

Co-Constructing Controversy: Content Analysis of Collaborative Knowledge Negotiation in Online Communities

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Abstract

Knowledge sharing online has flourished within organizations as well as open online communities due to the pervasiveness of Web 2.0 platforms. This paper builds on previous studies of social construction of knowledge online and investigates how contributors in online communities collaboratively share and construct controversial scientific knowledge. As the general public participates in such knowledge collaboration, understanding the processes through which they contribute content and roles that they play is imperative. We conducted the content analysis of three online communities that engage in knowledge collaboration on the subject of MMR vaccination, which is perceived as contentious knowledge by the public due to the widespread myth among parents that the MMR vaccine is associated with autism. The study's findings include that the content discussed is influenced by the purposes of the communities, nature of the tasks, and demographics of participants, although they discussed the same topic. We also found that the framework of knowledge reuse and knowledge co-construction sites is useful for investigating the content and roles that appeared in the three communities. The contribution of the paper includes the analytical framework of knowledge reuse and knowledge co-construction, articulation of the content and roles that appeared in online communities, and unboxing of discourses in three different online communities. Future research directions are also discussed.

Keywords: knowledge collaboration, online communities, controversy, Web 2.0

1. Introduction

Knowledge sharing online has recently become pervasive, especially within open online communities (Hara, Shachaf, & Hew, 2010), due to widely accessible Web 2.0 platforms, such as Twitter, Facebook, and Wikipedia (e.g., Flanagin, Hocevar, & Samahitob, 2014). Consequently, ordinary citizens tend to not rely on experts to gain scientific knowledge as in the past, to seek shared knowledge, and participate in knowledge co-construction in online communities.

Some argue that this may lead to democratization of knowledge (e.g., Qualman, 2012; Tapscott & Williams, 2006). In theory, anyone from any background can share and contribute to open online sources such as Wikipedia. Additionally, some scientific knowledge is contested even among scientists, requiring ordinary citizens to interpret competing findings. In online communities, participants sometimes share contested knowledge and collaboratively construct understanding of scientific knowledge.

The study described in this paper built on previous work on social construction of knowledge in online environments (e.g., König, 2013) and included more than one kind of community, in order to investigate types of interactions and roles played by participants. We selected a contentious scientific topic, child vaccination, which has implications for everyday decision-making. The following question motivated this research: How do people make sense of contested scientific knowledge in online communities? To investigate this question, we chose three open online communities that engage in knowledge collaboration. The specific research questions addressed by this article are: How are independent communities similar or different in terms of the content

of knowledge collaboration; and how do the roles that participants play in supporting knowledge collaboration differ or compare across communities?

2. Background: Knowledge Collaboration

The knowledge collaboration literature (Faraj et al., 2011) frequently discusses two types of activities. One is sharing existing knowledge, sometimes called knowledge reuse (Markus, 2001; Majchrzak, Cooper, & Neece, 2004). Yahoo!Answers represents this type, with participants sharing their own experience and knowledge (e.g., Rachavi & Rafaeli, 2012). The other type includes activities that aim to collaboratively construct knowledge through Web 2.0 platforms. Wikipedia is a salient example of a collaborative knowledge creation site (Goldspink, 2010; Fichman & Hara, 2014; Kane, Johnson, & Majchrzak, 2014).

Markus (2001) identified four types of knowledge reuse situations: capturing, packaging, distributing, and reusing knowledge. Knowledge reuse, as a construct, depends on the assumption that correct knowledge exists and that primary information behaviors are to locate, share, and disseminate. Previous literature examining knowledge reuse has often addressed motivations for sharing, identifying that the objective is for other individuals to have access to that knowledge (Hew & Hara, 2007; Nov, 2007). Seebach (2012) along with Hara, et al., (2010) classified the type of discourse that knowledge seekers and providers exchange in enterprise microblogging and Wikipedia, respectively. When dealing with knowledge seeking behavior, some use individuals' personal networks e.g., through Facebook (Lampe et al., 2012). Meservy, Jensen, and Fadel (2014) address how knowledge seekers evaluate provided content. They found that the source of expertise and validation that solutions worked in previous cases weigh more

in determining the quality of content than actual content quality for the study participants. Judging content is an acute issue on social media, such as Twitter (e.g., Liao, Wagner, Pirolli, & Fu, 2012).

