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The Effect of Semistructured Design Rationale Messages on Structuring Collaborative Problem-Solving in an Online Forum

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Abstract

Asynchronous problem-solving forum discussions play a pivotal role in supporting post-secondary learning distance education. Inherent in this asynchronous approach are characteristics that diminish learning (e.g. delayed corrective feedback). A blend of asynchronous forum and intelligent tutoring technologies suggests an approach for mitigating such negative learning characteristics, but requires imposing additional structure on student's forum postings. Towards this end, the effect of using semistructured design rationale messages to structure student's collaborative problem-solving postings in an online undergraduate object-oriented analysis & design course was studied. Students using semistructured messages (n = 23) posted significantly more messages and feedback to others than the control group (n = 19) without significantly decreasing the solution quality. A subsequent pilot study was conducted to understand the effect of guiding students with simulated 'Wizard of Oz' agents in a synchronous forum discussion. By answering leading questions, students in the pilot study were able to provide solutions that were not considered by their peers in the earlier study. The results of these studies lend support for pursuing further research on a blended intelligent tutoring approach.

Keywords: Asynchronous Education, tIBIS, Tutoring Systems.

Introduction

The impact of asynchronous discussion forum technology in nontraditional post-secondary education is extensive, but this impact cuts in two directions. In the positive direction, the different time and place communication metaphor inherent in asynchronous forums fosters collaborative learning within a supportive social setting (Berry, 2008; Schellens & Vacke, 2004), while offering significant convenience to students and faculty who cannot participate in a traditional classroom setting. In the negative direction, asynchronous communication can impede effective learning by, for example, delaying corrective feedback (Painter, Coffin, & Hewings,

2003; Vonderwell 2002), decreasing discussion coherence (Koschmann, 2003; Herring, 1999), and allowing peer support of erroneous content (see below).

Intelligent tutoring systems (ITS) technology has the potential to positively impact distance education by diminishing the detrimental characteristics of asynchronous forums while retaining the beneficial characteristics (e.g., Scheuer, 2008; Rey-López, Bursilovsky, Meccawy, Díaz-Redondo, et. al., 2008). Specifically, we are interested in integrating asynchronous forum technology with ITS technology. The unconstrained use of natural language presents a significant challenge to this integration. One approach to addressing this challenge is to better structure forum discussions in a manner that retains their overall quality, but facilitates this integration (Jonassen & Remidez, 2005). Towards this end, this paper explores the effect of using a semistructured (design rationale) messaging approach to structure the collaborative problem-solving postings of online students. A review of relevant literature is presented in the next section, followed by the presentation for two experimental studies of using semistructured messages in a problem-solving discussion forum. The paper concludes with a general discussion.

Background

As reducing the detrimental effects of using asynchronous messaging forums in nontraditional post-secondary education provides the primary motivation our research, the importance of this application area is first reviewed. Following this is an addition review, beyond that given in the introduction, of the role asynchronous forums play in online education. Attention is then focused on a short summary of the intelligent tutoring systems and use case modeling methodologies relevant to our approach.

Nontraditional Post-Secondary Education

The use of asynchronous messaging technology will continue to increase as universities increasingly focus on growth in nontraditional student enrollment and the employment of part-time faculty to address this growth. As early as 2002, The National Center for Education Statistics (2002) identified 73% of all (US) university students as being nontraditional (e.g. having one or more of the following characteristics: delayed entry into post-secondary education, part-time student, full-time job, single or married parent, and/or having a nonstandard high school diploma), with the majority being working age adults. Not too surprisingly, the responsibilities of family and employment make it difficult for adult students to attend traditional university classes. As a result, an increasing number of universities have begun offering online courses. In 2007, over 20% of all university students took at least one online course and one in five universities offering online courses made their very first online offering in the previous year (Allen & Seaman, 2008).

The increasing use of part-time faculty also provides a catalyst towards this shift to online education. In 2003, part-time faculty represented 43.7% of all (US) university faculty (Cataldi, Fahimi, & Bradburn, 2005). Most part-time faculty members are also employed as full-time professionals outside of the education field (Leslie & Grappa, 2002). As adult students are particularly motivated by education that has practical relevance to their profession, the work experience of part-time faculty makes them attractive educators (Robinson, 1994). Similar to the

nontraditional students they teach, part-time faculty also benefit from the convenience provided by asynchronous messaging technology when communicating with online students.

The use of asynchronous forum discussions in nontraditional higher education is also affected by the increased use of accelerated course formats (i.e. the compression of a traditional 15 week university course into a shorter duration). Although adult students tend to believe that accelerated courses provide a best-practice solution for older students, many find the time-compressed nature of accelerated programs to be overwhelming and, subsequently, compromise on covering all of the course content in order to selectively keep up with required assignments and exams (Kasworm, 2001). The convenience of asynchronous communication also assists students in handling the resulting increased demands on their time by allowing them to better manage when they participate in an accelerated online course discussion. However, the increased time pressure also limits the amount of time they have to participate in the online discussions.

