SPACES AND THEIR SOCIAL FRONTIERS: USING COMMUNITY DIMENSIONS TO DISTINGUISH BETWEEN TEACHER-FOCUSED HASHTAGS ON TWITTER

By

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ABSTRACT

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The purpose of this study is to begin describing the variety of social spaces that have been created on Twitter to support teachers and to describe the specific ways in which they vary. In particular, I have focused on Regional Educational Twitter Hashtags (RETHs)—hashtags that group tweets related to education within particular geographic regions. These hashtags can be conceived of as *spaces with community dimensions*. If they are to benefit from social interaction on Twitter, teachers must be able to identify those spaces that may be valuable for them and to recognize the social dynamics and practices that exist within them; the community dimensions of these spaces may therefore help teachers describe and distinguish individual RETHs. Researchers of online communities have proposed a number of these dimensions, which can be grouped into three broad categories: communication, participants, and activity.

This study can be described as a quantitative content analysis employing digital methods. I retrieved data associated with approximately 1.3 million tweets containing one of 62 RETHs from the Twitter API. I adapted the community dimensions identified in the literature—and related measures of social interaction on Twitter—into 20 measures that fell into the previously-identified categories of communication, participants, and activity. Then, to determine how RETH spaces differ from each other, I used principal components analysis (PCA) to reduce these twenty measures to four composite dimensions: one related to communication, one related to participants, and two related to activity. I then represented these four composite dimensions graphically, allowing me to look for patterns.

The results of this study help describe the average RETH and highlight the ways in which these hashtag spaces differ from each other. An examination of the original 20 measures demonstrates that within the average RETH, retweeting and link sharing each constitute a substantial minority of activity while replying and quoting are practiced rarely. Furthermore, the average tweet contains multiple hashtags but fewer than one mention, and the average participant has substantial experience on Twitter but has contributed little to the RETH itself. However, numbers of posts and handles vary from hashtag to hashtag. The four composite dimensions lend additional insight into the differences between RETH spaces. The single communication dimension distinguishes RETHs where messages are more characterized by sharing from those where messages are less characterized by sharing. The single participant dimension distinguishes RETHs whose participants have more previous experience on Twitter from those whose participants have less previous experience. The two activity dimensions distinguish RETHs from more volume to less volume and from more connected to less connected.

These results have both practical and theoretical implications. Because RETHs can be distinguished along four composite dimensions, each RETH may be similar to others in some ways while remaining distinct in others. Teachers may therefore find more value in some RETHs than in others; however, because RETHs are geographically-situated, this poses obstacles for teachers whose local RETH does not correspond to their needs. Furthermore, because a substantial proportion of RETH participants have long been active on Twitter, these spaces should make sure that they are welcoming to newcomers. In terms of theory, these results highlight the shortcomings of both the *community of practice* and *affinity space* frameworks and suggest that new framing is needed to fully appreciate this phenomenon.

Pour Kathryn et Élo.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Introduction

Like people generally, many teachers find value in participating in online social spaces. Scholars have studied social groups in online spaces since they emerged in the 1970s (Ling et al., 2005) and have highlighted the value that participants associate with these spaces. For example, McArthur and White (2016) argue that Twitter chats, one form of Internet-mediated social space, can serve some of the purposes of *third places*, "gathering spots outside of work and home for groups of people to connect to each other" (p. 1). However, these spaces allow for more than just a sense of personal connection. They can also serve as homes for support groups (Rodgers & Chen, 2005; Winzelberg, 1997), as places for pooling expertise and knowledge (Constant, Sproull, & Kiesler, 1996; Finholt & Sproull, 1990), as information exchanges (Burnett, 2000), or as staging areas for planning and carrying out collective action or creation (Ogan, 1993; Furlong, 1989; Van Osch, 2012).

Research has also explored why teachers—specifically—participate in online groups, with a particular focus on groups based on Twitter. Such participation can meet several different kinds of needs (Trust, Krutka, & Carpenter, 2016), including resource sharing and professional learning (Carpenter & Krutka, 2014, 2015; Forte, Humphreys, & Park, 2012; Visser, Evering, & Barrett, 2014), receiving emotional support and overcoming feelings of isolation (Carpenter & Krutka, 2014, 2015; Wesely, 2013), and building and maintaining interpersonal relationships (Carpenter & Krutka, 2015; Visser et al., 2014). Pre-service teachers who have had experience with teacher-focused Twitter groups have identified similar benefits (Carpenter, Tur, & Marín, 2016; Luo, Sickel, & Cheng, 2017).

If they are to benefit from social interaction on Twitter, teachers must be able to identify those spaces that may be valuable for them and to recognize the social dynamics and practices

that exist within them. All technologies are used in different ways by different groups (boyd, 2014; Kranzberg, 1986), and some scholars have found evidence that online social spaces differ in ways that reflect different populations (Veletsianos, 2017a) or different kinds of needs (Ranieri, Manca, & Fini, 2012). More specifically, researchers have already recognized that teacher-focused Twitter spaces differ in important ways, including ranging from the long-lasting and broadly-focused (e.g., Gao & Li, 2017) to the short-lasting and narrowly-focused (e.g., Greenhalgh & Koehler, 2017).

Nonetheless, as has been true in other veins of Twitter research (e.g., Bruns, Moon, Paul, & Münch, 2016), this recognized diversity of spaces that educators form on Twitter has not been fully examined in scholarly research. While findings from the existing literature suggest that the social dynamics of teachers' professional Twitter use should change from space to space—and even acknowledges the diversity of Twitter spaces—there has been little to no work establishing the language or frameworks necessary for making thorough and explicit comparisons between the community attributes and social practices that characterize different teacher spaces on Twitter.

The purpose of this dissertation is therefore to begin describing the variety of social spaces that have been created on Twitter to support teachers and to describe the specific ways in which they vary. In particular, this study will focus on spaces that are accessed through educational *hashtags* associated with either American states or Canadian provinces. The results of this study highlight how different groups of educators and educational stakeholders have used Twitter to create different kinds of spaces with different social dynamics and practices, which has implications for theory and practice. Similar to the work of literacy scholars in documenting diverse communities and their unique social practices, these results highlight different Twitter-

based practices that are valued in different measures by different social groups, thereby contributing to a more nuanced discussion of Twitter as an educational technology that is helpful for certain purposes when used in certain ways. These findings may also be helpful in developing frameworks that help teachers and other actors recognize how Twitter-based spaces differ from each other in social terms, thereby allowing them to find those best suited for their needs.

Background

In this section, I discuss the theoretical and empirical research that informs this study. I begin with a brief overview of Twitter, which is followed by a summary of existing research on teachers' professional use of Twitter, including the use of Regional Educational Twitter Hashtags (RETHs). I then review the major frameworks that have been used to account for teachers' activity on Twitter as a social activity and describe RETHs as social spaces with community dimensions.

Overview of Twitter

Twitter is a microblogging service, a "social media platform for sending, receiving, and sharing short posts" (Gleason, 2013, p. 967). On Twitter, these posts are referred to as *tweets* and are limited to 280 characters (though prior to November 2017—including during data collection for this study—they were limited to 140 characters). Figure 1 shows an example of one of my tweets and its constituent elements. Each tweet is composed by a specific Twitter user; for example, my name and Twitter username, or *handle*, (i.e., @spgreenhalgh) are clearly displayed alongside the tweet in Figure 1.

Although tweets are limited to a certain number of characters, users can employ multimedia and other Twitter conventions to supplement, expand, and enrich the text included in that limited space. For example, the tweet in Figure 1 *embeds* a short video and *links* to a Web resource. Finally, the tweet *mentions* another user's Twitter handle (@jrosenberg6432), which both alerts that user that he has been mentioned and brings him to the attention of anyone else reading the tweet. Finally, one of the words in Figure 1 is a *hashtag*, a keyword preceded with a hash (#) symbol that plays an important part on Twitter by organizing and indexing tweets on a particular topic (boyd, Golder, & Lotan, 2010; Lewis, 2014). For example, the "#miched"

hashtag groups together tweets related to education in the state of Michigan—clicking on this hashtag would lead to a page of tweets on this subject.

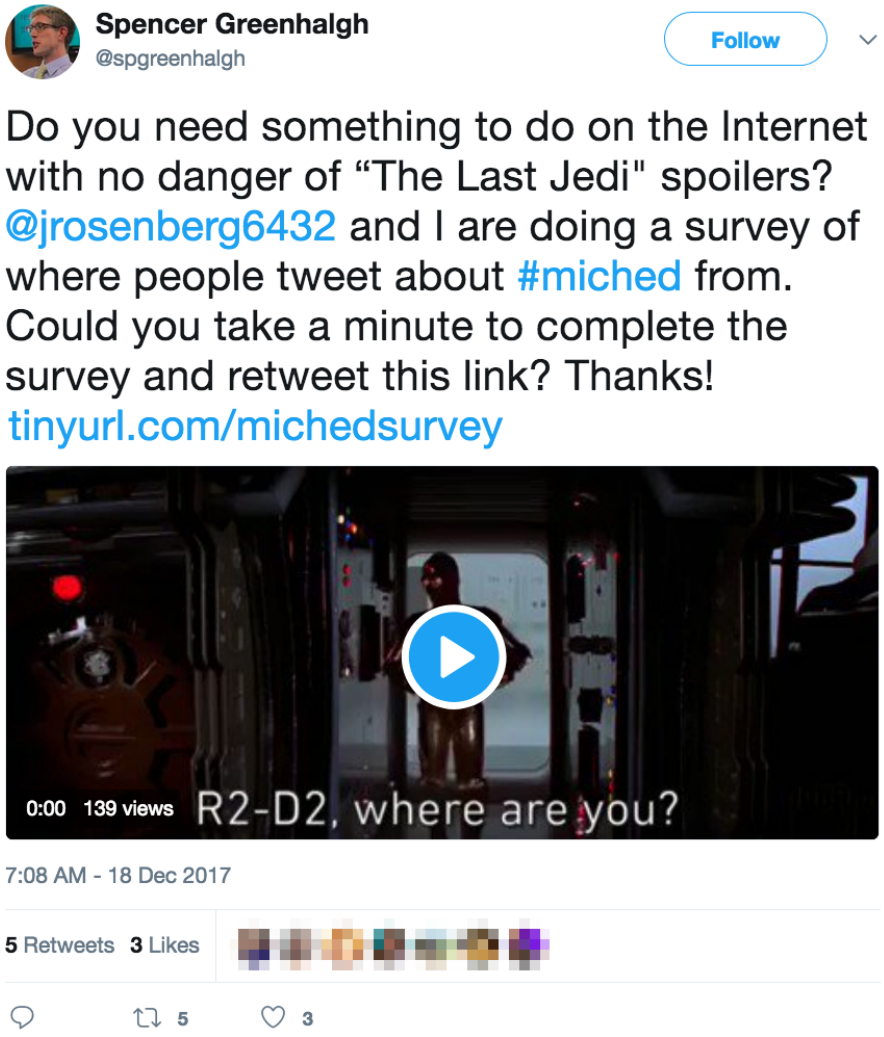

Figure 1. Screenshot of a tweet.

Twitter users may come across tweets in a number of different ways. First, as seen in Figure 1, a person can elect to *follow* other Twitter users—those users' original tweets as well as their retweeting of others' posts will then appear in the follower's main Twitter feed. Importantly, Gruzd, Wellman, and Takhteyev (2011) describe Twitter as asymmetrical in that someone can choose to follow someone without that person being obliged to follow them in return. Second, people can add other Twitter users to specific *lists*, thereby curating specific

streams of Twitter accounts that may overlap with but will remain distinct from the main list of accounts that they follow. Third, Twitter users can search for hashtags, which allows them to see all tweets on that subject regardless of whether they follow the users composing those tweets. There are also other ways that users may come across tweets, such as through generally browsing Twitter or seeing a tweet embedded in a website.

Figure 2. Screenshot of a quote tweet.

Twitter users have the possibility of interacting with any of the tweets that they come across. The icons depicted at the bottom of the screenshot in Figure 1 demonstrate the three most basic ways of interacting with tweets: *replying* (responding to a tweet), *retweeting* (reposting someone else's tweet), and *liking* (signaling interest or approval). At the bottom of Figure 1, it can be seen that this tweet has been *retweeted* five times and *liked* three times. An additional way of interacting with tweets is through *quote tweets*, which involve composing a tweet that links to—and embeds—another tweet, typically with the intention of commenting on or responding to

that other tweet. For example, in Figure 2, I have *quoted* one of my own tweets to translate the joke (and hashtag) it contains from French to English.

Teachers' Use of Twitter Hashtags

Twitter has been used in different educational settings (Gao, Luo, & Zhang, 2012), including across different settings related to teachers themselves. In some cases, teachers' professional use of Twitter happens in conjunction with formal learning settings—such as teacher preparation programs (Carpenter, 2015; Carpenter et al., 2016; Luo et al., 2017; Wright, 2010) or graduate studies in education (Greenhalgh, Rosenberg, & Wolf, 2016)—or semi-formal settings—such as conferences (Visser et al., 2014). However, teachers' use of Twitter is typically informal—that is, "teacher driven, public, largely unmoderated, [but] thriving" (Rosenberg, Greenhalgh, Koehler, Hamilton, & Akcaoglu, 2016, p. 25).

Hashtags play an important role in teacher professional use of Twitter by indexing conversations on particular topics. These hashtags (and topics) are highly diverse in their focus and scope. For example, #edchat is broadly focused on education, has existed continuously since 2009 (Anderson, 2012), and may be used in up to 7,500 tweets in a day (Staudt Willet, Koehler, & Greenhalgh, 2017). In contrast, the #educattentats hashtag was specifically focused on French educators' response to the November 2015 terrorist attacks in Paris, was active for less than a month, and was used in less than 6,000 tweets during that entire time (Greenhalgh & Koehler, 2017). Most teacher-focused hashtags fall somewhere between these two extremes. For example, hashtags like #sschat are focused on individual subject areas (in this case, social studies; see Krutka & Milton, 2013), a smaller scope than #edchat, but a larger one than a single-issue hashtag like #educattentats.

Regional Educational Twitter Hashtags (RETHs) represent a particular form of mid-scope hashtag. The term RETH is a variation on the concept of the State Educational Twitter Hashtag (SETH) proposed by Rosenberg et al. (2016); using the term "Regional" rather than "State" acknowledges that geographic regions other than American states also have associated teacher-focused hashtags. RETHs' focus on specific geographical areas allows educators within those areas to participate in local professional development communities (Asino, Haselwood, & Baker, 2016) or engage in local activism (Krutka, Haselwood, & Asino, 2018).

Although RETHs can collectively be described as mid-scope hashtags, there is still considerable variation between them. Rosenberg et al. (2016) examined 47 RETHs over the first six months of 2015 and found diverse levels of activity between (and within) them. In some cases, this diversity corresponded with the variations in teacher population in these states: for example, the hashtags for populous states like California and Texas were associated with higher numbers of tweets and participants. However, some hashtags associated with less-populous states like Oklahoma and Vermont saw higher rates of participation than expected, suggesting that the groups associated with these hashtags were unusually successful in building an engaging social dynamic.

RETHs as Social Spaces with Community Dimensions

In this section, I describe how RETHs can be considered to be social *spaces* defined by *community dimensions*. Teachers' use of Twitter is broadly recognized as an act of social learning, in keeping with longstanding conceptions of the relationship between learning, technology, and social factors. Vygotsky (1978) is among the most prominent theorists to comment on this relationship, arguing that it is within social groups that knowledge is transmitted from teachers to learners and that signs and symbols—which can be considered

cognitive technologies (Nickerson, 2005; Scribner & Cole, 1978)—are developed to ease this process of transmission. Literacy scholars have built on this relationship, framing literacy as a kind of practice—that is, as "the carrying out of a goal-directed sequence of activities, using particular technologies and applying particular systems of knowledge" (Scribner & Cole, 1978, p. 457)—and acknowledging that different practices are taught and learned within a range of social groups employing a range of analog and digital technologies (Mills, 2010). In keeping with this view, Greenhow and Gleason (2012) argued that educational uses of Twitter can be seen as a kind of literacy.

