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Designing Asynchronous Online Discussion Environments: Recent Progress and Possible Future Directions

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Abstract: Asynchronous online discussion environments are important platforms to support learning. Research suggests, however, threaded forums, one of the most popular asynchronous discussion environments, do not often foster productive online discussions naturally. This paper explores how certain properties of threaded forums have affected or constrained the quality of discussions, and argues that developing alternative discussion environments is highly needed to offer better support for asynchronous online communication. Using the Productive Discussion Model developed by Gao, Wang & Sun (2009), we analyzed current work on four types of asynchronous discussion environments that have been developed and researched: constrained environments, visualized environments, anchored environments and combined environments. The paper has implications for developing future asynchronous discussion environments. More specifically, future work should aim at (a) exploring new environments that support varied goals of learning; (b) integrating emerging technologies to address the constraints of current environments; (c) designing multi-functional environments to facilitate complex learning, and (d) developing appropriate instructional activities and strategies for these environments.

Designing Asynchronous Online Discussion Environments: Recent Progress and Possible Future Directions

Asynchronous online discussion plays an important role in online and hybrid courses by supporting a variety of educational activities. It is considered an extension of instructional practices that promotes dialogue, reflection, knowledge construction, and self-assessment (Gerosa, Filippo, Pimentel, Fuks, & Lucena, 2010; Kayler & Weller, 2007). Researchers believe that it frees learners from time and space constraints, providing ample possibilities for communication. Participating in asynchronous online discussion by sharing thoughts, asking questions, and providing feedback is one of the major means to support interaction and build communities in online learning environments (DeWert, Babinski, & Jones, 2006; Y. Yang, Yeh, & Wong, 2010). In addition, some argue that online discussion potentially allows for more in-depth discussions and more thoughtful learning than is possible in traditional face-to-face settings (Hawkes, 2006), because students in face-to-face discussions may not have sufficient time to think thoroughly before they respond. In online discussion forums, in contrast, the entire discussion is available for perusal, providing learners with opportunities for identifying, examining, and reflecting upon ideas (Collison, Elbaum, Haavind, & Tinker, 2000).

Asynchronous online discussion environments, typically threaded discussion forums, have been widely used in educational settings for such purposes. Despite of the popularity of threaded forums, it is argued that they "might not be the best technology to support the interactive and collaborative processes essential to a conversational model of learning" (Thomas, 2002, p. 364). Researchers have identified some problems in having students participate in threaded discussions. For example, there is a frequent lack of focus

in threaded discussions. The digressions in threaded forums prevent students from focusing on course content or developing an incisive understanding of the learning materials (Knowlton, 2001). In addition, some researchers notice that there is not much meaningful interaction taking place in threaded forums. In many forums, students post condensed expositions of their own ideas, without attending or responding to the ideas of others (Hara, Bonk, & Angeli, 2000; Larson & Keiper, 2002). Finally, the discussions often remain at a surface level, such as sharing or comparing information, seldom delving to deeper levels that involve negotiating meaning, synthesizing, or applying newly acquired knowledge (Gunawardena, Lowe, & Anderson, 1997).

To promote the quality of discussions, researchers have investigated different instructional approaches, including developing online activities to engage learners (Nussbaum, 2005; Seo, 2007), teaching and modeling ways of interaction (Choi & Johnson, 2005; Smet, Keer, Wever, & Valcke, 2010), and adopting teaching or moderating strategies (Bradley, Thom, Hayes, & Hay, 2008; Chen, Kinshuk, Wei, & Liu, 2011). A few researchers have taken a different approach and noticed that some of the problems result from the design and structure of threaded forums. Therefore, there is a need to design discussion environments with specific features to increase the likelihood of effective discussions. We argue that, to improve the quality of asynchronous online discussion, more attention should be paid to such effort. This paper discusses the theoretical basis of online discussion, analyzes the constraints of threaded forums, summarizes current work on designing discussion environments, and offers suggestions for designing online discussion environments.

