Building trust in virtual organisations: a case study of trust and gender in a scientific virtual organisation breeding environment

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Abstract: This paper examines an online life science virtual organisation breeding environment (VBE), an incubator of temporary or more permanent virtual organisations (VOs). In the VBE studied, scientists could connect and collaborate with one another using various social media technologies such as profiles, messaging, blogs, and forums. This article is particularly focused on the ways in which social media technologies facilitate interactions between participants in the 'WomenScientists1' group. This study employs content analysis of all textual discourse on the group and social network analysis to understand the relationship of users in this network. This paper seeks to address three core questions. First, we explore what types of interactions facilitate trust formations. We find that interactions that share personal information positively elicit trust from other users. Second, we examine which demographic attributes contribute to the growth of trust interactions. We find that a user's gender and their membership of the group are correlated with trust interactions. Third, we find that if users are unilaterally trusted (via a 'leap of faith'), they are likely to reciprocate, forming bilateral or multilateral trust relationships.

Keywords: virtual organisation breeding environment; VBE; trust; gender; online communities; sentiment analysis; online forums; virtual organisations; VOs; mistrust.

Reference to this paper should be made as follows: Murthy, D. and Eldredge, M. (2013) 'Building trust in virtual organisations: a case study of trust and gender in a scientific virtual organisation breeding environment', *Int. J. Organisational Design and Engineering*, Vol. 3, No. 2, pp.185–205.

Biographical notes: Dhiraj Murthy is a Senior Lecturer in Sociology at Goldsmiths College, University of London. His current research explores social media, virtual organisations and big data quantitative analysis. His work on social networking technologies in virtual breeding grounds was funded by the National Science Foundation, Office of CyberInfrastructure. He also recently published *Twitter: Social Communication in the Twitter Age*, the first academic book about Twitter (published by Polity Press).

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1 Introduction

As information sharing becomes easier, online communities are rapidly becoming an important part of scientific networks (Rodrigues et al., 2004). Some scientists see social media as having real potential in helping connect with fellow scientists from across their discipline and around the world. Wellman and Gulia (1999) argue that virtual communities are important entities in that they serve as vehicles to foster communities offline. Additionally, virtual scientific communities are now viewed with increased legitimacy than before (Cho and Lee, 2008; Bos et al., 2007), an issue inhibiting initial uptake of virtual platforms. Like offline communities, the users can ascertain the background of a user by discerning ability via, for example, answers to questions and certain other characteristics of the user such as profile data (Wellman and Gulia, 1999; Turner, 2009; Donath, 1999).

Bhuiyan et al. (2010) discussed the difficulties in finding and/or creating a universal definition of trust in the literature. However, they agree that trust is not only gradual but directional; person A may trust person B, but this does not require person B to trust person A. Moorman et al. (1992) argue that trust relies on two different components: there must be belief in another person or persons, and a willingness to act on that belief. Additionally, they refer to trust as being both a 'feature' and a 'determinant' of the state of a relationship. Although some literature discusses the potential for true trust relationships to disappear as face-to-face interactions disappear (Riegelsberger et al., 2003), trust can develop and even flourish online, not just offline (Ridings et al., 2002). The literature shows that trust can be seen in the information that users are willing to share with other users, which is based off the level of trust they have of another user (Bhuiyan et al., 2010).

Although there can be a disconnect between users who do not meet face-to-face due to the lack of visual cues (Goffman, 1981) and asynchronicity, this does not exclude the potential for meaningful professional relationships (including collaboration) to emerge from these online communities. For example, users are capable of building trust relationships with fellow users within online discussion, group-based task completion, and online social interactions (e.g., via social media). The ability to view a user's profile (which provides background information on that user), location, and archived public posts allows a context for users to build trust with others. Additionally, the content of a post provides further insight into the user's beliefs and opinions, providing an opportunity for other users to relate to their shared interests, experiences, and beliefs. As these trust relationships emerge online, they tend to influence other users who are members of the virtual space. From these interactions, an online community grows, replete with varying levels of trust. Just as in face-to-face interactions, this trust is important in online scientific communities for collaboration of two or more unique individuals of the community to further the progress of their work. Literature on virtual teams finds that virtual groups, unlike offline groups, must be effective from the beginning, as virtual participants in social media make immediate judgements and

impressions based on posts, sometimes leaving only marginal room for change of opinion (Kuo and Yu, 2009). However, this specific literature refers to teams that are required to work together. In cases of the potential to foster collaboration, initial 'swift trust', the quick formation of trust in task-oriented teams (Jarvenpaa and Leidner, 1998) does not develop in the same way. Rather, these initial impressions are ultimately derived from category-driven information (Kuo and Yu, 2009). In other words, trust becomes based on posted information such as degree level, gender, age, and location rather than derived from situational cues (Kuo and Yu, 2009).

In this research, we observed a specific virtual organisation (VO), WomenScientists1, which was focused on the task of increasing the representation of women in science. This group is based within a life sciences virtual organisation breeding environment (VBE), a virtual space which is the potential parent of temporary or permanent VOs. In this VBE, there are 870 forum groups, which are dedicated to a range of issues. This VO was started in May of 2009 and seeks to provide a place for individuals to share stories, provide support, and educate others in an attempt to increase the impact of women in science. At the time of this study there were a total of 171 members of the group, 39 of which have posted at least once in the group's discussion forum. An additional 70 users have posted at least once in the forum but did not become a member of the forum. The forum contains 65 topics with 326 replies, indicating the high popularity of the forum over its two-year lifespan. The forum is comprised mostly of female posters, with 52 out of the 69 users who reported their sex being women. The majority of the posters and members of the forum who reported their location were from Great Britain, followed closely by the USA. Users who reported their profession were members of a diverse set of industries including journalism, academia, and management. Users of the forum have selected varying degrees of anonymity, ranging from completely anonymous to a full profile with age, gender, location, and professional information provided.