Despite the broad consensus that participating in Twitter groups is a social act, there is some disagreement on how to conceive of those groups. For example, some researchers use the *community of practice* metaphor to describe teachers' use of Twitter (e.g., Gao & Li, 2017; Visser et al., 2014; Wesely, 2013), likely due to the prevalence of this framework in research on teacher learning (e.g., Darling-Hammond & McLaughlin, 1995; Jones & Dexter, 2014). However, whereas a community of practice is distinguished by specific features such as shared identity (Wenger-Trayner & Wenger-Trayner, 2015), existing research on educational uses of Twitter hashtags has highlighted the presence of participants with diverse identities (Greenhalgh & Koehler, 2017; Rosenberg et al., 2016; Veletsianos, 2017a) and other features that do not correspond with the community of practice as it is strictly understood.

Other scholars have therefore used the *space* metaphor to describe teachers' use of Twitter for professional purposes (Carpenter & Krutka, 2014, 2015; Greenhalgh & Koehler, 2017; Rosenberg et al., 2016). This metaphor is overwhelmingly associated with literacy scholar James Paul Gee (2004, 2005; Gee & Hayes, 2012), who proposed the concept of the *affinity space* for framing and accounting for social learning. While Gee acknowledged the value of the

community of practice framework, he also argued that a space-based approach is often more appropriate (Gee, 2004, 2005; Gee & Hayes, 2012): Social learning can (and does) happen where people share a distinct *space*, regardless of whether the characteristics defining a community of practice are present. However, using a strict space-based approach has its own problems; for example, because the affinity space is a "fuzzy concept" (Gee & Hayes, 2012, p. 133) whose boundaries are being challenged (Duncan & Hayes, 2012), it is not always clear how to make distinctions between different kinds of spaces. Furthermore, thinking of Twitter groups strictly in terms of the affinity space risks ignoring the community features that can exist within them (e.g., Carpenter & Krutka, 2014, 2015; Greenhalgh & Koehler, 2017; Greenhalgh et al., 2016).

Conceiving of RETHs as *spaces with community dimensions* retains the advantages of a space-based approach while also addressing its shortcomings. Dimensions can be understood as "one of the elements or factors making up a complete personality or entity" or as "one of a group of properties whose number is necessary and sufficient to determine uniquely each element of a system" (*Merriam-Webster's online dictionary*). Community dimensions can therefore be understood as features of communities that indicate the strength of community within a social space or the extent to which individual spaces differ from each other. Examining RETHs in this way therefore both allows for the possibility that community features may (but do not necessarily) exist within a social space and provides a means of distinguishing RETH spaces from each other.

Scholars of online communities have proposed a number of dimensions for describing or distinguishing these communities, and Twitter researchers have employed a range of measures that correspond with these dimensions. In Table 1, I summarize ten dimensions synthesized from a review of the relevant literature; this summary includes lists of established Twitter measures

that have explicit or implicit connections to these dimensions. These dimensions (and measures) fall into three broad categories that can serve as an organizational scheme for this study. In the following sections, I describe each of these categories, discussing specific dimensions that have been inspired by or synthesized from previous research and elaborating on how researchers have used Twitter practices to operationalize and apply these dimensions in their work.

Communication dimensions. Online communities can be described and distinguished in terms of the messages exchanged by the participants. For example, the success of a community may be tied to the quality—or qualities—of its communication (Butler, 2001; Preece, 2001; Van Osch, 2012). Although little work has been done to directly measure the quality of messages within Twitter-based communities, Greenhalgh et al. (2016) elected not to eliminate retweets from their coding sample because they felt that retweets implicitly indicated what qualities members of a community valued. The interactivity of communication or perpetuation of dialogue within that community has also been recognized as important (Gee, 2004, 2005; Jones, 1997; Preece, 2001; Van Osch, 2012); these concepts have been measured through identifying mentions, replies, and retweets (Bruns et al., 2016; Bruns & Stieglitz, 2012; Greenhalgh & Koehler, 2017; Gruzd et al., 2011). Finally, although advocates for online communities necessarily reject shared physical or geographical space as necessary for the existence of community (Haythornthwaite, 2009), Jones (1997) described the shared virtual spaces where communication takes place as a necessary component for an online community to exist. Twitter researchers have considered both hashtags (Greenhalgh & Koehler, 2017; Rosenberg et al., 2016) and URLs (Gleason, 2013) as portals to such spaces.

Table 1: Community Dimensions (and Related Measures) Identified in the Literature

Dimension	Category	Theoretical Roots	Related Measures in Twitter Research
Quality of communication	communication	• Butler's (2001) resource-based model • Preece's (2001) measures of success of online communities • Van Osch's (2012) generative collectives	• number of retweets per tweet
Interactivity of communication	communication	• Gee's (2004, 2005) social spaces • Jones's (1997) virtual settlements • Preece's (2001) measures of success of online communities • Van Osch's (2012) generative collectives	• proportion of retweets • proportion of mentions • proportion of replies
Spaces for communication	communication	• Gee's (2004, 2005) social spaces • Jones's (1997) virtual settlements • network views of online communities (e.g., Wellman et al., 1996)	• number of secondary hashtags • number of tweets having a URL
Participant identity	participant	• Butler's (2001) resource-based model • Preece's (2001) measures of success of online communities	• coded participant role or category
Participant activity	participant	• Preece's (2001) measures of success of online communities	• number of participants who tweet • number of participants who retweet • number of participants who like

Table 1 (cont'd)

Dimension	Category	Theoretical Roots	Related Measures in Twitter Research
Quantity of activity	activity	• Butler's (2001) resource-based model	• number of tweets • number of original tweets
Number of participants	activity	• Butler's (2001) resource-based model • Jones's (1997) virtual settlements • Preece's (2001) measures of success of online communities • network views of online communities (e.g., Wellman et al., 1996)	• number of Twitter handles • number of Twitter handles per unit of time
Activity per participant	activity	• Preece's (2001) measures of success of online communities	• number of tweets per handle
Sustained activity	activity	• Butler's (2001) resource-based model • Jones's (1997) virtual settlements • Van Osch's (2012) generative collectives	• size and composition of Follower and Following lists at different time points • number of weeks in which Twitter handles sent at least one tweet
Participant relationships	activity	• Preece's (2001) measures of success of online communities • Van Osch's (2012) generative collectives • network views of online communities (e.g., Wellman et al., 1996)	• mentions, retweets, and replies between participants • Twitter accounts following and followed *by* another account

Participant dimensions. In addition to examining the messages exchanged by the participants in an online community, scholars can examine the participants themselves. One can understand a community through the identity of its participants (Preece, 2001)—that is, the professions, experience, or expertise held by its members, which implicitly indicates what participants can contribute to the group (Butler, 2001). In keeping with this, Twitter scholars have sometimes found value in describing or categorizing hashtag participants (Asino et al., 2016; Greenhalgh & Koehler, 2017; Rosenberg et al., 2016; Veletsianos, 2017a, 2017b). Communities can also be distinguished in terms of participant activity—that is the number of participants who actively participate and the number that "lurk" (Preece, 2001). Recognizing different forms of participation on Twitter, Greenhalgh and Koehler (2017) examined how many of the total participants within the #educattentats hashtag engaged in original tweeting, retweeting, and liking.

Activity dimensions. The dimensions in this section also draw on communication and participants but do so in order to describe general patterns of activity within a community rather than specific attributes of the messages or people present within them. The quantity of activity (Butler, 2001) and number of participants (Butler, 2001; Jones, 1997; Preece, 2001) in a community are both important measures and have been frequently used in Twitter research in the form of the number of posts over a certain period of time (Bruns et al., 2016; Bruns & Stieglitz, 2012; Rosenberg et al., 2016) and the number of distinct handles that are involved in a network, hashtag, or chat (Bruns & Stieglitz, 2012; Gao & Li, 2017; Greenhalgh & Koehler, 2017; Gruzd et al., 2011; Rosenberg et al., 2016). In conjunction with these two measures, the amount of activity per participant can also be considered a measure of a community's success (Preece, 2001); on Twitter, this can be measured by dividing the total number of tweets by the total

number of Twitter handles (e.g., Gao & Li, 2017; Rosenberg et al., 2016; Veletsianos, 2017a, 2017b). Researchers can also understand a community by the ties (i.e., connections) between participants (Haythonthwaite, 2009; Preece, 2001; Van Osch, 2012). Ties within a Twitter community can be measured in terms of mentions, retweets, and replies (Gao & Li, 2017; Greenhalgh & Koehler, 2017; Gruzd & Haythornthwaite, 2013; Rosenberg, Greenhalgh, Wolf, & Koehler, 2017); implicit in this understanding is a distinction between the number of these connections *made by* and *received by* each handle within a hashtag (Bruns & Stieglitz, 2013). Alternatively, scholars can count the number of Twitter accounts *following* and *followed by* another account (Gruzd et al., 2011; Staudt Willet et al., 2017).

Purpose and Research Questions

The purpose of this study is to describe the variety of spaces that have been created on Twitter to support teachers and to determine the community dimensions along which they vary. In particular, I describe how Regional Educational Twitter Hashtags (RETHs) differ based on the communication-, participant-, and activity-focused dimensions of community present within each of them. In order to describe and classify RETH spaces in terms of community dimensions, I ask the following questions:

1) To what extent are dimensions of community present in RETH spaces?
2) How do RETH spaces differ in terms of communication?
3) How do RETH spaces differ in terms of participants?
4) How do RETH spaces differ in terms of activity?

Method

This study is a quantitative content analysis that employs automated digital methods. The purpose of content analysis is to study human communication (Babbie, 2010) in order to "identify consistent patterns and relationships" (Julien, 2008, p. 122). Communication that takes place on the Internet leaves behind *digital traces* (Lazer et al., 2009; Welser, Smith, Fisher, & Gleave, 2008) that can be studied using online and digital technologies, including through automated processes. This allows researchers to study patterns of communication at scale; indeed, Gruzd and Haythornthwaite (2014) suggest that this approach is of particular interest for the study of online communities. In the following sections, I describe the data I collected for this study, the measures I created using those data, and the analysis I performed of those measures.

Data Sources

This study focuses on 1,326,656 tweets (and related data) associated with 62 Regional Educational Twitter Hashtags (RETHs). This includes 51 American RETHs (see Table 2)—two for Kansas, Nevada, Texas, and Utah, and one for every other American state except Alaska, New Mexico, and Vermont. Eleven Canadian RETHs are also included (see Table 3)—two for British Columbia, Ontario, and Saskatchewan, and one for every other province but Prince Edward Island (and none for the three Canadian territories).

The initial data for this study came from 69 RETHs that were collected using a series of Twitter Archiving Google Sheets (TAGS; Hawksey, 2014). In February 2018, I then used the rtweet package for the R programming language (Kearney, 2017) to collect the full versions of tweets (in case of truncation; see Bruns & Stieglitz, 2013), collect metadata associated with these tweets, eliminate since-deleted tweets, collect profile information on the Twitter users in the TAGS data, and eliminate tweets from deleted, suspended, or private accounts.

Based on the purpose of this study and other considerations, I limited this data in certain ways. First, I limited my analysis to tweets composed during calendar year 2016. Second, I removed possible spam accounts—and corresponding tweets—from the data being considered for each hashtag. To identify these accounts, I calculated the tweets composed per day over the lifetime of all accounts associated with that hashtag and removed accounts associated with high values that could be considered "far out" outliers for that hashtag (i.e., higher than three times the interquartile range plus the value of the third quartile; Tukey, 1977, p. 44). Finally, I removed 7 RETHs whose total number of tweets in 2016 fell within the bottom 10 percent (i.e., fewer than 464.8 total tweets), judging them to be not sufficiently active to warrant analysis.

Table 2: American Regional Educational Twitter Hashtags Included in This Study

RETH	State
#aledchat	Alabama
#azedchat	Arizona
#arkedchat	Arkansas
#caedchat	California
#coedchat	Colorado
#ctedchat	Connecticut
#edude	Delaware
#fledchat	Florida
#gaed	Georgia
#edchathi	Hawai'i
#idedchat	Idaho
#iledchat	Illinois
#inelearn	Indiana
#iaedchat	Iowa
#ksed	Kansas
#ksedchat	Kansas
#kyedchat	Kentucky
#laedchat	Louisiana
#edchatme	Maine

Table 2 (cont'd).

RETH	State
#mdedchat	Maryland
#edchatma	Massachusetts
#miched	Michigan
#mnedchat	Minnesota
#msedchat	Mississippi
#moedchat	Missouri
#mtedchat	Montana
#nebedchat	Nebraska
#nved	Nevada
#nvedchat	Nevada
#nhed	New Hampshire
#njed	New Jersey
#nyedchat	New York
#nced	North Carolina
#ndedchat	North Dakota
#ohedchat	Ohio
#oklaed	Oklahoma
#oredu	Oregon
#paedchat	Pennsylvania
#edchatri	Rhode Island
#sced	South Carolina
#sdedchat	South Dakota
#tnedchat	Tennessee
#txed	Texas
#txeduchat	Texas
#uted	Utah
#utedchat	Utah
#vachat	Virginia
#wateachlead	Washington
#wvedchat	West Virginia
#wischat	Wisconsin
#wyoedchat	Wyoming

Table 3: Canadian Regional Educational Twitter Hashtags Included in This Study

RETH	Province or Territory
#abed	Alberta
#bced	British Columbia
#edtechbc	British Columbia
#mbedchat	Manitoba
#nbed	New Brunswick
#nsed	Nova Scotia
#onedchat	Ontario
#onted	Ontario
#eduqc	Québec
#saskedchat	Saskatchewan
#sked	Saskatchewan

Measures

In this section, I describe the 20 measures used in this study. To generate these measures, I have adopted or adapted the dimensions and measures listed in Table 1; as a result, these measures correspond with the three broad categories listed earlier in this paper.

Communication-focused measures. The following measures focus on the communication characteristics of the tweets associated with each RETH:

- *Proportion of retweets*: the ratio of retweets to the total number of posts within a RETH; represents how much communication is dedicated to disseminating others' tweets. This measure has previously been used by Bruns and Stieglitz (2012), Bruns et al. (2016), and Greenhalgh and Koehler (2017) to describe communication within Twitter hashtags. Gruzd et al. (2011) also included retweets as part of a broader Twitter measure of interactivity.

- *Proportion of replies*: the ratio of replies to the total number of posts within a RETH; represents how much communication is dedicated to responding to others. Gruzd et al. (2011) included replies as part of a broader measure of Twitter interactivity.
- *Proportion of quote tweets*: the ratio of quote tweets to the total number of posts within a RETH; represents how much communication involves disseminating and commenting on others' tweets. This measure is a natural extension of existing measures of interactivity on Twitter; however, as the quote tweet is a relatively recent addition to Twitter, it has not been used as a measure in the literature reviewed in this study.
- *Mentions per tweet*: the average number of Twitter handles included per original tweet in a RETH; represents the average number of explicit interpersonal connections made by the average tweet. Gruzd et al. (2011) included mentions as part of a broader measure of Twitter interactivity, though this was a measure of the proportion of tweets containing mentions rather than a measure of the mentions per tweet.
- *Hashtags per tweet*: the average number of hashtags included per original tweet in a RETH; represents the number of Twitter-based spaces or communities that the average tweet connects with. Bruns and Stieglitz (2013) suggested that measuring "secondary hashtags" (p. 102) within a hashtag space could provide valuable insight.
- *Proportion of tweets with URLs*: the ratio of original, non-quote tweets containing at least one URL to the total number of original, non-quote tweets within a RETH; represents how much activity within a RETH connects to or shares Web resources outside of the Twitter ecosystem. Bruns and Stieglitz (2013) have suggested measuring the proportion of tweets in a hashtag space containing URLs, and Gleason (2013) used this measure to measure the other "learning spaces" (p. 969) connected to from a specific hashtag space.