A Model for Productive Online Discussion

The assumption that active participation in asynchronous online discussion is important for learning has been widely recognized (Morris, Finnegan, & Sz-Shyan, 2005). Learning through discussion involves a wide variety of cognitive and social activities. Researchers have studied learning occurring in online discussion forums from different perspectives, attempting to conceptualize its complex meanings (e.g., Henri, 1992; Garrison, Anderson, & Archer, 2000; Gunawardena, Lowe, & Anderson, 1997). Based on these theories, Gao, Wang and Sun (2009) proposed the Productive Discussion Model (see Table 1), suggesting that in a productive discussion, it is essential for participants to embrace the following four dispositions: (a) discuss to comprehend, (b) discuss to critique, (c) discuss to construct knowledge, and (d) discuss to share. These four dispositions address different but interrelated perspectives on learning.

**** Insert Table 1 ****

Discuss to Comprehend

A productive discussion involves learners' diverse and complex cognitive activities. Based on perspectives of cognitive psychologists, information is more likely to be understood or retained when individual learners are actively engaged in cognitive efforts such as questioning, interpreting, elaborating or relating the information to his/ her prior knowledge (Pressley, Wood, Woloshyn, & Martin, 1992). During productive discussions, participants need to comprehend the issues to be discussed or ideas shared in discussion forums by interpreting and elaborating ideas, building connections, and so on.

Discuss to Critique

Researchers taking the individual constructivist perspective emphasize the importance of argumentation in online discussions to trigger learners' knowledge

construction. From this perspective, knowledge acquisition originates from cognitive conflicts from social interactions. The conflict between the individual's existing understanding and new experiences creates disequilibration, which, in turn, leads the individual to questioning original assumptions and exploring new resolutions (Piaget, 1985). Based on this perspective, conflicting statements should be carefully developed and examined in productive discussions.

Discuss to Construct Knowledge

Researchers taking a social constructivist perspective focus on investigating collaborative knowledge construction in online discussions. From this perspective, individuals do not learn in isolation. Each individual may conceive the external reality somewhat differently, based on their unique prior experiences and their beliefs about them (Jonassen, 1991). A productive online discussion, as a result, should offer opportunities for social interaction and collaboration, where individuals can compare different perspectives, negotiate personal interpretations with those of others, and construct a richer understanding of the topic.

Discuss to Share

Related to the idea of collaborative knowledge construction, psychologists have also studied the role of learning community (Lave & Wenger, 1991). They consider that learning occurs when learners are immersed and play a role in communities of practice. According to this perspective, a productive online discussion is carried on in an online learning community in which learners embrace a sense of belonging, show mutual support, create shared values, and enjoy their shared identity.

In this paper, we will use this model as a framework to evaluate and critique the research on asynchronous online discussion environments because the model addresses diverse critical perspectives of learning in online discussion, thus it can serve as a useful framework to analyze the types of learning that is supported or inhibited in online discussion environments.

Constraints of Threaded Discussion Forums

One of the most commonly used environments for asynchronous online discussion is a threaded forum. In a threaded forum, participants can either start a new thread of discussion by creating a new post or continue an existing thread by replying to others' posts. Posts in a given thread are linked to each other in chronological order. Although the practice of having online discussions is well supported by learning theories, a few researchers believe that certain properties of threaded discussion forums may affect or constrain the quality of discussions. In particular, they have identified the following limitations of traditional threaded forums.

First, it is difficult to maintain a focused discussion in threaded forums. Many threaded forums are set up in a way that participants are likely to pay attentions to unread posts (bolded) and the most recent posts (listed at the top of the forums) rather than posts with important content. Hewitt (2003) noticed that, because participants are more likely to respond to recent posts and less likely to revisit older posts, the excessive focus on new posts can unintentionally shift participants' attention away from discussing important issues. Herring (1999) believed the asynchronous threaded discussion system resulted in a high level of overlapping exchanges and topic decay. She cited Lambiase's (2010) work, where Lambiase found that during the first nine days of discussion, the percentage of

posts on the group's global topic decreased steadily from 65% to 33%. Meaningful reflection, social interaction and knowledge construction can hardly occur when participants fail to maintain the focus of discussion on the learning content.