This paper seeks to build from VOs literature by specifically addressing two key gaps, the behaviour of voluntary VOs in terms of trust formation and the ways in which gender mediates this. This study focuses on a specific, prominent life sciences VBE and examines the ways in which trust has been formed, developed, and maintained within a particular sub-group, WomenScientists1. This article concludes that the posting of personal, often social material by group members leads to the development of reciprocal trust relationships. Trust levels between specific demographics and language which engenders or is indicative of trust are areas which are also explored. Interestingly, once high levels of trust are established, collaboration often moves off forum. This article also specifically investigates the role of gender in this process and finds that group members who openly ask questions about gender and discuss gender are more trusted. Ultimately, gender discussion serves as a way to signal shared beliefs, experiences, and backgrounds. This helps bridge the lack of face-to-face situations and facilitates trust formation.

2 Trust, sentiment analysis and VOs

As the volume of data available from social media increases exponentially, sentiment analysis has become an increasingly popular method to help analyse virtual social interactions (Murthy, 2013). Most literature pertaining to sentiment analysis discusses the difficulties surrounding creating an automated process for classifying text and reviews by their overall sentiment, and how they attempt to solve this problem (Godbole et al., 2007;

Pang and Lee, 2004; Wilson et al., 2005). The reason for this recent drive to construct automated sentiment analysis is due to what Liu (2010) describes as a recent and sudden growth in text-based opinion, a result of internet-generated data. Word-of-mouth (WOM) communication has always been pervasive (Goldenberg et al., 2001). With the growth of online communications, electronic word of mouth (eWOM) has grown (Litvin et al., 2008) and, as a consequence, social interactions online have increased, making sentiment analysis a popular method of data analysis (Liu, 2010). Liu points out that there are two important aspects of opinion relevant to sentiment analysis. These consist of direct opinion and comparative opinion. Direct opinion is a positive or negative opinion about a particular object or person, while a comparative opinion is an opinion based from a comparison between two or more objects or persons and is much more difficult in determining a positive or negative opinion (Liu, 2010). Sentiment analysis has been effectively used in studying interactions in forums (Abbasi et al., 2008), Twitter (Agarwal et al., 2011), and other social media.

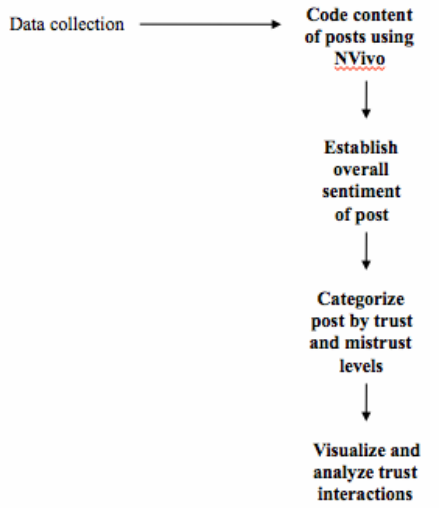
The trust literature, which has been applied to studying virtual groups and virtual teams, is highly developed (Kuo and Yu, 2009; Butler, 1999; Dibben, 2000; Saunders and Thornhill, 2004). Swift trust (Jarvenpaa and Leidner, 1998) sees trust as developing in virtual groups and teams quickly and usually for the purposes of accomplishing a task. Calculus-based trust (CBT) (Lewicki and Wiethoff, 2000; Rousseau et al., 1998) sees trust as following more of a reward/punishment model. Reputation maintenance and building is also important to CBT. Information in this initial stage comes from quick active discovery. In the context of social media, the analogy for 'quick active discovery' would be looking at a user's profile. This could translate to a 'trusted information source' (Brown et al., 2007) following the model of 'eWOM'. Knowledge-based trust (Robert et al., 2009), or personal trust, is trust that is built from previous knowledge of a person's behaviours, which leads to a certain level of predictability. Conflict can arise from trying to solidify dynamics and goals of the group. Within knowledge-based trust, members of virtual groups can have 'personal trust', by trusting another user's intentions as well as information. Identification-based trust (IBT) (Lewicki and Wiethoff, 2000) sees trust as a more personal behaviour. As individuals in the group become acquainted with one another, motives and commitment are solidified in the member's minds and a collective identity emerges where the group seen as an 'us' rather than individual and 'them' – group identity. Unsurprisingly, this commitment to collective goals is instrumental for successful collaboration.

3 Methods

In order to examine and study this virtual environment, each forum in the site was assigned a numerical identifier, and a random number generator subsequently selected forums at random to be studied. Overall, the study of this site used 42 distinct forums. In order to code interactions, we employed emergent coding (Holton, 2010) to ensure proper coding of the text for several different characteristics of the VBE. The emergent coding was done in the qualitative data analysis package QSR NVivo and resulted in 22 different codes with 10 free nodes (categories) and 12 tree nodes (categories with subcategories). Some of the most important and frequent codes in the WomenScientists1 forum are related to gender, personal information sharing, answering questions, and asking questions.

We designed an application based on the WebHarvest API to 'scrape' information from WomenScientists1 (Murthy et al., 2013), including author ID, posts, and the author's profile information. NVivo was used to read through the text of these posts sequentially and to tag them with relevant category codes (see Figure 1 for a representation of textual analysis). Additionally, the interactions between users in the discussions were compiled into a matrix comprised of the user who sent the interaction, the type of interaction, and the user to whom the interaction was sent. The two main aspects viewed in order to evaluate the interactions in the WomenScientists1 Forum were trust and sentiment. These variables allowed us to examine the general sense of community amongst the users, as well as to see what topics members agree on. By observing the consensus amongst users, individuals reveal shared values and norms. Analysing the forum for these two aspects meant analysis of all textual discourse within the forum and recording what sentiment users had when replying to a topic or to another user. We see trust in complex online social situations as less of a rational choice (i.e., 'Prisoner's Dilemma') and, instead, depending more "on enduring relationships, built through many iterations of giving and receiving trust". 'Trust and distrust are not opposite sides of a single continuum' (Lewicki et al., 1998) but rather involve an integrated view with positive-valent, negative-valent, and ambivalent attitudes (what we refer to as 'neutral').