- *Proportion of tweets with embedded media*: the ratio of original tweets containing embedded media to the total number of original tweets within a RETH; represents how much activity within a RETH involves media artifacts. Bruns and Stieglitz's (2013) use of the *proportion of tweets with URLs* measure included links to media artifacts; however, I have separated this into a distinct measure.

Participant-focused measures. The measures listed below focus on the characteristics of the participants associated with each RETH. As described above, previous research has determined the characteristics of participants in a Twitter space by coding profiles (e.g., Veletsianos 2017a, 2017b), or by measuring participants' activity within that space (e.g., Greenhalgh & Koehler, 2017). This study recognizes the theoretical importance of considering participant characteristics that underlies these measures but measures different characteristics, including:

- *Days on Twitter*: the average number of days that participants in a RETH have been active on Twitter as of 31 December 2016. This represents participants' overall experience with Twitter.
- *Total tweets*: the average number of tweets that participants in a RETH have composed across all of Twitter. This represents participants' posting activity on Twitter.
- *Total likes*: the average number of tweets that participants in a RETH have liked. This represents participants' responding activity on Twitter.
- *Total following*: the average number of accounts that participants in a RETH follow. This represents the extent to which participants engage with other Twitter users by subscribing to their posts.

- *Total followers*: the average number of accounts that participants in a RETH are followed by. This represents the influence and audience that participants have across Twitter as a whole.
- *Total listed*: the average number of public lists that participants in a RETH have been added to. This further represents the influence and audience that participants have with certain other Twitter users.

Activity-focused measures. These measures draw on characteristics of communication and participants in order to describe general patterns of activity within each RETH.

- *Number of posts*: the total number of posts (i.e., original tweets, retweets, and replies) that include a particular RETH. Bruns and colleagues (2016; Bruns & Stieglitz, 2012) have endorsed this measure for comparing hashtag spaces, and Rosenberg et al. (2016) used it to specifically compare RETHs.
- *Number of handles*: the total number of Twitter handles that have composed or retweeted posts containing a particular RETH. Bruns and Stieglitz (2012) have endorsed this measure, and a number of scholars (Gao & Li, 2017; Greenhalgh & Koehler, 2017; Gruzd et al., 2011; Rosenberg et al., 2016) have used it to describe specific Twitter spaces.
- *Posts per handle*: the average number of posts containing a particular RETH per handle. Bruns and Stieglitz (2012, 2013) have endorsed this as a measure, and it has been used to describe patterns of activity within several educational hashtags (e.g., Gao & Li, 2017; Rosenberg et al., 2016; Veletsianos, 2017a, 2017b).

- *Sustained activity*: the average number of calendar weeks in which participants in a RETH contributed at least one post. Rosenberg and colleagues (2016) used this measure to examine patterns of activity within RETHs.
- *In-ties per handle*: the average number of other Twitter handles within a RETH that mention each handle in tweets. A number of Twitter studies (e.g., Bruns & Stieglitz, 2012; Gao & Li, 2017; Greenhalgh & Koehler, 2017; Gruzd & Haythornthwaite, 2013; Rosenberg et al., 2017) have endorsed or used the inclusion of Twitter handles in other tweets to measure ties between Twitter users.
- *Out-ties per handle*: the average number of other Twitter handles within a RETH that are present in tweets associated with each handle. This measure is built on the same precedents as *in-ties per handle*.
- *Reciprocated ties per handle*: the average number of other Twitter handles within a RETH that are found to both reference and be referenced by each handle. This measure is built on the same precedents as *in-ties per handle* and *out-ties per handle*.

Data Analysis

In this section, I explain how I used the measures described above to answer the research questions associated with this study.

RQ1: To what extent are dimensions of community present in RETH spaces? To answer this research question, I began by calculating each of the measures used in this study for each of the RETHs. I also calculated summary statistics (i.e., mean, median, interquartile range, standard deviation, skew, and kurtosis) of these measures across all RETHs, thereby lending insight as to the extent to which these dimensions of community are present within the average RETH as well as the variation among RETHs in terms of these dimensions of community.

RQ2: How do RETH spaces differ in terms of communication? I used principal components analysis (PCA) to distinguish RETH spaces in terms of communication. PCA is a technique used to reduce a set of variables (in this case, the seven variables associated with communication) to a smaller number of components (or composite dimensions) that retain as much of the variance in the data as possible. I used the *stats* package in R (R Core Team, 2015) to carry out this PCA, standardizing the variables in order to reduce the effect of their different units of measurement on the resulting component structure (Joliffe, 2002). Furthermore, to reduce the effect of any outliers on the resulting component structure, I removed from consideration data from any hashtag whose value on any of these seven variables could be considered a "far out" outlier (i.e., higher than three times the interquartile range plus the value of the third quartile or lower than the first quartile minus three times the interquartile range; Tukey, 1977, p. 44).

After carrying out the PCA, I selected and interpreted an appropriate number of the resulting components. I used the *nFactors* package (Raiche, 2010) to carry out a parallel analysis to determine the number of components that adequately summarize the original measures. Then, I interpreted them using the loadings of the original measures on the components as well as, when appropriate, a biplot (Joliffe, 2002) generated with the *ggbiplot* package (Vincent, 2011). After interpreting each of the components, I calculated the component values for those outlier RETHs that had previously been removed. I then plotted all component values, allowing me to observe patterns in the RETHs.

RQ3: How do RETH spaces differ in terms of participants? I used the same techniques described in the previous section to carry out a principal components analysis—and the resulting interpretation—using the six participant-focused measures described earlier.

RQ4: How do RETH spaces differ in terms of activity? I used the same techniques described in the previous section to carry out a principal components analysis—and the resulting interpretation—using the seven activity-focused measures described earlier.

Results

In this section, I describe the results of this study and use them to answer my four research questions.

RQ1: To what extent are dimensions of community present in RETH spaces?

Table 4 shows the extent to which the 20 measures of community considered in this study are present in RETH spaces by displaying the descriptive statistics for these measures. The tables in Appendices A, B, and C provide further information by displaying (respectively) all community-, participant-, and activity-focused measures for each of the 62 RETHs.

These statistics help to paint a picture of what the average RETH looks like in terms of community dimensions. For example, tweets in RETHs tend to contain multiple hashtags but more often than not do not mention other Twitter users. Retweeting constitutes a minority—but a substantial minority—of the activity within the average RETH—a similar pattern holds true for the proportions of tweets containing URLs or, to a lesser extent, media. In contrast, replying and quoting are practiced rarely. Within the average RETH, the average participant has been using Twitter for over four years and has been rather active in tweeting, liking, and building a network during that time; however, they have only contributed seven posts to that RETH over the course of a year, participated in that RETH between two to three weeks during that year, connected to about three other participants, and been connected to by three participants, with few of those connections being mutual.

Table 4: Descriptive Statistics Across all RETHs for Community Dimensions

Community Dimension	Mean	Median	Interquartile range	Standard deviation	Skew	Kurtosis
Communication-focused:						
Hashtags per tweet	2.57	2.29	0.93	0.99	1.52	2.12
Mentions per tweet	0.45	0.42	0.89	0.14	0.57	-0.16
Proportion of retweets	0.39	0.37	0.17	0.12	0.19	-0.53
Proportion of replies	0.09	0.08	0.10	0.08	1.00	0.94
Proportion of quote tweets	0.08	0.07	0.03	0.02	0.27	-0.74
Proportion of tweets with embedded media	0.22	0.19	0.10	0.10	1.13	0.72
Proportion of tweets with URLs	0.39	0.34	0.28	0.21	0.60	-0.67
Participant-focused:						
Days on Twitter	1662.57	1664.18	123.05	90.27	0.88	2.17
Total tweets	7001.57	6926.37	2145.04	2034.75	1.34	3.26
Total likes	4877.52	4782.84	1496.33	1278.99	0.64	1.03
Total followers	2402.00	2330.06	1093.33	742.32	0.40	-0.68
Total following	1413.71	1354.44	545.61	379.94	0.44	-0.49
Total listed	120.22	115.98	59.24	41.15	0.35	-0.41
Activity-focused:						
Number of posts	22089.61	11826.00	22884.75	29538.76	2.46	6.88
Number of handles	3203.50	1508.50	3045.50	3903.39	1.58	1.31
Posts per handle	6.76	5.65	4.27	3.74	1.13	0.98
Sustained activity	2.28	2.22	0.60	0.50	0.81	0.62
In-ties per handle	2.46	2.32	1.24	1.03	0.76	0.34
Out-ties per handle	3.22	3.02	1.60	1.19	0.61	-0.05
Reciprocal ties per handle	0.65	0.56	0.40	0.39	1.45	2.63

Yet, there are important limits to any discussion of typicality among these hashtags. This is most notable in terms of the numbers of posts and handles associated with each hashtag. These two measures have notable differences between the means and medians and are also

characterized by relatively high interquartile ranges and standard deviations. In combination, these measures suggest that some of the most striking differences between RETH-based communities are in terms of size. More specifically, the strong right skew of each of these measures suggests that RETH communities tend to be smaller (in terms of posting and participation), with a small minority of larger RETHs.

RQ2: How do RETH spaces differ in terms of communication?

Table 5: Loadings of Communication-focused Measures on One Principal Component

Original measure	Loading on principal component
Hashtags per tweet	**0.45**
Mentions per tweet	**0.28**
Proportion of retweets	**0.35**
Proportion of replies	**-0.43**
Proportion of quote tweets	**-0.28**
Proportion of tweets with embedded media	**0.35**
Proportion of tweets with URLs	**0.45**

Note. Component loadings whose absolute value is greater than half of the absolute value of the maximum loading are shown in boldface (see Joliffe, 2002).

Parallel analysis suggested retaining a single composite dimension; this dimension explains 52.7% of variance and represents a continuum from *more sharing* to *less sharing*. Appendix D contains additional information about the choice and interpretation of this component. As seen in Table 5, high values on this dimension are associated with higher rates of practices related to sharing—URLs and media represent content being shared, hashtags and mentions help that content reach a wider audience, and retweets are an explicit act of further disseminating the content in question. Figure 3 demonstrates many of these practices. The author of the tweet has included a link to an endorsed resource and used an embedded picture to further advertise that resource; finally, she has included several RETHs with the intention of sharing this resource with as many communities as possible. However, this focus on sharing is not always

benign. Figure 4 shows another tweet that demonstrates these same practices—however, what is being shared is not an educational resource but rather an item to be purchased. Rather than truly participate in a RETH, the author of this tweet appears to be intruding on the hashtag space for the purposes of self-promotion.

Figure 3. Example of sharing practices to disseminate relevant information.

Figure 4. Example of sharing practices to disseminate irrelevant information.

Low levels on this composite dimension are associated with lower levels of sharing practices; however, this lower level of sharing may also indicate higher levels of practices associated with conversation. That is, low values on this dimension are associated with higher proportions of replies and quote tweets, which involve responding to and commenting on others' posts. For example, the author of the tweet in Figure 5 is jumping into a conversation that already involves three other people to express his thanks for their contributions. However, even when these conversational practices are absent from a tweet, the simple absence of sharing practices may also indicate a more conversational approach. The tweet in Figure 6 is neither a reply nor a quote tweet; however, elements of the message suggest that the tweet is being composed as part of a synchronous tweet chat, in which participants use a common hashtag (in this case, a RETH) to carry out a conversation by tweeting in real time. Because of the limited number of characters available within a tweet, including more hashtags, mentions, and other sharing practices necessarily constrains a participant's ability to engage in more conversational behavior; their absence therefore suggests the possibility of more such behavior.

Figure 5. Example of an explicit conversation with other Twitter users.

Figure 6. Example of an implicit conversation with other Twitter users.

Figure 7 shows how the 62 RETHs considered in this study fall along this continuum. Although there are small clusters of RETHs at certain points along this dimension, their distribution is largely even, with hashtags such as #ctedchat and #kyedchat characterized by higher rates of sharing practices, others such as #idedchat and #wvedchat characterized by lower rates of sharing practices (and, therefore, possibly higher rates of conversational practices), and still others such as #mdedchat and #ndedchat appearing to be characterized by moderate amounts of sharing.

RQ3: How do RETH spaces differ in terms of participants?

Table 6: Loadings of Participant-focused Measures on One Principal Component

Original measure	Loading on principal component
Days on Twitter	**0.27**
Total tweets	**0.44**
Total likes	**0.37**
Total followers	**0.44**
Total following	**0.45**
Total listed	**0.44**

Note. Component loadings whose absolute value is greater than half of the absolute value of the maximum loading are shown in boldface (see Joliffe, 2002).

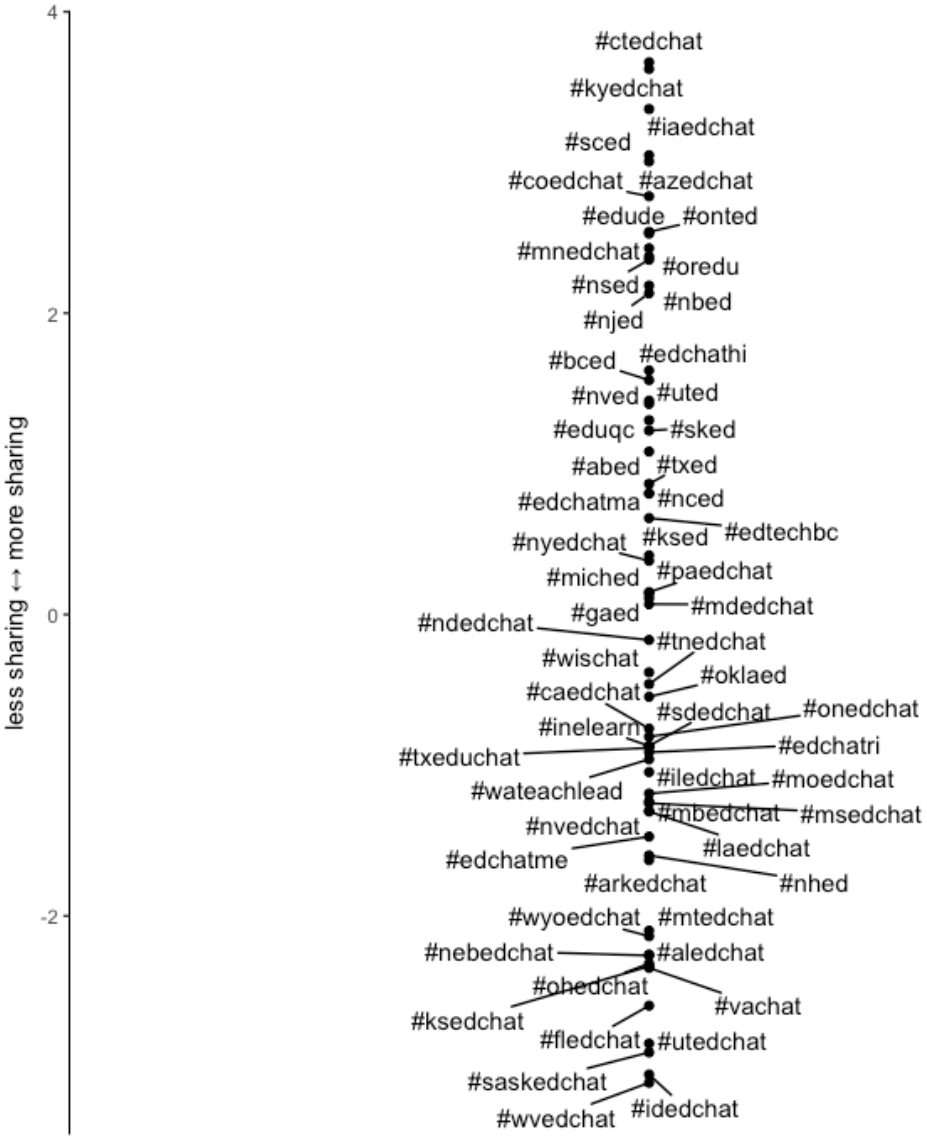

Figure 7. RETHs plotted along a communication-focused dimension of more to less sharing.