Prior scholarship has investigated the collaborative construction of knowledge. The underlying assumption about knowledge in this line of research is that participants debate what acceptable knowledge is and that the goal is to eventually agree on producing representative knowledge. For example, the collection of articles presented in the special issue of *Participatory knowledge production 2.0: Critical views and Experiences* (Wyatt, Bier, Harris, & van Heur, 2013) address this research domain. König (2013) in that special issue analyzed the democratization of the knowledge production process in the German Wikipedia. Her examination of the article, ‘the September 11, 2011 attacks in the U.S.’ identified that the existing knowledge hierarchy offline marginalized alternative interpretation of the incident. König asserted that existing knowledge authorities were mirrored in this seemingly open knowledge production site. Similarly, Swarts (2009) studied social construction of knowledge in a Wikipedia entry on clean coal technology. He used Actor Network Theory to analyze the process and specifically focused on two acts: opening moves and closing moves. These are rhetorical moves that shape discourse in terms of presenting ‘facts.’ Although these studies shed light on how crowds collaboratively construct knowledge, it is uncertain what types of knowledge are shared and re-constructed in this process. A notable exception is a study of the autism article in Wikipedia (Kane, et al., 2014). They examined the deliberation processes on the Wikipedia discussion forum (called Wikipedia Talk pages) associated with this article.

Certain knowledge is contentious—there are issues for which no consensus exists among the general public. This includes issues related to science and technology (e.g., climate change; see Jang 2014) as well as living individuals' biographies (Joyce, Pike, & Bulter, 2011). Jang (2014) examined four controversial topics in science and identified how individuals' previous attitudes influence online information seeking behavior. As consumers of information, individuals in the study were not greatly influenced by previous attitudes and bias, while searching for conflicting knowledge. Joyce et al. labeled artifacts or objects as 'contentious objects' when conflicts remain unresolved due to differences in groups' goals. They contend that 'contentious objects . . . create affordances for conflict' (p. 30) and called for more investigation of contentious objects.

While previous studies are informative, they are lacking in the following aspects: 1) addressing generic topics, but not scientific topics, that affect everyday decisions; 2) focusing on one community, commonly Wikipedia; 3) examining specific content and role. To address the lacuna in the literature, further examination of content and roles is needed while participants are engaging in knowledge collaboration, especially regarding contentious scientific knowledge. In response, we compare three online communities that deal primarily with collaborative knowledge production in this article.

3. Methodology

Innumerable public controversies have evolved during the social media age, leading to collaborative and distributed negotiation of truth and perspective in online social environments. While traditional media have long lent particular perspectives to analysis of controversy (Holton, Weberling, Clarke, & Smith, 2012), in recent years, parallel and subsequent discussion has continued online (Nagar, 2012). In selecting an

appropriate case through which to consider social construction of knowledge, important factors included: multiple distinct points of view, confluence of layperson and scientist perspectives, on-going debate and interest, and social significance of interpretations. These criteria highlighted a number of possibilities, ultimately leading to the selection of the Measles, Mumps, and Rubella (MMR) vaccine, due to the widespread myth among parents that the MMR vaccine is associated with autism. The persistence of this type of vaccine myth was recently reported (Clift & Rizzolo, 2014).

The MMR vaccine became a serious and polarizing controversy as a result of a combination of research misconduct, misinterpretations, media sensationalism, and confusion. Research by Andrew Wakefield posited links between the MMR vaccine and Crohn's disease as well as Crohn's disease and autism, yet Wakefield's research was based on non-random, non-anonymous, and in-valid sampling, in addition to being funded by an interest group (Holton et al., 2012; Petts & Niemeyer, 2004). When this work was published, the media publicized it in an unusually aggressive way and it was publically interpreted as proving autism was caused by vaccination (Holton et al., 2012). Many politicians (e.g., Representative Dan Burton (R-Indiana)) and celebrities, notably Jenny McCarthy who wrote a book on the subject, support this belief (Holton et al., 2012; Petts & Niemeyer, 2004). However, research results were contested and contradicted (Purssell, 2004), many of Wakefield's co-authors rejected the research, and the journal that published the results later retracted the paper (Petts & Niemeyer, 2004). Yet, in wake of this controversy, fear that the MMR vaccine had led to the autism epidemic spread and vaccination rates declined (Gardner et al., 2010; Shelby & Ernst, 2013), with significant public health impacts due to outbreak and spread of diseases that were virtually absent in

developed countries in the previous decade (Gardner et al., 2012). The debate over the MMR vaccine's risks continues (Larson et al., 2013) and interest in the controversy has grown, in parallel with significant events and publicity.

The level of interest in the subject is significant. First, fearful parents of autistic children have latched onto the single study in order to hyper-rationalize autism and the idea has found support through a combination of social deference to scientific 'Expertise' without true understanding (John, 2011). Medical professionals have failed to explain why the fears are irrational and why further scientific investigation through proper procedures invalidates the Wakefield data and contradicts the findings (Purssell, 2004). Second, the rise in social information sharing (Shelby & Ernst, 2013; Skea et al., 2008) and sense-making (Petts & Niemeyer, 2004) makes analysis of the online communities in which this happens more salient as people from many perspectives co-construct knowledge.

The debate online about the MMR/autism controversy has included parents seeking information from experienced parents, experts seeking to dispel falsehoods and reduce fear, conspiracy theorists, and online knowledge curators, such as Wikipedians and social Q&A users. In this sense, this controversy is ideal for examining contextual differences in collaborative knowledge development because the participants and the communities are so diverse.

