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Florence R. Sullivan[a], Manu Kapur[b], Sandra Madden[a] & Stefanie Shipe[a]
[a] University of Massachusetts, Amherst, MA, USA
[b] National Institute of Education, Nanyang Technical University, Singapore
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Florence R. Sullivan[a*], Manu Kapur[b], Sandra Madden[a] and Stefanie Shipe[a]
[a]University of Massachusetts, Amherst, MA, USA; [b]National Institute of Education, Nanyang Technical University, Singapore

In this study, we examined whether gendered discourse styles were evidenced in online, synchronous, physics collaborative learning group discussions, and the extent to which such discourse patterns were related to the uptake of ideas within the group. We defined two discourse styles: the oppositional/direct style, theorized to be the socialized discourse pattern typically used by males, and the aligned/indirect style, theorized to be the socialized discourse pattern typically used by females. Our analysis indicates the presence of both styles in these chats and the styles were generally utilized along theorized, gendered lines. However, we also observed male use of the stereotypically 'feminine' discourse style and female use of the stereotypically 'masculine' discourse style. Moreover, we found no main effect for discourse style on the uptake of ideas. The findings indicate that, contrary to prior research in both face-to-face science classroom settings and online physics settings, ideas were taken up at relatively similar rates regardless of the gendered discourse style employed. Design implications of this study are discussed and suggestions for future research are made.

Keywords: *Online Learning; Collaborative Learning; Gender Bias; Secondary Science Education*

In this paper, we report the results of our investigation into the impact of socially constructed, gendered discourse styles on the uptake of ideas in online, physics problem-solving, chats. Our work builds on previous work in science education and in online

*Corresponding author. University of Massachusetts, Amherst, MA, USA. Email: fsullivan@educ.umass.edu

learning that suggests that women and girls may be taken less seriously in science class discussions due to their discourse style (Guzzetti & Williams, 1996; Herring, 2003; Jeong, 2005; Lemke, 1990). The term, 'socially constructed, gendered discourse styles', refers to the fact that ways of speaking are *not* innate; they are learned through socialization (Lakoff, 1975; Tannen, 1994) and interaction in specific social groups (Bakhtin, 1981).

Moreover, while the term 'gendered discourse style' may suggest gender essentialism, we reject essentialism and embrace the term from a post-structuralist, feminist viewpoint. From this viewpoint, the term indexes *power* (as much as gender) in a given context (Hall, 2004; McConnell-Ginet, 2004). Given the historical, societal power relations of men and women, the 'masculine' discourse style indexes greater power, and the 'feminine' discourse style indexes less power (Lakoff, 1975). From a post-structuralist view of gendered identity, we maintain that, depending on the context, women and men may use a more stereotypically 'masculine' or 'feminine' style of speech (Mills & Mullaney, 2011). Further, we argue that in science learning settings gender is highly salient. In such settings, women are positioned as less powerful; this positionality may incline them to use a less powerful 'feminine' style of speech, and this gendered style may affect whether and how ideas are taken up in the online conversations.

In this study, we examine the use of stereotypically 'feminine' discourse which is theorized as indirect, non-confrontational, polite discourse that seeks harmonious agreement with others—we term this stereotypically 'feminine' discourse as 'aligned/indirect (AI)' discourse. We also examine the use of stereotypically 'masculine' discourse, which is theorized as direct, confrontational, seeking independence and dominance—we term this stereotypically 'masculine' discourse as 'oppositional/direct (OD)' discourse.

Our work explicitly focuses on student responses to proffered ideas. This focus is important because, as research in face-to-face collaborative learning environments has clearly shown, how students take up and respond to one another's ideas has a strong impact on learning outcomes (Barron, 2000, 2003; Mercer, 1996). For example, transactional exchanges, in which students directly take up, question and elaborate upon one another's ideas are the primary mechanisms by which learning occurs in collaborative learning environments (Barron, 2003; Cohen, 1994; Mercer, 1996). Our goal is to determine whether and how ideas are taken up in online, science learning settings by focusing on ignored initiations. Ignored initiations are comments in the chat thread that are not responded to by anyone.

While research has been conducted on issues of gender in online learning environments (reviewed below), little research has explicitly focused on the role of gendered discourse in the uptake of ideas in online science learning environments. Therefore, this research adds a new and important dimension to our understanding of interaction in such environments. We undertook this study because there remains a gender gap in science, technology, engineering and math (STEM) participation overall and in engineering, physics and technology-related disciplines specifically (American Association of University Women, 2010). Indeed, while girls are closing the gap in taking advanced mathematics and chemistry courses in high school, this is not the case for physics (Lindberg, Hyde, Peterson, & Linn, 2011). For example, in the USA, only 21% of physics majors at universities across the country are women (Ivie & Tesfaye, 2012). The data for this study were collected in India, where the situation for women in science, engineering and technology is similar. For example, according to a recent study, 23% of engineering majors in India are women (Gupta, 2012), 34% of majors across all of the natural science fields are women (Gupta & Sharma, 2003) and 30% of students enrolled in masters programs in physics are women (Godbole, Gupte, Jolly, Narasimhan, & Rao, 2005). These numbers are similar in other countries, as well, for example, only 14% of engineering majors in the UK are women (Gupta & Sharma, 2003).

