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Gabriela C. Weaver
Purdue University, gweaver@purdue.edu

Kellie Green
Purdue University, kfgreen@purdue.edu

Aliya Rahman
Miami University, rahmanam@muohio.edu

Erik Epp
Purdue University, erikepp@gmail.com

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Keywords

Online learning, Scientific discourse, Computer aided education, Synchronous communication

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Gabriela Weaver
Purdue University
West Lafayette, Indiana, USA
gweaver@purdue.edu

Kellie Green
Purdue University
West Lafayette, Indiana, USA
kfgreen@purdue.edu

Aliyah Rahman
Miami University
Oxford, Ohio, USA
rahmanam@muohio.edu

Erik Epp
Purdue University
West Lafayette, Indiana, USA
erikepp@gmail.com

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This exploratory study investigated an online office hour and a face-to-face recitation for similarities and differences. The online office hour and face-to-face recitation were a part of general chemistry courses taught at different universities. The courses covered the same material at the same level. The results of the investigation revealed that in the online environment students must articulate their ideas clearly to convey them in a text-only medium. The written text seemed to help the instructor to identify misinterpretations made by the students. The instructor-dominated hierarchy between instructor and student is present in both environments. When comparing the percentage of total student and instructor events (the sum of questions and statements) in the online environment, students' events were significantly greater than instructor's events. This finding is an indication that the online environment shows promise for improving student participation.

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Introduction

Distance education provides individuals with an alternative to the traditional classroom. Distance learners have the advantage of learning at their own pace, and at times that are convenient for them. The origins of distance education came with the development of correspondence courses which relied on postal mail for disseminating and receiving information between instructor and student. With the advent of technologies such as radio and television, distance education evolved to incorporate these technological tools. In a similar evolution, computers, the Internet, and mobile technology have transformed distance education.

Instructors can use the Internet to convey information to students in a manner similar to the way that books have been used for years. However, digital technologies also afford many other communication methods. Computer mediated communication (CMC) tools are either synchronous, occurring in real-time, or asynchronous, which has a time delay. Synchronous tools include various chat facilities, video conferencing and instant messaging; examples of asynchronous tools are e-mail and bulletin boards. The capabilities of these technologies make them attractive for use in distance education programs.

It would seem logical to immediately incorporate these tools into distance education programs; however, there are still questions about the impacts of CMC on teaching and learning (Tallent-Runnels et al., 2006). For example, debates still exist about the value of using CMC's to conduct the laboratory component of science courses (Carr, 2000). Therefore, it is uncertain whether these technologies can be used in science and if so, what their impacts on learning will be. The usage of CMC to convey scientific concepts is further complicated by the distinctions between scientific and nonscientific discourse.

Science Discourse

Science is a culture with unique language, beliefs, and practices (Fuller, 1997). The vocabulary and structure of science discourse differs from common day-to-day dialogue (Lemke, 1990), which makes the appropriation of science language difficult for students (Wallace, 2004). Furthermore, the literature suggests that science discourse is best learned while engaged in authentic activities (Brown, Collins, & Duguid, 1989; Crawford, Kelly, & Brown, 2000). Authentic activities are activities that are closely aligned with normal activities of a culture; for instance, in science, authentic activities are activities which mimic the daily practices of scientists. Brown et al. (1989) define cognitive apprenticeships as opportunities to engage in authentic activities within the culture of study. During cognitive apprenticeships, the tacit knowledge of experts within the culture becomes available to the novices (Brown, Collins, & Duguid, 1989).

The language, both verbal and non-verbal, and behavior of scientists are important within the enculturation process of learning the science language. For example, scientists use their hands to describe molecules (Goodwin, 1995; Ochs, Gonzales, & Jacoby, 1996). Roth and Lawless (2002) state "gestures are not only an integral part in students' (proto) scientific language, but these gestures actually facilitate the emergence of scientific language" (p. 371). As a result, science discourse in chat-rooms poses additional concerns for novice science students because it does not allow directly for gestures.

Furthermore, scientists also rely on visual images such as graphs, photographs and animations to convey scientific information (Lemke, 1998; Linn, 2003; Velázquez-Marcano, Williamson, Ashkenazi, Tasker, & Williamson, 2004). Visual literacy is the ability to explicate the meaning of visual images, which often distort and/or over simplify reality in an effort to explain a scientific concept (Lowe, 2000). Even though visual images are sometimes complex and require interpretation by students, visual images can be useful for representing ideas. Animations, for example, have been used in chemistry to represent microscopic phenomena, such as the motion of molecules (Velázquez-Marcano et al., 2004). Concepts that were better suited for explanation using visual images such as diagrams, charts, and tables may not transfer well to a text only medium (Lemke, 2000). Other possible concerns with using CMC are explicated in the next section.

CMC Communication Challenges
In a chat-room, interaction is often in the form of typed discourse which resembles a verbal conversation (Barnes, 2003). Participants sometimes feel as though they are anonymous when participating in group discussions using CMC (Sullivan, 2002). The desire to convey feelings causes users to rely on figurative language, metaphors, and paralinguistic sounds (Tu & McIsaac, 2002). It has been noted that writers often mix paralinguistic sounds and ellipses to mimic spoken language. For example, “Uh… maybe it is for the best.” In this example, the writer uses a paralinguistic sound (“Uh”) and an ellipsis to indicate hesitation. Capital letters are sometimes used to indicate shouting, such as in the phrase, “I REALLY DON’T CARE!” Extra letters are sometimes added to words along with punctuation for emphasis. Take for instance the phrase “Girl you are toooooo much!” (Barnes, 2003).