Asynchronous Online Discussions

Asynchronous online forum discussions provide both social and pedagogical benefits. From a social perspective, they provide students with a convenient mechanism for building a strong sense of peer community, which in turn, increases student success, persistence, and learning (Rovai, 2002). Community contributes to a sense of inclusion that significantly enhances adult student's motivation to learn (Wlodkowski, 2008) and positive correlations between motivation and academic success exist (Uguroglu and Walberg, 1979)[1]. A student's sense of community also increases with peer communication frequency (Dawson, 2006). From a pedagogical perspective, the effectiveness of collaborative learning, as a teaching approach, is also well documented (Johnson & Johnson, 1993) and using computer support for collaborative learning can be effective (O'Malley, 1995) and asynchronous discussion forums provide an effective collaborative learning environment (Biesenbach-Lucas, 2004).

Despite these successes, how to better utilize asynchronous discussions to improve online learning remains an open research question (quality/quantity ref). In addition to the feedback delays, which also has a negatively affect on student learning in non-distance education (e.g. Corbet & Anderson, 2001) and discussion coherence eluded to in the introduction, asynchronous learning environments are problematic in that they also result in student frustration (Vonderwell, 2003). Generic issues with asynchronous messaging also carrying over into online education setting, such as the fact that focusing attention on unread messages hastens the death of some message threads and reduces the likelihood of inactive threads becoming active again (Hewitt, 2005) or posting replies to erroneous threads (Wiley, 2004).

A number of recent research efforts have focused attention on the effect of structuring online forum discussion assignments on enhancing student learning (e.g. Brooks & Jeong, 2006; Kramarski & Mizrachi, 2006). Included in these structuring efforts is the investigation of the amount of forum intervention provided by the instructor, which has been found to be detrimental to learning when either too much or too little intervention occurs (Ref from ITS ref) and strategies

[1] In this study of K-12 students, which is believe to generalize to all students, 98% of 232 correlations between motivation and academic success where shown to be positive in a study of 637,000 students.

for faculty interventions to guide students when a discussion inappropriately concludes as a result of a single student proposing a solution (Hou, Chang, & Sung, 2008). The idea that intelligent agent technology might provide this type of discussion guidance, via intervention, is currently over a decade old (Aroyo & Kommers, 1999) and continues as an open research issue.

Issue-Based Information Systems

The Issue-Based Information System, IBIS, provides a structuring foundation for decision making and design process (Kunz & Rittle, 1970), capturing design rationale, gIBIS, (Conklin & Begeman, 1988), and tutoring ill-defined design tasks, tIBIS, (Blumenthal & Karamouzis, 2008). Using the IBIS methodology, stakeholders work through an argumentative design process that is structured as a dialogue consisting of rhetorical moves that raise *Issues*, propose *Positions* that resolve an Issue, and make *Arguments* that support or object-to a Position[2]. The IBIS methodology provides a natural foundation for structuring online forum discussions in a manner that suggests an approach for integrating intelligent tutoring systems into asynchronous discussion forums by providing students guidance in a collaborative problem-solving activity.

Intelligent Tutoring Systems

At the broadest level, intelligent tutoring systems attempt to develop systems for automating education (Anderson, Boyle, Corbett & Lewis, 1990). The systems have been successfully deployed in a number of traditional classroom settings, e.g. see (Viadero, 2007) (VanLehn, Lynch, Schulze, Shapiro, & Shelly, 2005) and have demonstrated significant gains in student learning (Corbet, 1997). A number of these systems utilize a dialogue-based approach to tutoring, e.g. (Cade, Copeland, Person, & D'Mello, 2008; Heffeman & Wiemer-Hastings, 2004). Of particular interest is the tIBIS intelligent tutoring system prototype (Blumenthal, 2008), which teaches students object-oriented analysis & design by allowing them to participate in an IBIS-based design dialogue with multiple tutoring agents. Following a semistructured design dialogue, in which a student or the tutoring system can make one or more rhetorical moves in the ongoing dialogue, these agents are able to guide students in exploring the issues, positions, and arguments associated with a UML use-case requirements problem-solving design task.

Modeling Use Cases in UML

The Unified Modeling Language (UML) can be used to represent the functional requirements associated with a software application using use cases and actors (Arlow & Neustadt, 2005). *Use cases* model a sequence of actions with an observable outcome that the system performs for some actor. Actors represent external entities that interact with the system and may be human users or other software entities. In the case of human users, the actors are typically roles played by a particular user. For example, in an online bookstore application, a public user may search for a book. In this example, the 'Search for Book' is a use case that the 'Public User' actor initiates. UML also provides a formal mechanism for visually depicting use cases, their relation to actors,

[2] These are the primary rhetorical moves in the IBIS methodology. Additional moves, and relations among moves, are supported and introduced later in this paper as appropriate.

and the associations among use cases, such as whether one use case necessarily or optionally includes another.

Experiment 1

In this experiment, we attempted to identify the effect of using the tIBIS methodology to structure the asynchronous forum postings made by students, as part of a collaborative problem-solving assignment, during the first week of an accelerated object-oriented design course.

Method

Participants

Participants in the study consisted of nontraditional university students who registered for an accelerated 8-week online Object-Oriented Analysis & Design course as part of their undergraduate degree curriculum. After registering for the course, students were randomly assigned to either a control or a tIBIS manipulation group, which were taught as separate course sections. The study was also repeated in a subsequent term and, consequently, each student participant falls into one of four groups, the Summer-term control group (M^{C}_{term})[3], the Summer tIBIS manipulation group (M^{T}_{term}), the Fall control group (F^{C}_{term}), or the Fall tIBIS manipulation group (F^{T}_{term}). Each of the four sections was taught by the same faculty member. Table 1 lists the number of students in each group (i.e. there were 19 students in the combined control groups).

