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DOCUMENTING STUDENT CONNECTIVITY AND USE OF DIGITAL ANNOTATION DEVICES IN VIRGINIA COMMONWEALTH UNIVERSITY CONNECTED COURSES: AN ASSESSMENT TOOLKIT FOR DIGITAL PEDAGOGIES IN HIGHER EDUCATION

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Documenting Student Connectivity and Use of Digital Annotation Devices in Virginia Commonwealth University Connected Courses: An Assessment Toolkit for Digital Pedagogies in Higher Education

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Educational Research and Evaluation at the School of Education, Virginia Commonwealth University

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In true connected learning fashion I was planning on creating color-coded network maps to demonstrate how everyone interacted with each other, the content, and me. However, my itinerant scholar-friend Frances Bell warned me that it is best to keep dissertation acknowledgements short and sweet. I find Frances to be the right about most things, so I will keep this simple.

I approached this doctorate very differently than my medical degree. Among other things, I decided to be publicly vulnerable in the learning process. I'm sure my openness was not to everyone's taste, but it afforded me something I'd never really experienced before: the true kindness of strangers who then became something more than strangers.

Many passages within this work represent my ongoing struggle to find a balance between what could be and what was good enough. Woven into that struggle is the impact of people who took time to read, think, and comment on my work; who told me to keep going; who removed barriers and pushed back deadlines; who quietly took care of things so that I had space to think. The tweets, likes, retweets, replies, direct messages, emails, and Google Hangouts you provided for me – I felt and benefitted from them all.

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Abstract

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Virginia Commonwealth University (VCU) is implementing a large scale exploration of digital pedagogies, including connected learning and open education, in an effort to promote digital fluency and integrative thinking among students. The purpose of this study was to develop a classroom assessment toolkit for faculty who wish to document student connectivity in course-related blogging and microblogging ("tweeting") activities. Student use of digital annotation devices, including hyperlinks, embedded images, mentions, and hashtags, were studied in four university courses as potential indicators of student connectivity, defined as the ability to connect current thoughts and experience with other concepts and people across space and time. One thousand one hundred and eighty six (1186) hyperlinks and embedded images, 2708 mentions, and 135 hashtags were collected from 498 learner blog posts and 5343 tweets through mostly automated, digital workflows and analyzed through a combination of statistical, content, and

network analysis. General criteria for “connected course” design, a model for connectivity as a form of learning, connectivity-based learning goals, and integrated, potentially scalable assessment practices are discussed. Content analysis led to the development of classification systems for the types, sources, and communicative impact of hyperlinked and embedded materials in blogging and tweeting contexts. Network analysis was adapted to visualize, document, and describe course-related social interactions and student use of web-based information sources. Real student data are used to describe annotation-focused assessment criteria, analytic assessment dashboards, rubrics, and approaches to real-time graphic visualization of student performance.

Chapter 1

Background

In the last five years, Virginia Commonwealth University (VCU) has experienced rapid growth and development – growth in terms of capital construction projects, grant acquisition, and strategic fundraising initiatives, and development in terms of examining and redefining institutional goals and values (VCU University Relations, 2015). At the moment, VCU is an institution in transition moving towards becoming a nationally-recognized premier urban research institution. This goal is embodied in the VCU Quest for Distinction, a strategic plan that speaks directly to institutional ideals of academic quality, student success, research and innovation, faculty excellence, community impact, and resource accountability (VCU Office of the Provost and Vice President for Academic Affairs, 2015). It is reinforced through VCU's "Make it Real" marketing campaign, which represents the university as a place where students and faculty "make it real" through a commitment to innovative pedagogy, meaningful learning, and authentic interaction with world beyond the classroom (VCU University Relations, 2013). The combined message is clear: VCU aims to assert itself as a global and community presence by promoting innovative and collaborative design, data-driven approaches to student success and teaching excellence, and educational approaches dominated by participatory and problem based learning.