The written dialogue in CMC varies from formal to informal. Informal dialogue in CMC may contain misspellings, typos and improper grammar, which is sometimes used purposefully for emphasis, to mimic spoken dialogue or to speed the typing process. An example is “u ain’t seen nothing yet.” In this example “u” replaces the word “you”. Improper grammar is sometimes used to give a sense of humor to the dialogue. This particular goal has resulted in the evolution of a great deal of text shorthand that is becoming increasingly familiar. For example, acronyms are used to represent common phrases. An example is “LOL”, which means “laugh out loud.” Graphic accents called emoticons, use typed characters to represent an emotion or object. For example, a flower lying with its stem and leaves to the right can be represented by “@-{~”(Barnes, 2003).

Abbreviations, acronyms, and graphic accents are used to enhance communication within the limits of the textual environment. However, a text-only environment is still limited because there are nuances found in speech, such as inflection of voice and non-verbal cues that are not readily mimicked in a text-only environment. There are additional differences between communication that occurs via e-mail, bulletin boards, and chat-rooms, rather than from face-to-face (F2F) communication, because participants are unable to see each other. The issue of anonymity is of especially interesting to those studying gender in the online environment.

Gender Issues
How to make science education equitable for all students, especially female students, is a nationally recognized area of concern (American Association for Advancement of Science, 1990; National Research Council, 1996). To accomplish the goal of science education for all, the National Science Standards (1996) incorporate the professional development of teachers, which includes the development of better teaching practices, because teachers and teaching practices are integral to issue of equability in the classroom. Teacher treatment of female students and teacher attitudes about female student ability can be linked to the anxiety that female students have in their ability to do science (Brownlow, Jacobi, & Rogers, 2000).

Teacher treatment of females within class discussions is sometimes not equitable (Duffy, Warren, & Walsh, 2002). Discussions are important because they allow students to voice opinions, ask questions, and aid in the modification of previous gaps in knowledge (Dillion, 1988).The information, regarding whether online environments are able to provide an equitable environment for discussion, is conflicting (Gunn, 2003). However, studies have indicated that female students are more likely to be apprehensive about computer usage (Yates, 2001). Conversely, there is evidence that online environments may provide a more conducive environment for equal opportunities for participation in class discussions,

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especially when female students are allowed to participate anonymously (Hsi & Hoadley, 1997). Additionally, there is evidence that female students are just as likely as their male counterparts to participate in online discussions and enroll in online classes (Price, 2006). In a study conducted by Kimbrough (1999), the online environment seemed to be favored by females. In the Kimbrough study, females participated more than males in online chat-room discussions. Nevertheless, studies have reported that the gender divide seems to be narrowing in regards to females' access to technology, the Internet and usage of computers (Ono & Zavodny, 2003). The next section will discuss the impact of learning in the online environment for participants.

Learning in Online Environments

Participants of online learning environments represent a unique culture whose interaction is limited by the restrictions of the chat-room. The discourse that occurs is the result of collaborative interactions between participants with the purpose of reaching a common goal or answer to a problem. The result of these collaborations is knowledge that has been scaffolded via interaction by participants with their peers and the "expert", which is the instructor (Gunawardena, Lowe, & Anderson, 1998). Therefore, the online environment promotes social constructivism, which states that people learn through active interaction with their environment and others (Vygotsky, 1978). It is via collaborations with peers and instructors that individuals increase their zone of proximal development.

The method of knowledge construction is different between the F2F and online environment because the nature of the environments is also different. Participants of online environments are a part of a new social environment that has interactions that occur differently than in the F2F environment (Thurmond & Wambach, 2004). Interaction within a learning community can be defined as communication for the purpose of instructional competition or social relationship building (Gilbert & Moore, 1998). Learner-content, learner-learner, and learner-instructor are three types of interaction, as defined by Moore and Kearsley (1996), and are important to study in learning environments because these various interactions are pivotal in achieving learning objectives.

The student-instructor relationship in traditional classrooms has been shown to be instructor-dominated, with few interactions between students and instructors (Klinzing & Klinzing-Eurich, 1988). Researchers have stated that students rarely pose questions of their instructors in traditional classroom settings (Blosser, 2000; Dillion, 1988). However, online environments have been shown to include more student-instructor interaction (Hartman et al., 1995). Students seem to feel more comfortable participating in the online environment and dominate discussion (Ruberg, Taylor, & Moore, 1996). Because of the textual nature of the chat-room environment, personal and physical attributes are not immediately known by participants, and users feel that they can participate without fear of discrimination (Sullivan, 2002; Tu & McIsaac, 2002).

Online environments also provide users access to content. Learner-content interaction can be defined as the "process of intellectually interacting with content that results in changes in the learner's understanding, perspective, or the cognitive structures of the learner's mind" (Gunawardena, 1999). Online discussions help students in the learning of content (Thurmond & Wambach, 2004) by providing the student with a means to discuss and ask questions about the content. These discussions often are in the form of written dialogue, which requires the student to think about the wording of responses.

According to Vygotsky (1978), written discourse necessitates the use of higher order thinking skills more so than verbal discourse. The textual nature of CMC promotes higher-order thinking because it requires participants to think about ideas and then write the ideas, which is an additional step beyond simply verbalizing the idea (Brown, 1997). Comprehension is increased when individuals can articulate how knowledge fits within their existing schema (Hacker & Niederhauser, 2000).