Parallel analysis suggested retaining a single composite dimension—a continuum from more previous experience to less previous experience that explains 63.3% of the variance in these variables. Appendix E contains additional information about the choice and interpretation of this component. As seen in Table 6, higher values on this dimension are associated with higher values of each of the original participant-focused variables, suggesting that this component summarizes overall experience with (and, therefore, overall activity on) Twitter.

Figure 8 demonstrates the distribution of RETHs along this dimension—although most cluster near the middle, there are also distinct clusters of RETHs that are characterized by either higher or lower levels of experience.

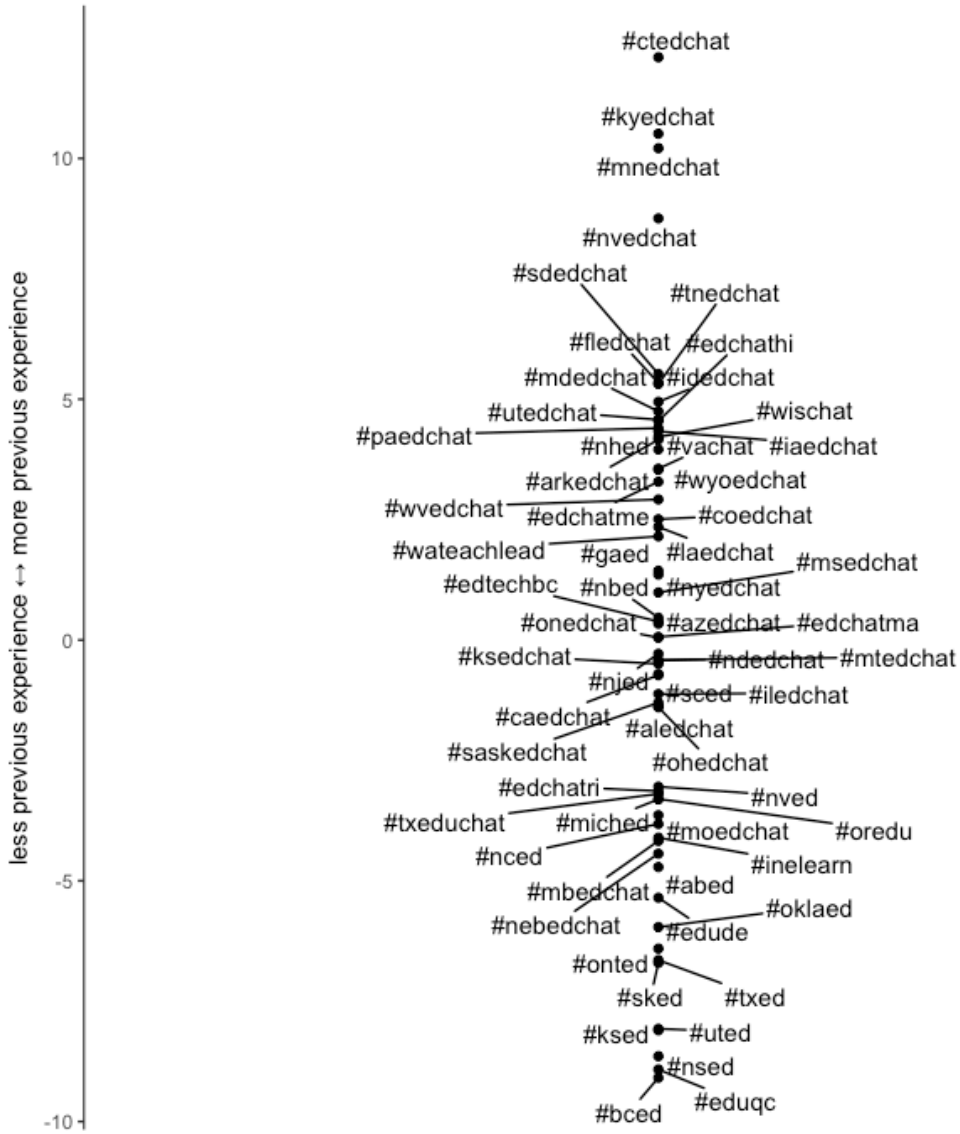

Figure 8. RETHs plotted along a participant-focused dimension of less previous experience to more previous experience.

RQ4: How do RETH spaces differ in terms of activity?

Table 7: Loadings of Activity-focused Dimensions on Two Principal Components

Original Measure	Loading on first principal component	Loading on second principal component
Number of posts	**-0.25**	**0.61**
Number of handles	*-0.13*	**0.70**
Posts per handle	**-0.42**	*-0.22*
Sustained activity	**-0.40**	0.01
In-ties per handle	**-0.46**	-0.05
Out-ties per handle	**-0.46**	-0.06
Reciprocal ties per handle	**-0.39**	*-0.28*

Note. Component loadings whose absolute value is greater than half of the absolute value of the maximum loading for that component are shown in boldface; component loadings whose absolute value is between a quarter and a half of the absolute value of the maximum loading for that component are shown in italics (see Joliffe, 2002).

Unlike the previous two categories, parallel analysis suggested retaining two composite dimensions to summarize the measures focused on activity. Appendix F contains additional information about the choice and interpretation of these components. As seen in Table 7, all of the original measures are negatively associated with the first dimension, which explains 63.7% of the variance within these measures; however, it should be noted that positive and negative values for principal components are arbitrary (Joliffe, 2002). Although this dimension is associated with all of the variables related to activity, most of these variables—including those with the highest loadings—are related to *connection*, either between participants and the hashtag space (e.g., posts per handle and sustained activity) or between participants themselves (e.g., in-ties, out-ties, and reciprocal ties).

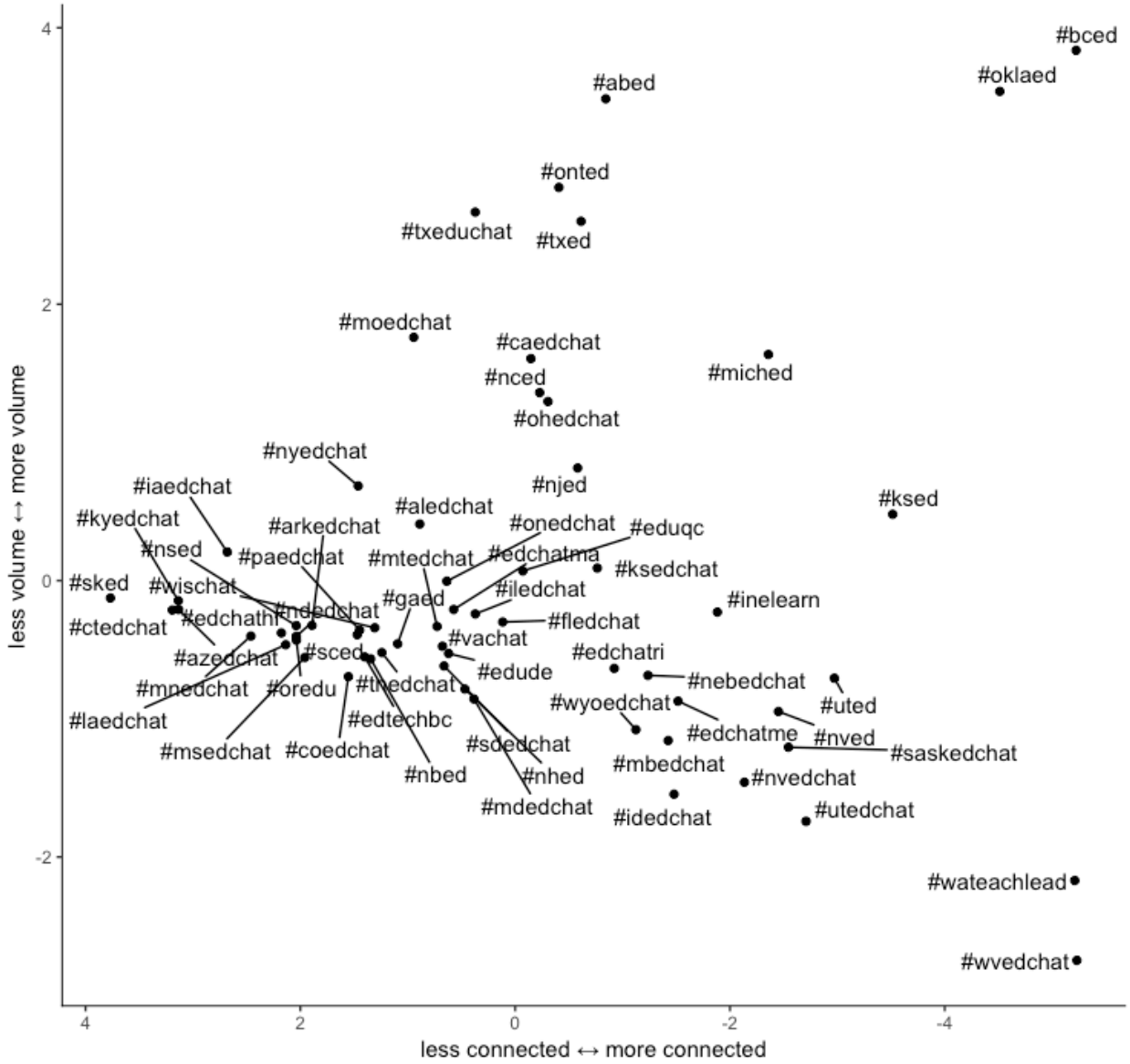

Figure 9. RETHs plotted along two activity-focused dimensions of more connected to less connected and more volume to less volume.

Whereas the first activity-focused dimension represents a measure of the levels of connection within RETHs, the second generally distinguishes high-volume RETHs from low-volume RETHs. However, as evidenced in Table 7, this composite dimension is not simply a function of number of posts and number of handles. Rather, because of the negative loadings on posts per handle and reciprocal ties per handle, one RETH may be listed as higher volume than another even if the second has higher numbers of posts and handles. This dimension explains a

further 25.9% of the variance within the original measures. Figure 9 then demonstrates how these dimensions interact with each other (note that the x-axis of Figure 9 has been flipped to facilitate a more intuitive understanding of the plot). Low-connection RETHs are clustered near the middle-left of the graph, with RETHS with more volume of participation expanding to the top and more connected RETHs expanding to the right (and lower—likely because the posts per handle and reciprocal ties per handle measures influence both dimensions).

Discussion

Many teachers and other stakeholders participate in social groups mediated by Twitter and focused on education—the findings of this study include some considerations that can help these participants identify those spaces that may be valuable for them and recognize the social practices that exist within them. Previous research has established that teachers may have a range of different motivations for participating in social groups on Twitter (e.g., Carpenter & Krutka, 2014, 2015; Forte et al., 2012; Visser et al., 2014; Wesely, 2013) and has implicitly established that different hashtags are associated with different kinds of social spaces (e.g., Gao & Li, 2017; Greenhalgh & Koehler, 2017; Carpenter, Tani, Morrison, & Keane, 2018). This study has seen the emergence of four composite community dimensions (more to less sharing in communication, more to less experience on Twitter of participants, more to less volume of activity, and more to less connectivity of activity) that describe how these 62 RETHs differed from each other over the course of 2016 and suggest ways that participants might think about describing and distinguishing hashtag spaces (and possibly other learning spaces) in other contexts.

In the following sections, I examine these composite dimensions in greater detail and consider their implications. I begin by considering each dimension's value as a conceptual guideline by examining its connections to the literature as well as how it might inform teachers' decision making in terms of what communities to participate in. As appropriate, I also discuss how this dimension might inform learners' considerations in other community contexts. I then discuss the interaction between these dimensions in individual RETHs, including by describing how they play out in three specific hashtags. Finally, I discuss the implications of the specific

findings of this study for both practice (i.e., participation within and organization of RETHs) and theory (i.e., how to best conceive of social learning groups like RETHs).

The Dimensions as Conceptual Guidelines

The first, communication-focused, dimension distinguishes RETHs that are more focused on sharing from those that are less focused on sharing (and, by extension, more focused on conversing). This finding was not unexpected, as it fits nicely with much of the existing literature on teachers' use of Twitter. That is, RETHs characterized by high levels of sharing may be more attractive for teachers whose participation in Twitter spaces is motivated by resource sharing and professional learning (Carpenter & Krutka, 2014, 2015; Forte et al., 2012; Visser et al., 2014). In contrast, RETHs characterized by lower levels of sharing may also be characterized by higher levels of conversing and may therefore better support teachers who are seeking emotional support, trying to overcome feelings of isolation, or looking to establish interpersonal relationships (Carpenter & Krutka, 2014, 2015; Visser et al., 2014; Wesely, 2013).

This dimension also connects with some of the existing scholarship on online communities and may therefore be useful for those investigating—or pursuing—social learning in spaces other than Twitter. For example, Burnett (2000) noted that online social groups can serve both information-sharing and social purposes and that some groups put more emphasis on one purpose than the other. On an even broader level, social perspectives on learning place emphasis on the importance of identity and social relationships (e.g., Lave & Wenger, 1991; Wenger-Trayner & Wenger-Trayner, 2015), not just the explicit acquisition of information and knowledge, making both socially-focused spaces and information-focused spaces valuable to those trying to develop particular identities and particular knowledge. Recognizing that both kinds of spaces exist—and being able to distinguish between them—may therefore be helpful for

those who are pursuing learning and identity development in any of a number of different contexts.

The second, participant-focused, dimension distinguishes RETHs whose participants have higher levels of experience with Twitter from those whose participants have lower levels of experience with Twitter. This simple dimension departs from the distinctions between participants made in previous research on teacher-focused Twitter groups, which has tended to focus on the specific identities and roles associated with participants (e.g., Asino et al., 2016; Greenhalgh & Koehler, 2017; Rosenberg et al., 2016; Veletsianos, 2017a, 2017b). This departure is, naturally, a function of the data being analyzed; whereas previous studies have used the text content of Twitter profiles to determine what participants might stand to gain (or contribute—see Butler, 2001; Preece, 2001) from a community, this study has used quantitative data associated with Twitter profiles to examine if participants in different RETHs display different patterns of activity on Twitter as a whole. This is, therefore, less a contradiction of previous findings as it is relatively new territory for those studying participants in educational Twitter spaces.

While this may be relatively new territory for the specific literature on teachers' use of Twitter, the theoretical significance of this dimension becomes apparent from a comparison to the broader literature on online communities and social learning. For example, Preece (2001) suggested that an online community might be defined in part by the experience of its participants in online spaces. More broadly, Lave and Wenger (1991) framed learning as a process of gradual accumulation of experience within a community, with less-experienced members at an implicit disadvantage until they spend sufficient time with their more-experienced peers. RETHs (or other social groups) whose participants have more collective experience with Twitter (or other technologies and systems for collaboration) could therefore represent spaces with more

collective experience with these technologies and systems to share with newcomers. However, they may also represent spaces where it is more difficult for novice participants to become enculturated within the existing social group. Yet, Gee (2005) argues that "newbies and masters" (p. 225) are equally able to achieve their goals within certain social spaces, so differences in experience may not pose an obstacle after all. In summary, it is likely that the collective experience of a community's participants with the technologies that mediate their interaction may have practical implications for a wide range of digitally-mediated technologies (not just Twitter). However, the specific implications are unclear and may change from space to space (and from technology to technology).