Table 1. Number of participants

Term	Control	tIBIS Manipulation
M_{term}	8	15
F_{term}	11	8

Materials

Asynchronous messaging was provided by the forum discussion component of the Angel Learning Management System, LMS, (Angel Learning Inc., 2009). In addition to providing students access to the discussion forum, the LMS also contained additional course material (e.g., weekly overview, objectives, UML presentations, and assignments). Of particular importance are the instructions for completing the collaborative forum assignment, which included information on making asynchronous forum postings using semistructured tIBIS messages and the electronic-bookstore system description used in the forum assignment.

[3] As students may also take courses in a Spring term and our second experiment was conducted in the Spring, we use 'M' to indicate the Summer term.

Semistructured tIBIS Messages

The instructions given to the tIBIS manipulation group introduced the tIBIS methodology by describing the semistructured tIBIS messaging format required when posting messages to the forum. Semistructured messages are defined as "messages of identifiable types, with each type containing a known set of fields, but with some of the fields containing unstructured text" (Malone, Grant, Lai, Rao, & Rosenblitt, 1987). The convenience associated with designing software with the capability to respond automatically to some messages and to suggest likely responses to other messages, makes semistructured messages a practical choice for structuring each dialogue step in a tIBIS forum discussion. The five semistructured tIBIS templates and examples given in the assignment instructions are given in Table 2.

Table 2. Semistructured tIBIS message templates

Template	Example
Issue: I-<*id*> **Relations**: <*relation list*> **Text**: <*issue text*>	**Issue:** I-1 **Relations**: None **Text**: What use cases are required to satisfy the requirements of the online bookstore application?
Position: P-<*id*> **Relations**: <*relation list*> Text: <*position text*>	**Position**: P-2 **Relations**: Responds-to I-1 **Text**: A login use case is required.
Argument: A-<*id*> **Relations**: <*relation list*> **Text**: <*argument text*>	**Argument**: A-3 **Relations**: Supports P-2 **Text**: System description requires a Login use case.
External: E-<*id*> **Relations**: <*relation list*> **Text**: <*external text*>	**External**: E-4 **Relations**: Relates-to I-1 **Text**: Here's my attempt at a use-case diagram.
Other: O-<*id*> **Relations**: <*relation list*> **Text**: <*other text*>	**Other**: O-5 **Relations**: Relates-to E-4 **Text**: You forgot to attach the use-case diagram.

Online Bookstore System Description

The bookstore system description (see Appendix) used in this experiment was originally written by a university faculty member as an asynchronous forum assignment for an accelerated undergraduate Object-Oriented Analysis & Design course[4]. Prior to the start of the experiment,

[4] The system description was written with no knowledge of tIBIS or the experiments described here.

three additional university faculty, who teach UML as part of an undergraduate Object-Oriented Analysis & Design course, were independently asked to use a noun/verb analysis (Arlow & Neustadt, 2005) to identify the actors and use cases in the bookstore system description, which they had not previously seen.

Collectively, the faculty identified nineteen *candidate* use cases in the bookstore system description[5]. These candidates represent software functionality that is explicitly referred to in the system description, as opposed to functionality that can be inferred from the system description (see below). As several of the candidate use cases describe the same functionality or functionality that is part of another candidate use case, the faculty subsequently classified the candidate use cases into primary and auxiliary subcategories. Using this classification, the faculty identified twelve *primary* use cases that collectively cover all of the functionality explicitly referred to in the system description. The remaining seven candidate use cases were considered to be *auxiliary*. For example, according to the system description, the process of buying a book requires checking out. Consequently, the candidate 'check out' use case is considered as primary, but the candidate 'buy book' use case is considered as auxiliary since the only purpose of checking out is to buy a book.

The faculty also identified five additional use cases that are *implicit* in the functionality described in the system description. For example, the ability to add a book to the shopping cart, which is explicit and a primary use case, implies that there must be functionality to remove a book from the shopping cart. The identified implicit use cases are: logout, deregister customer, remove book from cart, debit account, and debit credit card. Note there is no implied 'cancel' use case since students were specifically taught in the weekly LMS notes to treat the ability to cancel a use case to be part of the use case's secondary functionality.

In summary, combining the primary and implied, the faculty identified seventeen use cases capturing the functional requirements needed to provide a successful software application based upon the supplied bookstore system description. As two of the auxiliary use cases are synonyms for the primary use cases, the five remaining auxiliary use cases, which are component aspects of a primary use case, result in a total of 22 use cases that might be legally identified by students.

Procedure

At the beginning of the week, students were given the collaborative task of identifying the use cases and actors described in the online bookstore system description. As part of this assignment, each student was required to submit a *primary* forum posting that contributed to the bookstore use-case design. Additionally, each student was required to make two feedback postings that constructively critiqued the previous postings of fellow students. The manipulation groups were given instructions that required them to utilize the tIBIS semistructured message methodology when posting to the discussion forum. The control groups were not given any instructions for structuring their postings, but were required to read instructions that were similar in size to the

[5] The candidate use cases identified by the faculty are underlined in the bookstore system description given in the Appendix. A solid underline indicates the primary use cases and a dashed underline indicates auxiliary use cases.

tIBIS instructions given to the manipulation groups, but were neutral in content. The faculty member provided clarification postings concerning the assignments, but did not contribute specific feedback concerning the use-case design contents of a posting[6].