Study Goals

Fully online courses and the supplemental use of online content delivery are growing popularity; hence it is important to investigate the differences between these modes of communication. The main goal of this exploratory study was to provide insight into how the online environment may differ from the traditional F2F environment. We were specifically interested in the following questions:

1. What is the general procession of events in an online office hour? Do these events share similarities with the F2F environment?

2. How are informal and formal language used in either environment?

3. What types of questions are asked in either environment?

4. Does the environment impact how students and instructors interact with each other? Is the role of the instructor different in the online environment?

5. Are students more or less likely to ask questions in either environment?

6. Does the environment impact how males and females participate? Is the online environment more equitable for female participation?

This study did not evaluate specific general chemistry topics discussed in either environment. We were interested in a holistic investigation of the dynamics promoted by the two environments. The questions posed here are in keeping with the goal of exploration of the two environments versus a study of the chemistry content discussed in each environment.

To answer these questions, the scientific discourse of the participants in both an online and a traditional classroom environment were analyzed and compared. We chose to design our study to have the same instructor so that any differences that were seen in student participation would be attributable to the different environments.

Description of Populations Studied

A general chemistry course taught in a partial distance learning format at University A was compared to a traditional F2F course taught at University B. University A is located within a large Western City (population of 2.4 million); it does not have dormitories and the students must travel to campus for face-to-face instruction. University A's enrollment is approximately 12,200. University B is larger than University A with an enrollment of approximately 38,000. University B is a traditional research university in a small Midwestern city (population of 175,000). The average student age is 27 for University A and 21 for University B. Current data indicate that the average SAT scores are 1080 for University A and 1145 for University B (Collegeboard, 2008). Both universities are designated by the Carnegie classification system as research universities with very high research activity (RU/VH). The sample population for both sample groups was predominately Caucasian students. Students in both settings consisted of science and engineering majors in a required on-sequence 2nd semester chemistry course; overall both courses covered the same material at the same level.

In the online environment there were 7 males and 16 females who were registered for the course where 37 online sessions were observed. The exact number of students in each session varied to some extent. In the F2F environment, 12 different recitation sessions were observed one time only. The total number of students observed for all 12 recitation sessions were 69 males and 52 females. The instructor in this study was female. She worked at University A for 7 years and later accepted a position at University B. The instructor noted that she had similar interactions with students at both universities.

University A's General Chemistry distance learning course was designed for non-traditional students who are unable to attend courses with a traditional schedule and structure. This course utilized both asynchronous communications, such as e-mail, and synchronous tools, such as Internet chat-rooms. The students were given lectures on videotape, which they viewed on their own time. They were required to attend the laboratory portion of the course on alternating Saturdays. Online sessions were optional and held weekly via Internet chat-rooms during the evening hours. The sessions lasted approximately one hour and were usually tutorial sessions for a group of five students on average. Students who participated in the online discussions met once every two weeks with the instructor in a traditional course setting.

The second semester general chemistry course at University B caters to traditional college freshman taking it as part of the science major requirements. The required classes for the course convened on campus during regular academic hours. The recitation classes, which are a part of the course, are 50 minutes long and designed to be tutorial or problem-solving sessions. Recitation classes were chosen randomly for observation. A different group of students were observed each time with an average of 10 students per observation. University B's recitation classes are typically conducted by teaching assistants. However, in this study, the instructor for the course conducted the recitation sessions observed. Recitation classes are similar in nature to the student-instructor interaction in the online-environment; student-instructor interactions are in the form of questions and responses in both environments. These recitations provide a similar educational approach to the online sessions, but allow for the comparison of different communication media.

Methods

A mixed analysis approach, incorporating qualitative and quantitative methods, was used to explore the data. The study initially began with an investigation using only qualitative methods. Topics and themes emerged that warranted the use of quantitative methods to clarify and enhance the study. Each of these approaches provided different perspectives of the data obtained. The qualitative methods provided data for a rich description of the sequence of events in the online and F2F environment. Qualitative methods also allowed for investigation of the absence and presence of cues in the environments. Quantitative methods provided statistical descriptions of student and instructor questions. In some instances, the approaches directly complemented each other. For instance, the qualitative method of coding identified the types of questions within the transcripts; quantitative analysis was necessary to determine the number and percentage of the questions. These analysis approaches will be discussed separately because, they answer different aspects of the set of research questions, rather than being a simple quantitative/qualitative paring for each one. The qualitative section, which contains the qualitative methods and results, will be presented first. This section will be followed by the quantitative section which explains the quantitative methods and results.

Qualitative Methods

The logs of University A's online chat-sessions were saved by the instructor of the course. The logs are documents which contain the text of the online dialogue as it occurred in real time. In this study, the logs will be referred to as online transcripts. The F2F transcripts were derived from video and audio recordings of recitation classes conducted at University B. The online and F2F transcripts form the basis of the online communication portion of this study.

The transcripts were coded in a series of steps. Each transcript was read thoroughly to obtain an overall idea of the dialog. After reading each transcript, statements and questions were identified. Participants in the online environment would sometimes omit punctuation. In the F2F environment participants sometimes did not make their intentions clear. For example, students sometimes verbalized phrases (statements that were not full sentences) with the intent of eliciting a response from the instructor or others present; these were coded as questions. Once questions were identified and coded, they were further coded according to level and type as described below. Additional codes were selected to represent the participant who posed the statement or question. This resulted in four main areas of consideration: student responses, student questions, instructor responses, and instructor questions. Each of these four areas was further divided based on content and gender.