The final two, activity-focused, dimensions distinguish RETHs with high levels of connectedness from those with low levels of connectedness and those with high levels of volume of activity from those with low levels of volume of activity. The dimension focusing on volume of activity has an unsurprising connection with the existing literature. Rosenberg et al.'s (2016) early work on RETHs highlighted considerable diversity between them in terms of number of posts and number of participants, and much of the literature on online communities has suggested that the number of participants is an important measure (Butler, 2001; Jones, 1997; Preece, 2001). Similarly, this dimension has intuitive value for participants in RETHs and many other online or offline social groups. More participants and more activity implicitly mean that there are more resources available within a community (Butler, 2001), and knowing how much activity exists within a space would allow a potential participant to determine how much information will be available on a regular basis (e.g., Rosenberg et al., 2016).

While the second of the activity-focused dimensions is not itself unintuitive, the way that it interacts with the volume of activity dimension may come as a surprise to some. On one hand,

connections between participants have been the focus of much research on both teachers' use of Twitter (e.g., Greenhalgh & Koehler, 2017; Rosenberg et al., 2017) and online communities more generally (e.g., Haythornthwaite, 2009; Wellman et al., 1996). On the other hand, as seen in Figure 9, the four hashtags that see the most connected activity include two of the hashtags with the highest volume of activity (#bced and #oklaed) and the two hashtags with the lowest volume of activity (#wateachlead and #wvedchat). This may violate an unwritten assumption on the part of some that a *bigger* group of people is necessarily a *more effective* group of people. This dynamic appears to correspond with Butler's (2001) assertion that larger groups of participants and higher levels of communication activity can be either advantageous or disadvantageous for a given online group. In keeping with this observation, the combination of these dimensions has considerable practical value for participants in RETHs (and other social groups), who should refrain from assuming that the size of a particular community is necessarily or universally evidence of its success and instead pay attention to other key ways in which communities differ.

Although each of these four composite dimensions has some connection with the broader literature on both online communities and social learning, it should be noted that their specific nature may be due in part to the specific ways that this study was carried out. For example, I chose to carry out three separate principal components analyses on three distinct groups of measures that corresponded with three categories that emerged from my review of the literature. I could have chosen instead to organize the measures by their level, carrying out one PCA on tweet-level measures, another on participant-level measures, and a third on hashtag-level measures, which would have organized the measures differently and may therefore have resulted in a different number of dimensions with different interpretations. Furthermore, I could have

chosen to carry out a single PCA on all twenty measures chosen for this study; this would have resulted in a grouping of the measures into dimensions based solely on characteristics of the data rather than using theoretical or methodological considerations to limit the measures that could be considered as possibly contributing to the same dimension.

The Dimensions in Individual RETHs

Just as important as considering these composite dimensions' relationships to broader contexts of social learning and online communities is considering their relationships to individual RETHs. The results of this study indicate that within the broad conception of RETHs as shared social spaces, there are indeed different kinds of these spaces. Table 8 shows a small sample of RETHs represented simply along all four composite dimensions and thereby demonstrates that one RETH may be similar to another along one or some of these dimensions while still remaining distinct along others.

While Table 8 provides a high-level view of the diversity that exists among RETHs, a more detailed examination of two of these hashtags—#sked and #saskedchat—allows for a more precise picture of what this diversity looks like in practice. A teacher who began participating in the #sked hashtag in 2016 would find that it is a space characterized by lots of sharing information but little explicit connection between participants. More specifically, that teacher should expect that a majority of tweets would include some kind of link, and that the average tweet would include several hashtags and therefore not focus uniquely on a #sked-based audience. In conjunction with this divided attention, a teacher joining #sked during this time should expect not to see most participants on a regular basis (e.g., the average participant tweeted less than twice over the course of the year and participated over course of one or two weeks). Furthermore, compared to other RETH spaces, they should expect the volume of activity to be

relatively low and for participants to have relatively little experience with Twitter. However, what experience they do have is focused on their *production* on Twitter (e.g., the average #sked participant has composed 15,000 tweets over their history with Twitter). In summary, this teacher could have expected #sked to be a "bulletin board" space, where they could find what other people have posted and where they would be encouraged to post things themselves with little expectation of commitment to this particular board or to the other posters.

Table 8: Simple Comparison of Six RETHs along Four Dimensions

RETH	Sharing dimension	Previous experience dimension	Connectedness Dimension	Volume Dimension
#bced	More	Less	More	More
#moedchat	Less	Less	Less	More
#idedchat	Less	More	More	Less
#saskedchat	Less	Less	More	Less
#sked	More	Less	Less	Less

Note. "More" refers to RETHs having a positive value for the sharing, previous experience, and volume dimensions or to RETHs having a negative value for the "Connectedness" dimension, with "Less" referring to the opposite.

If this same teacher also began participating in the #saskedchat hashtag in 2016, they would find a number of differences. For example, in stark contrast to #sked, they could have expected much more focus in this space on connection and conversation and much less focus on sharing information. Indeed, during this time, the #saskedchat hashtag saw higher rates of replies (approximately 36% of total tweets) than any other RETH examined in this study. This teacher could also have expected to see more developed social networks and more commitment to the RETH space—the high rate of replies supported relatively high levels of in-, out-, and reciprocal ties among these participants and was accompanied by higher levels of connection to the RETH space (e.g., an average of 14.5 total contributions to the space and an average of 2.6 weeks of participation). As for #sked, this teacher could have expected relatively low rates of activity and

collective experience with Twitter—however, whereas #sked participants' experience with Twitter was defined with higher levels of tweets, #saskedchat participants had relatively lower levels of tweets (an average of 7,000 per user) but were defined by larger social networks, having both followed more people and been added to more lists. In summary, this space is more of a "water cooler" space, where appropriate behavior is more focused on conversing with one another and building a social network. Those within that space might sometimes refer to resources or information outside of the immediate social context, but not with the same focus as those gathered around a bulletin board.

These two hashtags provide a particularly interesting contrast because they are both associated with a single region, the Canadian province of Saskatchewan. In other words, educational stakeholders within this province appear to have divided opinions on what is valuable within a RETH space—as a result, they have created two spaces that differ in important ways. In other words, this hypothetical teacher has the option of choosing which space to participate in. This appears to be the case for four other regions considered in this study (Kansas, Nevada, Texas, and Utah), where a RETH having "chat" in its name appears to be more focused on conversing whereas another appears to be more focused on sharing. This is particularly noteworthy given that one study has suggested that synchronous activity within one RETH was associated with more social interaction whereas asynchronous use was associated with more content dissemination (Greenhalgh, Staudt Willet, Rosenberg, Akcaoglu, & Koehler, 2018), which corresponds with other findings of different patterns of activity between scheduled, synchronous Twitter chats (see Carpenter & Krutka, 2015; Gao & Li, 2017) and asynchronous uses of the same hashtags (Carpenter et al., 2018; Rosenberg, Akcaoglu, Staudt Willet, Greenhalgh, & Koehler, 2017). It is beyond the scope of this study to examine the extent to

which RETHs are characterized by either synchronous or asynchronous activity, but this parallel suggests that hashtag "twins" may include one hashtag focused on synchronous interaction and another focused on asynchronous interaction.

Although a comparison of #sked and #saskedchat is instructive in describing how these dimensions play out in RETHs, examining an additional hashtag—British Columbia's #bced—provides further insight as to what these differences between RETHs mean for the people who participate in them. Whereas #sked was distinguished by high levels of sharing and #saskedchat by high levels of connection, a teacher joining #bced in 2016 would see high levels of both. However, #bced's focus on sharing differs from #sked's in that it manifests through high levels of mentioning other Twitter participants and high levels of retweets within the hashtag space. This demonstrates that even if two RETHs have relatively similar values on a composite dimension, this may be due to different combinations of factors that mean different things for the teachers participating in these spaces. That is, a teacher joining #sked in 2016 should expect to share resources and ideas by including several hashtags, but a teacher joining #bced at this same time should expect to share resources and ideas by calling specific participants' attention to them (i.e., through mentioning) and by retweeting messages to further their reach. Furthermore, because retweeting and mentioning are sharing activities that both build and leverage social networks, a teacher participating in #bced can expect to be more connected with other participants than a teacher participating in #sked (and be more involved in sharing than a teacher participating in #saskedchat). However, that teacher should also expect to see higher volumes of activity than their peers participating in Saskatchewan-based hashtags; with an average of nearly 400 total tweets per day (125 of which are original tweets), this RETH may even be difficult to

keep up with. In summary, this hashtag may be thought of as a "convention" space: large and bustling, with a focus on both sharing information and building personal networks.

Implications for Practice

Although one indirect purpose of this paper is to help teachers identify those Twitter-based social groups that may best suit their needs, the geographic nature of RETHs may pose problems for teachers whose needs do not correspond with the characteristics of a local RETH. Teachers living in a region where "twinned" RETHs exist have the choice of which RETH to participate in; in contrast, if teachers in a region with only one RETH find that that hashtag does not correspond to their needs, they may need to find other Twitter-based communities to participate in. Although there are educational Twitter hashtags related to subject matter, grade level, or other non-geographic affinities (see, for example, Carpenter et al., 2018), this may help explain why some research has shown evidence of RETH participation from outside expected regions (Greenhalgh, Staudt Willet, Rosenberg, & Koehler, 2018). However, participants in RETH spaces may also help address this issue by reflecting on and modifying their practices or by helping establish a "twinned" RETH that meets a different set of needs.

The results of this study also raise some important practical questions about who is participating in RETHs. As previously stated, the existing literature on experience within a learning community is somewhat ambiguous about the practical consequences of participants having more or less experience. However, the average participant in the average RETH started using Twitter in mid-2011; furthermore, there is remarkably little variation in this measure across RETHs. Even allowing for variation in levels of experience within individual hashtag spaces, these results suggest that a substantial proportion of RETH participants have been active on Twitter for a considerable amount of time (i.e., around 5 years). Experienced participants should

ensure that RETH spaces are welcome to newcomers and that they are taking steps to support these newcomers in adopting the particular practices employed in these spaces; this is especially important given that previous research has found that more experienced participants in RETHs tend to receive more interaction from other participants (Koehler & Rosenberg, 2018) and that some pre-service teachers have identified drawbacks or obstacles to using Twitter as a professional resource (Carpenter, 2015; Carpenter et al., 2016; Luo et al., 2017).

Implications for Theory

As described earlier in this paper, there is some disagreement on how to conceive of Twitter-based social groups, with some authors describing them as communities of practice and others describing them as affinity spaces. The results of this study suggest that community is indeed present in these RETH spaces but join with the results of other work to suggest that the community of practice is not the best way to conceive of this community. As discussed previously, the dimensions of community that have emerged from this study correspond with key concepts in the existing literature on online communities. However, practices that indicate direct conversation with other Twitter users—the kind that have been traditionally associated with the concept of community—are relatively rare within these spaces. In the average RETH, practices such as replying and quote tweeting each account for less than 10% of activity, and mentions are present in less than half of tweets. Similarly, when measured by explicit in-, out-, and reciprocal ties between users, the social networks in the average RETH are relatively small. In contrast, communities of practice are defined in part by a "sustained interaction" (Wenger-Trayner & Wenger-Trayner, 2015, paragraph 7) that, by and large, cannot be said to exist in RETHs.

While Gee's concept of the affinity space is more helpful than the community of practice for accurately accounting for the social interaction within RETH spaces, the results of this study

also highlight ways in which this framework is insufficient. On one hand, using a loosely-defined concept like the affinity space (which has itself been simplified over time; Duncan & Hayes, 2012; Gee & Hayes, 2012) allows scholars to acknowledge RETHs (and other hashtag-associated groups) as social phenomena without overstating the interaction or sense of belonging that occurs within them. On the other hand, participation in RETHs sometimes strains even the loose boundaries established by Gee. For example, Rosenberg et al. (2016) described the hashtags associated with RETH spaces as the "portal" referred to by Gee (2004, 2005) as necessary for entering a shared social space. However, defining social participation as simply as employing the correct hashtag "portal" makes it possible to simultaneously participate in multiple spaces (in the average RETH, this may exceed two hashtag spaces per tweet; see, for example, Figure 3). This possibility is not entirely unanticipated in the literature—for example, it corresponds with Wellman et al.'s (1996) assertion that that the Internet allows people to easily participate in multiple communities. However, even accounting for hashtags that do not represent shared social spaces (Bruns et al., 2016; Greenhalgh, Staudt Willet, Rosenberg, & Koehler, 2017), it represents a freedom and lack of boundaries in digitally-mediated social interaction that even Gee's framework does not fully account for.

Furthermore, Gee's rejection of the community of practice framework (i.e., through the establishment of the affinity space framework) ignores the fact that there exist other ways of conceiving of community (Wenger-Trayner & Wenger-Trayner, 2015). Indeed, community is a popular—and intuitive—way of describing online social groups, and scholars have done considerable work to describe how digital technologies are challenging and changing our conception of community (e.g., Gruzd, Jacobson, Wellman, & Mai, 2016; Gruzd et al., 2011; Katz, Rice, Acord, Dasgupta, & David, 2004). Bruckman (cited in Preece & Maloney-Krichmar,

2005) has gone so far as to suggest that scholars adopt a broad, loosely-defined conception of community, thereby avoiding definitional debates. The simple nature of the affinity space has allowed me to treat different RETHs as being part of the same phenomenon; however, only by adding a descriptive layer—i.e., community dimensions—to the underlying, loosely-defined framework have I been able to describe the differences between RETHs in sufficient detail. In other words, this study demonstrates that there are ways to acknowledge the presence of community in a way that affords distinguishing social spaces from each other while defining it loosely enough that it encompasses several kinds of social interaction.

It is beyond the scope of this study to identify or suggest another conceptual framework that can be effectively applied to RETHs and other teacher-focused Twitter hashtags; however, the results of this study identify some of the characteristics that this framework should have. Such a framework would need to be loosely defined: Twitter affords many different means of social interaction, much of which breaks with intuitive understanding or established expectations of how people interact in online spaces. However, the framework would also need to allow for an acknowledgement and rich description of community. The composite dimensions identified in this study make it clear that different kinds of community practices do exist within RETHs, and it is only through describing and distinguishing these practices that these spaces can be distinguished from each other and, therefore, fully appreciated.

Limitations

Despite the theoretical and practical insights described above, there are limitations to this study that should mediate the interpretation and application of these insights. For example, this study is entirely descriptive; that is, although it draws from theoretical frameworks such as the community of practice or affinity space, it does not test a theory in that it does not explore specific causal relationships. This, in turn, limits the practical implications of my findings. Although I have been able to describe the patterns defining the communication, participants, and activity within these RETHs over this time period, my discussion of the practical implications associated with these patterns should be understood as potential considerations for RETH participants, coordinators, and other stakeholders rather than as specific, clear-cut recommendations for next steps within these communities.

Furthermore, I acknowledge that my use of digital methods and my related focus on Twitter practices that are easily quantifiable and likely to be widespread limit the results and claims of this study in important ways. First, it provides a shallower view of the different social groups being considered, sacrificing rich description of their social dynamics and practices for the ability to consider them at scale. In particular, treating Twitter practices as quantitative phenomena precludes me from studying how different groups employ the same practice for different rhetorical reasons (e.g., boyd et al., 2010; Honeycutt & Herring, 2009; Meier, Elsweiler, & Wilson, 2014). Second, it prevents me from identifying emergent practices that are unique to a particular group, require deep qualitative analysis to fully appreciate, or are so emergent as not to be widely understood.