Results

An asynchronous forum manipulation, such as the tIBIS manipulation performed in this experiment, can affect the postings made by students in three broad ways (i.e. categories). First, it may affect, for example, the average number of postings made by students, which is a *quantitative* effect. Next, the manipulation may affect the specific problem domain content of the student postings, a *qualitative* effect. For example, in the current experiment, the content of the posting is focused on designing a use-case model based on the bookstore system description. Finally, there are a number of features associated with asynchronous forum postings that are independent of the problem domain and common to all asynchronous forum postings. These features are referred to as *domain independent* effects. For example, given a weekly assignment, a student posting may occur on the first day of the week vs. the last day of the week or a student may originate a new posting vs. making a posting that is in reply to a previous posting, or a student may reply to another student vs. replying to one of their own previous postings. The results given in the remainder of this section are partitioned using these categories.

Quantitative Results

Overall, the tIBIS manipulation had a significant positive effect on increasing the relative number postings focused on the collaborative problem-solving task. This effect derives from a comparison of problem-focused to problem-independent postings. *Problem-focused* postings are student postings that directly respond to the forum assignment by contributing to the use-case design. Problem-independent postings are either a*ssignment clarification* postings, which ask questions related to clarifying the instructions given in the forum assignment or, *miscellaneous* postings. Table 3 gives the total number of forum postings, by type, made by the students and Table 4 gives the average number of problem-focused postings made per student.

Table 3. Number of forum postings by type

	Control			tIBIS Manipulation		
Term	Problem Focused	Assignment Clarification	Misc.	Problem Focused	Assignment Clarification	Misc.
M_{term}	19	2	0	38	6	4
F_{term}	35	7	3	89	7	5

[6] As to not affect the experiment, but still provide a quality educational experience, the faculty provided problem focused comments to students in the subsequent course week, after the conclusion of the experiment.

Table 4. Average number of postings per student.

Term	Control	tIBIS Manipulation
M_{term}	2.38	4.75
F_{term}	3.18	5.93
Combined	2.84	5.52

The average number of student postings for the tIBIS manipulation group (n = 23) was significantly more than those made by the students in the control group (n = 19), $t(29.05) = 2.82$, $p = .004$ (one-tailed Welch's test)[7]. Additionally, the actual number of postings per student in the tIBIS manipulation group (M = 5.52, SD = 5.5) was also significantly more than the expected three postings ($\mu = 3$) required per student by the forum assignment, $t(22) = 2.87$, $p = 0.004$. The actual number of postings made per student in the control group (M = 2.84, SD = 1.6) was not significantly more than the expected required number of postings, $t(18) = -0.44$, $p = 0.33$.

Table 5 gives the ratios of problem-independent to problem-focused postings and miscellaneous to problem-focused postings (e.g. from Table 3, in the control group there were 12 problem-independent and 54 problem-focused postings, 12/54 = 0.222). The tIBIS manipulation had no significant effect on either the ratio of problem-independent postings, $z = 0.36$, $p = 0.36$ or on the ratio of miscellaneous postings, $z = 0.90$, $p = 0.82$. Thus, tIBIS had a significant effect on increasing the relative number postings focused on the collaborative problem-solving task.

Table 5. Proportions of problem-independent to problem-focused postings

Ratio	Control	tIBIS Manipulation
Independent to Focused	*22.2%*	*18.1%*
Miscellaneous to Focused	5.6%	7.1%

A number of students in each group made a single forum posting[8]. Table 6 gives the number of students that made multiple postings. The tIBIS manipulation had a significant effect on decreasing the number of students who made a single forum posting, $z = 1.457$, $p = 0.073$.

Table 6. Number of students who made multiple postings

Control	tIBIS Manipulation
13 of 19	20 of 23

[7] Unless otherwise noted, single tailed t-tests were used. Also unless stated otherwise, statistical significance or non-significance reported for a combined term was also mirrored by each of the individual term groups.

[8] Recall that students were required to make three forum postings. Hence, these students failed to fulfill the requirements of the weekly forum assignment.

Domain Independent Results

As defined earlier, domain-independent effects characterize features associated with asynchronous forum postings that are independent of the problem domain. One such feature concerns whether a posting is made in reply to a posting made by another student. Recall, that the forum assignment required each student to provide two feedback postings to other students. Table 7 givens the number students who satisfied this feedback requirement.

Table 7. Number of students providing feedback to others

Term	Control	tIBIS Manipulation
M_{term}	4 of 8	5 of 8
F_{term}	9 of 11	13 of 15

The tIBIS manipulation had no significance on the proportion of students providing feedback z = .722, p = 0.24. Although the tIBIS manipulation had no significant effect on the portion of students providing feedback, the larger class sizes of the F_{term} did have a significant effect on increasing the number of students providing feedback z = 2.02, p = .021[9].

Table 8 gives the ratio of postings that provided feedback replies to the total number of problem-focused postings (e.g. 8 of the M^{C}_{term} postings were made in response to a posting made by another student). The tIBIS manipulation had a significant effect on increasing the proportion of messages that provided feedback replies to other students, z = 1.32, p = 0.092. The larger class sizes of the F_{term} also had a significant effect on increasing the ratio of postings that provided feedback to other students, z = 1.61, p = 0.053

Table 8. Proportion of messages replying to others

Term	Control	tIBIS Manipulation
M_{term}	8 of 19	11 of 38
F_{term}	19 of 35	39 of 89

The final domain-independent effect examined in this experiment examines the average number of days between a student's first posting and their last posting, referred to as the *posting span.* This span may range from a minimal of zero, indicating that a student made multiple postings on the same day, to a maximum of seven days. Table 9 givens the average posting span for the combined control and tIBIS manipulation groups[10]. The tIBIS manipulation did not significantly affect the posting span, $t(28.31) = 0.581$, p = .57 (Welch's two-tail test).