3.1 Data

Online communities have extensively debated the relationship between the MMR vaccine and autism, including: the Wikipedia Talk community, the Baby Center, and the Berkeley Parents Network. They represent very different combinations of pro- and anti-

vaccine perspectives, along with concerned parents interested in the truth, general conspiracy theorists, and representatives of the public health and medical communities. Furthermore, the different patterns of behaviors and uses of information can lead to analysis along two comparative lines: co-construction of knowledge, exemplified by Wikipedia, and re-use of knowledge, exemplified by the Baby Center and the Berkeley Parents Network. It is important to examine multiple communities as they seek truth and understanding about the MMR vaccine and autism because a comparative perspective illustrates the impact, if any, of context, as well as the sources of difference in social understanding of the controversy. (See Table 1 for a summary of the data sources).

	Baby Center	Berkeley Parents Network	Wikipedia
Criteria for Inclusion	All references to MMR and/or MMR controversy	All references to MMR and/or MMR controversy	MMR talk page; MMR Vaccine Controversy talk page
Posts	541	98	705
Threads	33	18	119
Coverage	2007-2013	1999-2006	2004-2013

Table 1. Data Sources and Distribution

3.1.1 Wikipedia

Considerable attention has been paid to understanding Wikipedia as an online community, an information resource, and a platform for collective sense making (Nagar, 2012). While the Wikipedia articles receive substantial amounts of public attention, Wikipedia's Talk pages, in which contributors discuss the content of articles, are rich sources for the process of knowledge co-construction. Wikipedia Talk pages are attached to individual articles and archive all of the discussions occurred regarding the article

including the content, editorial decisions, and behaviors of contributors. As a venue for interpretation and representation of collective knowledge, its strict policies institutionalize community expectations for practice to ensure that sense making is not co-opted or subverted by poor practices (Nagar, 2012) or deviants (Shachaf & Hara, 2010). Providing protocol for behavior and mediation and intervention in the case of non-compliance is significant to collaborative processes for knowledge co-construction surrounding contentious, hotly debated topics.

It is within this complex context that Wikipedians' sense making process seeks a neutral point of view between all facts and interpretations within the community. Looking specifically at the sub-community that will be analyzed, collaborators in constructing knowledge seek to represent the MMR vaccine and its polarizing position in society, to provide a public reference. The community seeks less to debate the issue and more to ensure balanced coverage, though individuals sometimes detract. Contributors came from primarily the US, UK, and Australia, most of whom follow community policies and norms. A few contributors have dominated particular threads at particular times. The community of contributors was most robust and communicative when the page began in 2007, though many contributors still participate in similar pages¹.

3.1.2 The Baby Center

Thirty-six million mothers worldwide reference the Baby Center through 14 distinct websites in 11 different languages (Promisel & Centinaro, 2014). It is

¹ There is significant overlap in contribution between the pages for MMR vaccine and pages for: Varicella, Vaccination, Hives, Reye's Syndrome, Autism spectrum, MMRV vaccine, and Varicella vaccine. Pages with common contributors to the MMR vaccine Controversy page include: Autism spectrum, The Lancet, BMJ, and Andrew Wakefield, among others. This was measured by considering contributors as edges between pages, as nodes, using NodeXL.

administered by Johnson & Johnson (Promisel & Centinaro, 2014), which has a prominent legacy in products for children and promoting informed parenting. Focusing specifically on the US-targeted website, the Baby Center involves mainstream discussions on parenting, including questions for and feedback from experts. Sub-communities have formed around seekers and sharers of health information, with extensive discussion on vaccination and significant debate over the MMR vaccine in particular. There is a highly visible group of contributors who identify as vaccine skeptical. Whether they are a minority or majority, they dominate these debates. The discussions often appeal on an emotional level and are active diachronically.

This community has been subject to some research, mostly with emphasis on content, rather than knowledge collaboration processes. The Baby Center has been evaluated with respect to: trust production and privacy concerns in online social exchange (Luo, 2002); the role of site features, user attributes, and sponsor reputation in impacting perceived information credibility (Flanagin & Metzger, 2007); and flexible personalization of online services to users (Borenstein & Saloner, 2001). Scholars have determined that the Baby Center provides important services to parents and caregivers, which are more specifically targeted and approachable than offline parenting information equivalents. However, it remains to be determined how useful and reliable the information from this community is, particularly when the status of ‘truth’ is contested within the community and other communities.

3.1.3 The Berkeley Parents Network

The Berkeley Parents Network is an online forum that includes parents primarily from a closely proximate region in the San Francisco Bay area, with around 33,156

members who engage in parent-to-parent exchanges and receive weekly newsletters (Berkeley Parents Network, 2014). This network was founded in 1993 to support parents who worked or were students at the University of California, Berkeley, but has expanded to other parents in the area (Berkeley Parents Network, 2014).

