem with red in the first place. She justifies her view.

(Identify alternative opinions)

Thiva

“Hi there,
Yup, I agree with Jenny. Stick to the red but I’d suggest the bright tone of red be used for the slides only with the main headings. This means that the other slides with the main content (with many words) should have a milder red background. Not all students might enjoy such a strong color throughout the software. They might feel that their eyes are strained halfway through the software. Definitely stick to red, cause the theme you have used is Chinese New Year. Just think of the different tones of red for the other slides. The graphics match the theme as well, very cute and interesting.”

Student agrees with Jenny but she did not stop here.

(Identify alternative opinions)

Student goes on to assess the viability of the different suggestions and comes out with a novel suggestion that could accommodate the alternative viewpoints.

(Generate possible solutions and assess the viability of alternative solutions)

Fong

“I don’t agree with you [Thiva] that they should still use red as their background just because the topic is on “Chinese New Year.” We should also consider on the user, whether they can accept it and stay focus on it. I, myself find it too bright, and difficult to stay focus on the words. If you want to create the atmosphere, there are a lot of things (mandarin orange, fire cracker, Ang Bao etc.) that can be used to bring out “Chinese New Year” mood.”

Student disagrees with Thiva.

(Identify alternative opinions)

Student suggests that the design problem may be avoided by using other means to highlight the festive mood.

(Generate possible solutions)
An analysis of the results of the questionnaire shows that 64.6% of the pre-service teachers were more outspoken during the online discussion than in normal classroom situations. Not seeing each other’s faces in the text-based asynchronous online discussion seems to help the participants express their thoughts more freely and descriptively, as explained by one pre-service teacher, in a reflection log:

The classroom environment sometimes hindered us from expressing our views. This is especially so in the Asian culture. This may be due to the awkwardness in expressing [one’s views] in a crowd. The online discussions provide an alternative platform where such awkwardness can be evaded. There is more freedom of expression, as we do not see one another face to face. Discussions can therefore be more critical and hence benefiting every user.

Easy and permanent access to other people’s ideas—The permanent record of messages affords the participants a very convenient means of retrieving and reviewing other participants’ ideas, as explained by one pre-service teacher:

Comments made by other participants can be reviewed, as they are stored in a database. We can always reread some of these discussions or comments made.
It is more advantageous compared to verbal comments, which cannot be reviewed or repeated.

We believe the value of being able to repeatedly and conveniently review other people’s contributions may help a participant draw many different perspectives about whatever issue is being discussed, e.g., the problem space or the possible problem solutions. A person who revisits the contributions a number of times with different purposes in mind can come up with multiple presentations of information (Dick, 1992), an essential element when solving ill-structured problems.

Limitations of Using Asynchronous Online Discussion in Solving Ill-Structured Problems

Although the pre-service teachers’ perceptions of the asynchronous online discussion were favorable in general, there are also some limitations of using the online discussion. We describe three limitations found in this study.

Procrastination or failure to respond to messages—While the asynchronicity of asynchronous online discussion affords the pre-service teachers more time to think, it can also result in the problem of delays between message contributions. Therefore arriving at decisions, sharing ideas, and getting reactions from fellow participants require an extended time line (Hawkes, 2000). As one pre-service teacher noted, “there was no immediate response from my classmates on some ideas that I wish to clarify urgently,” while another said, “some [classmates] never respond to the message posted, as a result, the flow of communication was not so good.” Therefore, the problem of delays between postings not only could lead to communication anxiety, i.e., the feeling of speaking into a vacuum (Feenberg, 1987) but also make the momentum of a discussion difficult to maintain (McCabe, 1998).

Hard to express some ideas clearly in words—Besides the problem of procrastination and failure to respond to messages, some pre-service teachers found composing text a tedious and time consuming affair. Not all participants of online discussion could express themselves well in writing.