[9] Note, unlike most significance tests in this paper, which compares the control to the tIBIS manipulation group, this test compares the combined smaller M_{term} class size group against the larger F_{term} class size.

[10] As to not skew the results, these averages do not include students who made a single posting nor one student from the manipulation group who posted multiple postings after the assignment due date.

Table 9. Average day span between first and last postings

Control	tIBIS Manipulation
2.2	2.0

Qualitative Results

Unlike the domain independent results presented thus far, the qualitative results presented in this section focus on the content of the student's forum postings. Overall, the tIBIS manipulation had no significant negative effect on the number of use cases and actors identified by students in the forum discussions. Tables 10 and 11 give the total number of use cases referenced by students in each of the groups. For completeness, these postings are partitioned into one of six categories. The first three categories correspond to those identified by the faculty in their a priori categorization of the online bookstore system description (e.g. primary, auxiliary, and implied). The *plausible* category corresponds to use cases presented by students that aren't required to capture the functionality in the system description, given the existence of the primary use cases (e.g.) or use cases considered to be part of another system that helps provide needed functionality (e.g., inventory management). The *Duplicates* category gives the number postings that describe use-case functionality that was already described by the same student. The *Errors* category gives the number of use case postings that referenced syntactically (e.g. 'Web Site') or semantically (i.e. 'Withdraw Cash', i.e. a cut and paste error) illegal use cases. Table 8 also distinguishes between the number of use cases presented in UML diagrams and the tIBIS forum discussions. For example, in the Fterm, the UML diagrams covered 10 of the 12 primary use cases, and the forum discussion identified the remaining two use cases and hence, the total coverage was 12 of 12. The discussions in the control group always reference use cases in the UML diagrams across all categories.

Specifically, comparing the control to the tIBIS manipulation groups in both terms the tBIS manipulation did not significantly affect the coverage of the primary use cases presented by students in the forum for either term, M_{term} $z = 0.617$, $p = 0.269$ and F_{term} $z = 1.02$, $p = 0.154$.

As given in Tables 10 and 11, the feedback postings of the control groups did not introduce any additional use cases that were not present in the primary postings. However, the semistructured messages in the tIBIS discussion did result in references to additional use cases.

Table 10. Number of use cases identified in control group

Max possible	Primary (12)	Auxiliary (5)	Implied (5)	Plausible	Duplicate	Errors
M_{term}	10	2	0	6	1	1
F_{term}	11	5	2	7	4	9

Table 11. Use cases identified in tIBIS group (use case diagram / tIBIS forum discussion)

Max possible	Primary (12)	Auxiliary (5)	Implied (5)	Plausible	Duplicate	Errors
M_{term}	9 / 11	2 / 3	0 / 0	14 / 15	2 / 2	3 / 3
F_{term}	10 / 12	5 / 5	0 / 1	9 / 12	1 / 1	13 / 13

Table 12 gives the number of actors referenced by the students. The categorization of actors is analogous to the use case categorization previously described. The M_{term} for the tIBIS manipulation group failed to identify the external shipping agent actor. Both manipulation groups identified the implied 'employee' actor role, which was not identified in either of the control groups. The plausible actors represent roles related to database management, inventory control, etc. The errors include syntactic errors (e.g. 'initiate checkout', which is closer to a plausible use case, but certainly not a valid actor) and semantic errors (e.g. 'product/stock').

Each of the forum discussions also contained examples of student question postings that went unanswered by other students and inappropriate supportive replies to postings that contained erroneous information (e.g. a posting alluding to an illegal use case).

Table 12. *Number of actors reference in the forum discussions by category*

Term	Control				tIBIS Manipulation			
Max	Coverage (4)	Plausible	Implied (1)	Errors	Coverage (4)	Plausible	Implied (1)	Errors
M_{term}	4	2	0	1	3	5	1	1
F_{term}	4	1	0	3	4	6	1	5

Discussion

The results of experiment 1 indicate that the IBIS/tIBIS methodology can be used to increase the communication among students attempting to design a use-case model in a collaborative asynchronous forum assignment without adversely affecting the quality of the generated design. The highly significant increase in the number of problem-focused postings for the manipulation group is especially interesting since the tIBIS structuring resulted in students exceeding the minimal assigned number of postings required for the assignment. As no significance was found in the number of non-problem-focused postings between groups, it is unlikely that the manipulation group was simply more 'chatty' than the control group, which provides further evidence of the increased effect of the tIBIS structuring.

Although the tIBIS manipulation did not produce a significant increase in the number of students who posted feedback, it did significantly increase the number of students who made multiple postings and it did result in a significant increase in the average number of postings that provided feedback on other student's postings. As the tIBIS structuring makes it easier for students to respond to themselves (i.e. post an Issue, immediately followed by a Position on this Issue, and in turn, an Argument for this Position), this result is particularly interesting since it demonstrates that the increase in the average total number of postings wasn't limited solely to these types of self-referencing postings.