On a similar note, it should be noted that the data used for this study also limits it in important ways. For example, RETHs represent only one part of the landscape of Twitter

hashtags related to education (see, for example, Carpenter et al., 2018), and it is possible that the patterns of activity identified in RETHs may not extend to other teacher-focused hashtags. Furthermore, social media technologies, users, and practices are constantly changing (Hogan & Quan-Hasse, 2010), and this data—collected in 2016—may not therefore serve as a perfectly-accurate depiction of the RETHs landscape in 2018. This is true in terms of Twitter as a whole—as previously stated, the character limit for Twitter has changed since 2016—and in terms of specific RETHs—for example, Vermont's #vted stood out for its relative activity in 2015 (Rosenberg et al., 2016) but was eliminated from this study due to its relative inactivity in 2016. Given these two considerations, the findings of this study are best interpreted not as an authoritative account of community features in all teacher-focused hashtags at all times but rather as a specific description of the RETHs landscape in 2016 and as an indication of some of the concepts and language that may be helpful as teachers and scholars work to distinguish between different hashtag-based communities in their particular contexts.

In summary, the results and implications presented in this study are largely speculative and should be understood as such. However, as Hogan and Quan-Hasse (2010) write, "beyond the ebb and flow of everyday events and seemingly idiosyncratic usage, trends exist underlying long-term trajectories, persistent social practices, and discernable cultural patterns" (p. 309). That is, even when social media practices change either along with underlying technological changes or from context to context, "recurring insights" (p. 309) emerge from the literature as a whole. The findings and implications that I have presented here should therefore be further explored with more detailed studies in the future in order to help establish a more authoritative understanding of teacher communities on Twitter.

Future Work

As described in the previous section, additional studies on teachers' participation in RETHs and other Twitter hashtags are needed to more fully understand how these hashtag spaces differ. Although there are many ways that future work could contribute to this understanding, I discuss in this section areas for future work that are specifically supported by the results and implications highlighted in this study.

For example, future research is needed to assess the actual impact of these professional communities on teachers' well-being and practice. Studies on teachers' use of Twitter have frequently included claims that hashtags and other Twitter resources can act as sources of professional learning and development that are both effective and democratic (e.g., Carpenter & Krutka, 2015; Greenhalgh & Koehler, 2017). These claims are typically based on characteristics of the social spaces being studied; however, the results of this study raise practical questions about how the extent to which participants are actually active in these spaces. As noted in Table 4, the average handle in the average RETH only participates in that space between two to three weeks out of the year, composing fewer than 10 tweets during that time. Even if the structure of a Twitter-based community is conducive to professional learning and development, it may be the case that higher levels of participation are needed to reap the benefits of this community structure.

It should be noted that this pattern resembles those highlighted in previous research. For example, Rosenberg and colleagues (2016) found that 61% of RETH participants only participated in one week out of a six-month period, and research on other educational hashtags have also shown relatively low rates of tweets per user (Veletsianos, 2017a; Veletsianos, 2017b). Furthermore, research on educational uses of Twitter have corresponded with general

observations (e.g., Nielsen, 2006) that small proportions of participants are often responsible for large proportions of activity (Gao & Li, 2017; Greenhalgh & Koehler, 2017; Veletsianos, 2017a). Ethnographic studies of teachers' Twitter use may provide a clearer picture of how participation in RETH communities translates into personal or professional practice; quantitative measures may also demonstrate whether there are significant changes in practice due to Twitter use. Both veins of research may be able to investigate forms of participation in RETHs that cannot be measured as easily as the participation noted in this study (see Carpenter, 2015; Greenhalgh & Koehler, 2017; Romero-Hall, 2017).

Finally, the lower threshold for participation in RETHs—and other educational hashtags—raises practical and theoretical implications that have yet to be fully explored. As previously described, this lower threshold allows Twitter users to participate in multiple RETHs simultaneously; this development is consistent with the transition from Lave and Wenger's (1991) description of joining a community of practice through legitimate peripheral participation to Gee's (2004, 2005) description of joining an affinity space through knowing the correct "portals." However, Gee's framework nonetheless assumes that those within a social space share a common affinity. In contrast, Figure 4 demonstrates that Twitter users with no genuine affinity with a group can use a hashtag portal to insert themselves into the space occupied by this group. Other studies have also found evidence of this phenomenon in educational hashtags (e.g., Greenhalgh et al., 2016). Further work is needed to determine what the theoretical and practical implications of this unwanted participation are for participants in and leaders of online groups.

Conclusion

Technologies are repurposed by different groups for different ends, and Regional Educational Twitter Hashtags (RETHs) are no exception. Collectively, RETHs can be understood as *spaces with community dimensions*. That is, they are loosely-organized social groups characterized by experienced participants, overlapping memberships, and low levels of the interactions and close ties that are typically associated with communities; nonetheless, these groups are characterized by community features that serve as dimensions that distinguish them from each other. The composite dimensions considered in this study include the extent to which communication within a space focuses on sharing, the level of experience of a space's participants with Twitter as a whole, the volume of activity within a space, and the extent to which that activity is connected. RETHs differ in important ways along each of these dimensions, thereby demonstrating that these hashtag spaces are defined by different practices, different social dynamics, and presumably different goals.

The diversity of RETH spaces has a number of practical and theoretical implications. For example, that these hashtags vary widely in terms of size and practices employed suggests that teachers looking to join a hashtag space should consider its community features before determining if it will meet their needs; similarly, teacher educators should help pre- and in-service teachers recognize the complexity and diversity of participating in online social groups. Similarly, scholars should consider how best to frame social learning, interaction, and organization in spaces—like RETHs—that challenge our existing conceptions and show important diversity but nonetheless act as important social phenomena.

APPENDICES

APPENDIX A: Results of Communication-focused Measures for all RETHs

This appendix reports the values for each of the seven communication-focused measures for each of the 62 RETHs considered in this study (see Table 9).

Table 9: Results of Communication-focused Measures

RETH	Hashtags per tweet	Mentions per tweet	Proportion of retweets	Proportion of replies	Proportion of quote tweets	Proportion of tweets with embedded media	Proportion of tweets with URLs
#aledchat	1.64	0.25	0.44	0.10	0.12	0.09	0.14
#azedchat	4.79	0.36	0.45	0.01	0.07	0.45	0.71
#arkedchat	1.96	0.34	0.41	0.13	0.10	0.15	0.17
#caedchat	2.27	0.37	0.38	0.13	0.07	0.17	0.33
#coedchat	4.21	0.64	0.38	0.00	0.10	0.36	0.79
#ctedchat	4.74	0.41	0.46	0.00	0.06	0.51	0.75
#edude	2.87	0.56	0.49	0.01	0.03	0.31	0.65
#fledchat	1.65	0.30	0.26	0.23	0.08	0.17	0.17
#gaed	2.55	0.58	0.34	0.04	0.09	0.21	0.35
#edchathi	2.99	0.56	0.51	0.08	0.05	0.22	0.57
#ideдchat	1.64	0.40	0.19	0.25	0.10	0.15	0.14
#iledchat	2.18	0.39	0.33	0.13	0.08	0.16	0.33
#inelearn	1.89	0.44	0.35	0.10	0.07	0.19	0.22
#iaedchat	5.19	0.43	0.63	0.01	0.06	0.44	0.38
#ksed	2.24	0.34	0.57	0.03	0.06	0.15	0.38
#ksedchat	1.65	0.26	0.31	0.12	0.11	0.17	0.09
#kyedchat	6.18	0.23	0.32	0.00	0.05	0.46	0.83
#laedchat	2.28	0.39	0.34	0.15	0.11	0.22	0.27
#edchatme	1.98	0.48	0.31	0.12	0.10	0.16	0.22
#mdedchat	2.45	0.68	0.33	0.12	0.07	0.16	0.42
#edchatma	3.06	0.60	0.45	0.07	0.10	0.21	0.51
#miched	1.98	0.61	0.43	0.06	0.08	0.14	0.42

Table 9 (cont'd)

RETH	Hashtags per tweet	Mentions per tweet	Proportion of retweets	Proportion of replies	Proportion of quote tweets	Proportion of tweets with embedded media	Proportion of tweets with URLs
#mnedchat	3.53	0.57	0.35	0.01	0.06	0.33	0.79
#msedchat	2.16	0.22	0.26	0.09	0.07	0.22	0.26
#moedchat	2.11	0.32	0.43	0.13	0.08	0.16	0.23
#mtedchat	1.64	0.36	0.29	0.15	0.08	0.12	0.15
#nebedchat	1.61	0.36	0.28	0.13	0.09	0.10	0.13
#nved	2.86	0.66	0.39	0.02	0.05	0.15	0.53
#nvedchat	2.12	0.47	0.32	0.12	0.11	0.22	0.17
#nhed	2.19	0.35	0.22	0.23	0.06	0.21	0.31
#njed	2.98	0.74	0.47	0.03	0.06	0.23	0.62
#nyedchat	2.47	0.40	0.53	0.10	0.07	0.26	0.33
#nced	2.62	0.43	0.48	0.05	0.06	0.20	0.47
#ndedchat	2.63	0.30	0.24	0.04	0.07	0.28	0.40
#ohedchat	1.59	0.29	0.34	0.19	0.08	0.13	0.13
#oklaed	1.68	0.37	0.48	0.05	0.09	0.20	0.26
#oredu	3.77	0.48	0.35	0.00	0.05	0.32	0.71
#paedchat	2.46	0.42	0.30	0.19	0.04	0.36	0.45
#edchatri	1.87	0.47	0.35	0.08	0.08	0.11	0.29
#sced	3.17	0.72	0.53	0.01	0.04	0.45	0.45
#sdedchat	2.46	0.53	0.27	0.09	0.12	0.22	0.30
#tnedchat	2.69	0.37	0.32	0.15	0.09	0.30	0.41
#txed	2.29	0.55	0.53	0.05	0.06	0.15	0.47
#txeduchat	2.01	0.34	0.48	0.10	0.08	0.18	0.19
#uted	2.43	0.54	0.50	0.02	0.05	0.24	0.44
#utedchat	1.58	0.52	0.12	0.28	0.07	0.13	0.17
#vachat	1.93	0.26	0.27	0.19	0.09	0.12	0.25
#wateachlead	2.07	0.63	0.29	0.11	0.14	0.26	0.29
#wvedchat	1.47	0.38	0.17	0.19	0.11	0.16	0.09

Table 9 (cont'd)

RETH	Hashtags per tweet	Mentions per tweet	Proportion of retweets	Proportion of replies	Proportion of quote tweets	Proportion of tweets with embedded media	Proportion of tweets with URLs
#wischat	2.40	0.27	0.44	0.07	0.06	0.17	0.28
#wyoedchat	1.60	0.53	0.23	0.12	0.10	0.11	0.13
#abed	2.72	0.54	0.58	0.06	0.07	0.21	0.44
#bced	2.53	0.62	0.67	0.05	0.07	0.20	0.44
#edtechbc	2.06	0.43	0.24	0.01	0.04	0.05	0.88
#mbedchat	1.73	0.41	0.38	0.16	0.05	0.12	0.23
#nbed	3.66	0.85	0.45	0.01	0.10	0.32	0.46
#nsed	4.47	0.44	0.55	0.04	0.04	0.13	0.67
#onedchat	2.29	0.38	0.48	0.12	0.10	0.22	0.21
#onted	2.94	0.52	0.64	0.01	0.06	0.32	0.61
#eduqc	2.65	0.51	0.46	0.01	0.07	0.12	0.72
#saskedchat	1.50	0.33	0.21	0.36	0.05	0.17	0.25
#sked	4.20	0.37	0.35	0.07	0.04	0.16	0.59

APPENDIX B: Results of Participant-focused Measures for all RETHs

This appendix reports the values for each of the six participant-focused measures for each of the 62 RETHs considered in this study (see Table 10).

Table 10: Results of Participant-focused Measures

RETH	Days on Twitter	Total tweets	Total likes	Total followers	Total following	Total listed
#aledchat	1592.83	5211.04	4419.31	1622.89	1268.06	91.59
#azedchat	1661.54	6544.40	3798.35	2382.94	1591.47	125.85
#arkedchat	1605.66	7314.18	5831.61	3291.54	1552.71	149.44
#caedchat	1629.57	5138.95	4128.52	2022.27	1286.82	111.59
#coedchat	1825.62	6240.41	3410.51	2842.78	1986.61	170.67
#ctedchat	1708.71	9867.15	6968.96	4018.32	2314.03	217.66
#edude	1584.52	5786.96	3536.80	3720.43	1151.63	96.38
#fledchat	1637.09	7374.54	5831.54	3181.06	1719.41	158.52
#gaed	1680.38	6884.69	4773.62	2778.01	1618.13	136.08
#edchathi	1728.21	7712.62	5132.29	2798.02	1688.88	168.42
#idedchat	1589.14	7737.72	5462.95	3647.87	1794.21	154.49
#iledchat	1672.41	5756.54	4245.25	2052.70	1308.93	114.45
#inelearn	1549.78	3708.56	3036.02	1656.92	966.62	80.48
#iaedchat	1683.24	7877.31	6190.84	2567.92	1750.43	144.28
#ksed	1770.02	8828.91	6447.44	1263.81	987.94	49.00
#ksedchat	1533.29	4947.78	4541.88	1981.35	1192.86	96.15
#kyedchat	1776.88	9593.35	6720.41	3577.63	2223.39	213.13
#laedchat	1724.90	7288.81	5220.08	2578.10	1551.53	147.83
#edchatme	1631.43	6917.83	4899.14	2415.38	1464.00	143.53
#mdedchat	1668.78	8177.83	5411.33	3101.01	1741.82	160.73
#edchatma	1736.23	7475.69	4888.51	2677.26	1432.26	137.13
#miched	1713.29	7788.01	5566.44	1974.56	1209.02	93.53
#mnedchat	1758.07	9329.70	5495.44	4051.93	2373.88	219.43
#msedchat	1616.41	6451.46	4326.36	2807.55	1638.21	124.25
#moedchat	1558.33	3947.59	3468.19	1280.71	1009.07	75.72
#mtedchat	1594.48	5609.61	4282.11	2567.59	1335.51	113.92

Table 10 (cont'd)

RETH	Days on Twitter	Total tweets	Total likes	Total followers	Total following	Total listed
#nebedchat	1693.80	4811.73	3857.77	1748.27	1179.27	90.00
#nved	1773.32	13134.43	8999.81	3999.89	1330.43	106.40
#nvedchat	1633.46	8527.54	6146.61	3094.84	1936.10	179.02
#nhed	1761.70	8042.91	5917.45	2666.11	1874.88	153.98
#njed	1608.14	5769.15	4368.30	2106.72	1263.98	112.43
#nyedchat	1607.08	6338.46	5058.05	2130.58	1438.66	116.40
#nced	1693.51	7212.96	5252.26	1958.14	1142.61	89.69
#ndedchat	1626.09	5464.23	4165.35	1757.51	1187.78	113.18
#ohedchat	1544.06	4910.60	4322.14	1535.64	1146.96	86.47
#oklaed	1563.44	5120.03	4168.85	1342.32	855.30	56.01
#oredu	1644.99	5876.29	3049.00	2058.26	1092.72	107.33
#paedchat	1666.82	7598.04	5420.07	2395.72	1590.39	151.34
#edchatri	1700.79	5712.14	3972.12	3145.37	1318.98	118.86
#sced	1618.41	6653.55	4792.06	2095.35	1203.14	109.17
#sdedchat	1672.16	7340.84	5883.93	2812.17	1796.03	157.73
#tnedchat	1551.05	7509.94	6175.88	3057.73	1728.48	138.60
#txed	1656.78	5087.18	3959.01	1767.48	970.72	69.84
#txeduchat	1549.66	4126.43	3702.70	1365.02	1070.85	75.60
#uted	1710.55	5992.73	4380.53	1760.22	890.17	65.49
#utedchat	1505.73	6757.28	4950.62	2429.78	1625.85	128.11
#vachat	1706.88	8259.96	6064.92	2904.51	1693.62	149.40
#wateachlead	1630.27	7167.83	5154.99	3045.37	1956.92	123.57
#wvedchat	1568.59	6934.92	5644.51	3162.80	1562.98	130.71
#wischat	1770.67	8874.09	6023.16	3188.79	1881.42	165.10
#wyoedchat	1627.93	7349.89	5330.66	2677.39	1689.45	138.12
#abed	1694.56	10816.50	8490.56	1665.42	915.66	59.62
#bced	1760.61	6276.07	3675.99	1481.71	957.99	64.52
#edtechbc	2022.02	9482.17	3792.67	2265.28	1599.16	188.15
#mbedchat	1547.73	4946.06	3038.92	1452.66	940.38	78.20
#nbed	1758.25	7757.11	4225.77	2277.17	1407.37	145.38
#nsed	1762.13	7915.72	4289.87	1880.55	1017.00	68.71

Table 10 (cont'd)

RETH	Days on Twitter	Total tweets	Total likes	Total followers	Total following	Total listed
#onedchat	1566.07	5423.50	4129.09	1695.21	1237.51	104.91
#onted	1516.06	3777.74	2664.03	1188.43	783.35	55.88
#eduqc	1722.67	5531.02	2015.33	2031.90	929.25	82.46
#saskedchat	1729.58	7002.96	4769.23	1969.20	1373.37	115.56
#sked	1682.73	15083.80	6519.87	1949.76	903.70	63.74

APPENDIX C: Results of Activity-focused Measures for all RETHs

This appendix reports the values for each of the seven activity-focused measures for each of the 62 RETHs considered in this study (see Table 11).