Gendered Bias and Science Learning

Recent literature reviews on the persistent under-representation of women in STEM disciplines (Brotman & Moore, 2007; Scantlebury & Baker, 2007) implicate social and environmental factors. Social factors are related to the widespread implicitly held bias that the STEM disciplines are 'male' disciplines (Nosek et al., 2009). This bias is not only seen in the USA, but is also found in countries like India (Gupta, 2012). This bias is reflected in many ways, including young students' internalization of such stereotypes as evidenced in the literature on draw-a-scientist studies (Finson, 2002). These internalized stereotypes have debilitating effects. Steele (1997) has demonstrated that when negative stereotypes of women and minority students' abilities in STEM courses are made salient in a classroom environment, these stereotypes have a negative impact on students' actual performances. This phenomenon of threat extends to situational cues, such as the number of men or women in a given STEM learning environment (Murphy, Steele, & Gross, 2007) and to the perception of specific objects in a classroom environment as cueing 'maleness' and thereby alienating women from the class (Cheryan, Plaut, Davies, & Steele, 2009). Moreover, women in STEM majors report experiencing stereotype threat and higher levels of discrimination than do women in the Humanities or men in any major (Steele, James, & Barnett, 2002). Women who experience stereotype threat show less motivation to improve their class performance (Fogliati & Bussey, 2013) and they are more likely to consider changing their focus of study (Steele, et al., 2002). Recent research indicates that stereotype threat continues to be an inhibitive psychological factor for women involved in computer-based activities (Koch, Muller, & Sieverding, 2008).

Stereotype threat also affects the types of science learning environments that are created. For example, historically, research has shown that science teachers leading whole-class discussions ask high-level questions of boys more frequently (Becker, 1981; Hall & Sadler, 1982). And, they elaborate more on the responses of males than those of females (Jones & Wheatley, 1990). According to Lemke (1990) science teachers will take a student's argument on a position more seriously when it comes from a male. Meanwhile, Guzzetti and Williams (1996) have argued that when it comes to whole-class science discussions, adolescent girls and boys employ different discourse styles they have developed in relation to their gendered socialization. These socially constructed discourse styles tend to reinforce negative stereotypes of women's ability in science, positioning women as diffident and uncertain about their knowledge, while the socially constructed male discourse style positions them as confident and sure of their ideas.

While there was initial hope that communication in online environments would lead to a level of anonymity that would result in a reduction in this type of bias (Graddol & Swann, 1989), researchers report that gendered discourse styles are indeed found in online discussions (Herring, 1993); and, moreover, these gendered discourse styles affect the nature of the conversation in online discussions. For example, Jeong (2005) reports that when students use hedging qualifiers, such as 'but, if, may/might, I think, often, probably, and though' (p. 7), to introduce arguments in online discussions, these arguments elicit fewer responses. And this is particularly true when women offer such qualified arguments. Hedging qualifiers attenuate the illocutionary force of an assertion and introduce a diffidence that may reduce everyone's confidence in the worth of the argument. As will be discussed below, women tend to use hedging qualifiers in speech more often than men. However, recent research has shown that when discourse in online, asynchronous discussions is constrained by scripted elements that attempt to eliminate gendered aspects of talk, some of the differences in gendered discourse patterns are lessened (Jeong, 2006; Jeong & Davidson-Shivers, 2006).

Furthermore, it is not always the case that women use more qualifiers than men in online environments (Graddy, 2006). For example, Graddy found that men and women working on a team project in a college economics course used statistically equivalent numbers of qualifiers (stereotypically female style) and intensifiers (stereotypically male style) in their online posts. Palomares' (2006) self-categorization theory may explain this result. Palomares argues that individuals go through a process of self-categorization when they engage in any dialog; according to his theory, the relative salience of gender in the context will influence the individual's use of a gendered discourse style. If gender has low salience, gendered discourse is less likely to be used, if gender has high salience, it is more likely to be used. And, in fact, it may be argued that negative gender stereotypes are always present in specific science settings, such as physics classrooms due to the prevalent view of it as a 'male' discipline (White & Tesfaye, 2011). This helps to explain findings such as those reported by Ding and Harskamp (2006) and Ding, Bosker, and Harskamp (2011) who found that, in online, physics problem-solving discussions, girls who are randomly assigned to work in mixed gender dyads with boys (of equal ability) perform poorly in comparison to the male partner. These girls also perform worse than females working in single gender groups and males working in single gender groups, even though pre-tests show no pre-existing differences in physics ability for any of the students. These findings suggest that stereotype threat plays a role in these online physics learning settings as the only explanation for the girls' poor performance was their assignment to work in a mixed gender dyad.

Given the rapidly expanding practice and influence of online learning in both K12 and higher education settings (Means, Toyama, Murphy, Bakia, & Jones, 2010), and the dramatic under-representation of women in physics (Godbole et al., 2005; Ivie & Tesfaye, 2012; Lindberg et al., 2011), this paper investigates the role of gendered discourse in an online physics problem-solving setting. Specifically, we examine whether or not gendered discourse styles affect the uptake of ideas in these chat sessions, as they have been shown to do in the face-to-face classroom. As discussed previously, the uptake of ideas in collaborative learning groups affects learning outcomes for group members (Barron, 2000, 2003; Cohen, 1994; Mercer, 1996). Moreover, while there are many studies related to gendered discourse in online learning formats (reviewed below), we know of few studies that explicitly investigate the *uptake of ideas* in these formats. Therefore, this study contributes to our developing understanding of the role of gendered discourse in online science environments and in the consideration of designing for the social infrastructure of online, collaborative learning environments (Bielaczyc, 2001). As Hakkarainen and Palonen (2003) have noted, social support is a critical component of girls' successful participation in such environments.