In 2014, the VCU Quality Enhancement Plan (QEP) was revised to better align the institutional pedagogical approach with the strategic plan. The revised QEP aims to promote "learning that matters" through institution-wide commitment to generalizable education, or

"education that has substantial and lasting impact beyond any course, major, or degree" (VCU Office of the Provost and Vice President for Academic Affairs, 2014, para. 1). Furthermore, it suggests VCU will accomplish its goal of learning that matters when students, faculty, and staff engage other people, challenges, and opportunities with a developed sense of integrative thinking and digital fluency. Integrative thinking is a model that combines creativity, problem solving, and interdisciplinary process. Integrative thinkers have the ability to accept the postmodern reality of multiple perspectives and truths and see past them to generate creative solutions that respect the needs of all stakeholders (Sill, 2001). Digital fluency implies more than digital literacy, though being able to communicate through digital media is an important component. Rather, digital fluency speaks to underlying habits of mind that support living, working, and being effective in an integrative, networked world. As illustrated in Figure 1, integrative thinking and digital fluency intersect at the concept of connectivity: the ability to make connections with people and across concepts, space, and time in order to make cohesive meaning of the past and present and inform future action.

According to the QEP, the university must provide education for and of the digital age in which we live. Jenkins (2009) describes the digital age as a networked culture that is uniquely participatory, exhibiting:

> …relatively low barriers to artistic expression and civic engagement, strong support for creating and sharing one's creations, and some type of informal mentorship whereby what is known by the most experienced is passed along to novices. A participatory culture is also one in which members believe their contributions matter and feel some degree of