Second, it is difficult to promote interactive dialogues in threaded forums. In threaded forums, the hierarchical structure of discussion threads fails to represent the interrelationship of discussion posts. In a typical threaded forum, the hierarchical structure of the discussion only indicates the reply relationship between posts (by using indentation) and the time sequence of the replies (by showing the posts in a chronicle order). But Hewitt (2001) pointed out there is a significant distinction between the hierarchical structure imposed by the system and the linkages that are implicit in the text of the notes. "Online discussions may be much more intertwined and interrelated than the threaded representation indicates" (Hewitt, 2001, p. 210). In threaded forums, if a student's response is triggered by multiple messages posted by others, he/she may have difficulty in deciding whose post should be followed and how to integrate everyone's ideas in his/her response. In threaded forums, it can be hard for participants to perceive how discussions are interrelated and build upon previous discussions. As a result, threaded forums may not be able to "promote the interactive dialogue of conversation, but rather leads students towards poorly interrelated monologues" (Thomas, 2002, p. 351).

Third, it is hard to synthesize ideas in threaded forums. The hierarchical structure of threaded forums only supports the expanding and branching of the conversation, but provides little support for convergent processes (Hewitt, 2001). Rourke and Kanuka (2009), after reviewing the literature, found that researchers uniformly identify the majority of participants' posts in online forums as exploring ideas (*exploration)* and only

a negligible percentage of posts as integrating ideas for solutions (*resolution*). The absence of "counteracting processes that draw branches together, tease out the best ideas, and rally the community around promising new avenues of investigation" have made it difficult to build consensus or co-construct knowledge (Hewitt, 2001, p. 217).

Finally, there is a lack of emotional cues and timely feedback in threaded forums. Threaded forums are asynchronous text-based environments, making it hard to provide emotional cues and timely feedback. The lack of emotional cues may reduce the extent and the effectiveness of communication (Curtis & Lawson, 2001). Participants in Murphy and Coleman's (2004) study reported that, in the text-only environment, it was difficult to "discern the flavour of a reply", "read into responses" or avoid taking "a comment the wrong way" (Challenges Related to Text-Only, Online Communication section, para. 1). Lack of timely feedback may also affect the quality of discussion, because having to wait for several hours or days for replies from others greatly inhibit the momentum and flow of discussions (Jeong & Frazier, 2008).

In sum, threaded forums, though commonly used in online classes, have certain constraints, and may not be ideal to support various learning goals that might be achieved through asynchronous online discussion. To enhance the quality of online discussions in threaded forums, researchers have investigated how to provide appropriate instructions and guidelines to provoke good discussions (Ertmer et al., 2007; Nussbaum, 2005; Seo, 2007), and how to enhance participants' discussion skills (Choi & Johnson, 2005; Y. C. Yang, Newby, & Bill, 2005) as well as moderators' facilitation skills (Berge & Muilenburg, 2002; Bradley, et al., 2008). An alternative way, however, is to enhance the design of threaded forums or to design new discussion environments that encourage

particular learning processes. Unfortunately, limited progress has been made on designing alternative asynchronous online discussion environments. The next section discusses current work.

Method

Identification of Research

To present an overview of the discussion environments that have been developed and researched over the past few years, studies were selected based on the following steps. First, we searched for articles on online discussion environments in six refereed educational technology journal (*British Journal of Educational Technology*, *Computers and Education*, *Educational Technology Research and Development*, *Journal of Computer Assisted Learning*, *Journal of Educational Computing Research,* and *Journal of Educational Technology and Society*) from 2000 to May, 2011 using the key words such as "online discussion", "online communication", "asynchronous discussion", "discussion environment", and "discussion environment design". These journals were selected because they are among the most important channels where scientific research on the design, development and use of such environments take place.