The research literature discusses that some interpretation has to be done by the researcher; however it should be done objectively with caution to avoid sacrificing the validity of the data (Rourke, Anderson, Garrison, & Archer, 2001). Two researchers independently coded a set of five transcripts, and discrepancies between researchers were counted in order to calculate inter-rater reliability using percent agreement. Discrepancies were discussed for the sake of improving agreement between researchers, and this cycle was repeated for subsequent sets of five transcripts until inter-rater reliability was found to remain above 90% for two successive sets of transcripts. After this point, the remaining transcripts were coded by one researcher only.

It is important to mention that the type and level of the question had to be determined within the context of the dialogue. Taken without the surrounding text the question or statement often would not have the same meaning. The type of a question is related to its intent or purpose, which was determined by reading the question in context. Question types with representative examples from transcripts are shown in Table 1. Question types were clarification, class content/chemistry, prompting, leading, technology, and class administration. The level of a question was associated with the degree of mental work required to answer the question. The levels include input, processing, and output based on a taxonomy developed by Costa (1985) and are further explained in Table 2.

Table 1. Description of Question Types and Examples

Question Type	**Description**	**Example**
Clarification	Checks to make sure that the responder is following the discourse	"Did this answer your question?"
Class Content	Asks about conceptual content	"So, there's a particular type of chromium, and what is it doing in this reaction?"
Prompting	Asks the responder to say more or to continue the discourse	"Ok, anything else?"
Leading	Guides the discourse in a direction to solve a problem	"What are you going to do with that number once you get it?"
Technology	Relates to technology and computer applications or usage	"How are you selecting the data and how are you telling the program to plot them?"
Class Administration	Aids in class organization and task management	"Ok, you know about the quiz right?"

Table 2. Description of Question Levels and Examples

Question Level	Description	Example
Input	Asks a responder to recall information from memory or derive it from sensory data	"How many significant figures are in this problem?"
Processing	Asks the responder to draw relationships between data	"There's actually a lot of different forms of work. So, if I'm pushing on this thing *(pushes on cart)*, it goes back to physics, right? If I'm pushing on this thing, and I'm moving across the room, and I apply a force to it. Now I come over here, and I'm going to push on the board *(pushes on the board)*. **Am I doing work in this case, or in that case, or both?**"
Output	Asks the responder to use data to hypothesize or evaluate	"For example, H is ALWAYS a terminal atom. Do you know why?"

Qualitative Results of the Online Chat-room Sessions and F2F Classroom

Each chat session began and ended in a manner similar to what one would see in a traditional classroom. During the introductory segment of the chat, the instructor and students would often engage in greetings and chit-chat about extracurricular topics such as the weather. The closing would consist of wrap-up by the instructor, including a final bid, call for questions and/or reminders of upcoming events such as quizzes. Following the wrap-up, the sessions would end with farewells from the participants. Three general categories of discourse would occur between the introductory segment and wrap-up: problem solving, classroom management, and explanation. In the F2F environment, the same categories of discourse emerged. Students also solved problems in small, collaborative groups. The instructor was not able to actively participate and monitor each small group discussion. Therefore, small group discussions will not be discussed in this paper.

In the following sections, excerpts of transcripts are used for illustration purposes. In the case of the online discussions, transcripts were taken directly from the chat-room session logs without alteration of grammar, spelling or punctuation. The F2F transcripts were transcribed from videotape; spelling and punctuation were determined by the researcher. All names have been changed. The textual transcripts for both environments were analyzed for participant language, looking for the use of formal or informal language, as well as embellishments such as the use of acronyms, emoticons, and abbreviation.
The next sections provide examples taken from the online discourse to illustrate the examples of problem solving, classroom management, and explanation.

Problem Solving
Problem solving discourse consisted of question and answer exchanges, initiated either by the students or the instructor. Instructor-initiated problem solving occurred when the students did not have any pre-selected problems they wanted to solve. The instructor would ask students to work on problems related to the content discussed in the videotaped lectures. Therefore, most problem solving occurred after the students had watched the videotaped lectures. Student-initiated problem solving occurred when students asked content-related questions either of the instructor or each other. There were numerous instances when students would begin to help one another spontaneously. The following is an example of this sort of student-initiated problem solving occurring online.

Tim: Ya, I finished. Have you done the labs yet?
Jade: I started but I haven't done the computer part, also I was at the library doing the pre-lab and it took me forever.
Tim: The pre lab for next week?
Jade: Yes that prelab.
Tim: I got stuck on question 6, lab 10, the one about determining the heat capacity of the
Tim: apparatus with two different water temps.
Jade: OK what i got on that so far was put very hot water in the cup
Jade: then dump it out, then put room tmep water in the cup. The water will raise in temp whatever amount of heat the cup absorbed.
Tim: Wow! That makes sense. Do you use that formula Theresa gave us?
Jade: So you know the amount of heat the cup is able to absorb,,,,Then I think htere's some trick with JOules, calories & densitt
Jade: which formula?
Tim: It is Qrxn = - (Qh2o + Qcal)
[Problem solving continues]

It was common for the students to help each other to solve problems in the online environment. This cooperative behavior was observed whether or not the instructor was engaged in the discussion.