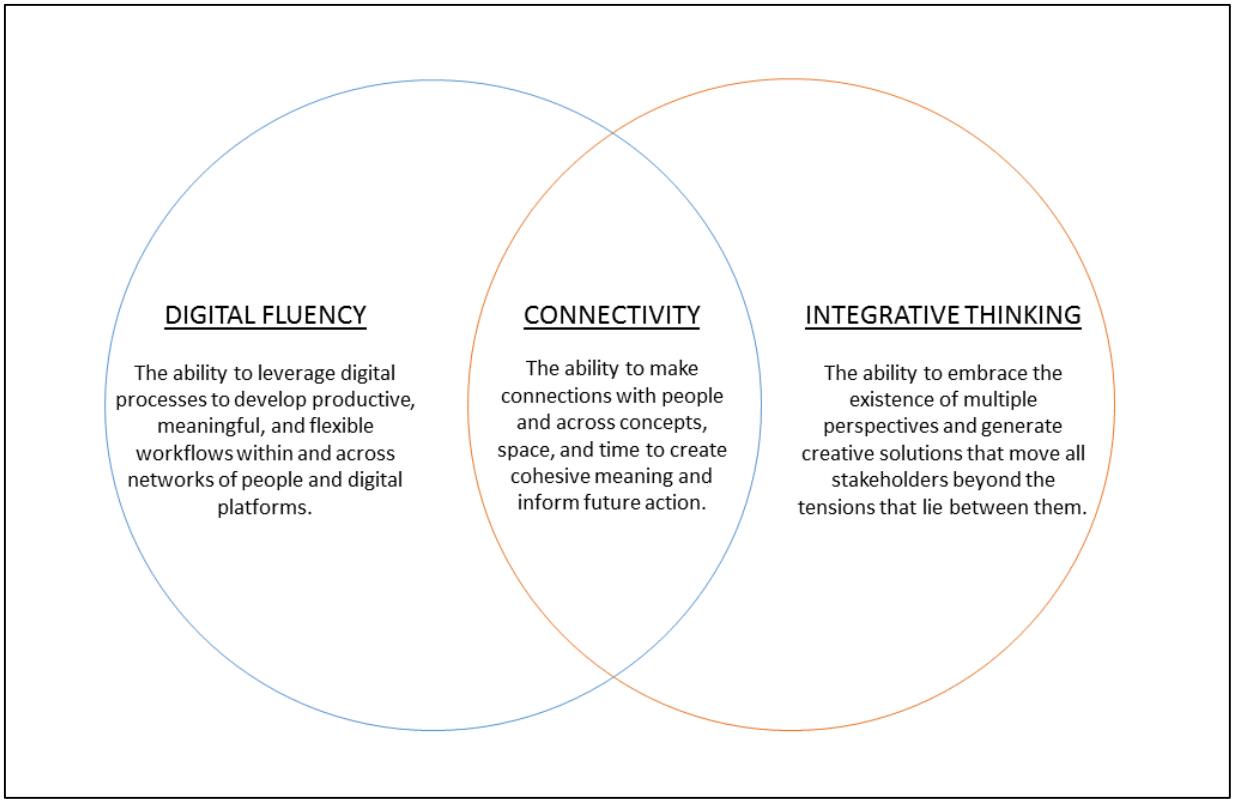


Figure 1. Digital fluency, connectivity, and integrative thinking.

> social connection with one another (at the least they care what other people think about what they have created). (p. 3)

Individuals who navigate digitally networked participatory cultures successfully think critically while contributing to crowdsourced, collaborative, and creative environments. They design workflows that allow for the efficient collection, organization, visualization, remixing, and redistribution of information and knowledge (Kasworm, 2011). They capitalize on their comfort with information saturation to embrace multiple and shifting realities and work towards integrative solutions for the conundrums of the world (Siemens, 2004).

To help facilitate the work of the QEP, VCU established an open campus publishing platform named after the university mascot, Ram Pages (http://rampages.us), which offers students, faculty, and staff the opportunity to develop individual, course, and organization

websites. Ideally, as these sites are used to support personal interests, social and co-curricular activities, and formal academic experiences, their content will become networked to form a rich, virtual learning environment layered onto and extending beyond the physical VCU campus. The public nature of Ram Pages allows for the easy integration of student and faculty work with the larger World Wide Web, increasing opportunities for connectivity, "real world" learning, and global and community partnerships (Hart, 2015).

Since its inception in 2014, Ram Pages has expanded to 13,000 websites and continues to grow rapidly (T. Woodward, personal communication, December 2, 2015). Increasingly, the Ram Pages community is being used across a variety of disciplines and programs to support formal, academic credit-bearing "connected courses." Although each connected course is different, they share an underlying course structure: (1) a majority, if not all, course materials, activities, and group announcements are found on a public course website; (2) students complete at least some of their assignments as public blog posts their personal websites (while many students choose to start a Ram Pages website, some use other blogging platforms); (3) students' blog posts are aggregated by an RSS feed on the course website so that all blogged assignments can be viewed in one space (known as the course "bloggregate"); and (4) students participate in course-related public discourse, such as commenting on each other's blog posts or engaging in conversation on social media platforms like Twitter.

The research needed to explicate the potential and impact of VCU connected courses is in its initial stages. Their ability to promote connectivity, digital fluency, integrative thinking, and student engagement and success must be evaluated. However, one of the barriers to this process is the lack of assessment protocols or practices that document student connectivity. If VCU connected courses are to be successfully developed and expanded in higher education settings,

then meaningful, pedagogically aligned, and logistically feasible assessments for student connectivity must be established. Only then will student connectivity and the impact of connected courses be documentable through educational research.

Overview of the Study

Connectivity is the ability of learners to connect their current thinking to their previous and others' experiences for the purpose of understanding themselves, their goals, and plans for the future. This study began to address the assessment of connectivity as it is demonstrated by VCU connected course students. It took the stance that assessment is documentation rather than measurement of learning and sought to capture the knowledge construction process as well as product. The study explored the notion that the uniquely digital aspects of the courses might be used to capture and document student connectivity. These findings were translated into the prototype for a toolkit of strategies meant to assist VCU faculty, staff, or students who seek to assess connectivity as a student performance measure or learning outcome. Based on a review of the literature, the decision was made to focus the study on the student use of annotations during blogging and tweeting, two common learning activities found in VCU connected course designs. Annotations are discourse devices included in the body of the digital text that serve an organizational or communicative purpose, directing or providing additional information about the main content of the text. Examples include hyperlinks, embedding codes, mentions, and hashtags added to blog posts or tweets (Kontopoulos, Berberidis, Dergiades, & Bassiliades, 2013). This study examined student use of annotation devices across four VCU connected courses by employing a combination of statistical, content, and network analyses. From these analyses, typologies for organizing, describing, and quantifying student use of annotations were created. Using an approach philosophically consistent with the field of social learning analytics (Ferguson