Gendered Discourse Styles

Sociolinguists have long been interested in the differences in discourse styles among men and women (Lakoff, 1975; Tannen, 1990). For example, Lakoff notes that women are more likely to make use of tag questions at the end of statements, which serve to attenuate the illocutionary force of the remark. Lakoff argues that tag questions position the speaker as less confident about her own statement and puts the addressee in the position of being able to confirm or disconfirm the statement. According to Lakoff, women are taught to use tag questions as a form of polite conversation and as means to prevent women from making strong statements that may result in direct conflict or confrontation with others. Another aspect of politeness in conversation, according to Lakoff, is the use of hedges:

> Another manifestation of the same thing is the use of 'I guess' and 'I think' prefacing declarations or 'I wonder' prefacing questions, which themselves are hedges on the speech-acts of saying and asking. 'I guess,' means something like: I would like to say . . . to you, but I'm not sure I can (because I don't know if it's right, because I don't know if I have the right, because I don't know how you'd take it, and so on), so I'll merely put it forth as a suggestion. (1975, p. 54)

Meanwhile, Tannen (1990) has identified women's discourse style as 'interdependent' and 'cooperative' fulfilling a 'rapport' function; while men's is more 'independent' and 'assertive' fulfilling a 'report' function. According to Tannen:

> For most women, the language of conversation is primarily a language of rapport: a way of establishing connections and negotiating relationships. Emphasis is placed on displaying similarities and matching experiences . . . For most men, talk is primarily a means to preserve independence and negotiate status in a hierarchical social order. This is done by exhibiting knowledge and skill, and by holding center stage through verbal performance such as storytelling, joking, or imparting information. (1990, p. 77)

For Tannen, the rapport function is akin to 'private speaking', whereas the report function is akin to 'public speaking'. However, one can perform private speech publicly, and public speech privately.

This earlier work on stereotypically female and male speech is supported by more recent work that shows similar patterns. For example, Mullaney (2007) has demonstrated that when women managers in business settings use more assertive language they are viewed as 'unfeminine' by others. Walsh (2001) has found that women in male-dominated professions who use assertive language in their professional actions are viewed negatively by others; and Mills (2006) has determined in her research that women academics experience more performance anxiety than men when faced with public speaking tasks. According to Mullaney, this is due, in part, to their perception that public speaking requires a gendered performance that is masculine in nature and, hence, outside of their typical performances.

It is important to note that these 'gendered' ways of talking are learned through socialization (Lakoff, 1975; Tannen, 1994). They should not be seen as innate ways of speaking, but, rather, as taught and learned ways of speaking—congruent with a world view of male dominance. *Despite 40 years of feminist consciousness, such a world view persists in many areas and especially in science*. For example, recent research by Moss-Racusin, Dovidio, Brescoll, Graham, and Handelsman (2012) has demonstrated that a representative sample of professors of science in the USA continue to discriminate against women in hiring and career advancement situations *based on gender alone*. Discrimination against women in science is not a phenomenon that is confined to the West, but is found in other areas of the world. For example, in India, where the data for this study were collected, research indicates that Indian women scientists and engineers face similar gender bias as that faced by women in the West (Gupta, 2007). Indeed, Godbole et al. (2005) point to gender bias as the reason for the low number of women in physics in India. Gupta and Sharma (2003) explain this bias as having roots in the patrifocal organization of Indian society. Patrifocality, a term coined by Mukhopadhyay and Seymour (1994), refers to the particular arrangement of male domination in Indian society. In this view, the public sphere is the province of the male and the private (home) sphere, that of the female (Gupta, 2007). While these views of men's place and women's place may be slowly changing in India, they still present special barriers to women's participation in the sciences (Gupta, 2012). Hence, we argue here that women in both the USA and India are facing similar situations when it comes to participating in science learning and that research on gender in learning environments will have implications for both settings, and, most likely, beyond.

Gendered Discourse in Online Environments

Similar to the science classroom-based language research discussed above, language research on gendered discourse patterns in online environments also report a pattern of gendered discourse. For example, Herring (1993) found women's contributions on electronic bulletin boards evidenced 'attenuated assertions, apologies, questions, personal orientation and supports others', while men's discourse featured 'strong assertions, self-promotion, rhetorical questions, authoritative orientation, challenges others and humor/sarcasm'. Women are more likely to adopt an aligned stance in online discourse, whereas men are likely to adopt an oppositional stance (Herring, 1996). Likewise, Jaffe, Lee, Huang, and Oshagan (1999) found that in online discussions women are more likely than men to demonstrate discourse patterns based on an idea of social interdependence. Specifically, they are more likely than men to refer to other's comments, make self-referential comments, and make supportive comments. However, when online discussions are numerically imbalanced (e.g. predominately male or predominately female) participants from the minority gender are apt to adopt aspects of the majority gender's online discourse style (Jaffe et al.). Herring (1996) also found that men are likely to post more and longer comments than women.