Discussions stem from personal questions to guide decision-making, rather than an interest in un-prompted knowledge sharing or general discussion. Threads are often short, ending when parents have been answered. The community favors progressive perspectives and approaches, as indicated by the number of threads on alternative medicine. Discussions on MMR vaccine concerns reflected individual experiences, such as with allergies, and circumstances, somewhat independently of the general controversy, and ceased in 2006, before the controversy peaked in other communities and popular media. This forum has not been studied, though it appears similar to other online forums, albeit with approximate geographic boundaries encompassing a majority of participants.

All complete, publicly available threads pertaining to or including discussion of the MMR vaccine and the vaccine-autism controversies up until August 15, 2013 were harvested from each of these three communities. This included 705 talk posts from Wikipedia, 541 posts from the Baby Center, and 98 posts from the Berkeley Parents Network. Data was collected and considered with posts as the unit of analysis, except for analyzing discussions to distinguish controversial from non-controversial threads.

3.2 Analysis

Consideration of these posts and threads through textual analysis was systematic. First, a codebook was developed to apply to social construction of knowledge and social information sharing in a previous study about the Fukushima disaster with Wikipedia

(Reference Removed for Blind Review). The codebook was revised, so as to specifically relate to the types of online communities addressed in this study. Table 2 presents the definitions of all codes applied, with the exception of dates, which were also applied to reveal longitudinal patterns and instances of correspondence between bursts of collaborative activity and important events along the historical timeline of controversy development.

Context	Code	Definition
Editorial	Editorial	Comments related to the editorial aspects of the article, e.g., the length of the article, naming of categories, etc.
Knowledge Components	Background knowledge	Some background knowledge about peripheral topics, e.g., autism generally, availability of the MMR vaccine, other vaccines, vaccine preservatives, or the measles disease
	Definitions	Definitions of terminology related to the topic
	Facts about the topic	Claimed facts about the topic, e.g., details about the Wakefield study and subsequent public fallout; discussions about the controversial and contested link between the MMR vaccine and autism as well as the MMR vaccine itself.
	Media report about the topic	Reporting of media coverage about this event, e.g. USA Toda reported...
	Resources	Sharing of any useful resources related to the topic, but not necessarily related to facts per se
Knowledge Scaffolding	Citations	Any discussions of or citing of sources to justify facts or background knowledge for the purpose of convincing others
	Claimed expertise	This refers to users who base their arguments on their educational or professional expertise (i.e. 'as a pediatric RN,') or asks for the expert credentials of other users or resources. This also includes any instances in which participants explicitly claimed no expertise.

	Confusion	This refers to a user either identifying confusion in other users' arguments or explicitly stating that they are confused by the facts or presenting contradictory information in the same post
	Credibility	Instances in which users evaluate the credibility of another actor's claims, including their arguments, relevance of expertise, etc.
	Experience	Presents information about their own lived experiences and social knowledge from their offline lives, associated with the topic
	Inquiry	This refers to actual questions posed to stimulate discussion
	Interpretation or Opinion	This refers to associated discussions in which the poster restates their opinion of another user's comments or says 'in my opinion...' or presents information on the topic or as background information and then explains how they will act on that or what it means to them. This also includes instances in which underlying motivation, values, or logic was discussed with respect to facts or background information as evidence of interpretation.
Vandalism	Vandalism	Discussions about how to deal with malicious users

Table 2. Codebook for content

Codes were applied as appropriate once per post, without limit to the total number of codes that could be applied to a post. Frequencies, as the percentage of total posts in a specific community that exemplified particular themes, were then compared across communities. Codes were applied by the investigators and by an additional coder. Additionally, qualitative assessment of threads, assessed as posts were coded in thread sequence, allowed deeper understanding of the nature of communities and the status of understanding.

Second, we coded the posts based on roles that each participant played. A codebook was developed based on the literature review (see Table 3). The roles appear in three different contexts: one for the roles that appear while participants engage in identifying and sharing knowledge, the second for the roles that modify shared knowledge, and the third for the roles that facilitate knowledge sharing discourses (Reference Removed for Blind Review). Furthermore, we added two more roles based on the data: distractor to the first category, and judge to the second category. Distractors seek to have a negative impact on the process either by interrupting, trolling, or vandalizing. These users often include promoters seeking to advertise a semi-related product, service, or alternate information source, such as personal blogs, by spamming the thread. Distraction also occurs when those who play constructive roles engage with distractors and thus digress from the discussion subject. Discussants are not necessarily distractors when they simply hold false or unpopular opinions. Judges serve to evaluate and/or demand justification for changes in content, process, and style. Judges also evaluate personal statements and actions, though they do not judge individuals as people. Inter-rater reliability calculated using Cohen’s Kappa for both roles and contexts between two coders range from 0.43 to 1 (see the Appendix). Hallgren (2012) delineated that 0.41 to 0.60 indicate moderate agreement, 0.61 to 0.80 mean substantial agreement, and 0.81 to 1.0 would be interpreted as almost perfect agreement.