Table 11: Results of Activity-focused Measures

RETH	Number of posts	Number of handles	Posts per handle	Sustained activity	In-ties per handle	Out-ties per handle	Reciprocated ties per handle
#aledchat	26698	4030	6.62	1.88	1.86	2.72	0.49
#azedchat	472	206	2.29	1.63	1.02	1.53	0.13
#arkedchat	6218	1385	4.49	1.60	1.62	2.34	0.47
#caedchat	45167	8722	5.18	2.25	2.54	3.21	0.58
#coedchat	693	187	3.71	2.05	1.93	2.07	0.60
#ctedchat	625	298	2.10	1.52	1.01	1.54	0.18
#edude	3269	784	4.17	2.59	2.36	2.90	0.48
#fledchat	19534	2557	7.64	1.96	2.49	3.16	0.75
#gaed	4589	1065	4.31	2.31	1.77	2.75	0.52
#edchathi	1890	676	2.80	1.73	1.69	2.11	0.40
#idedchat	8732	658	13.27	2.39	2.71	3.77	1.19
#iledchat	13985	2467	5.67	2.20	2.44	2.97	0.67
#inelearn	31093	3648	8.52	2.67	3.46	4.32	1.06
#iaedchat	4776	2159	2.21	1.74	1.41	1.76	0.13
#ksed	55344	4150	13.34	3.84	4.02	5.02	0.45
#ksedchat	31094	3728	8.34	2.41	2.83	3.55	0.74
#kyedchat	563	218	2.58	1.91	0.91	1.17	0.06
#laedchat	2570	640	4.02	1.57	1.67	2.13	0.43
#edchatme	20002	2023	9.89	2.32	3.21	4.17	1.13
#mdedchat	3716	622	5.97	2.00	2.07	4.01	0.69
#edchatma	10071	2334	4.31	2.34	2.27	3.02	0.60
#miched	69423	8828	7.86	2.68	3.68	4.59	0.88
#mnedchat	660	250	2.64	1.94	1.20	1.71	0.37

Table 11 (cont'd)

RETH	Number of posts	Number of handles	Posts per handle	Sustained activity	In-ties per handle	Out-ties per handle	Reciprocated ties per handle
#msedchat	1829	322	5.68	1.91	1.46	1.88	0.36
#moedchat	42062	8885	4.73	1.95	1.62	2.62	0.44
#mtedchat	15252	2117	7.20	1.88	2.05	2.77	0.65
#nebedchat	17655	1972	8.95	2.54	3.14	4.04	0.89
#nved	16053	1538	10.44	3.05	3.98	4.79	0.89
#nvedchat	9060	821	11.04	2.68	3.44	4.58	1.20
#nhed	7262	993	7.31	2.12	2.17	2.75	0.76
#njed	33574	6414	5.23	2.44	2.78	3.76	0.72
#nyedchat	18920	5351	3.54	1.69	1.97	2.52	0.47
#nced	41703	7345	5.68	2.53	2.65	3.11	0.45
#ndedchat	1509	372	4.06	2.22	1.23	1.91	0.30
#ohedchat	50334	7352	6.85	2.03	2.57	3.34	0.67
#oklaed	147755	12157	12.15	3.11	4.29	5.19	0.91
#oredu	857	268	3.20	2.14	1.42	2.03	0.34
#paedchat	7148	1479	4.83	1.79	2.00	2.43	0.52
#edchatri	14163	1896	7.47	2.52	3.06	4.04	0.83
#sced	3797	1070	3.55	2.08	1.85	2.51	0.48
#sdedchat	7857	1110	7.08	2.05	2.06	3.03	0.58
#tnedchat	5457	1025	5.32	1.92	2.01	2.58	0.53
#txed	63023	11605	5.43	2.47	2.79	3.46	0.38
#txeduchat	58464	12211	4.79	1.96	1.98	2.99	0.43
#uted	23723	2132	11.13	3.38	4.02	5.08	0.85
#utedchat	12655	941	13.45	2.48	3.58	4.76	1.50
#vachat	10997	1618	6.80	2.06	2.14	2.71	0.64
#wateachlead	15873	1063	14.93	3.17	5.10	6.51	1.90
#wvedchat	10041	511	19.65	2.97	4.70	5.76	2.08
#wischat	7287	1322	5.51	2.10	1.82	2.41	0.42
#wyoedchat	14933	1201	12.43	2.29	2.71	3.80	0.92

Table 11 (cont'd)

RETH	Number of posts	Number of handles	Posts per handle	Sustained activity	In-ties per handle	Out-ties per handle	Reciprocated ties per handle
#abed	76243	14845	5.14	2.54	2.92	3.27	0.37
#bced	139615	13678	10.21	3.50	5.49	6.04	0.67
#edtechbc	1424	226	6.30	2.38	1.47	2.47	0.23
#mbedchat	9761	1132	8.62	2.50	3.31	4.17	1.11
#nbed	1441	397	3.63	2.21	1.85	2.67	0.47
#nsed	2139	636	3.36	1.96	1.58	2.27	0.28
#onedchat	16941	3245	5.22	1.82	2.43	3.15	0.64
#onted	58920	12831	4.59	2.71	2.39	3.21	0.35
#eduqc	15757	2797	5.63	2.79	2.65	3.42	0.35
#saskedchat	26390	1813	14.56	2.55	3.35	4.16	1.34
#sked	498	291	1.71	1.40	0.51	1.11	0.14

APPENDIX D: Additional Information on Communication-Focused PCA

This appendix provides additional information about the principal components analysis carried out on the seven communication-focused measures in this study. Figure 10 is a biplot that shows the relationship between the first two components produced by this analysis and the original measures considered in this study.

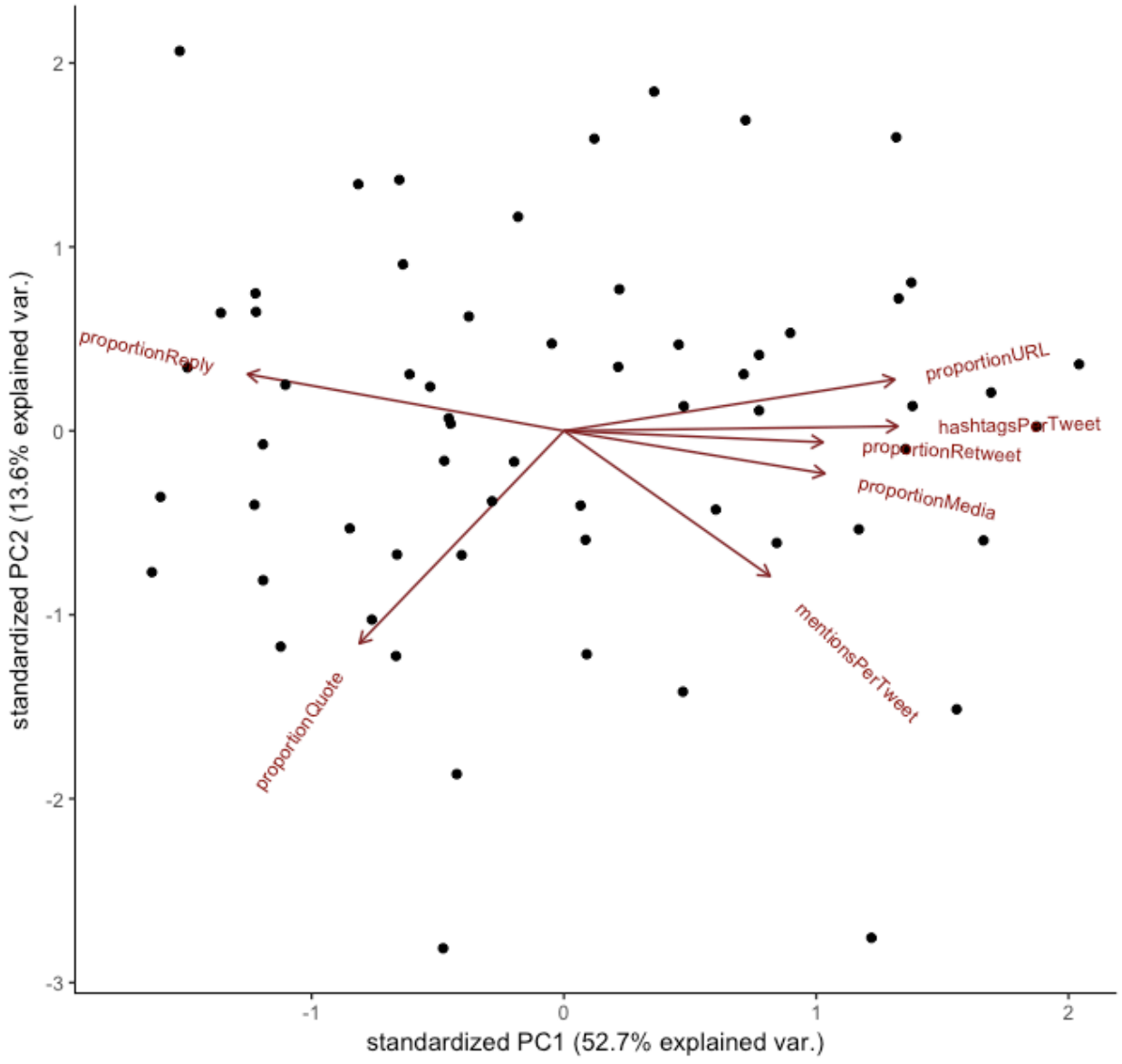

Figure 10. Biplot of first two components resulting from communication-focused PCA.

Although a biplot is useful for interpreting the first two components, it does not indicate whether these (or other) components are worth retaining for the investigation of a phenomenon. In contrast, parallel analysis is a technique for determining how many components in a PCA should be retained. The components derived from a PCA are compared with the components derived from randomly-generated data having similar characteristics to the original data. Only those components with higher eigenvalues (i.e., higher amounts of variance explained) than the components derived from the simulated data are retained. Figure 11 is a visual representation of the parallel analysis carried out for the communication-focused PCA and demonstrates that only one component performs better than the simulated components.

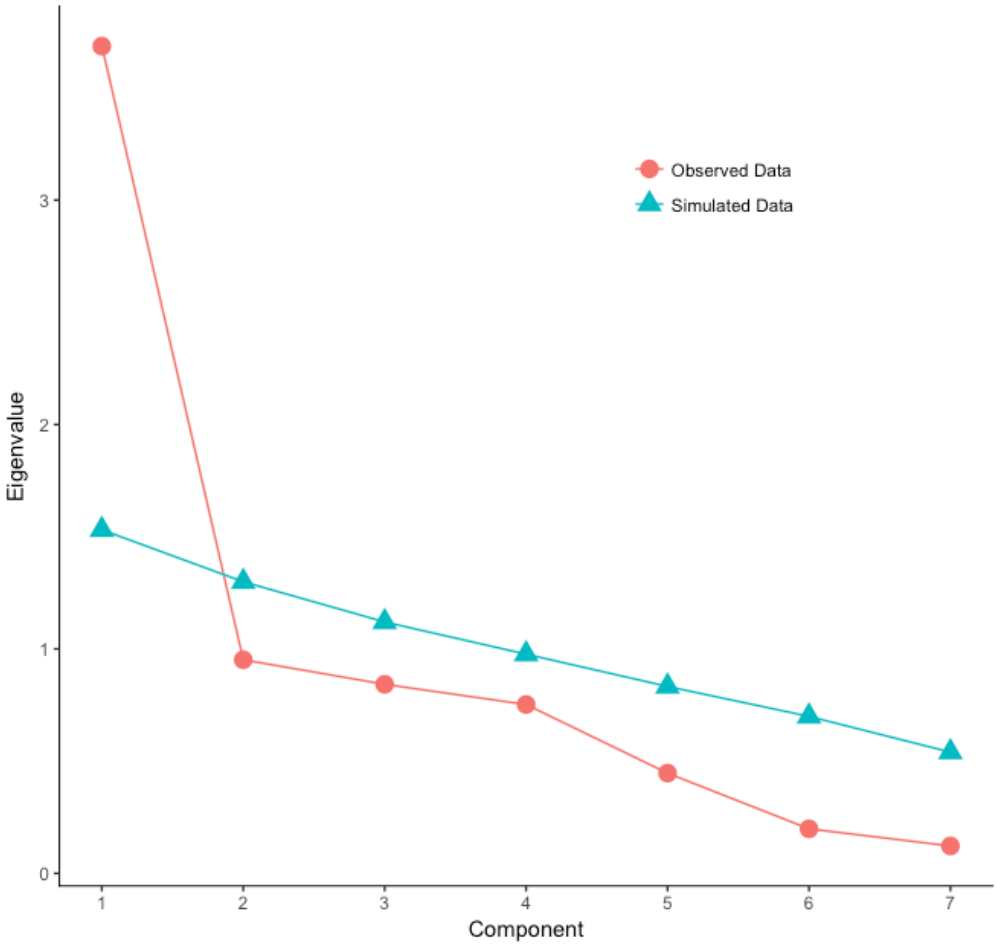

Figure 11. Parallel analysis of components resulting from communication-focused PCA.

APPENDIX E: Additional Information on Participant-Focused PCA

This appendix provides additional information about the principal components analysis carried out on the six participant-focused measures in this study. Figure 12 is a biplot that shows the relationship between the first two components produced by this analysis and the original measures considered in this study.