Herring (2003, 2004) has argued that language itself can expose a participant's gender in online communication (p. 544). For example, in her research on gendered discourse behavior in online discussion boards and chat rooms, she reports results that were ' ... positively Lakoffian. Not only did it turn out that men used measurably more assertive and less polite language than women, but women also expressed more aversion to such language' (p. 217). This may be so because, as Jeong and Davidson-Shivers (2006) have suggested, the 'social constraints manifested by gender differences continue to place a significant influence on gender behavior and participation in computer mediated communication [online discussions]' (p. 544). Based on our reading of the research, we agree completely with this assessment.

Moreover, we argue that the perception of STEM disciplines as 'male' disciplines makes gender a salient variable for all involved in STEM topic-based discussions. Indeed, given the view of physics as a male profession (White & Tesfaye, 2011), the context for the interpretation of women's discourse in online, synchronous, physics learning collaborative group discussions is one that positions women as less powerful than men. Based on prior research in both science classrooms and online environments, it is likely that gendered discourse styles will be utilized in synchronous online science discussions. Furthermore, it is possible that these styles will influence the uptake of ideas in the online chat, and, in turn, affect learning outcomes for participants in the chat. To examine these possibilities further, we propose the following hypotheses derived from our reading of the literature:

(1) Students will evidence the use of the OD discourse style characterized by strong assertions featuring absolute and exceptionless adverbial terms, presuppositions and flaming comments and the AI discourse style characterized by attenuated assertions featuring hedges, tag questions, qualifiers and politeness indicators in science-based, online, synchronous discussions.
(2) On the average, male-dominated chats will be more likely to utilize the OD discourse style than female-dominated chats and female-dominated chats will be more likely to utilize the AI discourse style than male-dominated chats.

(3) Due to the rapport function of stereotypically female discourse styles, chats that are characterized by the AI discourse style will evidence fewer ignored initiations than chats that are characterized by the OD discourse style.

Methods

The data for this study were derived from a larger study that examined the role of productive failure (Kapur, 2008; Kapur & Kinzer, 2009) on high school physics students' collaborative problem solving in a synchronous, online discussion. Briefly, all of the problems in the study dealt with car accident scenarios, which necessitated the use of concepts drawn from Newtonian kinematics to solve. Eleventh-grade students enrolled in a physics course in secondary schools in a Northern Indian city were randomly assigned to solve either well or ill-structured physics problems (for a full description of the design and methods used to collect the data, see Kapur, 2008 or Kapur & Kinzer, 2009).

Kapur's (2008) findings revealed that while students in ill-structured problem groups *initially* failed to solve the problems (compared to those in well-structured problem groups), they outperformed students in the well-structured problem groups on subsequent near and far transfer problem-solving tasks. Kapur terms the experience of students in the ill-structured problem groups as productive failure. Kapur attributed productive failure, in part, to the wider exploration of the problem and solution spaces engaged in by students in the ill-structured problem group, even though such exploration did not result in problem-solving success initially, there was a lasting positive learning effect of such exploration (Kapur & Rummel, 2009; Kapur, Voiklis, & Kinzer, 2005). Given that these findings also revealed that a person's gender or a group's gender makeup did not affect group or individual outcomes, the productive failure groups constitute an intriguing sample of students to examine our hypotheses concerning gendered discourse patterns.

Specifically, we wanted to examine if Kapur's (2008) findings of no gender effects were, in part, due to a lack of gendered discourse patterns in productive failure groups and hence did not influence the uptake of ideas. If, however, we were to find that gendered discourse patterns are prevalent as theorized but do not influence the uptake of ideas, this is also important to understand. Either way, our analysis will add an important explanatory layer to the role of gendered discourse styles in online science learning environments.

Data Analysis

Data sources for this paper consist of 38 chats derived from 38 separate student groups. Each chat includes three students. The students, while in the same high school classes, were anonymous to one another in this chat environment, identified by a number only. Nine of the 38 chats were predominantly female (2 females and 1 male, or 3 females) and the remaining 29 chats were predominantly male (2 males and a female or 3 males). Due to the fact that fewer girls were enrolled in the secondary school physics course than boys, there were fewer predominantly female chats in the dataset. One of the predominately male chats included a significant amount of text in Hindi. We translated the text in this chat using an online translation system. The interpretation provided by the online translation system was meaningful and indicated that the students were solving the problem using both languages (Hindi and English). Therefore, our data corpus consists of 38, three-person chats, 9 of which are predominately female and 29 of which are predominately male.

Analysis of the chats proceeded in two phases. The first phase consisted of quantitative content analysis (Chi, 1997). In this method, one establishes a coding system, trains coders on the use of the coding system, codes the data, establishes inter-rater reliability, counts the codes and then performs non-parametric statistical analysis of the categorical data. To perform our quantitative content analysis, we began by creating a gendered discourse, coding scheme. This coding scheme consisted of two codes that were theoretically derived from the work of Herring (1993), Lakoff (1975) and Tannen (1990) (for a discussion of theoretically derived coding schemes, see Strauss & Corbin, 1990) and seven data-driven codes. The data-driven codes were created in order to account for *all* utterances in the chat. Accounting for all utterances in the chat is important for establishing inter-rater reliability. The construct of interest in this study is gendered discourse. Therefore, the analytically significant codes are the two theoretically derived gendered discourse codes. These codes were the AI and the OD code. The AI code was used to code utterances that utilized specific discourse features argued to be typical of women. The OD code was used to code utterances that utilized specific discourse features argued to be typical of men. Table 1 presents a qualitative description of the gendered discourse features that determine these codes, as theorized by Herring, Lakoff and Tannen; an example of such discourse from our dataset and the code we applied to utterances that evidenced the gendered discourse feature. See Appendix for our complete gendered discourse codebook and data examples of each code.