Second, we read the abstracts of each paper found in the search results, and selected those studies that focus on designing asynchronous online discussion environments. Studies that are not related to discussion environment design or address only synchronous environment design were excluded. Altogether, seven articles were identified.

Finally, snowball sampling was conducted examining related articles cited in these seven papers. Six more articles were identified as per the selection criteria, and were thus added to the existing pool. We understand that the list of 13 studies is not exhaustive, but

the purpose of this study is not to provide a comprehensive review on the topic. Instead, it aims to critically evaluate a number of discussion environments that have been rigorously studied and represented the current research effort on designing asynchronous discussion environments. Evaluating these environments will thus provide insights for future research in the field.

Data Analysis

We conducted an analysis of the 13 studies in two phases. During the first phase, we coded each study for the following characteristics: environment names, features, and educational goals. During the second phase, we analyzed those environments based on their features to determine the major types of discussion environments. The first two authors first independently coded each of the studies for categories, and then discussed their coding and determined the major types of environments. The four types of discussion environments emerged from the data analysis were: constrained environments, visualized environments, anchored environments, and combined environments (see Appendix 1).

Four Types of Asynchronous Discussion Environments

This section describes the four types of asynchronous discussion environments in detail and discusses how the quality of online discussion in such environments can be improved based on the Productive Discussion Model.

Constrained Environments

Constrained environments are a pre-structured form of discussion environments that scaffold participants to participate in the discussion in certain ways. Typically, it requires participants to start their notes with a predefined phase - a note starter, such as "my

argument is..." (Jonassen & Remidez, 2005) or label their notes using a predefined set of post types, such as *evidence* or *elaboration* (Oh & Jonassen, 2007). The rationale is that such structured environments can promote participants' metacognitive thinking and engage them in desired cognitive processes (Jonassen & Remidez, 2005; Scardamalia & Bereiter, 1994). A few scholars have investigated the effectiveness of such environments.

Nussbaum and colleagues (2004), for example, encouraged counter-argument using a constrained environment, in which students were asked to choose from a drop-down menu such note starters as "on the opposite side," "I need to understand," and "my argument is" to begin their notes. By comparing discussion in this environment with that in threaded forum, they concluded the approach significantly increased the frequency of disagreement. However, note starters are not equally effective for different types of learners. They are particularly useful for students with low degrees of curiosity or assertiveness.

In addition to note starters, some researchers designed environments where participants are required to add a post type label adjacent to the titles of their posts. Hoadley and Linn's (2000) *SpeakEasy* environment uses semantic labels such as *and*, or, *but*, *i.e.*, and *?* to indicate the relationship of current post and previous posts. In their study, students were prompt to categorize their comments by picking a semantic label before providing a subject heading. When comparing student discussions in *SpeakEasy* with that in a regular threaded forum, they found no significant difference. Both discussion formats supported students to gain integrated understanding of the learning content. But research has led to inconsistent findings. In a constrained environment developed by Oh & Jonassen (2007), both post type labels (which are *hypothesis cause*,

solution generation, *verification*, *rebuttal*, *evidence*, and *elaboration*) and note starters (including 'My experience is . . .'; 'I believe . . .'; 'Research shows . . .'; 'A scholar says . . .') were applied. By comparing the online argumentation occurred in this environment with that in a threaded forum, Oh and Jonassen concluded that participants in the constrained environment generated more evidence posts, more hypothesis and hypothesis testing posts. The study conducted by Jeong and Joung (2007), however, reported negative effect of using such labels. Jeong and Joung compared the nature of online argumentation of three groups: (a) control group; (b) constraints-only group, where students posted only specific types of message from a prescribed set of message categories such as *arguments*, *evidence*, *critique* and *explanation*; and (c) constrained-with-labels group, where students posted specific types of message and at the same time manually labeled each message with a prescribed post type label. The study found that participants in the constraints-with-labels group were less likely to critique others and respond back to critiques than the other two groups, suggesting post type labels inhibited the process of developing deeper and more critical analysis of individual arguments.