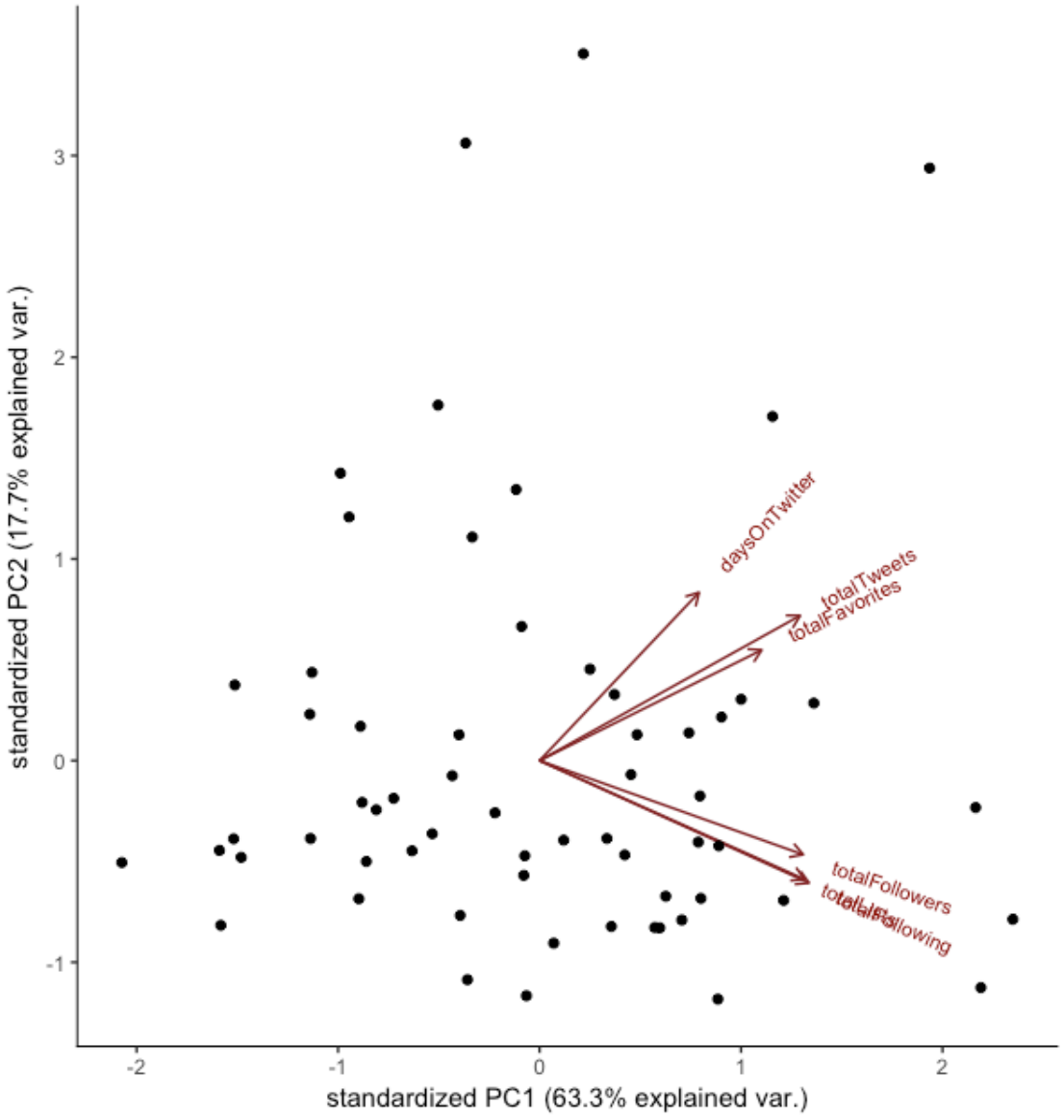

Figure 12. Biplot of first two components resulting from participant-focused PCA.

As explained in Appendix D, however, a parallel analysis is necessary to determine whether these (or other) components are worth retaining for the final investigation of this phenomenon. Figure 13 is a visual representation of the parallel analysis carried out for the participant-focused PCA and demonstrates that only one component performs better than the simulated components.

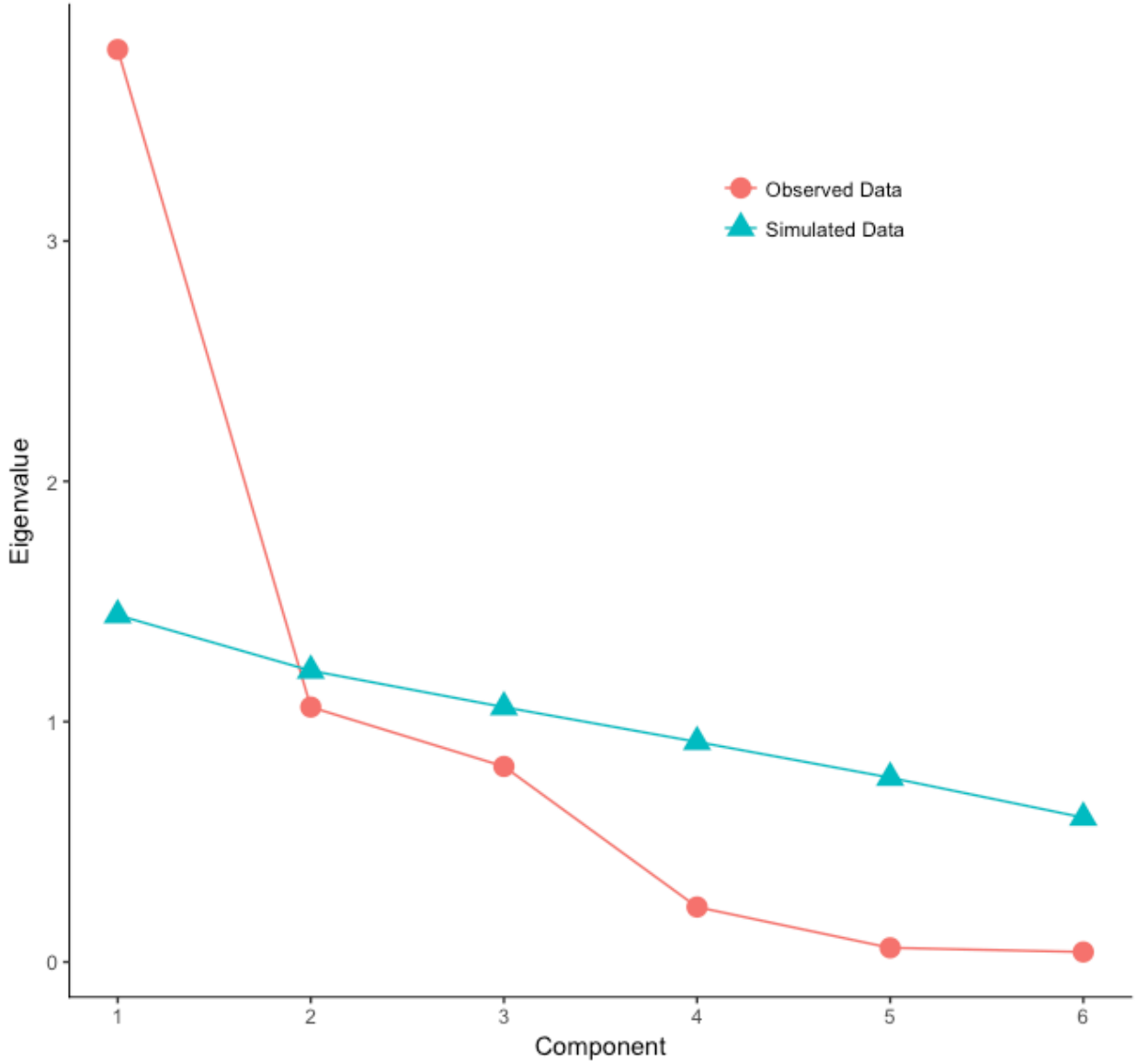

Figure 13. Parallel analysis of components resulting from participant-focused PCA.

APPENDIX F: Additional Information on Activity-Focused PCA

This appendix provides additional information about the principal components analysis carried out on the six communication-focused measures in this study. Figure 14 is a biplot that shows the relationship between the first two components produced by this analysis and the original measures considered in this study. Note that although this is essentially the same figure as Figure 9, the x-axis appears differently in that figure, which flips it to facilitate interpretation.

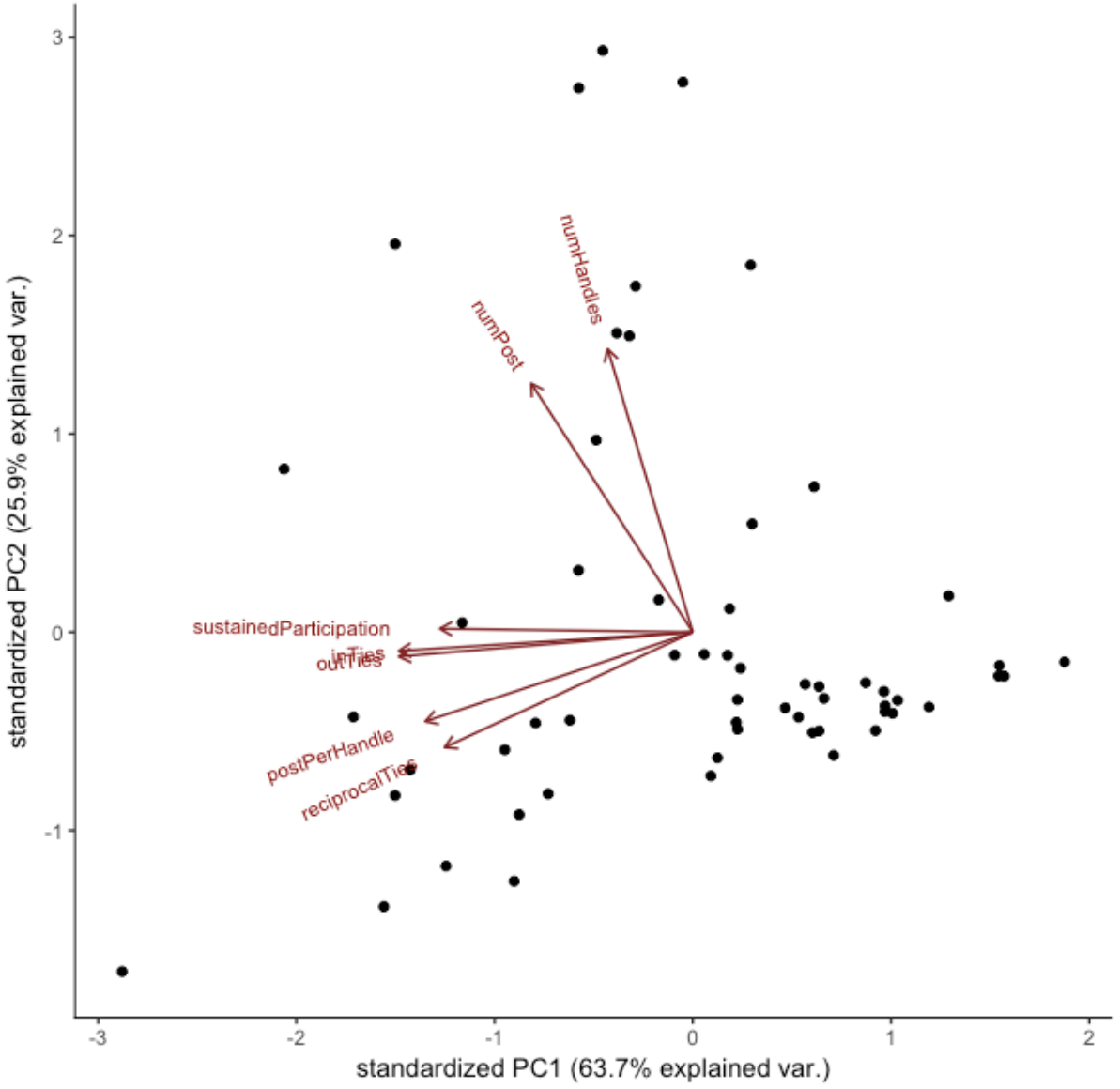

Figure 14. Biplot of first two components resulting from activity-focused PCA.

As explained in Appendix D, however, a parallel analysis is necessary to determine whether these (or other) components are worth retaining for the final investigation of this phenomenon. Figure 15 is a visual representation of the parallel analysis carried out for the activity-focused PCA and demonstrates that two components perform better than the simulated components.

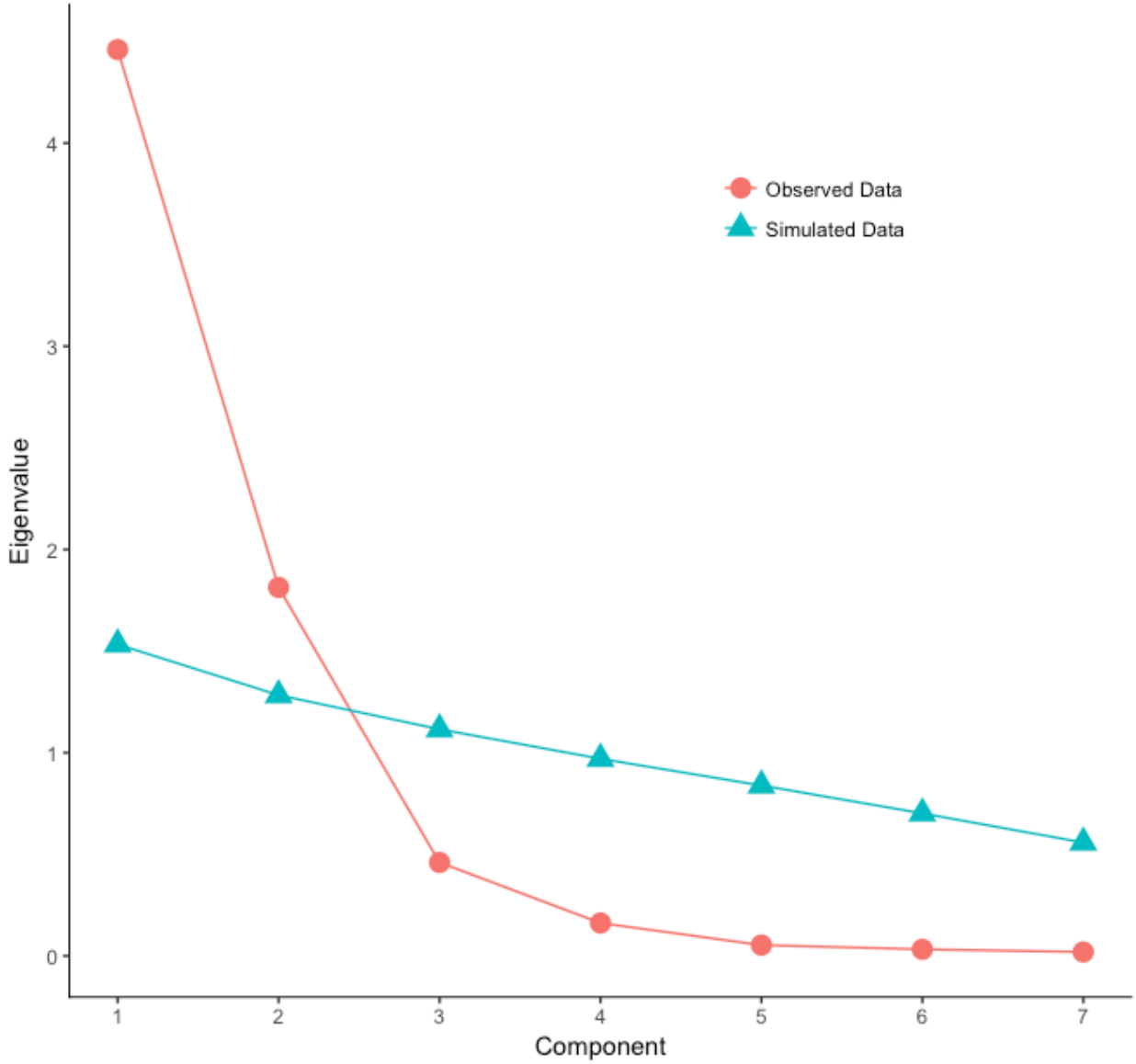

Figure 15. Parallel analysis of components resulting from activity-focused PCA.

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