Two graduate students were trained on the use of the coding scheme. These students were not aware of the gender makeup of the students in the chat while coding. Krippendorf's alpha was utilized to determine the inter-rater reliability of

Table 1. Examples of theoretically derived, gendered discourse features and codes

Discourse feature	Example	Code
Typically female		
Hedges and qualifiers	I think, maybe, perhaps, it might be, etc.	AI
Tag questions	do you agree?, right?, etc.	AI
Politeness indicators	please, sorry, thank-you, etc.	AI
Typically male		
Exceptionless adverbials	by no means, never, etc.	OD
Presuppositions	it is clear, it is obvious, etc.	OD
Absolute adverbials	Obviously, definitely, etc.	OD
Flaming comments	that is stupid, shut up, etc.	OD

each chat controlling for agreements arrived at by chance. We calculated Krippendorf's alpha for each chat individually and then over the entire 38 chat dataset, alpha for individual chats ranged from .58 to .91. Inter-rater reliability for the entire dataset was calculated at $\alpha = .80$. Disagreements were resolved through discussion with the first author of the study. The coding of the chats allowed us to test our first hypothesis related to whether or not gendered discourse styles could be detected.

Next, we tabulated the number of total gendered comments in each chat and calculated the proportion of OD comments to the total number of gendered comments in each chat. Each chat was initially coded AI if the proportion of OD comments was less than 0.5 and OD if the proportion was greater than 0.5. At this point, we were confronted with an analytical dilemma. We sought to identify chats for which we could be confident that the proportion of OD comments did not simply represent chance variation from a 50/50 population. That is, we wanted to include chats for which the signal within each chat was significantly different from 50% OD. While each of the 38 chats featured gendered talk, some of the chats were almost even in the proportion of AI and OD comments uttered. Therefore, we faced the problem of confidently assigning a given chat to one gendered discourse category or the other. To address this dilemma, we constructed 95% confidence intervals for each sample proportion and used these intervals to categorize the chats into either the AI or OD category. Confidence intervals containing 0.50 suggested that the chat could not be confidently categorized as AI or OD; whereas confidence intervals lying below 0.5 were considered AI and those above 0.5 were OD. Twenty of the 38 chats were eliminated from further analysis because their corresponding confidence intervals contained 0.50. However, almost half of the entire dataset remained in the analysis and each of these chats is a statistically valid example of the gendered discourse style. We elected to work with this reduced dataset as we reasoned that the possibility of gender effects on the uptake of ideas would be most likely in chats that evidenced a clear use of gendered discourse.

Of the 18 remaining chats, 4 of the chats featured the AI discourse style and 14 featured the oppositional direct discourse style. We then performed chi-square analysis of these 18 chats to examine our second hypothesis regarding the association between gender and specific discourse styles (AI, OD). In so doing, we used Fisher's exact test for small sample sizes. See the results section for our findings regarding hypotheses 1 and 2.

In the second phase of data analysis, we utilized a second coding scheme (Table 2) that allowed us to identify idea initiations in each chat and to examine whether or not each idea was taken up. To accomplish this analysis, we adapted a scheme first developed by Barron (2000) in her work on face-to-face collaborative groups. In this scheme, we coded problem-solving idea initiations, acceptances, clarifying questions, elaborative responses, comments that rejected an idea with a rationale, comments that rejected an idea without a rationale and comments that sought to organize the work of the group. If an idea was rejected without a rationale, or if the idea had not been responded to in one form or another within 10 chat turns, we counted the idea as having been ignored.

Table 2. Example of idea initiation coding analysis transcript

Chatter/utterance	Type of comment
isp1301 isp1301 > let's start solving the problem	Organizational comment
isp1303 isp1303 > please first let me read the problem	Organizational comment
isp1301 isp1301 > total mass = 1570 + 75 = 1645	Idea initiation (1)
isp1301 isp1301 > Where is our third member(1302)	Looking for chatter
isp1303 isp1303 > what do you mean by this	Clarification question (1)
isp1301 isp1301 > is any one interested in solving the problem?	Organizational comment
isp1303 isp1303 > yes	Organizational comment
isp1301 isp1301 > so let's start	Organizational comment
isp1302 isp1302 > hi i amback again lets start doing	Greeting
isp1303 isp1303 > there is no fault of mr gupta whats your opinion	Idea initiation (2)
isp1301 isp1301 > I think we will solve it Energy consevation. and the ques. which you have asked would be answered later on	Idea initiation (3)/organizational comment
isp1301 isp1301 > Energy conservation or momentum conservation?	Clarification question (3)
isp1303 isp1303 > momentum conservation	Elaborative response (3)
isp1301 isp1301 > so do it.	Organizational comment
isp1303 isp1303 > sorry there is no collision so there is no question of momentum	Rejection of elaborative response with valid rationale (3)
isp1301 isp1301 > so Energy conservation, right?	Clarification question (3)
isp1303 isp1303 > yes	Acceptance (3)

Given the multi-threaded nature of online chats, the complexity of following the overall conversation is increased. Due to this complexity, we adapted the approach of analytic collaboration as defined by Hogan, Nastasi, and Pressley (1999); the first and fourth authors worked collaboratively and iteratively in refining the identification of the idea initiations and whether or not they were expanded into discussion threads. Based on this analysis, we created a ratio of ignored initiations (number of ignored initiations/total initiations) for each chat. Finally, we compared the means of the ratio of ignored initiations by chat discourse style in order to test our hypothesis that chats characterized by the AI discourse style would result in fewer ignored initiations than chats characterized by the OD discourse style.