The above increases in forum postings and communication among students is especially encouraging since these increases didn't negatively affect the student's ability to collaborate to identify the number of use cases and actors presented in the bookstore system description. In fact, in both manipulation groups, the number of primary use cased identified by students was increased by tIBIS related forum postings that were not part of the primary use-case diagrams posted by the students. This suggests that the tIBIS structuring may help students in noticing missing functionality that hasn't been previously identified.

While the tIBIS manipulation had no effect on the number of students providing feedback to other students, the class size did have a significant effect. The group size also has a significant effect on the proportion of messages providing feedback. Though not directly related to the tIBIS manipulation, these results reaffirm the previously reported importance of group size on asynchronous forum discussions (Schellens, 2004). Given the current results, it is difficult to ascertain whether the effect is simply a result of the increased opportunity to interact with other students, in sheer numbers, or a more subtle issue such as whether students avoid providing feedback to others when previous feedback exists, as found by Hou, Chang, & Sung (2008).

Although these increases in communication and unaltered quality in the use-case design by the tIBIS manipulation are encouraging, the results also indicate that many of the issues associated with the postings of the control group, and previous discussed literature on asynchronous forum discussions, are still present in the tIBIS postings. For example, students continue to pursue tangent postings that related to plausible use cases and actors that aren't required to cover the functionality given in the system description. Additionally, they still make mistakes in posting duplicate use cases and actors, as well as, illegal use cases and actors. Finally, the tIBIS manipulation did not assist the students in identifying the implied use cases.

Experiment 2

In this pilot experiment, we attempted to identify the effect of using the tIBIS methodology as part of a synchronous online tutoring interaction between a university student, two 'Wizard of Oz' software agents, and an expert human observer. Additionally, the study attempted to collect data concerning the potential use of an intelligent tutoring system agent as a participant in an online forum discussion.

Method

Participants

As with experiment 1, the four participants in this second pilot study consisted of nontraditional university students who registered for an accelerated 8-week online Object-Oriented Analysis & Design course as part of their undergraduate degree curriculum[11].

Materials

Support for the synchronous messaging in this experiment was provided by the chat room component of the Angel Learning Management System (LMS). Similar to experiment 1, this LMS also contained additional weekly instructional material. The semistructured tIBIS message formatting instructions and online bookstore system description from experiment 1 were also used in this second experiment.

Questionnaire

A follow up questionnaire containing four questions focused specifically on the identification of use cases was used in this experiment. Figure 1 gives these questions and the associated Likert scale (Likert, 1932).

Procedure

Prior to the start of the experiment, email was used to schedule a one-half hour block of time in which the student would be available with access to a telephone and the Internet. One day prior to the start of the experiment, the student was emailed the semistructured tIBIS message posting instructions[12]. These instructions also informed the student that they would be participating in a tIBIS structured dialogue with two software agents in an online chat room with the purpose of collaboratively identifying the use cases in a given system description. Additionally, these instructions also informed students that a faculty expert would also be observing the dialogue, had the ability to respond to student questions, and could reset the software agents should any problems occur. Finally, the instructions noted that that the software agents required a brief amount of time to parse the dialogue steps being made in the chat room.

Immediately prior to the start of the experiment, the faculty member started a chat room in the LMS and added three participants to the chat room. One participant was identified as the faculty member, the second as Molly, and the third as James. At this point, the faculty member telephone the waiting student, answered any questions related to the structure of the experiment, emailed the student the bookstore system description, provided the student with verbal

[11] The students in the second experiment were enrolled in the Spring semester of the OOAD course and, hence, were not part of the control or manipulation groups from Experiment 1.

[12] A modified version of the instructions from Experiment 1, which accounted for the change from asynchronous forum discussion to synchronous chat room discussion, was used.

instructions for joining the chat room, a verified that the student could in fact see the two software agents named Molly and James, as well as the faculty member.

Q1. To what extend do you believe the Positions (yours and the software agents) in the dialogue identified all of the use cases suggested by the System Description

Identified Use Cases	None of the use case (1)	Some of the use cases (2)	Most of the use cases (3)	Almost all of the use cases (4)	All of the use cases (5)

Q2. To what extend did the Position postings of the two software agents help you to identify the use cases?

Help Level	Not Helpful (1)	Somewhat Helpful (2)	Moderately Helpful (3)	Very Helpful (4)	Extremely Helpful (5)

Q3. To what extend did the prompting by the expert help you identify additional use cases?

Help Level	Not Helpful (1)	Somewhat Helpful (2)	Moderately Helpful (3)	Very Helpful (4)	Extremely Helpful (5)

Q4. To what extend did the prompting by the software agents help you to identify additional use cases?

Help Level	Not Helpful (1)	Somewhat Helpful (2)	Moderately Helpful (3)	Very Helpful (4)	Extremely Helpful (5)

Figure 1. Follow up questionnaire

At the start of the experiment, the student was informed, via the phone conversation, that the faculty member would make the first posting, that the two software agents would make the next seven postings, and that they should not post until the faculty member made the nine posting. These first nine postings are depicted in Figure 2. The student was not told that they were participating in a Wizard of Oz study in which the faculty member was actually playing the roles of the Molly and James software agents. As Wizard of Oz studies have provided useful mechanisms for understanding and fleshing out the design requirements of intelligent software agents that interact with human users via a user interface (Maulsby, Greenberg, & Mander, 1993),

this type of study provided an excellent approach for understanding the potential use of an intelligent tutoring agent in an online tIBIS forum discussion. After posting the ninth message to the chat room, the student was informed that the software agents were waiting for the student to respond, that the faculty member could respond to questions directed at them, and the telephone conversation with the student was concluded.