Classroom Management
Classroom management discourse refers to discussions about scheduling quizzes and exams, and technical issues related to Internet chat-rooms. Students would also use the sessions to express their concerns about future assignments. Sessions in which classroom management was the major focus were often shorter than the other sessions and contained

elements of the other discourse categories. The following is an example of a short segment of discourse that occurred near the beginning of the semester, when students were first learning how to use Internet chat-rooms. In this segment, the students are referring to specific computer servers when they mention “server A”, “server B” and “server C”. The instructional technologies services group for this university is abbreviated as X. (Names have been changed for anonymity.)

Instructor:	Yes. Since you have just started with the video then perhaps this time would be ...
Lacey:	I logged in through the web but would like to Telnet via server B. However I have a server account C and was not able to
Instructor:	better spent by you watching videos. This [internet chat] thing is pretty easy, as you can see.
Instructor:	Yes, that's right. Server A will not accept server C accounts.
Lacey:	Can I get a server B account and, yes, you're right time would be better spent on videos!
Instructor:	Yes, you can get a carbon account. You can go to the X office in Y and ask them to set one up.

Explanation

The explanation discourse was similar in structure to traditional classroom lectures. The instructor acted as a lecturer and explained a topic to the students. Explanation discourse occasionally occurred when students entered the chat-room without having watched the videotaped lectures for that week. In the following example, the instructor uses the session as an opportunity to convey information to the students.

Instructor:	"yes" means neither of you has started?
Tim:	I have not started.
Amy:	No, that mean I have not watched it yet.
Instructor:	ok, that's fine. Last night was a similar situation on the [Internet chat-room] What I did was....
Instructor:	give an overview of the material that was going to be presented in the video and answered general questions. Shall we do that tonight as well?
Tim:	That sounds good.
Amy:	sure
Instructor:	Ok, this whole video is about the various properties of solutions. A solution...
Instructor:	as you might recall, is a HOMOGENOUS MIXTURE of two or more components. Everyone...
Instructor:	comfortable with the term "homogeneous mixture"?
Amy:	yes
Tim:	yes
Instructor:	Alright, a lot of this material is very "common sense" because...
Instructor:	much of it is stuff that you have had an opportunity to observe or experience in your daily lives. For example,

Instructor:	the types of solutions that can exist are gas/gas, gas/liquid, gas/solid, liquid/liquid, liquid/solid, solid/solid...
Instructor:	Someone give me an example of a gas/gas solution (homogeneous mixture) that you experience every day?
Tim:	The air we breathe?
Tim:	I think it is a solution of O2, CO2, and other things...
Instructor:	that's right. In fact...
Instructor:	the air we breathe is mostly nitrogen (N2), 78%. 21% is oxygen (O2), and most of the remaining is argon (Ar).
Instructor:	ok, how about a gas/liquid solution? There are examples of these which people consume.
Amy:	coke?
Amy:	CO2 and H2O

The Absence of Cues: Text-based Responses Online

In the online transcript segments shown above, it is possible to see the effects that a real-time textual form of communication has on grammar, spelling and multitasking of thoughts. Textual communication becomes conversational in this environment. Spelling and grammar are not important in conveying the message to other participants. In the examples presented above, a variety of spelling and grammatical errors are seen. The need to enter discourse quickly could have resulted in spelling and grammatical errors. This particular chat program does not post the text until the writer hits the enter key. As shown in the previous example, rather than have the participants wait for a reply, the writer would break long sentences into shorter segments, sometimes indicated by ellipses. In the previous segment, the instructor has broken a response into several lines of discourse.

Prompting

In some cases, the participants must be prompted to encourage discussion. In the online environment, reasons for participants not readily responding are not immediately apparent. Prompting provides the conversational starting point that students may need to begin actively participating. This is illustrated by the following transcript excerpt:

Instructor:	Formic Acid HCO2H has a K_a of 1.8 x 10^-4. What is the formula of its conj. base and what is the K_b of that conj. base?
Lisa:	conj base= HCO2 -, Kb= 5.5 x 10^-11
Instructor:	Amanda, what do you think? Do you know how to a approach this problem?
Amanda:	I can do the conj base = HCO2- , I am not sure about the Kb
Instructor:	Lisa, can you offer some assistance to Amanda?
Lisa:	yes, but let me think of how to word it
Lisa:	Well, Ka x Kb = Kw
Lisa:	Kw always = 1.0 x 10^ -14
Lisa:	So, we already know the Ka. Solve for Kb
Lisa:	Did I say that right?
Amanda:	I'm pretty sure I understand now thanks

The instructor posed a question to which one student responded while the other student was prompted to give a response. The instructor could not immediately tell if Amanda did not respond to the question because Lisa had given the correct answer or because she did not know how to solve the problem. In this case, one student provides an explanation for another student, which serves to aid in the learning process.

Clarification of Misunderstandings and Concepts

A particular benefit of the textual environment lies in its ability to facilitate the sharing of many different viewpoints. The instructor's position and voice are similar to those of the students, in contrast to the F2F environment where the instructor's voice is typically heard above the students and the instructor stands in the front of the room. The instructor is not dominating the discourse online, but is directing the flow of discourse. The participants are presenting their views in a written, rather than oral, format; all participants can see all of the viewpoints presented. This becomes helpful for evaluating correct responses to questions, such as in the next excerpt, in which the participants responded to a question using different physical units of measurement.