& Buckingham Shum, 2011), these findings were used to inform prototypes of assessment criteria, analytic dashboards, rubrics, and real-time graphic visualizations meant to document student connectivity in future connected courses.

Significance of the Study

Research suggests that assessment practices significantly impact the quality of learning in the classroom (Entwistle, 1996; Maki, 2010). Therefore, assessment practices should align with underlying pedagogical philosophies, frameworks, and instructional designs so that they support rather than undermine the educational messaging of the course (Black & Wiliam, 1998). Traditionally, classroom assessments in higher education have focused on the students' content acquisition (Cheng, Jordan, & Schallert, 2013). While these are useful to track student progress towards some learning goals, they cannot speak to student connectivity, which is an ongoing, highly individualized process of creating meaning, recognizing patterns, cultivating resources, and developing strategies for personal success. Traditional assessment strategies become problematic when learning processes, networking fluency, and individualized learning goals are privileged over mastery of specific and standardized course content (Ito et al., 2013).

This study advances VCU's agenda for connected courses in two ways. First, it proposes a concrete, operationalized understanding of connectivity as a desired learning goal or outcome for connected courses. The information provided within this study can be used to frame faculty development, instructional design, and pedagogical interactions with students. Second, it offers an array of alternative, potentially scalable assessment strategies that document acts of connection as students make them. These strategies align well with current trends in assessment reform, because they provide feedback that can be used to support peer- and self-assessment as well as instructor-driven formative assessment (Davies, 2010).

Summary of the Literature

VCU plans to promote digital fluency and integrative thinking through a distinctive blend of connected learning and open education (VCU Office of the Provost and Vice President of Academic Affairs, 2014). Connected learning is an emerging approach to instructional design that employs strategies of digital networked participation to encourage students to synergize personal interests, peer culture, and academic pursuits (Ito et al., 2013). Open education is a social movement, educational philosophy, and multi-faceted pedagogical approach that focuses on the potential for openly accessible digital technologies to promote high quality, democratic, sustainable, and scalable education (Veletsianos & Kimmons, 2012). The educational approaches overlap in several important ways, including the value they place on educational equality and access, digitally networked participation, self-determined and active learning, and authentic and relevant learning opportunities (Ito et al., 2013; Veletsianos & Kimmons, 2012). Furthermore, both assert the pedagogical value of connectivity, or the deeper learning that occurs when students form, document, and reflect on meaningful connections across concepts, people, contexts, and time (Kumpulainen & Seton-Green, 2014).

The act of pedagogical connection is a multistep, active process that follows the experiential learning model (Kolb, 2014). Students learn when they experience or form connections, reflect on them, critique and analyze them, and experiment with new connections that move them forward towards their learning goals. Learning occurs through social connection as described by social constructivist theories (Bandura, 1977; Vygotsky, 1980), research on communities of practice (Lave & Wenger, 1991), and personal learning networks (Downes, 2007). It also occurs when learners connect concepts as described in schema theory (Gruber & Voneche, 1977). Schema theory provides the theoretical foundations for such common pedagogical

practices as advanced organizers (Ausubel, 1968), concept mapping (Novak & Canas, 2008), and the spiral curriculum (Bruner, 1966). It also relates to the transformative act of information synthesis as described by Bruner (1996), Downes (2007), and Meyer and Land (2003). Finally, knowledge transfer occurs when learners are able to make connections across space and time, recognizing patterns and applying previously held knowledge despite different contexts, conditions, or passage of time (Bransford, Brown, & Cocking, 2000).