In sum, the educational goal of most constrained environments is to promote the quality of online argumentation using note starters or post type labels, probably because, compared to other forms of discussion, argumentation has a stricter format and requires the presence of certain key components such as claim, ground (evidence, data), warrant, backing, rebuttal (Toulmin, 1958). In such cases, note starters or post type labels can provide learners necessary scaffolds through the process of argumentation. Both positive and negative effects were identified in using such environments. Researchers in these studies have investigated different starters or post type labels, and evaluated the quality of

discussion based on different criteria. As a result, it is hard to synthesize the research findings across the studies or to conclude what specific types of constrained environments are effective in what way.

The constrained environments have mainly been used for scaffolding the two types of dispositions specified in the Productive Discussion Model (disposition 2: *discuss to critique* and disposition 3: *discuss to construct knowledge*). Because in these studies, participants' response were restricted to the pre-determined types, such as *hypothesis cause*, *solution generation*, *verification*, *rebuttal*, *evidence*, and *elaboration*, it is hard for learners to participate in the discussion in other ways, such as interpreting or clarifying ideas (in disposition 1) or providing support or encouragement (in disposition 4). As a result, the discussion may become too convergent and somewhat artificial. Therefore, although constrained online discussion environments embrace the advantage of enhancing focused student-student interactions, such environments are also challenged by its possibility of hindering the diversity of discussion threads. Perhaps this disadvantage can explain why the participants who used such discussion environment in Jeong and Joung's (2007) study did not outperform their peers using other discussion environments in terms of critique ideas or responding to critiques. It is, therefore, crucial for online instructors who plan to use the constrained discussion environment to be very clear about their instructional goals and develop pre-defined discussion scaffolds based on their goals.

Visualized Environments

Visualized discussion environments use maps or tables to create graphical representations of different viewpoints and their relations (Ertl, Kopp, & Mandl, 2008; Suthers, Vatrapu, Medina, Joseph, & Dwyer, 2008). Researchers believe that learners

benefit from co-constructing graphical representations because the processes of construction, such as linking new claims to an existing argument graph or filling in cells of a table, may prompt the externalization of particular cognitive processes (Andriessen, Baker, & Suthers, 2003).

One of the most researched visualized environments is *Belvedere* developed by Suther and the colleagues (Andriessen, et al., 2003; Suthers, et al., 2008; Suthers, Weiner, Connelly, & Paolucci, 1995). Belvedere is a visualized online argumentation environment where participants can visually express relations of evidence between data and hypothesis objects by creating notes of different shapes and links between notes. Additionally, participants can set different belief levels for statements and relations and display these as line thickness (Suthers et al., 2001). Researchers found that the use of Belevedere increased the generation of coherent arguments and problem-solving actions (Cho & Jonassen, 2002), and participants using *Belvedere* were more likely to state hypotheses early, elaborate on their hypotheses, and integrate them with data than learners using a threaded forum (Suthers, et al., 2008).

BeyondShare is another discussion and collaboration tool based on concept map (Kao, Lin, & Sun, 2008). In this environment, students can construct their personal concept maps, and integrate their maps with their classmates' maps by establishing interlinks between the maps. They can also make comments to evaluate their classmates' maps and select "personal best fit" concept maps. The map receiving the most votes earns the designation of "best fit" map. Based on the analysis of the learners' questionnaire responses, the authors claimed that *BeyondShare* was capable of engaging learners in active knowledge construction and learning.

A visualized environment can be an ideal environment to "provide new representations of discourse structures", "make it easier for learner to review global progress", and "allow learners to view more than one note at a time" (Hewitt, 2001, p. 217-218), which according to Hewitt, are important features for a successful discussion environment. Capturing and representing the flow of discussions by using shapes and links, visualized environments can encourage learners' analytical reasoning (i.e., disposition 2: *discuss to critique*) and knowledge construction (i.e., disposition 3: *discuss to construct knowledge*). Nevertheless, when online discussions are more complicated, multi-faceted, prolonged or recursive, visualization may no longer be illuminating. Therefore, the popularity of this type of environments in the future relies on the effort and the success to release this limitation. Using other functions, such as color coding or highlighting different types of posts, are suggested to support the flexibility of discussion flows.