Instructor:	So, how much HCl is in the solution now to react with the base?
Tim:	.95 mmoles?
Karen:	0.00095 mols
Cynthia:	9.5 mL
Amy:	9.5mL
Instructor:	Hmmm, some of you are talking in moles and some of you are talking in mL. Which do you think makes the most sense if we are?
Instructor:	thinking about a reaction and its stoichiometry?
Cynthia:	mmoles?
Tim:	I would say moles or mmoles.
Karen:	moles
Instructor:	Amy?
Amy:	moles

The instructor was able to sort out the confusion over which units should have been used in the problem. Because this exchange is written, the participants could all see that there were discrepancies in their answers.

The power of the written environment to help elucidate student misconceptions is seen repeatedly throughout the transcripts. Students cannot give visual or verbal cues to the instructor, and must respond using written explanations. Students must articulate their problems and views so that the instructor can understand them. This excerpt is an example of a student verbalizing his understanding of a concept:

James:	Before last Saturday I pictured a shared e-
James:	to be in an orbit around one atom and sort of
James:	occupying a space around the other atom, for
James:	instance, take H2O.
James:	The single H e- would sort of take a space in the
James:	outer loop of O electrons.
James:	This has some problems, like how to keep the
James:	O and H e- from smacking into each other, so

Keith:	I thought we were looking at electrons, in more of a cloud, or space around the atoms
Keith:	than orbits or loops
James:	I thought last Saturday's talk about molecule geometries
James:	answered the question of how to share an e-.
James:	But now I'm more confused…….

(Here the student refers to his textbook to find a picture that represents an atomic orbital.)

James:	bonds. For H20 it shows the "cloud"…….
James:	There's still 2 dots for the electrons

Here, the student had to put into words what he was thinking. This is different from the F2F environment because the student must put increased thought into typing the response and cannot simply point to a picture to express an idea or concept. In this case, a misconception was created by a figure in a textbook that included two black dots visible in an orbital drawing, prompting the student to believe that the dots were discreet objects within an orbital-shaped container.

The Presence of Cues: Contrasting F2F and Online

In the F2F environment, unlike in the online environment, the students and instructor would refer to diagrams, drawings, and reactions without using specific terms. The F2F discourse was laden with words such as “this” and “that”, used to refer to specific entities in reactions or parts of a diagram. In the example below, the students and instructor talk about a reaction without referring to the reactants or products by their actual names, but rather by pointing to reactions written on a chalkboard.

Instructor:	This thing and what about the base?
Felicia:	Water
Instructor:	Okay alright how about the other side?
Instructor:	(she writes on board) Acid…I am going to put little conjugates and we are left with that. Okay, how does the ka2 equation look to everybody?
Joe:	Super
Instructor:	Super, yes and who’s acting as the acid over here?
Joe:	First thing
Instructor:	Okay, hopefully you’ve noticed that parallel, right? That’s what we talked about yesterday right, that amphoteric behavior. This thing it’s in equilibrium and it can either accept this proton back and make the acid again in which case it is acting as a base or it can just keep going further.

Even though several lengthy instructor monologues are seen, exchanges between instructor and students were short. Student responses in the F2F environment were often brief, and prompting in the F2F environment consisted of short questions and answers, as seen in the following example.

Instructor:	Okay, the lead?
Angela:	Yeah

Instructor:	and that is using 1.6 for
Angela:	yeah
Angela:	8.86 x 10 to minus seven
Instructor:	What was your first number?
Angela:	3.38
Instructor:	I mean what was your previous number
Angela:	Oh, um 5.97
Instructor:	You went to 6 and then you went to 8.86 times ten to the minus seven?
Angela:	Yeah

These short exchanges were seen quite often in the F2F environment. In this example, the exchanges are so fast that the instructor does not finish her question before the student replies. This may be because visual cues prompted the instructor to stop speaking. The absence of visual cues and the speed at which discourse can be entered in the online environment does not allow these rapid exchanges.

The discourse in the F2F environment was not as clearly articulated as in the online environment. The instructor asked numerous questions in the F2F environment, prompting the students to explain their reasoning for their answers to problems. In one session, the student realized that the instructor wanted further clarification.

Instructor:	So, what was next?
Erica:	Oh, okay then we put that in a ICE chart and I'm assuming zero for both the products and um we put .10 as for the initial of EA, EDTA and then we put the value in for the one EDTA.
Instructor:	What did you guys do with your numbers, you find the concentration with, and what did you do with those?
Corey:	We set-up an ice table.
Instructor:	(turning to a different group of students) So you also set-up an ice table?
Corey:	Yeah, you want me to explain?
Instructor:	Actually would one of you guys be willing to come up and write out your ICE table, just the column and the row headings we could fill out the numbers together.

The instructor would often get the students to write on the board to enrich the discussion because of the brief responses given when questions were asked.

In the F2F environment, there were side conversations that could distract the instructor and students; this was not a problem in the online environment, where side conversations could occur in separate chat-rooms visible only to the people participating in that conversation. Another phenomenon not observed in the online environment was students waiting after class to ask questions even after bids for questions from the instructor during class time. It appeared that students were intimidated by asking questions in the classroom environment when all of the students were present; instead, they would wait until class ended and then line up to ask their questions to the instructor one at a time.

Both environments appeared to be similar in the sequence of events; there was an opening bid for questions by the instructor, followed by a question and answer series with participation from the instructor and the students. The instructor directed the discourse in both environments. The instructor's questions in the online environment elicited responses from the students and in the F2F environment questions served a similar role. In the both environments, the instructor's questions helped to clarify students' responses. The instructor's responses to students' questions were also similar in nature in both environments.