Posting messages simply for the sake of participation—It was also found that some of the pre-service teachers’ suggestions sounded very much the same. According to Bodzin and Park (2000), this may be due to the following reasons:

1. The pre-service teachers could have posted their comments without first reading the comments that have already been posted by others.
2. The pre-service teachers could have merely repeated someone else’s comments without adding any new information or insights. As one pre-service teacher said in the interview:
<table>
<thead>
<tr>
<th>Comments/suggestions from classmates</th>
<th>Accept/Reject</th>
<th>Reasons for acceptance/rejection</th>
<th>Ill-structured problem solving processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>I personally find that the picture of the two bears on page 12 is not very suitable. It is quite obscene.</td>
<td>Reject</td>
<td>“We both find that the picture is appropriate and not obscene as it shows how bears mate before reproduction can take place. In our students’ task, we ask the students to find out how mammals and fish reproduce. This is a critical and important area to determine whether a particular animal lays eggs or gives birth.”</td>
<td>Both students rejected the suggestion that the picture of the two bears was obscene. They provided their reasons that showed why they were against the idea. (Assess the viability of alternative solutions)</td>
</tr>
<tr>
<td>I think you could place the navigation [buttons] all along the side or the bottom of the screen. It looks neater and the user will know where to go... because now there’s a table at the left corner, resources at the right side and some more others at the bottom right. I would suggest [you] to place all these along just one side and not “all over the place.”</td>
<td>Reject</td>
<td>“We feel that there is nothing wrong with the placement of these icons. We feel that if we squeeze all the icons at the bottom of the screen, it will be too cramped and confusing. We feel that the main navigation icons should remain at the bottom and the other extra icons/hyperlinks should be elsewhere to prevent confusion.”</td>
<td>(Assess the viability of alternative solutions)</td>
</tr>
</tbody>
</table>
I noticed that the navigation buttons are rather inconvenient to use mainly because they are animated. I think buttons should be simple so that the focus would be on the activity itself and not on the navigational devices.

Just to check, what is the purpose of the navigation buttons on slide 3? I suggest that you provide a “back” or “content” button on slide 8. This is because “itchy hands” students like me will press on that button just to see where it will lead me and when I can’t return, I will get panicked.

Accept  “We agree that perhaps there is a bit of a distraction with the use of animated navigation buttons. We will minimize the distraction by using normal navigation buttons.”

Accept  “We will make the necessary additions for easier learner control to prevent confusion, as learner control is an important aspect of a hypermedia design.”

(Assess the viability of alternative solutions, monitor the solution option and implementing the solution)
Students often tend to echo what other students have said rather than giving their own viewpoints. They will just give suggestions for the sake of participation.

This problem of commenting just for the sake of participation could possibly be due to the discussion deadlines and the awarding of grades by the tutor. As mentioned earlier, the asynchronous online discussion ran for two weeks, and by the end of it, students should have posted at least one comment, suggestion, or question about someone else’s hypermedia project. Although discussion deadlines can serve as a participant motivator, it can nonetheless stifle actual dialogue conversation because some students were simply racing to post messages by the due date as opposed to reading and responding to one another’s messages (Dennen, 2001). We believe that this problem becomes more acute when grades are provided for participation. Students therefore felt pressurized to “make themselves heard.” However, this is not to say that deadlines are disruptive to the discussion. We agree with Dennen’s (2001) observations that deadlines, if properly selected and used, can promote discussion. Some possible guidelines for the use of deadlines will be presented in the final section of this article.

4. How did the pre-service teachers perceive the use of the reflection log?

As mentioned previously, the main purpose of the reflection log was to have the pre-service teachers reflect and assess the suggestions or comments that they received from their peers with regards to the pre-service teachers’ own hypermedia design projects.

Generally, the pre-service teachers found the reflection log a good way to help them further improve their hypermedia projects. As remarked by one pre-service teacher:

> It [the reflection log] is a very good exercise because we have to look through every point that is raised by our classmates. We then have to consider whether to accept or reject the points made.

Another pre-service teacher commented in an interview:

> Reflection logs are necessary to force us to consolidate our own thoughts and put them on paper. While we are doing our projects, the reflection logs also act as checklists to see if we have achieved applying what we had learnt into our projects.

Lastly, we believe the following remark by another pre-service teacher sums up clearly the role of the reflection log:

> If I wasn’t asked to do this [reflection log], I would most probably not be self-reflecting when I looked through the project. It’s good to be analytical . . .
to reflect back on what we’ve done. If there’s no reflection, there’s no learning.

**DISCUSSION**

In this study, we investigated the roles of asynchronous online discussion and reflection log in supporting ill-structured problem solving. The discussion on the above findings will be grouped into two themes: asynchronous online discussion and reflection log.