Connectivity is a complex mixture of content, procedural, and metacognitive knowledge that cannot be captured accurately by instruments that measure content acquisition (Cheng et al., 2013). Recently, connected and open digital scholars have called for educational assessment reform, citing the need to make all assessments of learning more instructionally integrated, process oriented, scalable, and student driven (Davies, 2010). Learning analytics, an interdisciplinary field that capitalizes on the digital traces of student online activity to assess student engagement, comprehension, and likelihood of student success, has emerged from this effort (Siemens & Long, 2011). Social learning analytics is a subfield of learning analytics that de-emphasizes the technical, highly individualized, often non-transparent algorithms of mainstream learning analytics research to focus on the open, social, and connective nature of digital learning spaces (Buckingham Shum & Ferguson, 2012). Of the five research methodologies emphasized in social learning analytics, two show promise as potential avenues for classroom assessment strategies: social network and discourse analytics. Researchers have used these techniques already to evaluate the relationships between digital connectivity and student outcomes such as deeper learning comprehension and self-regulation (Dawson, Tan, & McWilliam, 2011; Matsuzawa, Tohyama, & Sakai, 2014).

This study acknowledges that learning cannot be measured; rather it relies on philosophical, ethical, and epistemological arguments for reframing the research and pedagogical discourse around student assessment, from one of measurement and standardization to the documentation of student learning. It takes an approach consistent with the philosophies of social learning analytics by exploring student use of annotations as potential acts of connectivity in blogging and tweeting learning activities. To date, most research on digital annotations has been performed by the social media and business analytics communities as they seek to find scalable indicators of public perception. However, their work suggests that many of these annotations indicate users' desires to make connections with people or to other concepts (Black, Mascaro, Gallagher, & Goggins, 2012; Honeycutt & Herring, 2009).

Research Questions

The purpose of this study is to explore uniquely digital solutions for the task of assessing student connectivity in VCU connected courses. It is driven not so much by discrete and fixed research questions as by the idea of a question, divided into the following strands:

- How do learners use annotation devices, specifically hyperlinks, embedded images, mentions, and hashtags, while engaging in course-related blogging and tweeting?
    - How does their use vary across different connected courses and instructional designs?
    - How does their use relate to connectivity-based learning goals?
- How can documentation of student annotations be generated, translated, and displayed in ways that are meaningful and practical for providing student feedback and assessment? Specifically, how does student annotation and its documentation:
    - Differ between students to create a meaningful spectrum of student performance?

    - Lend itself to a pedagogical assessment toolkit, including analytic assessment dashboards, rubrics, assessment criteria, and digital graphic visualizations?
- How do these assessment strategies conform to published recommendations for 21st century digital assessments?

Design and Methods

This retrospective, descriptive, mixed-methods study explored data from four, eight-week long, fully online connected courses sponsored by VCU in the summer of 2015. Course-related blog posts (n = 1618) and tweets (n = 5343) were collected from course websites and Twitter API. Hyperlinked uniform resource locators (urls) and hypertext markup language (HTML) embedding codes were isolated from a sample of learner blog posts (n = 498). Hyperlinked urls, mentions, and hashtags were isolated from learner tweets (n = 3066). Statistical and qualitative content analysis were employed to demonstrate the connective qualities of annotations and to establish typologies for organizing, describing, and quantifying learner annotations. Network analysis provided alternative methods for visualizing and measuring hyperlink and mention use. These results were integrated and applied towards the development of analytic dashboards, rubrics, and graphic visualizations for the purpose of documenting and stratifying individual student connectivity and indicating potential areas for providing actionable feedback.

Researcher Bias and Assumptions

By my own and others' definitions (Costa, 2013), I am an emerging digital scholar. I blog about my research. I maintain a Twitter-based personal learning network. Previously, I designed and published on Twitter-based learning experiences and was involved in assisting with the design and implementation of one of the connected courses included in this study ("CC;" see Chapter 3 for details). While I acknowledge the validity of concerns about unequal access, power, and

personal security within open digital learning spaces (see Gourlay, 2014; Knox, 2013), a comprehensive critique of these issues lies outside the scope of the current study. This study aims to provide pragmatic support for the position of the VCU QEP (VCU Office of the Provost and Vice President of Academic Affairs, 2014), which carries an underlying assumption that open digital scholarship is a valuable pedagogical activity.