Students' responses differed in nature between the environments. The students' responses in the online environment tended to be more thoroughly articulated than in the F2F environment. The higher level of detail that we observed for online students, may be the result of their need to verbally compensate for a lack of diagrams and other visual aids that are often available in a F2F environment.

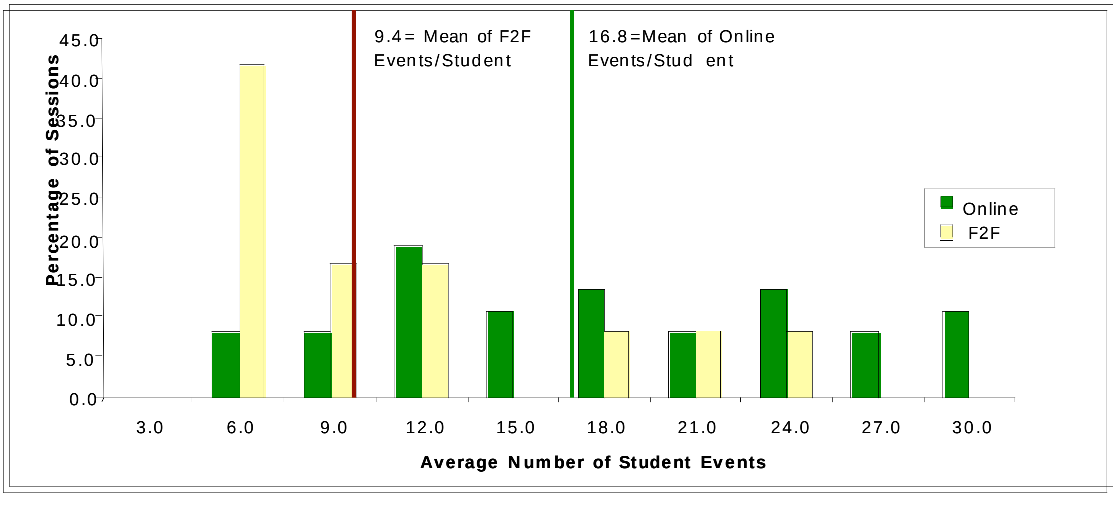
Quantitative Methods

SPSS was employed to perform statistical analyses of the data obtained. The students' and instructor's statements and questions were counted in the various subcategories, and frequency data were obtained. In order to carry out gender based comparisons, it was necessary to normalize the number of gender-based events. An event is either a question or statement.

Results of Quantitative Data for the Online and F2F environment

The average number of events per student is 9.4 for the F2F environment and 16.8 for the online environment in the in figure 1. In the online environment, there is a higher average number of events per student than in the F2F environment.

Figure 1. The average number of student events represented as an occurrence frequency over the sessions



General Effect of the Environment on Participant Behavior

Table 3 shows the percentage of event types for both students and instructors within each environment. In the F2F environment, significantly more student and instructor questions are asked than online ($p<.01$), and as shown in Table 4 significant differences were tested by using t-tests to compare the means of both populations.

Table 3. Percentage of Event Types for Instructor and Students within Environments

Environment	Questions	Statements
Online	32.53%*	67.47%
F2F	40.89%*	59.11%

Note *p<.01

Table 4. Effect of the Environment on Question Level

Question Level	Environment		*t*	*df*
	Online Mean *(Std Dev.)*	F2F Mean *(Std Dev.)*		
Input	.7711 (.14320)	.9217 (.05863)	2.887	36
Processing	.2068 (.14230)	.0736(.05774)	-2.570	36
Output	.0220 (.03011)	.0047(.00975)	-2.669	36

Note. *$p<.05$, ** $p<.01$

Statistically significant differences were found between the environments for the content, clarification, technology and leading questions as shown in Table 5. The results of question type distributions are shown in Table 5. These data include student and instructor combined. Significantly more content questions were asked online than F2F. This information, along with the fact that significantly more processing and output questions were asked online, suggests that the online environment promotes scientific discourse and higher-order thinking.

Table 5. Effect of the Environment on Question Types

Question Type	Environment		*t*	*df*
	Online Mean *(Std Dev.)*	F2F Mean *(Std Dev.)*		
Clarification	.2281(.09607)	.3529 (.06906)	3.430**	36
Prompting	.1776 (.02325)	.1862 (.07147)	.183	36
Technology	.0309 (.06550)	.0016 (.00448)	-2.432*	36
Administrative	.0952 (.01930)	.0581(.03755)	-1.583	36
Content	.4278 (.14489)	.3039 (.08379)	-2.303*	36
Leading	.0404 (.05248)	.0972 (.05514)	2.619*	36

Note. *$p<.05$, ** $p<.01$

Instructor vs. Student

T-tests were carried out to look for significant differences between student and instructor questions, statements, and total events. In the F2F environment, the instructor asks significantly more questions ($p<.001$) than students (Table 6), and more total events can be attributed to the instructor ($p<.01$). Students tend to dominate the discourse online, as shown by the percentage of total events ($p<.001$). There is a significant difference between the percentage of student questions asked online compared to F2F ($p<.000$).