Results

We proposed three hypotheses for this paper; we address each in turn.

> Hypothesis 1: Students will evidence the use of the OD discourse style characterized by strong assertions featuring absolute and exceptionless adverbial terms, presuppositions and flaming comments and the AI discourse style characterized by attenuated assertions featuring hedges, tag questions, qualifiers and politeness indicators in science-based, online, synchronous discussions.

Table 3. Example of OD discourse style drawn from the chat

Chatter ID > utterance	Discourse feature	Code
isp0403 > an eye witness also mean to say that there was no fault of the driver		PS
isp0401 > what petitions we sh'd give in order to defend him		PS
isp0403 > Mr Gupta is n old guy & we can't punish him		PS
isp0401 > it was the boy totally at fault	Absolute adverbial	OD
isp0401 > a person of 52 yrs is not old		PS
isp0403 > boy shoul be careful while crossing the road		PS
isp0401 > more over, law is applicable on each &everyone		PS
isp0403 > we r not here to discuss the age of man. We have to fimd whether Gupta should be punished or not??????????	Emphatic punctuation	OD
isp0401 > can u draw some pict.to weigh ur points		PS
isp0403 > *no, i cant*	Exceptionless adverbial	OD

Through the coding of the chats, we determined that students do indeed use the specific discourse features typical of both the OD discourse style and the AI discourse style. In fact, these discourse styles were evident in every chat that we analyzed. Table 3 provides an example of the OD discourse style, and Table 4 provides an example of the AI discourse style, both drawn from the chat corpus. The first column in each table contains the chatter ID number assigned by the original researcher (Kapur, 2008) and the individual's utterance. Within the utterance itself, we have italicized the discourse feature that garnered the code. In column 2, we list the name of the discourse feature itself, and in column 3, we provide the actual code (see Appendix for code book abbreviations).

Table 4. Example of AI discourse style drawn from the chat

Chatter Id > utterance	Discourse feature	Code
isp2203 > *i think* mr. gupta is not guilty	Hedge	AI
isp2202 > ya *i also think* so	Hedge	AI
isp2201 > *what do u think* who is more responsible for this fault	Tag question	AI
isp2203 > as being told by the eyewitness it was the boys neglence		PS
isp2202 > *i feel* the boy as he was running b/w the road	Hedge	AI
isp2201 > *dont u think* so some how about the fault of mr gupta	Tag question	AI
isp2202 > *i think* if nobody sustained any injury so there may not be any fine	Hedge	AI
isp2203 > but as per according to the client's file he has violated traffic rules earlier also		PS
isp2202 > ya i agree *bu do not you think* that this time this was the mistake of boy *most probably*	Hedge qualifier	AI
isp2203 > according to the medical reports he also has n' drunk		PS
isp2201 > but *dont u think* its the whole care lesness dealing with :as done by the boy	Tag question	AI

Table 5. Chi-square analysis of discourse style by gender

Discourse type * Gender crosstabulation
Count

		Gender		Total
		F	M	
Discourse type	AI	3	1	4
	OD	2	12	14
Total		5	12	18

> Hypothesis 2: On the average, male-dominated chats will be more likely to utilize the OD discourse style than female-dominated chats and female-dominated chats will be more likely to utilize the AI discourse style than male-dominated chats.

Chi-square analysis was used to address hypothesis 2 by examining the association of gender to discourse style. Due to the small sample size, we calculated Fisher's Exact Test which was significant (χ^2 (1, $N = 16$) = 5.716, $p = .044$, Cohen's $w = 0.60$). In spite of the small sample size, we interpret Fisher's Exact Test as being a significant result because the effect size—Cohen's *w*—is large. In other words, even though there are only a small number of chats within our sample (due to our conservative confidence interval estimate), we still have a *p*-value of .044 and a large effect size. The analysis shows that male-dominated chats are more likely to use the OD discourse style and female-dominated chats are more likely to use the AI discourse style in online, synchronous chat discussions. The contingency table for the analysis is presented in Table 5.

As can be seen from the contingency table, three female-dominated chats featured the AI discourse style and one male-dominated chat did so. While 2 female-dominated chats utilized the OD discourse style and 12 male-dominated chats did so.

> Hypothesis 3: Chats that are characterized by the OD discourse style will evidence more ignored initiations than chats that are characterized by the AI discourse style.

In order to test the third hypothesis, we performed an independent samples *t*-test with discourse style as the independent variable and ignored initiation as the dependent variable. The results of the test were not significant $t(16) = .052$, $p = .959$. Hypothesis 3 is not supported; there is no difference in the number of ignored initiations by discourse style.