Figure 1 Flow of textual analysis



The first qualifier used to classify the interactions amongst users comes from the sentiment users expressed in their interactions with each other or the group. We developed a model of interaction, which recorded inferred interaction even if users did not address one another directly by quoting them or stating their name. These types of sentiment arcs were more generally directed to the group and were coded as 'general reference' to denote a difference amongst the direct and indirect interactions amongst users. Of the seven different options for the modifier, six of these were: positive, negative, neutral, and the 'general reference' equivalent of these three. Current sentiment analysis literature tends to focus on the messages posted amongst individuals but does not

seek to grasp the relationships between individuals holding a conversation. Neviarouskaya et al. (2007) argue that the 'overall mood' of a conversation should be accounted for to better capture nuanced dynamics. Kim and Hovy (2006) recommend creating an additional category of neutral. But, given the nature of the different posts, it was necessary for us to add more categories, such as unrelated, and the general reference equivalent of positive, negative, and neutral. Since topics usually begin with a question being posed, a reply cannot have positive or negative sentiment to support or oppose the original post. Additionally, the topics in the forums tend to repeat a central point so the general reference captures these cases by capturing the sentiment while noting that the replier does not directly reference the original poster. The seventh option of 'unrelated' was used to describe a post that was a response to another user but had no connection to its subject matter. A 'positive' post from a user meant that they strongly supported the previous poster's comments or ideas while a 'negative' post meant that the user opposed a prior user's position or post on that particular subject matter. 'Neutral' posts signified that there was no evidence of the user taking a position with regards to the topic or post by the other user. Our model also draws from the concept of 'expression norms' (Thoits, 1989) which refer to 'expectations governing public exhibitions of emotion' (Thoits, 1990) as sentiment expressed in social media needs to take into account the public nature of social media.

Table 1 Types of trust

Type of trust	*Definition*	*Example*
Trust		
Collaboration trust	A user seems willing to work with another user in a real or virtual setting	*[I am]…Ready to join hands*
Personal trust	Identifying with another user's position or situation, in response to someone revealing personal information	*I'm still starting up my scientific career […] I can't see how to work part-time and raise children in the first two years. I would like to hear the experiences of other "scientific" mothers.*
Trusted information source	A user shows signs of trusting another user as a source of information	*I agree with you. As for your comment on advisor/ subject/publication mentioned, I am thinking up some original ideas about the "ASC" that seems like the "CSC".*
Mistrust		
Mistrusted intentions	A user is seen as stymieing the conversation, purposefully diverting attention away from member intentions, or expressing malicious intentions	*Alternative medicine is irrelevant for the forum. I believe that alternative medicine lacks scientific basis and is nonsense.*
Mistrusted information source	A user does not trust the data or study that another user has cited or brought up. The user will cast doubt or attack the reasoning of the article	*This article was interesting but biased. Its claim […of a] lack evidence is simply ludicrous.*

The second qualifier used was trust. Following Butler (1999), we implemented three distinct trust choices: trusts, mistrusts, and neutral. When looking at a post, language served as a marker for determining an established relationship of trust. If a user's post attempted to identify with another user's situation and/or views, or echoed their ideas, then this user showed some level of trust ranging from confirmatory support to the high levels of support needed for potential collaboration. A general level of support/trust is exemplified in a response to a post about women juggling a career with raising children; one user began a reply with: 'I am in a similar position to you'. Though this sense of identifying with the previous poster exhibits trust, it is weak as the user goes on to discuss their own personal information and also seeks advice from the other posters. Additionally, the replier does not directly interact with the topic-poster or show an indication of wanting to collaborate.

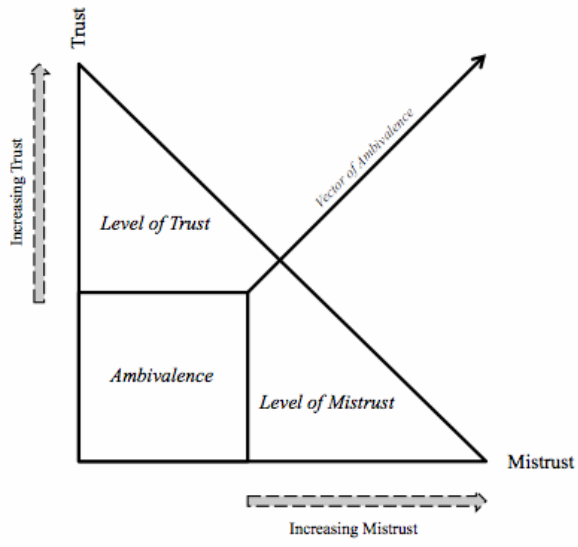
4 Collaboration

As previously discussed, the presence of collaboration trust indicates that the forum can be used for users to work with one another in either face-to-face or virtual settings. However, the strength of such connections differs amongst the users, so there exists a spectrum for the different types of collaborations that the forum facilitates. In Table 1, for example, a user wishes to work with another user, by simply stating, "[I am]... ready to join hands". This post arises on a thread about the personal experiences of a researcher in Egypt and their difficulties in trying to secure government funding for research and fostering a scientific community. However, in the same thread, a stronger collaboration effort exists. From this topic, two users, UserB and UserC decide to come together to promote the research of scientists in the Middle East in order to foster a scientific community. UserC, a student, attempts to contact professors who are willing to be interviewed for this project. UserB would be conducting the interviews, write the article, and post it to the forum. Here is the exchange that took place between the two users:

> "UserC: [UserB], Their [two professors] only wish to have face-to-face interviews and I believe that this will be the general request of others since no one knows this forum. They wish to maintain their credibility and reputation. I agree and would not like to put my contacts and professors in a situation I don't approve since it would be my reputation too. I could serve as a moderator between the two of you and please send me a private message. What do you think?"
>
> "UserB: Thanks for your help UserC. Completely understand, I sent you a private message."