Table 6. Student and Instructor Event Distribution between Environments

Category	Environment	Events	Percentage	Significance
Statements	Online	Student Statements	65%	$p<.001$
		Instructor Statements	35%	
	F2F	Student Statements	68%	$p<.001$
		Instructor Statements	32%	
Questions	Online	Student Questions	42%	$p<.01$
		Instructor Questions	58%	
	F2F	Student Questions	13%	$p<.001$
		Instructor Questions	87%	
*Total Events	Online	Total Student Events	58%	$p<.001$
		Total Instructor Events	42%	
	F2F	Total Student Events	46%	$p<.01$
		Total Instructor Events	54%	

Note. * Total events are sum of the statements and questions

Male vs. Female Student

The number of male and female students in each session varied. Sessions in which only one gender was present were removed from the analysis. To compensate for the variation in participation between males and females, the average number of items (events, questions, and statements) per gender was calculated. Normalizing the data in this way takes into account both the unequal distribution of males and females registered for the course, as well as difference in daily attendance.

These numbers were tested using binomial and chi-squared tests, against an equal distribution that would have resulted if males and females behaved the same. The results indicate that the male contribution to online questions was statistically significantly higher than from females in that environment. This also contributed to an almost significant difference observed between genders for the overall events in the online environment. No statistically significant differences were seen in the F2F environment.

Table 7. Total events per student over the course of each semester (normalized by male/female attendance at each session)

Category	Student Gender	Environment	
		Online	F2F
Events per Student	Male	535.1*	58.8
	Female	475.4*	59.9
Questions per Student	Male	138.2**	6.2
	Female	94.8**	11.1
Statements per Student	Male	369.9	52.6
	Female	380.6	48.8

*Chi-square p=.059, ** p<0.01

Participant Thread Initiation

Related events, including both statements and questions, were grouped sequentially into threads. Related events are events which are a part of the same thought or topic. The number of events in each thread was determined, as well as who initiated the thread.

Initiation was defined as the beginning of a new topic or process of thought. Male and female students initiated similarly in both online and F2F environments. Male student thread initiation accounted for 69% and 67% of student initiated threads in the online and F2F environment respectively. The instructor in the F2F environment initiated significantly more threads than the students, but there was no significant difference in the online environments. In table 8, the percentages of student and instructor initiated threads are given.

Table 8. Participant Thread Initiation

Environment	Thread Initiation	Percentage	Significance
Online	Instructor Initiated Threads	54.39%	p=.82
	Student Initiated Threads	45.61%	
	Instructor Initiated Threads	80.98%	p<.01
F2F	Student Initiated Threads	19.02%	

The data discussed here suggest that the online environment resulted in eliciting more higher-order thinking as shown by the larger percentage of output and processing questions. However, input questions were found to be the greatest fraction of questions in both environments, which implies that lower-order questions dominate in both environments. Both environments are comparable in the percentage of chemistry-related questions asked by participants. A greater incidence of content questions means that the language of science was used more often. This, in turn, means that students in the online environment were required to think more often about how to word responses to scientific questions than those in the F2F environment. Processing and output questions require higher-order thinking and elicit responses that require articulation of science ideas. Students had to effectively “talk” science in the online environment to answer processing and output questions.

Discussion of Quantitative and Qualitative Results

The online and F2F environments are similar in the types of discourse that emerges: problem solving, classroom management, and explanation. The results of the present study provide examples in which the instructor must act as a manager and teacher in the online environment. This result is similar to the results obtained by Avgerinou and Andersson (2006). Their study investigated teachers’ perception of their role in online environments. In their study they were specifically investigating whether the categories of “pedagogical, social, managerial, and technological” were consistent with teachers’ perceptions of their role in online environment. Their study showed that teachers who taught in the online environment had perceptions of their role that were consistent with those categories.

Our results do not show that the online environment is more favorable for female participation. However, Anderson and Haddad (2005) found favorable results for female participation in online discussions. The female participants of their study perceived that they achieved a greater depth of learning online. Anderson and Haddad concluded that female’s perceived depth of learning was due to the online environment providing them with opportunities to “voice” their opinions, more so than in the F2F environment. Anderson and Haddad defined voice “as the degree to which students feel comfortable expressing their views in class and the extent to which they feel their views are heard and valued by other students" (p. 4). Kimbrough's study (1999) also found that female students favor online communication. In contrast, in a review of gender usage of CMC, Li (2005) suggests that the online environment may not be as equitable as perceived. Li's review indicated that further research needs to be done of CMC and provided a list of suggestions.

This study also suggests that the online environment is a suitable environment for dialogue between instructor and students: students were required to provide detailed responses, which helped to facilitate a meaningful dialogue between the instructor and students. The percentage of higher-order questions asked in the online environment also supports the assertion that the online environment helps to promote higher-order thinking.

Limitations

Two dissimilar courses form the body of this study. The dissimilarity in student demographics may play a role in the observed differences in discourse behavior. We are unable to determine at this time the exact extent of this effect. Even in the face of uncertainty regarding the impact of student demographics on discourse style, the data regarding the online behavior do provide insight into the dynamics that professors will likely encounter when teaching in an online environment and its likelihood of being different from their experiences in a traditional setting.

Conclusions

In spite of the differences between the universities, this study presents some interesting findings. Our data and analyses indicate that the online students had to articulate their thoughts clearly using only text. Careful, textual articulation was necessary because the chat-room sessions consisted only of text and were void of the visual cues present in F2F environments. The students' text-based responses helped the instructor to identify misunderstandings. Therefore, students' and instructor's modes of participation were impacted by the online environment.

This study is a starting point to understanding the impact of environments on the communication of science. Further research is needed to gather information about which scientific topics are most suitable for online communication. In addition, the emergence of tools such as Skype™ and Adobe Connect that allow for synchronous video-conferencing also warrant an investigation of how multimodal communication impacts scientific discussion and the differences and similarities such an environment will have when compared to the traditional ones.

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