The research presented in this study is messy, in the sense that it interrupts and exceeds the tidy categorizations of research designs and methods (Lather, 2006). Furthermore, its design is emergent, because formal institutional definitions of connectivity and connected courses do not yet exist. Even the informal understanding of these constructs among the engaged VCU faculty and staff continues to shift in the face of ongoing innovation and the growing collective experience. Therefore, I approach this study as an essential but also essentially fluid design task, undertaken with the acceptance that it will challenge the typical frameworks and standards associated with dissertation research in the institution which supported it. I designed and implemented this study with the information and criteria available to me in the moment, open to whatever worked in terms of epistemologies, methodologies, and methods. Therefore, I offer this work as my attempt of what Collier and Ross (in press) describe as a "fruitful mess, born of dwelling in radical and enduring uncertainty and the acknowledgement of the need for complexity in educational research."

Definition of Terms

Animated .gif: A variant of a graphic interchange format (gif) file, often used on the World Wide Web to provide moving images. The format supports multiple frames that give the impression of motion when displayed in sequence, like an animated cartoon or flipbook.

Annotation: A discourse device that provides communicative or organizational intent for the content to which it is attached. Annotations associated with blogging include tags, categories,

hyperlinks, and embedding code. Those associated with Twitter include but are not limited to hyperlinks, mentions, hashtags, hat tips, and retweets.

Application: A computer program designed to complete a specific task, also known as an "app."

Application Programming Interface (API): A web library or interfacing tool that allows one piece of software or app to talk with another. The APIs associated with social media platforms store digital traces of user activity in public and easily retrievable formats.

Blog: A frequently updated website that consists of thematically related content ("posts") typically created by one person. Blogs are a form of social media and different from other forms of single-author websites because they typically allow readers to comment on posts. This leads to potential interaction between or among readers and the author. Most blogging platforms support text, animated and still image, video, audio, and hyperlinked content.

Bloggregate: An institution-specific term that refers to the feed of course-related blog posts created by the RSS feed on a connected course website. The bloggregate is the webpage or feature on which all finished blogging assignments can be viewed together. It is useful for efficient reading, commenting, and assessment.

Bot: An Internet bot, short for robot, is a software application that runs automated tasks over the Internet. They are most frequently used for web spidering, in which an automated script fetches, analyzes, and files information from web servers.

Connected courses: An institution-specific term used to indicate the type of course settings in which these assessment strategies would be used. VCU connected courses exist in a variety of disciplines, course formats (web-enhanced, hybrid, and fully online), and for undergraduate and graduate students. A full description of connected courses can be found in Table 1 (Chapter 2).

Connectivity: The ability to form, reflect on, analyze, and make decisions based on connections with people and across concepts, space, and time.

Course Hashtag: A specific annotation device added to course-related messaging so that it can be aggregated and visualized by all course participants.

Diigo: A public social bookmarking platform that allows individuals or groups of individuals to curate and comment on web-based documents.

Electronic Portfolio: A collection of digital documents that demonstrates the creator's abilities or activities over time. Also known as e-portfolios or digital portfolios.

Embedding Code: Code that allows for data from another source to be stored in a different file without a connection to the original source file. In this study, embedding code was most commonly used to insert images, videos, audio files, or .pdf files into blog posts.

Hashtag: A digital annotation system found on a variety of social media platforms including Twitter, Instagram, and Facebook. It involves the use of the pound sign (#), followed by a short phrase or statement (e.g. #blacklivesmatter). When a hashtag annotation is included in a social media post it allows the content to be aggregated and visualized with other posts including the hashtag regardless of the author.

Hyperlink: Code which allows for the connection between a specific location within a website or post (typically a word, phrase, or image) and another web document. The data that is linked remains in its original location and is accessed either by opening another window or movement to the other website address.