The strength of this collaboration is much stronger, and demonstrates a willingness to act on the users' collaboration trust rather than simply state willingness. Sending private messages rather than simply communicating via posts reflects the need for more private, task-specific collaborative interactions. Meanwhile, the 'ready to join hands' variety of interaction indicates a weak form of collaboration trust. These two different types of collaboration take place within the same thread and show the potential that the forum has for different individuals in establishing various degrees and forms of trust.

Figure 2 Trust, mistrust, and ambivalence map, modelled from Saunders' and Thornhill's trust-mistrust-absence triangle



Source: Saunders and Thornhill (2004)

4.1 Trusted to mistrusted information source spectrum

The categories for trusted information source and mistrusted information source overlap with each other in the sense that they are on a continuum. In this instance trust and mistrust are not opposites of each other, but rather there are different degrees of mistrust moving from strong mistrust into weak mistrust and then into weak trust and strong trust, a spectrum established by Saunders and Thornhill (2004) and adapted to our study (see Figure 2).

4.2 Strong mistrusted information source

> MKW: "Melanie, Your answer to my comment on your "social acceptability" is, honestly, weak. This is a scientific space. If BOTH evolutionists and creationists criticize you, that is not proof of your extraordinary ability to be neutral, but of your frightfully weak commitment to science!"

Prior to this post, MKW called the article 'unscientific junk' which triggered a response from Melanie. MKW reacts via this comment. Given this back-and-forth between the two users, it becomes clear that this is a case of strong mistrust, as MKW attacks both an article that Melanie defends, as well as Melanie.

4.3 Weak mistrusted information source

> "Honestly, I believe that the piece is misleading and has little information on mental enhancer. The facts may not reflect what the authors demonstrate in the article. I'd check them before discussing the ethics of a Focasyn vapor as I go into the room."

The mistrust in this comment arises from the authors' conclusion based on the details and understanding of the use of mental enhancers since this user believes that the facts should lead to another conclusion. However, compared to the previous example, this mistrust is weaker because the author does not attack a specific individual or directly question them. The user shows that they do not trust the facts, but does not seem to be distrustful of a particular user.

4.4 Weak trusted information source

> "Thank to both of you for your answers and opinions. I'm going to attempt my experiment again but this time aware of the fact that my results might not be trustworthy. I'll have to start fresh to avoid contamination."

In this example, the user values the ideas that the other two users forwarded. He demonstrates his trust by following advice obtained from the virtual group, as he sees what the two users say as trustworthy and relevant to his situation. This is an example of a weak trusted information source because while the user acknowledges and states his/her intention for applying the information given to them but does not seek further information. The user trusts the individual, but perhaps not enough to solicit more information from them.

4.5 Strong trusted information source

> "Dear SKA: I am thinking up some original ideas about the "ASC" that seems like the "CSC". […] Which advisor do you recommend for this? Thanks for your help. HCT"

This user clearly demonstrates a trusted information source since, as with weak information source trust, the user values the opinions of another user. The example above shows that the user, HCT, asks SKA for advice, which shows a strong sense of a trusted information source. HCT trusts SKA enough to not only take their advice, but also to elicit more, based on their initial interaction.

Once collected interactions were coded following this rubric, we were able to turn the matrix into a visualisation (see Figure 3) using the network visualisation software Cytoscape. The nodes of the visualisation represent the various users that posted on the WomenScientists1forum, while the arcs between the nodes represent the interactions established in the forum, colour-coded according to their respective modifiers. The nodes are sized proportionally to the number of unique interactions. The nodes are also grouped together by the similar characteristics coded into their interactions. For example, all nodes that have a singular connection to a particular user are grouped near one another, as are nodes that link two users together. This creates a clearer picture of who are active users and occasional users of the forum.

5 Results

As Figure 3 illustrates, the network of WomenScientists1 is reasonably intermeshed (with a degree of ~3.85). What was surprising was that the majority of the interactions on the WomenScientists1 forum consisted of ambivalent and neutral classifications for both

trust (87.27%) and sentiment (34.16%) respectively. However, in this particular forum the number of trust interactions (34) far exceeds the number of mistrust interactions (7). Additionally, the total number of positive sentiment arcs (108) more than doubles the total number of negative sentiment arcs (53). The trend in this forum is to generate trusting interactions as well as positive responses. These results stem from the remit of the forum, which seeks to promote equal opportunities for women in science and discusses the difficulties women face in the pursuit of scientific careers. The majority of posts consist of personal stories and experience, which do not typically lend themselves to argument or debate.