Step	Participant	tIBIS Dialogue Step
1	[Expert]	Issue: I-1
		Relations: None
		Text: What use cases are required in the bookstore application?
2	[$Agent_1$]	Position: P-1
	(Molly)	Relations: Responds-to I-1
		Text: The application requires a ‘Search Books’ use case.
3	[$Agent_1$]	Argument: A-1
	(Molly)	Relations: Supports P-1
		Text: The system description allows a user to ‘Search Books’.
4	[$Agent_1$]	Position: P-2
	(Molly)	Relations: Responds-to I-1
		Text: The application requires a ‘Register User’ use case.
6	[$Agent_2$]	Argument: A-2
	(James)	Relations: Supports P-2
		Text: I agree with Molly, they must register before logging in.
7	[$Agent_2$]	Position: P-3
	(James)	Relations: Responds-to I-1
		Text: The application requires a ‘Login’ use case.
8	[$Agent_2$]	Argument: A-3
	(James)	Relations: Supports P-3, Supports P-2
		Text: The system description allows a user to ‘Login’.
9	[Expert]	Other: O-1
		Relations: Relates-to I-1
		Text: Are there additional use cases?

Figure 2. First nine postings in Wizard of Oz discussion

At this point in the experiment, the faculty waited for the student to make a tIBIS posting to the chat room. As the subsequent postings made by the faculty had to account for student postings, no specific script could be followed. However, the faculty member did follow a general strategy for participating in the conversation. First, the faculty member attempted to always provide the student with ample time to make a posting. Second, each posting made by the faculty, either as the faculty facilitator or as one of the software agents, was selected from a predefined set of possible postings. Finally, the selection of these predefined postings was based on an ordering that followed the linear introduction of the use cases in the corresponding bookstore system description. At any point in the conversation after the student, a software agent had posted, and the student wasn't responsive, the faculty member would repost a tIBIS Issue asking 'Are there any addition use cases?'.

At the point when the student didn't respond and eight of the 'primary' use cases in the system description were posted as Positions in the dialogue, the faculty member used the James software agent to ask whether a specific 'primary' use case was required and waited for the student response. If the student didn't respond, the software agent repeated the question and waited for a response. This strategy was also used in having the James software agent ask whether a specific 'implied' use case was required. The faculty member also used the James software agent to respond to erroneous postings made by the student by asking the student clarifying questions or to state an Argument that objected to the student's Position posting.

The faculty also used the general strategy of ensuring that either the student or one of the software agents posted a message that identified each of the twelve primary use cases and one of the implied use cases. However, posting related to a few of the primary use cases by the software agents were made as an Issue question and the implied use cases were always posted in this manner. For example, the software agent would post the question, 'Is there a need for a remove from cart use case?'.

One-half hour after the start of the experiment, the faculty member posted a message as the facilitator that the experiment was concluded and thanked the student for participating in the experiment. At this point in time, the students were asked to complete the follow up questionnaire and email the results to the faculty member.

Results

Table 13 gives the number of semistructured tIBIS messages posted to the chat room during each of the four experiments. An average of 35 total messages (SD = 6.5) were posted with the students posted an average of 10 messages (SD = 3.7). A message corresponding to each of the 12 primary use cases and one implied use case from the bookstore system description was made in each of the experiments[13].

[13] This accounts for the primary variance in the number of agent postings since the strategy of the faculty included ensuring that each of the primary use cases were covered.

Table 13. Number of messages posted by each student

Experiment	Student	Faculty	Agents
1	10	5	14
2	6	6	24
3	15	4	24
4	10	5	17

Each of the four students posted at least one tIBIS position containing an appropriate primary use case in response to "Are there any additional use cases?" question posted in step nine of the dialogue (see Figure 1). At some point in the conversation, each of the four students also failed to respond to the same question when a previously non-referenced primary use case still existed and, hence, could be posted. In this situation, each of the four students was able to respond in the affirmative to a question that referenced a missing primary use case. For example, a software agent would ask a question, 'Is there a need for the X use case?' and the student would respond with an argument that affirmed the need for this particular use case. Additionally, each of the students was able to provide a positive affirmation when asked a similar question about one of the implied use cases.

Two of the students posted an erroneous use case during the chat room discussions. In each case, the faculty used one of the software agents to question the posting made by the student in a manner that suggested the error made by the students. One of the students agreed with the software agent's posting and essentially changed their position. In the other case, the student maintained their incorrect position.

Table 14 gives the average Likert values of the four students to the four questions in the follow up questionnaire. The responses for question one ranged from 2-5, for question two all responses were 3, and for questions three and four the responses ranged across two Likert values.

Table 14. Questionnaire results

Question	Q1	Q2	Q3	Q4
Average Likert Value	4	3	2.5	3.75

Discussion

Although limited in scope, the results of this pilot study reveal a number of interesting points. For example, in a situation where a student is presumable stuck since they are unable to identify a needed use case when asked a general question (e.g. 'are there any additional use cases?), they were able to affirm the need for a previously unidentified use case when directly prompted with the specific missing use case. This result is especially interesting in relation to the implied use

cases since the results of experiment 1 revealed that virtual all students in both the unstructured control and semistructured tIBIS manipulation groups did not identify the implied use cases in the system description[14].