Further Analysis of Hypothesis 3

In order to verify our finding in hypothesis 3 that there is no gender bias in the uptake of ideas in the online chats analyzed in this study, we performed within-group analysis of the mixed gender group chats to examine the number of ideas offered by women in male majority chats and the uptake of their ideas. Of the 18 chats that evidenced a dominant gendered discourse style, 11 included mixed gender groups. Of these, seven featured one woman with two men. To analyze these chats we tabulated the proportion of ideas contributed by each member to the chat and the proportion of each chat participant's ideas that were ignored by other members of the group. Because there are three people in each chat, one might expect to see one participant contribute around 33% of the ideas. And, since about 35% of ideas were ignored in each chat (based on the calculated mean reported above) one would expect about 35% of any one contributor ideas to be ignored. This analysis indicated that females in male-dominated chats, on average, contributed slightly more than the amount of ideas one might expect them to (42%), given the number of people in the chat.

We then performed an independent samples *t*-test with these seven groups. In this test, gender was the independent variable and proportion of ideas and proportion of ignored ideas were the dependent variables. The results were marginally significant for the proportion of ideas offered ($t(19) = 1.88$, $p = .076$), with females offering a greater proportion of ideas ($M = .42$, SD = .15) than males ($M = .29$, SD = .16). The results for the proportion of ignored ideas were not significant ($t(19) = 1.56$, $p = .13$). In this instance, the proportion of ideas presented by females which were ignored ($M = .45$, SD = .31) was not statistically different from the number of ignored ideas offered by males ($M = .27$, SD = .20). This analysis confirms the null status of hypothesis 3.

Discussion

The results of this study confirm hypotheses 1 and 2 but do not support hypothesis 3. Individuals evidenced the use of gendered discourse styles when interacting in physics-based online chats; males were more likely to utilize an OD discourse style than females and females are more likely to utilize the AI discourse style than males. However, discourse style does not appear to affect the uptake of ideas within a chat.

While our research empirically bolsters theoretical claims to the existence of a preferred style of online talk for males and females (especially as regards the preference of males for the OD style), it does not confirm the idea that such gendered modes of communication have an impact on important aspects of the discussion, in particular, whether or not more ideas are taken up within a chat that features an AI style. This study has significant implications for girls and women who study physics in online settings. While prior research indicates that girls' speech acts in face-to-face science class are taken less seriously than boys' speech acts (Lemke, 1990) and that girls perform less well in mixed gender groups in online physics settings (Ding et al., 2011), this does not always appear to be the case. Our results show that the girls in this study were on equal footing with their male peers in participating in the physics collaborative problem-solving activity as regards the offering and the uptake of ideas.

One explanation for this could be the level of online anonymity featured in the particular online setting used in our study. Participants in the chats were identified by a number only; while all of the participants were members of the same high school physics class, in the online environment, their identities were concealed. We did observe identity-seeking behavior within the chats, and this behavior, at times, overtly focused on determining the gender of students in the given group. However, these attempts at discovering who was in the group were mostly ignored. Therefore, one might reasonably argue that the relatively anonymous character of online chats presents an important opportunity for females to equitably participate in science discussions with males, regardless of discourse style. Indeed, it may not be a diffident and polite use of language that put female students at a disadvantage in face-to-face science classrooms, but rather, their sheer physicality. Indeed, the body is precisely what is missing in text-based chat environments. And, in this study, nominal gender information was also missing. This is important, as a recent study of bias against women in the sciences has shown that nominal indication of gender alone is enough to trigger significant bias (Moss-Racusin et al., 2012).

In this study, with no physical or nominal representation to indicate gender, *telegraphing gender through discourse style does not appear to have had a negative effect on these participants*. Moreover, the female-dominant groups in this study demonstrated a broader repertoire of gendered discourse styles than the male groups; two of the five female-dominant groups used an OD style, so, even if people were able to guess gender from discourse style, they would have been wrong in these two cases. This begs the question as to whether or not students are reading specific discourse styles as typically feminine or typically masculine. Perhaps, in an anonymous, text-based environment, the ability to pick up on such clues may not be widespread. As noted above, previous work on gender in asynchronous online discussions has shown bias against the use of the aligned style—and this bias was intensified when used by a woman (nominal information provided). When identifying information is not provided, it is not clear how easy it is to guess the gender of group mates from discourse style alone. Our work appears to support the early hopes related to learning in completely online environments. Complete anonymity, then, is an important point to consider when designing online environments for secondary school science learning. Future research should examine the role of complete anonymity and gender makeup of groups in online science problem-solving settings. It would also be very worthwhile to examine the role of complete transparency of gender on such online discussions. In other words, in order to truly understand whether or not gender plays a role in group interactions in science learning settings, it is important to have a control group where gender is clearly indicated and an experimental group where gender is completely concealed. In this way, we could determine the learning affordances of design decisions.

It is important to recognize that students in this study from both genders utilized both styles of discourse in each of the individual chats. So, while girls tended to use the AI style more often, they did not do so exclusively and vice versa. The hedging comments utilized in this setting may be indicative of students' tentative understanding of the topic at hand. Students, regardless of gender, who feel less confident about the material may use hedging, qualifiers and tag questions to attenuate the negative effects of misunderstanding or incorrect assertions. Moreover, these findings support a post-structuralist, feminist view of gender as performative and contextual (Mills & Mullaney, 2011).