Table 2 Breakdown of trust arcs

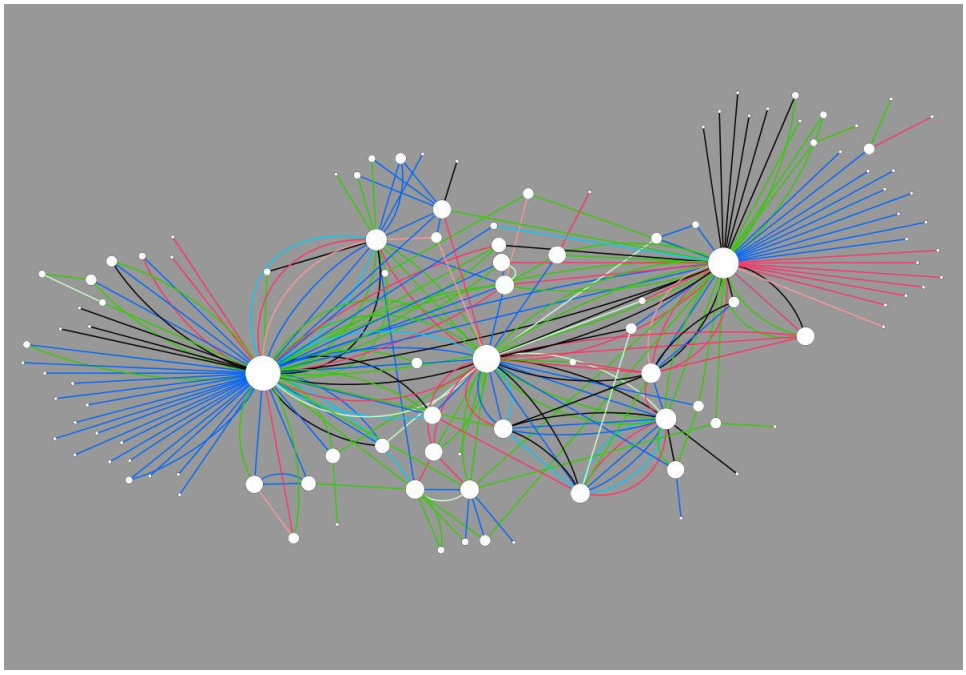
Modifier	*Arc count*	*% of total arcs*
Mistrust	7	2.17%
Ambivalent	281	87.27%
Trust	34	10.56%
Total	322	

Table 3 Breakdown of sentiment arcs

Modifier	*Arc count*	*% of total arcs*
General reference negative	8	2.48%
General reference neutral	14	4.35%
General reference positive	10	3.11%
Negative	45	13.98%
Neutral	110	34.16%
Positive	98	30.43%
Unrelated	37	11.49%
Total	*322*	

The mapping of these sentiment and trust arcs can be seen in Figures 3 and 4 respectively. Figure 3 illustrates the sentiment network with the seven different types of sentiment arcs. The lighter coloured arcs represent the general reference arcs of their respective colour (i.e., blue is a neutral arc with lighter blue being the general reference neutral arc). It is noteworthy that most, though not all, outlying users have links that are disproportionately neutral, negative or unrelated compared to the positive links seen in the central regions of Figure 3. Looking at Figure 3 reveals some of the emerging trends of the interactions. Some of the users tend to foster a large number of bilateral interactions while other users appear to create many more multilateral and multi-interaction connections. Additionally, there are clearly some users associated with positive sentiment while others have a much stronger association with negative sentiment.

Figure 3 Interaction sentiment (see online version for colours)



Notes: Blue: neutral, red: negative, green: positive, black: unrelated.

Table 3 and Figure 4 support the findings that very few 'trusts' or 'mistrusts' relationships emerge on the WomenScientists1 forum. Ambivalent arcs make up a large majority (87%) of the connections between nodes in the 'trust' network map. While very few trust interactions exist, the few that do tend to form around the three top contributors to the forum. For one user, there are eight 'trusts' interactions compared to no 'mistrusts' interactions. The other two key contributors do have a few 'mistrusts' interactions, but they also follow the trend of 'trusts' clusters, with one of them having six 'trusts' and one 'mistrusts' interactions and the other having nine 'trusts' and three 'mistrusts'. These numbers indicate that the three users that post most frequently have created groups of trust amongst the users that reply to their topics and comments.

These emerging groups of trust could be the result of two phenomena. One of the phenomena would be that simply the more a user posts in the forums, the more that other users trust him or her. The other is that these three users have backgrounds and expertise that make them naturally more trustworthy. While both of these influences may be playing a role in the groups of trust forming around them, the background of these three users certainly has an impact. One of the users is an editor for a prominent scientific journal. Another of the users works for the UK Resource Centre for Women in Science, and the third user is an award-winning journalist and the moderator of the WomenScientists1 forum. Their professional pedigrees lend a level of trust to their contributions within the group. All three of these users are also women. This demographic combination increases the chances of trust developing from other users to them.

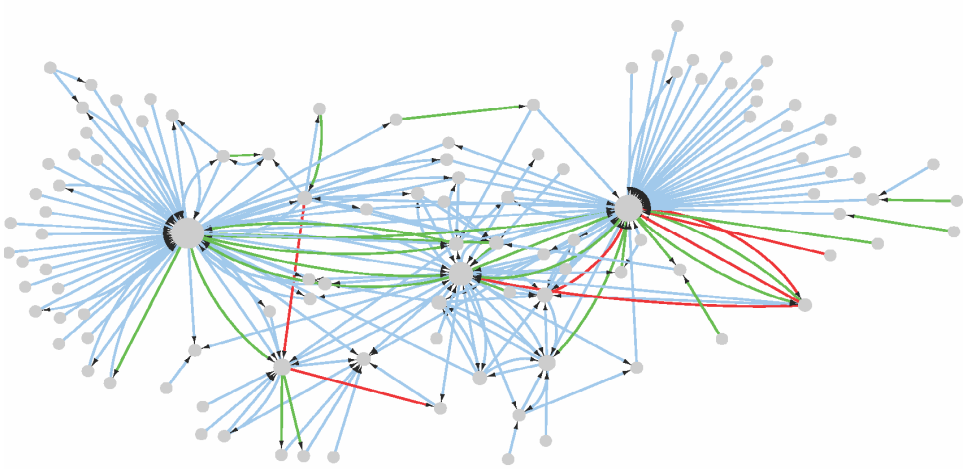
Each one of these contributors, however, has a different trend in relationship connections stemming from them that appear to show the different reactions to the three varying styles of posting. These differences in style are apparent in both the content of the posts and the role of the poster. One of the three users posted a large quantity of topics that contained general information or questions. These general posts did not provoke debate (and thus did not result in mistrust relationships). Another of the three users also posts numerous topics, but the content of the topics tends to be more controversial than the other users. This results in the emergence of a few mistrust relationships and many more negative sentiment arcs also often in one arc connection. The third major user did not post many topics, but rather posted replies to other topics and conversations. This difference leads to a node that connects most other nodes together and connects to a number of different clusters of nodes. These three unique users provide a clear example of the different forum methods for generating conversation and debate.