Context	Role	Definition
Identifying and Sharing Knowledge	Distractor	Those who play this role often seek to have a negative impact on the process, either by distracting, interrupting, trolling, or drive-by vandalism.
	Help-Giving [Giver] (Hara et	Helpers specifically provide information, knowledge, and experience related to the subject of

	al., 2009; Hargadon & Bechky, 2006; Kane et al., 2014)	the thread or content of the knowledge being constructed, based on help sought by the original poster or any mover who reshaped the overall discussion.
	Help-Seeking [Seeker](Hara et al., 2009; Hargadon & Bechky, 2006; Kane et al., 2014)	Hargadon and Bechky assume a process-based approach in which help is sought and given, with a collective sensemaking approach.
	Mover (Swarts, 2009)	Opening and closing movers serve as highly specialized facilitators by transitioning the discussion to new or adjacent points, as well as funneling the discussion to specific aspects.
Modifying Knowledge	Judge	Judges serve to evaluate and/or demand documentation or justification for changes in content, process, and style. Judges also evaluate personal statements and actions, though stop short of judging individuals as people.
	Knowledge Shaper (Majchrzak, et al., 2013)	Shapers often remove content and rewrite, without adding new content, in order to convey coherence or particular perspectives. This role simplifies content, removing repetition, and makes information accessible.
	Organizer (Faraj, et al., 2011)	This type of actor synthesizes and represents the information shared by other users into a more usable set of links or facts. Organizers summarize discussions, rather than shaping content.
	Reflective Reframing [Reframer] (Hargadon & Bechky, 2006; Kane et al., 2014)	This role seeks to build on the assumed process based approach in which help is sought and given, with a collective sensemaking approach to evaluating help; reframers reconstruct the consensus, serving to translate information collectively deemed useful from conversations into useful and consistent content.
	Reflective reinforcing [Reinforcer] (Hargadon & Bechky, 2006; Kane et al., 2014)	Individuals playing this role seek to reinforce identified truths; reinforcers reconstruct the consensus, serving to repeat conclusions and provide evidence in support of consensus.
Facilitating Knowledge Collaboration	Cross-Thread Connectivity [Connector] (Kuk, 2006; Kane et al., 2014)	Some individuals are interested in issues that weave across threads, leading them to assume a role in which they coordinate multiple topics to provide consistency and continuity across online communities.

tion	Facilitator (Kane, et al., 2014)	Facilitators assume the role of smoothing and expediting the production process within ongoing discussions by seeking to identify quorums and moderate discussions that will lead to progress.
	Governance-Oriented Approach [Governor] (Schroeder & Wagner, 2012)	Experienced users and those with an interest in protecting the status quo employ institutionalisms to prevent new comers from making drastic changes from process or to content.
	Mediator (Faraj, et al., 2011)	Mediators step in when tensions run high within a community and when there are entrenched interests in multiple perspectives. They are similar to facilitators, but they specifically manage conflicts within discussions.
	Supporter (Faraj, et al., 2011)	This type of user both provides support for particular positions articulated within discussion and seeks out references and resources to support claims and positions. Supporters generally do not contribute to content or provide new arguments within discussions.
	Unmasker (Faraj, et al., 2011)	When anonymity or identity deception is allowing an actor to harm a community, an individual might seek to become an unmasker by investigating the behaviors of possible perpetrators in order to either expose the harmful actor or force them to apologize.

Codebook for Participant Roles

Third, the data were aggregated based on the type of sites, i.e., knowledge reuse versus knowledge re-construction sites. For the content, we aggregated the data based on the purposes of contents into four categories: knowledge components, knowledge scaffolding, editorial, and vandalism. In addition, we created aggregated frequency rows based on three types of roles: identifying and sharing knowledge, modifying knowledge, and facilitating knowledge collaboration. Then, cross tabulation analysis was conducted using the statistical package R (version 3.0.1).

4. Findings

4.1 RQ 1: How are three communities similar or different in terms of the content of knowledge collaboration?

Context	Codes	Baby Center	Berkeley Parents Network	Wikipedia
Editorial	Editorial	0.00	0.00	35.18
Knowledge Components	Background knowledge	60.44	74.49	40.71
	Definitions	2.22	0.00	3.12
	Facts	14.42	19.39	22.13
	Media reports	2.96	9.18	5.82
	Resources	21.63	24.49	13.33
Knowledge Scaffolding	Citations	10.35	12.24	30.78
	Claimed expertise	8.50	12.24	1.84
	Confusion	9.24	7.14	8.09
	Credibility	22.55	8.16	31.91
	Experience	41.40	62.24	2.55
	Inquiry	16.27	24.49	14.33
	Interpretation/opinion	80.41	57.14	80.14
Vandalism	Vandalism	1.29	0.00	4.68

Table 4. Distribution of content codes as percentages of posts within communities

Generally, all three communities have interpretation/opinion and background knowledge among the top three codes (see Table 4). The communities categorized as knowledge reuse have the same top three codes: interpretation/opinion, background knowledge, and experience. This is probably due to the fact that knowledge reuse communities take advantage of their own experience, opinions, and existing knowledge to contribute to the discussions. In contrast, within Wikipedia, a knowledge co-construction site, editorial discussions become more prominent as the users collaboratively create and edit an article. In addition, considering the nature of knowledge

co-construction sites used by the general public, Wikipedia suffered from vandalism more than the other two communities. When we examined the defining characteristics of each community separately, differences between the communities also became evident.