Anchored Environments

A group of researchers believe that discussions should be focused on the topic and sustained over a period of time to have a positive effect on learning (Guzdial & Turns, 2000), and have studied how anchored environments support sustained on-topic discussion. In an anchored discussion environment, participants can identify a portion of text and type in a comment while they are reading an online document. The comments are shown alongside the document with a visual indication of the associated text, so all other participants can read and respond to each other's comments. As a result, discussions are anchored within specific content.

WebAnn (Brush, Bargeron, Grudin, Borning, & Gupta, 2002; Marshall & Brush, 2004) is a system that supports anchored discussion of online documents. When comparing the discussion in *WebAnn* with that in *Epost*, a typical threaded discussion board, Brush and her colleagues found there was more discussion in *WebAnn*, and students perceived that the discussion in *WebAnn* focused more on the text, and was more thoughtful. When van der Pol et al. (2006) compared an anchored discussion forum with regular threaded discussion forums in Blackboard, they investigated the quality of discussion by analyzing students' posts. They found that discussion in the anchored discussion forum referred more frequently to the text, and was more focused and more communicatively efficient.

Some anchored environments were enhanced by integrating a threaded discussion forum. The advantage of such design is that participants can have the freedom to use either the anchored environments to share annotations while studying the learning materials or the threaded forums to have more in-depth discussions. Nokelainen and colleagues (2005) designed such an environment called *EDUCOSM*. Their study showed a positive correlation between the quality of annotations and learners' final grade. Similarly, in Wei and Chen's (2006) *e-book*, participants can annotate the text, which serves as anchors for subsequent discussion. The anchors are linked to a threaded forum for continued discussion. Participants can also use mobile phones to access the discussion forum anytime and anywhere. Wei and Chen found that the e-book environment significantly increased the level of participation in the discussion as compared to the threaded forum. The quality of discussion, however, was not examined in the study.

In sum, anchored environments share a common purpose, which is promoting more contextualized and more focused discussion on the learning materials. The discussion in anchored environments mainly encourages disposition 1: *discuss to comprehend* and disposition 2: *discuss to critique*. Though their effects on learning remains unknown, across studies, researchers found that there were usually more discussions in anchored environments than in threaded forum and the discussions were more focused on the learning materials. So far, anchored environments have mainly been used to discuss text-based materials. Based on the reported positive effects of anchored environments, we argue that anchored environments may potentially support other types of artifact-centered discussion. The artifacts can take a variety of forms, such as graphics or videos. Within anchored environments, learners can highlight a particular part of the artifact, making to-the-point, focused discussion.

Though an anchored environment has made it easy to have in-depth and focused discussions on specific section of the readings, comparing and contrasting views across posts (Disposition 3 of the Productive Online Discussion Model) and synthesizing discussion or ideas across the readings (Disposition 4 of the Productive Online Discussion Model) could be hard, and the scope of discussion could be limited because general discussion is unlikely to occur when all the comments are made based on specific texts (Gao, 2009). That is, such environments may be difficult to trigger knowledge connections due to its localization effect. This is an issue that needs to be resolved in the future when designing anchored environments.

Combined Environments

Combined environments refer to those that integrate more than one of the three

types of environments. Two environments that identified as combined environments are

CaMILE and *Knowledge Forum*.

CaMILE is an online discussion system developed by Guzdial and Turns (2000). It

shares the features of constrained environments and anchored environments. Similar to

other structured environments, students chose a post type or classification, such as *new*

theory or *evidence*. In addition, when students create notes on a page in *CaMILE*, they

can choose to link them to a file, a web page, or other media. The selected file is

uploaded to *CaMILE* Server and attached to the note, which serves as an anchor for

subsequent discussion. Consistent to the research on anchored environments, discussion

in *CaMILE* was more sustained, more focused on class learning topics, and involved

broader participation.