Out of the three most active users, the user who most actively replies to other users appears to facilitate more intense conversation and debate, as there are many more multi-user connections stemming from their posts then from the other two main contributors. Their topic posts produce a large number of responses but do not spark debate, as they tend to be one time replies rather than the multi-user interactions forming around the other user.

To look further at these main contributors that we closely observed, we set the parameters of ten interactions sent and received to define a group of users that we labelled as 'leaders' of the forum. These parameters were chosen because they demonstrate that the user is both active in responding to other posters or supplying questions in the forum, and also that the other users of the forum are responding to their posts. It was determined that these users were fundamental in the facilitation of the forum discussion. By looking at the five users that make up this group of leaders in the forum, we observed a number of similarities and a few striking differences. The group is comprised of four females and one male. The average age of the leaders is 48.25, compared to the forum-wide average of 39.29 (with 50.5% of users reporting). The leaders have a much higher mean of trust interactions received (4.4) than the other posters in the forum (0.116). Overall, leaders in WomenScientists1 are typically older women with graduate degrees or higher who much more likely to receive trust interactions than the other users. All of these findings agree with the models that we developed to describe the network in the WomenScientists1 and suggest that older users are seen as more knowledgeable, experienced, and able to mentor.

However, there is a clear difference in the ways that these leaders interact with the forum and facilitate discussion. This is seen in the different +/– statistics for answers/asks that each of these users has. One of them has a value of –16, suggesting that this particular user spurs conversation by asking a lot of questions. Two of the users have values of 10 indicating that they are primarily answering questions and the other two users have values of –1, which shows a more balanced approach to using the forum. Although there are many similarities between these leaders, there are three distinct ways in which they are able to create discussion in the forum. Our theory supports that the more that a user posts, the more likely that they can establish a trust interaction or relationship with another user. A user seeing a pattern of interesting and informative posts by a particular user, will likely look for and trust the views of that user in the future.

Figure 4 Directional representation of trust (see online version for colours)



Notes: Blue: neutral, green: trust, red: mistrust.

The majority of users have a neutral feeling towards the rest of the users in this forum (see Figure 4). This indicates that the users might not view this VBE as a location where they feel connected with one another, but only feel connected to the main contributors to this site. The large number of neutral interactions might come from the coding process where some questions in the forum do not allow for positive or negative responses, as they are fact-based posts.

The majority of the sentiment interactions that individuals encounter are neutral or positive, which indicates that this VBE serves as a place where its users can gather to discuss their views, knowing that individuals will respect their views or agree with them, rather than ostracise or ignore them. Akin to Zorn's vifu (Zorn, 2004), members of WomenScientists1 offer support and have similar views amongst themselves.

To understand what drove the establishment of trust relationships and how gender affected the discussions in the WomenScientists1 forum, three related statistical models were created to explain the giving and receiving of trust interactions and the use of gender in forum posts. These three variables are important in the analysis and discussion of the WomenScientists1 forum because they can be used to illustrate relationship patterns that evolve from the discussion around gender issues in a women-specific forum. They reveal which users are trustworthy, which users are willing to trust others, and why these trust relationships are emerging.

6 Statistical models

The first of the three models involves the NVivo coding for gender discussion as the dependent variable. Our theory behind this variable is that gender *discussion* is a function of the total number of interactions sent (a proxy variable for the total number of forum posts by a user), the sex of the user, and the NVivo coding for personal information posted (a count for each time a user posts personal information about themselves). The total number of interactions sent should have a positive effect on the coding for gender

simply because the more a user posts to the gender-focused forum the more likely they will be discussing gender. During the data collection process, it was observed that a significant amount of discussion in the WomenScientists1 forum focused around women sharing their personal stories and experiences. All of the variables were hypothesised to have a linear relationship with gender.

When this linear regression was run (model 2 of Table 4), the results supported our initial theory. The coefficient on the total number of interactions sent was found to be 0.332 and it had a t-value of 15.148 (showing that it is statistically significant at the 5% level). For every extra interaction sent, gender was discussed 0.332 times. This coefficient indicates that it has a significant impact as the average count for gender coding was only 0.899, less than one code per user. The coefficient in front of personal information was 0.287 and had a t-value of 1.993, once again indicating a positive effect on gender. The coefficients on the male and female dummy variables were shown to be negative and positive respectively, reflecting our theory that men would be less likely to discuss gender than women. However, they were both shown to be statistically insignificant, particularly the female variable. The explanation for this insignificance stems from the option for users to not report their sex. In any event, the majority of the posters in this forum are women (75.4% of those reporting sex) and thus the majority of the users' not reporting sex are also probably women, when accounting for the similarities. Thus the model was run again but without the female dummy variable. The results of this second regression (model 1 of Table 4) agree with this observation. The resulting coefficient for the male dummy variable is –0.582 and it had a much larger t-value than before (–1.73). In other words, a user reporting male as their sex has over 0.5 fewer references to gender in their posts.