With respect to Wikipedia, the top three content categories were interpretation/opinion, background knowledge, and editorial (80.14%, 40.71%, and 35.18% respectively). There were considerable personal discussions and arguments unrelated to the content, with extended personal attacks and discussion of interests adversely impacting attempts to write and maintain a *neutral point of view*. These tangents and various edit wars led to multiple interventions by Wikipedia; interestingly, ‘Jimbo Wales,’ the Wikipedia founder, served as a moderator for the talk page for MMR vaccine controversy at a contentious point. Debate over the appropriateness of including quotations from famous people as evidence within the article had reached a stalemate; Jim Wales offered the following comments, diffusing the situation:

Although I think Bill Gates is likely correct here, I agree that his views don't need to be presented in this article. He is a major philanthropist in the area of vaccines, and as is his intense nature as a person, he seems to have done very intensive study, so I think he knows what he is talking about. However, rather than an off the cuff remark from a celebrity businessman/philanthropist style interview, it would be better to stick to verifiable medical sources.--Jimbo Wales (talk) 09:38, 8 February 2011 (UTC)

There was also significant debate over credibility of users (31.91%), citations (30.78%), and validity justifications for individual opinions (80.14%). For example, users debated whether the controversy article should be expanded to include other

controversies surrounding the MMR vaccine, such as: vaccine overload, concerns about the Urabe mumps strain within the vaccine, and associations to other vaccine controversies. In shaping a narrative about the MMR vaccine and controversy, issues of validity and bias dominated user concerns.

A theme that recurred within the Baby Center was emotionalism. Specifically, while instances of interpretation/opinion codes in other communities indicated what the participants took from the facts and background knowledge and how this might impact actions, Baby Center participants emphasized feelings and beliefs. An example of an emotion driven inquiry is as follows:

i just took my son Kaston to his 2 month checkup and they informed me that people are in mass confusion that this shot could cause autism....im a 1st time mommy and now that i have read some things about it,the statistics of 1 in 150 could be affected by this shot!! what the hell!! are you serious!!! im scared to death to get his shots,but im also scared to death that he may get sick if i DONT!! if anyone could please help me with some info on wether i should or should not get his shots,i would greatly appreciate it!!

Posted: 10/26/2011 by ladyethinol

There was particular emphasis on trust and distrust, tying this code closely to credibility (22.55%) in many instances, as well as evidence of fear more than skepticism. The discussions tended to stray both from the original post topic and the specific MMR/vaccine controversy into general autism and vaccine discussions, with participants providing significantly more background knowledge and experience than facts. Many participants seemed to value experience over both scholarly research and media or

celebrity narratives.

Discussions within the Berkeley Parents Network spanned a much greater breadth than within the other communities; specifically, even when threads began with the MMR vaccine controversy, posts considered public health consequences of non-vaccination, allergies, doctor-patient interactions, and policies. The discussants largely observed a question and answer structure, and when a participant strayed toward debate, the others re-identified and redirected the discussion back toward the original inquiry. This anonymous contribution illustrates an example of redirection:

Please listen to your doctor! The question is not "When was the last time anyone got measles around here?" It should be "How soon before an outbreak of this serious disease occurs because increasing numbers of well meaning (but misguided) parents defer or avoid MMR vaccinations for their children?" ... We can't all be experts on science or statistical research, but given that fact, we need to follow the current advice of a pediatrician rather than be guided by our own uninformed feelings or suspicions. Remember, this is not a personal choice issue - your decision affects the whole population. For the record, my son has received the MMR vaccination, and no, I'm not a doctor.

Opinions were valued far less often than experiences, and media coverage was acknowledged as having prompted many of the inquiries, rather than employed as support for facts or arguments. This was particularly evident when users sought to know how other parents had handled immunization issues with their own children; users did not seek opinions on what they should do, but rather exemplar experiences. The scope of discussion was largely personal, yet it was rational rather than emotional compared to

Baby Center, in terms of the arguments made and the language employed.