Knowledge Forum (previously called *CSILE*) (Scardamalia & Bereiter, 1994, 2003),

combined major features of all the three different environments. When composing a note

in *Knowledge Forum*, participants can choose a scaffold indicating whether the post

belongs to one of the subcategories of "Theory Building", "Opinion", "Assessment" or

"KB principles", and upload artifacts to support their statements. In addition, links can be

created to connect a note to the notes or artifacts previously created by others, making it

possible to anchor a note to another note or artifact. In the enhanced version of

Knowledge Forum, there is a graphical view function, where note icons related to a

particular topic of discussion can be placed and arranged visually to provide a higher-

level representation of ideas (Scardamalia & Bereiter, 2010). According to Scardamalia

and Bereiter (1994), students using *CSILE/Knowledge Forum* greatly surpass students in

ordinary classrooms in terms of the depth of learning and reflection, awareness of what they have learned or need to learn, and understanding of learning.

Not many studies on combined environments were found. Combined environments bring together the advantages of different types of environments to enhance the quality of discussion. In particular, Scardamalia and Bereiter's work on *Knowledge Forum* has received a lot of attention (Chai & Tan, 2009). Empirical studies on *Knowledge Forum*, however, are limited, so it remains unclear how the multiple features integrated in *Knowledge Forum* work together to promote learning. Future research is needed to examine the mechanism of such combined environments, which will in turn provide insights on designing new types of combined environments.

Implications for Designing Future Discussion Environments

This paper discusses why threaded forums may not be an ideal environment for asynchronous online discussion and presents four types of asynchronous online discussion environments that have been developed and researched as alternatives for threaded forums. In addition, we used the Productive Online Discussion Model as a framework to critique the existing design and suggest possible improvements. This section goes beyond the design of the four types of environments discussed so far and offers a few possible directions for designing asynchronous online discussion in the future.

First, the discussion environments in many of the reviewed studies (especially the constrained environments and visualized environments) aim at facilitating collaborative online argumentation. Research on designing environments to achieve other learning goals is limited. Online discussion serves a variety of purposes, including fostering an

online community (Mäkitalo, Häkkinen, Leinonen, & Järvelä, 2002), encouraging information sharing (Hew & Hara, 2007), promoting critical thinking (Chiu, 2009), and supporting collaborative problem-solving (Ge, Chen, & Davis, 2005). Effective environment for interaction and discussion varies when the educational purpose differs. Therefore, there is a need to identify and develop new types of discussion environments that best support other purposes of learning. For example, if the main goal of discussion is to foster online community, providing timely feedback and support could be crucial. In such case, some incentive mechanism may be designed into the discussion environment, so participants who respond timely will be awarded in certain ways.

Second, current discussion environments have addressed some of the constraints of traditional threaded forums. For example, the visualized environments try to provide a more conspicuous discussion structure for participants by visualizing the relationships among posts. Anchored environments try to solve the problem of digression in discussions by contextualizing the posts. Some other constraints of threaded forums, including lack of convergent processes, emotional cues or timely responses, have not been fully addressed. To address these problems, we should consider the possibility of integrating emerging technologies to enhance the effectiveness of discussion environment design. For example, Hewitt designs an environment called "Pepper", which integrates a Web 2.0 collaborative writing pad with a threaded forum, so participants can summarize what they have learned from the discussions on the writing pad as the discussions go on in the forum. Such environment may encourage participants to go beyond knowledge sharing, and actively process and synthesize information presented by others.

Third, the majority of current work on online discussion environments typically examines a particular discussion tool or environment. In reality, learning is a complex process that aims at the integration of knowledge, skills and attitude, and requires a high level of learners' engagement at multiple stages. To achieve a desired learning goal, discussion supported by a single tool may not be enough. Future work should consider designing multi-functional environments or systems that integrate asynchronous discussion environments with other new media technologies to facilitate learning at different phases and levels. The closest example we can find on multi-functional environments is Jamaludin, Chee and Ho's design (2009), where they combined asynchronous and synchronous environments to support different aspects of experiential learning: Second Life virtual environment was used for role-playing activities to support the extensional-apprehension mode of experiential learning; and a discussion board was used for argumentative discourse to support the intentional-comprehension mode of experiential learning.