Furthermore, hedging comments may also be a function of the problem-solving context itself in that ill-structured problems do not clearly present the underlying structure of the problem and solution space, thereby 'forcing' everyone to be just that much more uncertain and tentative about their ideas. In other words, the diffident style that typifies the AI discourse style may have been utilized by both genders in this study due to the difficulty of structuring an ill-structured problem and solution space. If so, this may, in part, explain why the gender makeup of productive failure groups did not influence students' performance on post-test assessments, as noted by Kapur (2008). This is an important point as regards design of online learning environments; ill-structured problems many not only be useful for their strength in enabling students to engage in productive failure, but they may also help to attenuate the effects of bias as wrought by gendered discourse patterns. With this in mind, it may be wise to present ill-structured problems that force all students to grapple with the fuzzy, real-life parameters of the problem.

Implications

The implications of this study for teachers and curriculum developers regard the design of online science learning activities. It appears very likely that ill-structured problems illicit a tentativeness that levels the discursive playing field. Of our 38 original chats, 20 could not be decisively categorized as specifically using either a typically male or a typically female discourse style. Of these 20 chats, 16 were predominately male. While these male chats, overall, did tend to use the OD style more, they also used the AI style. We argue that ill-structured problems are an important design element for science learning. Any advantage afforded males by the view of physics as a 'male' discipline appears to be significantly attenuated within the context of ill-structured problem-solving. Moreover, as noted above, complete anonymity may also be an important, leveling design feature for educators to consider when creating online science learning environments.

This research is significant for other researchers in that it problematizes the role of gendered discourse in online discussions. Much previous research has shown that gendered discourse features are prevalent in online discussions, making it possible to guess the gender of an onscreen presence. However, it is not at all clear that students are able to discern gender from gendered discourse features. Furthermore, our work indicates that mixed groups do not have an impact on the uptake of girls' contributions—and as reported by Kapur (2008) in their overall learning. This is in contrast to the previous work of Ding et al. (2011). An important difference in our study and Ding and colleagues is that our participants' gender was masked, whereas participants in the Ding et al. study knew the gender of their discourse partner. Our work indicates the need for more research aimed at exploring the role of complete anonymity in online discussions.

Conclusion

One limitation of this study is the fact that only 5 of the 18 chats included in the idea analysis were female-dominated. This is a reflection of the ongoing nature of the problem: the lack of women and girls pursuing STEM careers in both the USA and India (and, most likely, beyond). It is possible that with a larger number of chats in the corpus the results of this study would change. More research with a larger number of groups would help us determine the relative importance of discourse style on discussions in online science discussions. And, as noted above, this research should vary the anonymity feature of the online science learning environment. This will help us clarify the role of gender on interactions in such settings.

Another limitation of our study regards generalizability. We performed quantitative content analysis (Chi, 1997). This method is subjective in nature. While our codes are theoretically specified and constituted of well-defined discourse features, and while we used a very strong method for establishing inter-rater reliability (Krippendorf's alpha), individual analysts may reasonably disagree on the meaning of any particular utterance.

Our work investigates social factors that may inhibit or encourage girls and women's STEM education participation. This is an important area of research in that women continue to be under-represented in many science fields, including physics, and recent research has shown that women continue to face significant bias in science fields (Moss-Racusin et al., 2012). The significance of our study is in its focus on the *uptake of ideas* in the online discussions. Few other studies have investigated idea uptake in completely anonymous online science discussions.

In the long term, we view this study as a preliminary step in the development of digital designs that will help to scaffold equitable participation in synchronous chat environments that lead to discussions that are inclusive and productive, an agenda we argue to be consistent with theorizing and designing online learning environments. Toward that end, the main design implications that may be derived from this study are the importance of complete nominal and physical anonymity in online discussion settings and the use of ill-structured problems as scaffolds for addressing the role of gender bias in science discussions.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendix: Gendered Discourse Code Book

Theoretically-derived codes with examples.
Aligned/indirect (AI)

- Hedges and Qualifiers (e.g., "I think", "I wonder", "perhaps", "it's possible that", "may", "might", "seems", "sort of", etc.)
- Tag questions ("what do you think?", " . . . , right?", "isn't it?", etc.,)

- Implied tag question (Question marks at the end of sentences that are not direct questions?), e.g. ???
- Politeness Indicators (Please, sorry, etc.)

Oppositional/Direct (OD)

- Absolute Adverbials (e.g., "certainly", "definitely", "obviously", etc.)
- Exceptionless Adverbials (e.g., "never", "by no means", "no", etc.)
- Presuppositions (e.g., "it is obvious", "it is clear", "it is a fact that", etc.)
- Commands –(e.g., "you write it", "read it again", etc.)
- Overly emphasized punctuation that accompanies an actual comment???????
- Flaming and Shaming ("403 r u gone crazy," "Oh my God 1201 you are going cukko." "HURRY UP 303 IF U HAVE CALCULATED THE SPEED REALLY OR NOT??", etc.)

Data-driven codes with examples
Greetings (GR)

- "firstly i want to say hello."
- "Hi"

Looking for Chatters (LC)

- "201 r u there?"
- "what about 402, where's he/she"

Problem Solving only (PS)

- "before breaks it was retardation due to friction"
- "the coeff of friction is already between tyres and road so it is rolling friction"

Off Task (OT)

- "i will do after eating the patty"
- "03 will be on fire soon"

Identity Seeking (IS)

- "you are a male or female"
- "let me know your name 1403″

Re-direct (R)

- "so now let us start with soln or do u need some more time"
- "lets come to the point"

Uninterpretable – UI

- experience gaya tel lene
- anmol hai na