Table 4 Gender model regression table

Coefficients (with dependent variable gender)						
Model		*Unstandardised coefficients*		*Standardised coefficients*	*t*	*Sig. p-value*
		B	*Std. error*	*Beta*		
1	(Constant)	–.102	.141		–.720	.473
	Grand total sent	.333	.022	.826	15.359	.000
	Personal	.292	.143	.111	2.043	.044
	Male	–.582	.336	–.076	–1.730	.086
2	(Constant)	–.157	.200		–.788	.433
	Grand total sent	.332	.022	.824	15.148	.000
	Personal	.287	.144	.109	1.993	.049
	Male	–.522	.370	–.068	–1.413	.161
	Female	.107	.271	.019	.396	.693

The next model uses the number of trust interactions received as the dependent variable. The theory behind this model holds that trust received is a function of the total number of interactions sent, the +/– statistic for answering and asking questions, NVivo coding for personal information, the dummy variable for membership in the forum, the highest academic degree of the user, and the user's sex. It was hypothesised that the total number of interactions sent should have a positive effect on the number of trust interactions

received as the more a user posts, the more likely they are to be trusted by another user. The +/– variable for answers and asks is equal to the number of times a user answers a question minus the number of times a user asks a question and should also have a positive effect because a user that is answering a lot of questions should be more likely to be trusted than a user that is asking a lot of questions. Also, the higher the academic degree of the user, the greater chance they should have of receiving a trust interaction. Women in this forum should also be more likely to receive trust than males because it is a forum based around discussion of women. And NVivo coding for personal information should also have a positive effect on the number of trust interactions received because it is easier for another user to relate to someone who is willing to reveal personal information about themselves.

The initial regression run (model 2 of Table 5) revealed that the coefficients for the degrees were all insignificant except for a graduate degree. The coefficients also did not agree with our theory as a PhD degree had the smallest coefficient where an undergraduate degree should have had the smallest coefficient. The most likely reason for this may be that users do not look at a user's profile before they reply to their post. The terms for male and female were also insignificant. This finding is particularly interesting as our theory strongly suggested that women would receive more trust in WomenScientists1 than men. In the second regression (model 1 of Table 5) these six dummy variables were removed resulting in a much more significant model where each term's coefficient matched our initial theory. The total number of interactions sent had a t-value of 8.898 and a coefficient of 0.081, suggesting that for every additional interaction sent, a user will receive .081 trust interactions. This is a significant coefficient because the average number of trust interactions received was only 0.312. NVivo coding for personal information was found to have a t-value of 7.921 and a coefficient of .479, implying that personal information has a very large effect compared to the average number of trust interactions received. The +/– term for Answers and Asks was shown to be significant with a t-value of 6.233. This term also had a positive coefficient of .144. As such, the more times that a user posts and answer to questions rather than asking a question the more likely they will receive trust interactions.

The final model created used the number of trust interactions sent as the dependent variable. The theory behind this model was that trust interactions sent is a function of the NVivo coding for gender, personal information, and the +/– statistics for the answers and asks coding as well as the total number of trust and mistrust interactions received, the number of mistrust interactions sent, the total number of interactions sent, and the +/– statistic for the positive and negative interactions received (equal to the number of positive interactions received minus the number of negative interactions received). Both gender and personal information should have a positive linear effect on trust interactions sent because members should feel safer posting their personal information and sharing experiences, subsequently creating trustful relationships. A user that asks more questions than answers would be more likely to trust other users while the total number of interactions sent should positively affect the number of trust interactions sent because it indicates that the user is posting more often, and a higher frequency of posts is more likely to yield a trust interaction. The number of trust interactions received should positively affect the trust interactions sent, while mistrust interactions sent and received should both negatively affect the total. Positive interactions received should positively affect trust interactions sent because a trust relationship is more likely to occur between two users that agree with each other's views while negative interactions received should

have the opposite effect. A user's gender should also have an effect on the number of trust interactions sent. Because WomenScientists1 is focused around gender and science, women were hypothesised to be more likely to create trust interactions than men. Additionally, the poster's degree should affect the number of trust interactions sent, where the higher the degree a poster possesses, the less likely they are to send a trust interaction.

Table 5 Trust received model regression table

Coefficients (with dependent variable trust received)						
Model		*Unstandardised coefficients*		*Standardised coefficients*	*t*	*Sig.*
		B	*Std. error*	*Beta*		
1	(Constant)	–.250	.068		–3.653	.000
	Grand total sent	.081	.009	.513	8.898	.000
	Member	.189	.108	.083	1.745	.084
	Personal	.479	.060	.463	7.921	.000
	Answer and ask +/–	.144	.023	.297	6.233	.000
2	(Constant)	–.201	.082		–2.437	.017
	Grand total sent	.089	.009	.563	9.516	.000
	Member	.289	.127	.127	2.269	.025
	Personal	.330	.076	.319	4.349	.000
	Answer and ask +/–	.144	.022	.297	6.485	.000
	Male	–.059	.161	–.020	–.364	.716
	Female	–.197	.132	–.090	–1.487	.140
	Graduate	1.681	.477	.207	3.523	.001
	Other	.108	.516	.009	.210	.834
	PhD	.093	.157	.029	.595	.553
	Undergrad	.575	.519	.050	1.108	.271

In this model, the coefficients on the terms for mistrust sent and received were both positive and insignificant (t-values of 0.791 and 1.864 respectively) while the coefficients on the two dummy variables for male and female were both negative and also insignificant (t-values of –0.334 and –1.487). As there were very few mistrust interactions withinWomenScientists1, this would explain the insignificance of the mistrust terms. The insignificance of the male and female dummy variables is more interesting. This result suggests that women are not more likely to create trust relationships than men in the WomenScientists1 forum. Although, as previously shown, the user's sex has an impact on the number of trust interactions received, which in turn affects the number of trust interactions sent. When these terms were removed from the model, the resulting regression showed that the positive/negative +/– statistic was also found to be insignificant (t-value of 1.053). This indicated that trust relationships are not significantly impacted by whether people are agreeing with or supporting a user's posts.