	Knowledge Co-Construction Site (Wikipedia)	Knowledge Reuse Sites (Baby Center & Berkeley Parents Network)
Editorial	11.94	0
Knowledge Components	28.88	35.84
Knowledge Scaffolding	57.58	63.78
Vandalism	1.58	0.37

Table 5. Cross tabulation results of aggregated content and types of sites in percentage

Table 5 presents the 14 codes of content aggregated into four categories: knowledge components, knowledge scaffolding, editorial, and vandalism between knowledge reuse sites (Baby Center and Berkeley Parents Network) and knowledge co-construction site (Wikipedia). A chi-square of the content categories, excluding vandalism, in R (version 3.0.1) indicated a statistically significant difference between the knowledge reuse and knowledge co-construction sites ($\chi^2 = 12.9982$, $df = 2$, $p=0.001505$). The descriptive data showed the major differences between the knowledge reuse and co-construction sites were editorial and vandalism. Even though the value for the vandalism is small, when included in the chi-square test, the results indicated the difference between knowledge reuse and knowledge co-construction sites was statistically significant ($\chi^2 = 13.756$, $df = 3$, $p=0.003257$).

4.2 RQ 2: How are the three communities similar or different in terms of the roles that participants play in supporting knowledge collaboration?

In examining roles, as was expected, all three communities have *giver* as one of the top three most common roles (see Table 6). The communities categorized as knowledge reuse both have *giver* as most common and *supporter* as third most common.

Since the purpose of knowledge reuse sites is sharing and reconstructing the knowledge, it is natural that giving occurs most frequently. The supporting role helps sustain a collegial community and move the discussion into consensus. These two communities also did not have the role of *governor*, as they do not have extensive rules for using the sites, unlike Wikipedia.

On the collaborative knowledge creation site, Wikipedia, *judge* is the most frequently observed role. This is counterintuitive because the role of judge does not produce content. However, the role a judge plays is similar to the *knowledge shaper* described in Majchrzak et al. (2013). For example, a post commenting on a citation was coded as judge:

There's a big difference between being a key figure personally involved (like Horton, who approved the original article for publication) plus having written a book on it, and having expressed an opinion on the controversy. --Jkpjpk 05:45, 30 August 2007 (UTC)

Their contribution to knowledge collaboration is significant because it evaluates the content's value, e.g., whether part of content is accurate or whether a sentence should be deleted. It plays a role similar to metacognition in an individual's mind. In this community, all of the roles happened in the discussions. The least occurring role was *unmasker* (0.43%)

Two communities, Baby Center and Wikipedia, have the role of *distractor* as the second most frequent role. When participants engage in controversial topics, they have strong opinions about specific interpretation of these topics. The topic examined here, child vaccination, is a controversial topic. As a result, we sometimes see digressions

within discussions by people who have an agenda different from knowledge reuse or knowledge co-construction. These individuals are not contributing to the discussions, but rather diverting the discussions.

Despite the fact that the participants engage in the same controversial topic, the Berkeley Parents Network community did not have substantial appearances by *distractors*. Instead, *seekers* and *reframers* played major roles in this community. This may be due to the fact that participants here tend to seek out progressive perspectives and approaches. In addition, this community is smaller and less well known than the other two. As a result, discussions are inclined to stay focused on the topic specified by the initiator of a given thread. Within the Berkeley Parents Network, two additional roles also did not appear: *facilitator* and *unmasker*. Such roles likely were unnecessary because this community had fewer and less significant disputes. When disagreements occurred within controversial threads, the majority of participants ignored distractors or sought to return the discussion back to the topic, thereby playing the role of *reframer*.

Within the Berkeley Parents Network, *givers* dominate the discussions, providing the majority of the content in threads, as well as the majority of the knowledge being co-constructed. *Seekers* play the second most numerous role, closely followed by the aforementioned *reframers* and *supporters*. The dynamic of conversations within this community is much more oriented toward reuse of knowledge than on consensus forming, significantly impacting the distribution of roles.

Context	Codes	Baby Center	Berkeley Parents Network	Wikipedia
Identifying and Sharing Knowledge	Distractor	28.47	8.16	24.68
	Giver	59.52	67.35	17.30
	Seeker	9.98	22.45	7.66
	Mover	1.48	7.14	10.92
Modifying Knowledge	Judge	11.83	2.04	34.61
	Knowledge Shaper	0.55	1.02	7.94
	Organizer	0.92	1.02	2.13
	Reframer	5.73	18.37	7.66
	Reinforcer	2.96	9.18	5.96
Facilitating Knowledge Collaboration	Connector	2.03	3.06	5.82
	Facilitator	1.85	0.00	1.28
	Governor	0.00	0.00	8.09
	Mediator	4.44	3.06	3.69
	Supporter	12.94	18.37	14.61
	Unmasker	1.11	0.00	0.43

Table 6. Distribution of roles as percentage of posts within community

Table 7 represents aggregated codes of the three categories for the 15 roles between knowledge reuse sites (Baby Center and Berkeley Parents Network) and knowledge co-construction site (Wikipedia). A chi-square in R (version 3.0.1) indicated that there was a statistically significant difference between the knowledge reuse and knowledge co-construction sites ($\chi^2 = 9.2758$, $df = 2$, $p=0.009678$). The descriptive data indicated that the majority of roles appearing in the knowledge reuse sites were identifying and sharing knowledge roles, whereas roles are spread among the three in the knowledge co-construction site.