Fourth, learning environments alone cannot ensure successful learning. The quality of discussion can be influenced by a number of different factors in the learning environment, including the design of activities, learners' characteristics such as their knowledge and skills. For example, the constrained environments use scaffolds (i.e., post types or labels) to guide participants through steps of forming an argumentation. Providing such scaffolds, however, is not sufficient for participants to make strong arguments. Teaching the essential skills of argumentation may be still necessary to help students perform well in such environments. As a result, to improve the use of online discussion environments for expected instructional goals, educators or researchers should

also focus on designing appropriate instructional activities and developing suitable

teaching strategies that can improve participants' performance in these environments.

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Table 1. Productive Online Discussion Model

Disposition 1: Discuss to Comprehend Actively engage in such cognitive processes as interpretation, elaboration, making connections to prior knowledge.
Learner Actions
(a) Interpreting or elaborating the ideas by making connection to the learning materials
(b) Interpreting or elaborating the ideas by making connection to personal experience
(c) Interpreting or elaborating the ideas by making connection to other ideas, sources, or references
Disposition 2: Discuss to Critique Carefully examine other people's views, and be sensitive and analytical to conflicting views.
Learner Actions
(a) Building or adding new insights or ideas to others' posts
(b) Challenging the ideas in the learning materials
(c) Challenging the ideas in others' posts
Disposition 3: Discuss to Construct Knowledge Actively negotiate meanings, and be ready to reconsider, refine and sometimes revise their thinking.
Learner Actions
(a) Comparing and contrasting views from the texts or others' posts
(b) Facilitating thinking and discussions by raising questions
(c) Refining and revising one's own view based on the texts or others' posts
Disposition 4: Discuss to Share Actively encourage and support each other's thinking and share improved understanding based on previous discussions.
Learner Actions
(a) Showing support and appreciation
(b) Synthesizing discussion contents
(c) Coming up with ideas or questions that invite further discussion

Adapted from Gao, Wang and Sun (2009)

Appendix 1. Four Major Types of Discussion Environments

Environment Types	Authors	Environment Names	Features	Educational Goals
Constrained Environment	Nussabaum et al.(2004)	-	requires the use of note starters	collaborative argumentation
	Oh & Jonassen (2007)	-	requires the use of post type labels and note starters	collaborative argumentation
	Hoadley & Linn (2000)	SpeakEasy	requires the use of post type labels	knowledge building and integration
	Jeong & Joung (2007)	-	requires the use of post type labels	collaborative argumentation
Visualized Environment	Suther et al.(2008); Cho & Jonassen (2002)	Belvedere	visually represents argumentation objects and their relations	collaborative argumentation & problem solving
	Kao, Lin & Sun (2008)	BeyondShare	allows for collaborative construction and peer evaluation of concept maps	collaborative knowledge sharing and integration
Anchored Environments	Brush et al. (2002); Marshall & Brush (2004)	WebAnn	allows for anchored discussion on learning materials	focused and contextualized discussion
	Nokelainen et al. (2005)	EDUCOSM	allows for anchored discussion on learning materials and extended discussion in a threaded forum	learner-centered collaborative learning
	Wei & Chen (2006)	e-book	allows for ubiquitous access of anchored discussion on learning materials and extended discussion in a threaded forum	contextualized knowledge sharing
Combined Environments	Guzdial & Turns (2000)	CaMILE	requires the use of post type labels and allows for anchored discussion	sustained on-topic discussion
	Scardamalia & Bereiter (1994, 2003)	Knowledge Forum	allows for anchored discussion, visual representation of discussion, and the use of note starters	collaborative knowledge building