The two terms for personal information coded and the total number of interactions sent was statistically significant by itself and had coefficients that agreed with our theory. However, when the interaction terms were added to the regression to take into account

the multicollinearity between these two terms and the gender and trust received terms, it was seen that the personal information term and the total interactions sent term were indeed statistically insignificant with t-values of 0.543 and 0.872 respectively. Coding for personal information and the total number of interactions sent impacts the number of trust interactions received and the coding for gender, which both in turn affect the number of trust interactions sent. It is interesting to note that the dummy variable for an undergraduate degree consistently had the largest relative value, was always positive, and usually had the only positive coefficient. This indicates that users with lower degrees should be more willing to trust other users. Again, the small number of users reporting their degrees is the most likely cause for the lack of significance in these dummy variables.

Table 6 Trust sent model regression table

Coefficients (with dependent variable trust sent)						
Model		*Unstandardised coefficients*		*Standardised coefficients*	*t*	*Sig.*
		B	*Std. error*	*Beta*		
1	(Constant)	.210	.066		3.182	.002
	Answer and ask +/–	–.262	.028	–.502	–9.372	.000
	Trust received	.787	.058	.732	13.665	.000
2	(Constant)	.216	.072		2.992	.003
	Answer and ask +/–	–.271	.058	–.521	–4.712	.000
	Trust received	.782	.063	.728	12.353	.000
	Trust received_Answer and ask	.003	.016	.022	.193	.847
3	(Constant)	.235	.079		2.984	.004
	Answer and ask +/–	–.268	.060	–.515	–4.501	.000
	Trust received	.893	.073	.831	12.297	.000
	Trust received_Answer and ask	–.003	.017	–.020	–.164	.870
	Graduate	–1.584	.537	–.182	–2.950	.004
	Other	–.235	.643	–.019	–.365	.716
	PhD	–.154	.198	–.044	–.782	.436
	Undergrad	–.127	.644	–.010	–.197	.844

This analysis results in a final model of trust interactions sent as a function of trust interactions received, coding for gender, the +/– statistic for answers/asks, and an interaction term between trust received and the answers/asks statistic. In this final model, the trust received term has a coefficient of 0.329 and a t-value of 5.509. Thus, for every additional trust interaction received, a user will send out 0.329 trust interactions. This result holds well with the trust model that we are using in this study in which a person that receives trust feels like they now belong in the community and are subsequently willing to trust other members of that community. The gender term has a coefficient of 0.274 and a t-value of 11.016, revealing a significant effect on trust interactions sent .In other words, every time a user discusses gender, they will send out .274 trust interactions. In WomenScientists1, the discussion of gender topics results in more trust relationships

than other topics which is unsurprising since its remit is to discuss gender related issues in the sciences. When the interaction term is left out, the answers/asks term is statistically significant (t-value of 3.656). But, when the interaction term is added, it reduces the significance of the answers/asks term. Part of the explanation for the significance level is that the coefficient is small. The coefficients on both of these terms are both negative which agrees with our theory that someone who asks a lot of questions is going to be more willing to trust another user than someone who answers a lot of questions.

7 Conclusions

This paper has examined social media, VOs, and the development of trust in an online scientific community reliant on social media technology. By developing from existing literature on trust, we built models of trust most appropriate to interactions between scientists using social networking technologies. Our research employed qualitative and quantitative methods to build a comprehensive data set of a group within an online scientific community specifically interested in increasing the representation of women in science. This study found that life scientists interacting within a virtual space via social networking and social media technologies could not only develop a thriving community, but one with a strong leadership of prominent, highly educated women scientists. Although that developed via collaborative social media, the trust was often unilateral (i.e., directional and not reciprocal). This could potentially be due to the anonymity offered by social media. Leaders within Women Scientists1 were found to be trusted information sources and potential collaborators, while one-off or relatively inactive posters were more anonymous and less of a figure or personality within the community. Though average users of WomenScientists1 were young, white women from affluent Western countries, leaders within this virtual space were older, white women, which help support mentorship dynamics.

This study ultimately finds that posting personal information and answering questions leads to receiving trust from other users. Posting personal information makes it easier for other users to make a connection with or relate to the original poster resulting in a better likelihood of a trust relationship. Additionally, a user that is repeatedly answering questions is perceived as having greater knowledge than other users, which also will contribute to a greater chance of an emerging trust relationship. Second, we found that users that discussed gender and asked questions were more likely to give out their trust to other users. Asking a question in an online space demonstrates already that a user is more likely to give out trust as they are asking a partially unknown community. Third, we found that the receiving of trust makes a user more likely to give out their own trust. This agrees with the idea that when someone receives trust from a member of a community, they will feel more like they are a part of that community and thus are more willing to trust other members of the community. Fourth, we found that women were more likely to discuss gender issues, which resulted in an increase in the giving of trust to other users. In a women-oriented VO, it makes sense that women should discuss gender issues more than men and also that they should be more willing to trust other users in the forum as they would have an easier time of relating to the other users of WomenScientists1. Lastly, we found that there are diverse methods, which members of this virtual group used to facilitate online discussion via the various social media technologies available within this virtual scientific platform. This ranged from asking numerous questions to spur

conversation to answering a multitude of questions as trusted information sources. This study ultimately reveals interesting dynamics emerging within collaborative communities who use social media. It also specifically contributes to our understanding of how gender affects virtual collaborative processes and groups. The ability of social media platforms, for example, to deliver snapshots of ability and integrity, such as education, professional position, and publications enables the development of trusted 'personalities' within this virtual community.

Acknowledgements

The authors would like to thank Atilano Rodriguez for extensive coding of forum messages and feedback on an earlier version of this article, Alexander Gross for generating the Cytoscape-rendered figures, and Natalie Kass-Kaufman for editorial support.

This material is based in part on work supported by the National Science Foundation under Grant No. 1025428. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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