**Asynchronous Online Discussion**

The results of the study indicate that asynchronous online discussion appears to support mainly the following two types of ill-structured problem solving process: “Articulate the problem space” and “Generate possible problem solutions.” Why? Although most participants indicated in their comments that the major benefit of asynchronous online discussion was its flexibility and convenience, the more important implication is that participants perceived the flexibility to be conducive to deep reflective thinking, as shown in one of the pre-service teachers’ comment:

> The asynchronous online discussion gave us ample time to think and organize our thoughts before we comment about a project. Most of us need time to make careful analysis before we give comments or suggestions about other classmates’ hypermedia design projects, especially when we gather with classmates whom we only meet once a week.

Participants thus believed that the greater levels of personal reflection and critical thinking afforded by the asynchronous online discussion helped them better articulate the design problems of their classmates’ hypermedia projects and to suggest solutions to address those problems.

However, the relatively low rate of “Identify and clarify alternative opinions” process ($N = 93$), “Assess the viability of alternative solutions” ($N = 27$), and “Monitor the problem space and solution options” ($N = 41$) in the asynchronous online discussion are interesting findings. We shall discuss these in turn.

Regarding “Identify and clarify alternative opinions,” we had earlier anticipated the number of such process to be more or at least equal to the “Articulate the problem space” process. This is because an ill-structured problem is dialectical in nature and usually has divergent solutions, thus requiring the problem solver to identify all the various perspectives, views, and opinions on that problem (Jonassen, 1997). The low rate ($N = 93$) found in this study suggested that many pre-service teachers did not attempt to fully address other people’s different opinions about the design problems.

Why is this so? Perhaps one answer lies in the possibility that these pre-service teachers find it awkward to engage in a dialectical clarification of opinions in a
text-based environment as compared to a face-to-face environment. In the text-based asynchronous online discussion environment, the pre-service teachers have to type out every single question and comment. This may create problems for participants who are not so comfortable with writing, as commented by one pre-service teacher:

Sometimes certain messages are difficult to express in words. At other times, you may not understand what the other person is trying to convey.

Another participant also said, “Sometimes ideas that are put across may appear as something else to a reader.”

The second possibility could be due to the problem of delays between message contributions in an asynchronous online discussion. These delays, either due to procrastination or failure to respond at all, can cause great frustrations for participants who are waiting for someone to respond to their opinions or queries, causing them to give up altogether trying to clarify the alternative opinions; 13.9% of the pre-service teachers complained about having to wait for responses on some ideas they wished to clarify urgently. One elaborated, “We have to wait for responses unlike in face-to-face discussion where you can have it quickly.” Another pre-service teacher recounted how she had to wait for a few days before someone actually commented on her ideas or suggestions. This study confirms other research that found that the time lag between interactions frustrates participants of asynchronous online discussion (Jonassen & Kwon, 2001).

To shed some light on this problem of delay, we analyzed the pre-service teachers’ responses to the open-ended questions as well as their interview transcripts and found the following two reasons:

1. An overloaded online system, where it becomes difficult to make connections with the BlackBoard software over at NIE because the lines were busy. An analysis of the time of the message postings in this study revealed that about 260 messages were posted between 1200 and 1500 hrs. This may be the period where the pre-service teachers had difficulty logging to the discussion forum, prompting one participant to comment, “the slow Internet access time makes online discussion a very frustrating experience.”

2. In a face-to-face interaction, the pre-service teachers can also contribute through exchanges of non-verbal signals and cues. However, in an asynchronous online discussion, the only visible way of contribution is through written words. Some participants might therefore be disheartened to continue with the discussion when they did not get any non-verbal feedback from others. As one participant commented, “No facial expressions hence no feedback.”

With regard to the low rate of “Assess the viability of alternative solutions” and “Monitor the problem space and solution options,” it is important that one does not automatically interpret this as a sign that the participants are either
ignorant of these two types of ill-structured process or ignored them altogether. It is possible that some pre-service teachers might have been assessing and reflecting quietly on the issues presented in the asynchronous online discussion but for one reason or another did not explicitly share the knowledge with other pre-service teachers. We believe that a transcript analysis can only provide an indicator of the ill-structured problem solving process and is based on the assumption that the ill-structured problem solving process is an observable one.