Examples from the discussion and responses to the follow up questionnaire suggests that students are not blindly following the software agents, but are making evaluative judgments as to the contributions of the agents. In one case, a student changed their opinion when confronted with a direct question about their use case from one of the software agents, but in another example a student maintained their erroneous assumption. Comparing the responses to questions three, which targeted the expert's general use case prompting, with an average response (2.5) between 'somewhat helpful' and moderately helpful, to question four, which targeted software agent's specific use case prompting, with an average response (3.75) closer to 'very helpful', shows that the students were able to recognize the additional help being provided by the agents. When taken within the context of the response to question two, which targets the overall help provided by the software agents, the students consistent respond of 'moderately helpful', suggest that the students realize that the overall use case identification was a collaborative effort between the agents and themselves, but with the agents providing specific additional help. This is especially true when the 'almost all' (4) response to question one, which target the number of use cases identified, is considered.

Additional research is required to understand what conditions result in the students following, vs. opposing, the advice given by the software agents. Taken to an extreme, it may be possible to create a "good cop / bad cop" environment (Rafaeli & Sutton, 1991), in which various agents play different roles. In the follow up survey, two of the students correctly identified that one of the agents was providing more support than the other, which was true.

Finally, because students were forced to take more turns in the discussions with the software agents, they averaged 10.25 posted messages compared to the 2.84 and 5.52 averages of the control and tIBIS manipulation groups in experiment 1.

General Discussion

The studies in this paper demonstrate the potential of using a semistructured tIBIS design rationale approach to structuring a forum discussion as a basis for integrating a tIBIS-based intelligent tutoring system into an asynchronous discussion forum. Considerable research is still required in order to understand the full implications of this approach. For example, while students are generally satisfied with a blending of asynchronous online discussion and face-to-face discussions (Blankson & Kyei-Blankson, 2008), the social impact of integrating non-student agents into a forum discussion remains an open research questions. There is also an increasing need to understand the types of interactions that lead to learning gains (Chi, Siler, Jenon, Yamauchi, & Hausmann, 2001) and situations in which no learning gain occurred when a tutor led the problem solving activity (Boyer, Phillips, Wallis, Vouk, & Lester, 2009). A need to better understand and utilize the speech-acts associated with a tIBIS forum discussion remains an open question, e.g. (Ravi & Kim, 2007). At the most general level, issues concerning how to

[14] Two students, one from the control group, together identified two of the implied use cases.

technically integrate a tutoring system into a general purpose LMS also remain, e.g., (Rey-López, Bursilovsky, Meccawy, Díaz-Redondo, Fernádez-Vilas, and Ashman, 2008). The experiments in this paper provide one approach to understanding and beginning this integration.

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Appendix

Bookstore System Description

The **Metaphysical Bookstore** is developing an online bookstore system through which its customers can buy books and sell their used books. *Public users* are those who are not *registered customers* of the system

Public users or registered customers can search books by entering keywords, which may appear in the title, author or book description. The system displays a list of books that matches the keywords. Each entry of the book list consists of the book title, author(s), price, for a new copy and price range for used copies. The user can select a book from the list to display more detailed information about it (availability, price for new copy, prices for used copies, table of contents, author, ISBN).

The user can add a copy of the book (either new or old) to the shopping cart. The user can then continue to search for another book. When the user finishes searching, the user can check out the books in the shopping cart.

The system asks the user to login to his/her account by entering the user's email address and account password. If the user has not registered yet, the user can register for a new customer account at that point. The user enters the email address, home address and password. The system verifies that the email address has not been used by an existing customer before confirming the creation of the new customer account through an email message. The system then asks the user to select the shipping option (express, priority or ordinary). Different shipping options have different prices.

The user can then select the payment method (credit card or the user account of the book store). If the user selects payment by credit card, the user enters the card number, type and expiration date. The system then sends the credit card information and the

amount charged to the *external payment gateway*. The amount is calculated by adding the prices of the selected books and the selected shipping option. If the credit card transaction is approved, the external payment gateway sends back an approval code. Otherwise, the system will ask the user to reselect the payment method and re-enter the payment information. If the user selects payment by his/her account with a sufficient balance, the system charges the amount to the customer account. Otherwise, the system asks the user to re-select the payment method.

Upon completion of payment, the system arranges delivery of the ordered books. An *external shipping agent* is responsible for the delivery of the ordered books. If an order involves new books, the system sends a shipping request to notify the shipping agent to collect the books from the books store. New books in the same order are shipped together. If a used book has been ordered, the system sends a delivery request to notify the seller of the book and a shipping request to the shipping agent of the book store. The shipping agent collects the book from the seller and delivers the book to the buyer.

Used books of the same order from the same seller are shipped together. After the book(s) has/have been delivered to the buyer, the shipping agent sends a shipping completion message to the system. Upon receipt of this message, the system updates the seller's customer account by adding the price of the used book minus the commission charge for the service.

A public user or a registered customer wanting to sell a used book can go through the above process by searching the book and displaying its information. The user can then post a used copy for sale. The system will ask the user to enter the price and the general condition of the used book. Then the system further asks the user to enter the email address and password of his/her customer account for login purposes. If the user does not have an account, they can create a new account as described above.

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