	Knowledge Co-Construction Site (Wikipedia)	Knowledge Reuse Sites (Baby Center & Berkeley Parents Network)
Identify and sharing	39.65	68.48
Shaping	15.51	8.97
Supporting	22.19	15.49

Table 7. Cross tabulation results of aggregated roles and types of sites in percentage

5. Discussion and Conclusion

In this paper, we addressed the research question: How do ordinary citizens make sense of contested scientific knowledge in online communities? We analyzed three different open online communities—two focused on knowledge reuse and one on knowledge co-construction. We found that the three communities examined in the study differed in terms of the content that they discussed, but also that the knowledge reuse sites shared similar content. Likewise, the roles that participants play in these communities are different, but knowledge reuse sites show some resemblance to one another. The cross tabulation analysis showed statistically significant differences between knowledge reuse and knowledge co-constructions sites in terms of content and roles.

Although the roles that appear in online communities have been discussed in prior literature, they have not been explicitly defined. One of the contributions of this paper is the articulation of these roles based on the literature. Moreover, we identified two additional roles that play important functions in online communities that engage in knowledge collaboration: distractor and judge. Although distractors do not necessarily make productive contributions to knowledge collaboration, their roles affect identification and sharing of knowledge. Distractors are not likely to appear in closed online communities, such as those in corporate sites because of the expectations to act professionally. However, the distractive roles, such as those played by trolls, are not uncommon (see e.g., Shachaf, & Hara, 2010). As we crowd-source knowledge

collaboration (Wiggins & Crowston, 2011), managers and site owners need to pay attention to distractors and find a way to cope with them. Joyce et al., (2013) proposed the strategies of managing contentious objects that have implications for how to manage *distractors*. However, we need to explicitly examine the strategies for dealing with distractors. The other role that we identified was *judge*. Those who play the role of *judge* contribute to shaping of knowledge in general. This role appeared to be more important in knowledge co-construction sites, as one third of the participants in Wikipedia are coded as playing a judge role. When participants are socially constructing ‘knowledge’ online, someone needs to evaluate and make judgments about the quality of contributed content. We argue that this role is extremely important, though it has not been clearly addressed in the previous knowledge collaboration literature, despite the emphasis on the importance of knowledge shapers (e.g., Yates et al., 2010; Majchrzak et al., 2013).

In examining three online communities, we articulated a framework to examine the content of discussions in depth. We identified four major content categories (i.e., editorial, knowledge components, knowledge scaffolding, and vandalism) in these communities that engage in knowledge collaboration activities. Content analysis laid the groundwork to help us understand interactions happening in these sites. Other researchers can use this framework to analyze and compare other topics as well as other sites.

Although this study examined the discussions of a specific vaccine called MMR, the implications of the study expand beyond this vaccination and include other scientific controversial topics such as climate change or other types of vaccinations. This study sheds light on the practice of participating in knowledge co-construction. As more people participate in this type of knowledge production, it is important to reveal such practices

because this will help scientists and policy makers understand how the general public comprehends controversial scientific knowledge. Scientists and policy makers can adjust their practices and policies accordingly in terms of how to educate the general public about these topics.

One limitation of the study was that it relied on a single contentious topic, i.e., MMR vaccination. Second, because of the popularity of the topic, the discussions may not be considered typical. Third, we chose only three online communities. Although the numbers of posts in each community were not insignificant, if we had added more communities to the sample, findings might be different. At the same time, the tradeoff for including more than three would have meant that we could not conduct detailed analysis. For this reason, our limitation of the number of communities evaluated was justified.

Despite these limitations, we believe that this study makes important contributions to the field. First, we examined three online communities and found that the distinction between knowledge reuse sites and knowledge co-construction to be useful. We also articulated roles played in knowledge collaboration sites and identified new roles that have not been well examined in the knowledge collaboration literature. Similarly, we also identified different types of content appearing in these online communities. The contribution of the paper includes the analytical framework of knowledge reuse and knowledge co-construction, articulation of the roles that appeared in online communities, and unboxing of discourses in three different online communities.

In the future, we can expand the sample to include more open online communities. We are currently conducting a study to examine how the different roles

play in controversial and non-controversial threads. Another study underway is investigating the sequence of roles in threads. In addition, some roles that we identified can be investigated further, such as that of judge, as Majchrzak et al. (2013) scrutinized the role of knowledge shaper. The interplay between the roles and contents that we identified can be analyzed. We can also expand the study to include different controversial topics in science. This study shed light on how interactions occur in three online communities that engage in knowledge collaboration, in a case of contentious scientific knowledge. There is no question that more studies are needed in this area of research.

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