Therefore, one possible way to evaluate whether the pre-service teachers had indeed assessed and reflected on the various opinions offered in the online discussion is to have other additional forms of evaluation, e.g., the use of reflection log.

**Reflection Log**

Findings of this study indicate that the use of reflection log seems to facilitate the process of “Assessing the viability of alternative solutions” and “Monitor the problem space and solution options.” This shows that the pre-service teachers were indeed able to assess and monitor the alternative solutions but preferred to do so in a reflection log rather than in the asynchronous online discussion. Perhaps the pre-service teachers viewed these two types of ill-structured problem solving process as personal judgments, which are the result of personal reflections, and therefore did not feel the need to make these explicitly known to others.

The no occurrence of “Articulate problem space,” “Identify and clarify alternative opinions,” “Generate possible problem solutions,” and “Adapt the solution” process is not surprising given the nature and purpose of the reflection log which was to have the pre-service teachers think and assess the suggestions or comments they received from their peers with regards to their own hypermedia design projects.

**CONCLUSION AND IMPLICATIONS**

In this article, we examined the use of asynchronous online discussion and reflection log to help Singapore pre-service teachers solve ill-structured problems. Results reveal that the use of asynchronous online discussions in an Asian context appears to support mainly the following two types of ill-structured problem solving process: “Articulate the problem space” and “Generate possible problem solutions,” while the reflection log seems to facilitate the process of “Assessing the viability of alternative solutions” and “Monitor the problem space and solution options.” Analysis of the pre-service teachers’ perceptions of using asynchronous online discussion reveals that the use of the discussion forum is flexible and convenient in that it transcends time and space, thus allowing participants to take part in the discussion about hypermedia design anytime and anyplace they are comfortable with. The asynchronicity nature of the discussion also gives
participants more time to reflect about the design projects. Furthermore, the lack of social and facial cues in the online discussion reduces social dominance, making the participants feel more comfortable in expressing their thoughts more freely and descriptively, an important step to sharing ideas in order to solve ill-structured problems.

On the other hand, the use of asynchronous online discussion also has its limitations; it can lead to procrastination in responding to the message postings, which makes the momentum of a discussion difficult to maintain. The text-based form of communication also posed a problem to those participants who were not so skilled in writing. There were also some participants who were content to merely echo what other participants had said.

Regarding reflection log, we found that the pre-service teachers generally felt the use of such tool an effective and useful way to help them consolidate their thoughts, and improve their hypermedia projects.

Implications for design that stem from this study are the following: First, instructors should incorporate both asynchronous online discussion and reflection logs in the learning environment to help their students solve ill-structured problems. Our study highlighted the fact that the use of these two tools in tandem supports the ill-structured problem solving process better than if they were to be used alone. Second, instructors should include some face-to-face sessions during the duration of the asynchronous online discussion. This would help participants, who are put off by the absence of non-verbal cues such as facial expressions, to feel comfortable in contributing their messages. Third, instructors may wish to ask the online participants to post their messages within different time slots. For example, some students may be asked to post their messages between 1:00 P.M. to 4:00 P.M., and others between 5:00 P.M. to 8:00 P.M., and so on. This may help avoid the problem of overloading the online discussion forum where many participants decide to post their messages at the same time. This, however, would make the asynchronous online discussion less flexible in terms of time-independence. But we believe that the participants can make the necessary adjustments if the notice of the different time slots is given to them in advance. Fourth, instructors should provide guidelines and strategies to help online participants learn how to respond to each other’s comments or ideas. By giving such guidelines, participants will be more likely to identify, ask questions, and clarify each other’s alternative suggestions or opinions. Fifth, instructors should implement multiple deadlines that are carefully designed in order to allow enough time for students to reasonable contribute (Dennen, 2001). This would help mitigate the problem of students racing to post messages by a final due date (this is in the case of having only one final deadline), which results in some messages being alike in insights and content.

It is important to bear in mind, however, that the aforementioned implications should not be viewed as authoritative recommendations for the design of an ill-structured problem solving learning environment. Instead they should be
recognized as possible guidelines based on our experiences gathered from this research study. Future research could replicate this study among the pre-service teachers of other cultural groups or countries to determine how asynchronous online discussion and reflection logs can be used to support ill-structured problem solving in different sociocultural contexts.

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