Learning Management System ("LMS"): A software application for the administration, documentation, tracking, reporting and delivery of e-learning education courses or training

programs. Unlike the open web, almost all LMSs are accessible only to people who have permission or are registered within the system.

Massively Open Online Course (MOOC): A term created by Cormier (2008) to describe *CCK08*, a course designed and implemented by Stephen Downes and George Siemens for the University of Manitoba in 2008. MOOCs are courses that are characterized by unlimited enrollment ("massive"), public and cost-free accessibility ("open"), and web-based instructional formatting ("online"). They may or may not be associated with educational institutions or academic credit.

Meme: An imitable item or ritual that projects cultural ideas, symbols, or practices. An internet meme is a picture annotated with text that has achieved widespread recognition and transmission.

Mention: A digital annotation system found on Twitter that involves including another Twitter user's handle (e.g. @username) within a tweet. The use of a mention automatically notifies the other person that the tweet was published. Mentions are the basis for the social media-based social interaction mapping performed through social network analysis.

Ram Pages: VCU campus publishing platform; an open source, public WordPress installation on which all students, faculty, and staff are encouraged to register at least one website to support personal, organizational, or formal academic interests. The site supports many of the course websites and student blogsites used in the context of connected courses.

RSS Feed: Although technically an abbreviation for "Rich Site Summary," it is most frequently associated with the phrase, "Really Simple Syndication." It uses standard web feed formats to automatically publish frequently updated and distributed information such as blog posts or news headlines. RSS feeds enable course bloggregates to exist.

Selfie: A self-portrait taken with a camera phone held in the hand or supported by a selfie stick.

Social Learning Analytics: A term coined by Ferguson and Buckingham Shum (2011) to describe a subset of learning analytics meant to capture, organize, and demonstrate the inherently social, open, and connective aspects of networked participatory learning.

Twitter: A public social media platform on which users "tweet" messages of up to 140 characters. Messages can include text, hyperlinks, images, or video and any number of socially normed annotation systems and devices, including mentions, retweets, hat tips, and hashtags (see Table 2, Chapter 2). Users identified by Twitter handles (e.g. @username) can view their own tweets on their profile page or the tweets of those they follow on their timelines.

Uniform Resource Locator (URL): The multi-part web address of a stored digital file or document. It can be broken down into the protocol (i.e. "http"), the server and domain names (which usually indicates the organization or agency responsible for the information), and the resource ID and file type (which usually indicates the specific webpage or unit of information being accessed).

Chapter 2

The development of assessment strategies requires a comprehensive understanding of the pedagogical contexts as well as the qualities of learning being assessed (Maki, 2010). This chapter seeks to address these requirements, but in doing so becomes something more than a review of the existing educational research literature. This study focuses on developing assessment protocols for VCU connected courses, a pedagogical context that transcends that which has been researched. The pedagogical approaches used in these courses are still being developed, and our understanding of the associated student experience is still emerging. Much of what is written in this chapter about the pedagogical contexts and learning practices that need to be assessed signifies a series of stakes in the sand – informed yet tentative definitions offered so that work can progress. This in not to say the descriptions of educational philosophies, course designs, learning outcomes and constructs that are provided are not without theoretical or practical foundation. In fact, what is described here aspires to represent praxis, the physical embodiment of connections made across diverse bodies of educational theories and research literature.

This chapter is divided into three sections. The first draws from connected learning, open education, and current VCU faculty practice to describe the pedagogical contexts for the assessments this study aims to develop. The second section delves into theories of experiential, social, connectivist, constructivist, and constructionist learning to explain the nature of connectivity, the core learning construct this study seeks to assess. Finally, a social learning

analytics lens is applied to what is already known about the learning activities used in connected courses to provide the necessary background to explain the approaches employed in this study.

Connected Learning for a Networked World

The VCU Quality Enhancement Plan (QEP) supports research and development of pedagogy that facilitates "connected learning for a networked world" (VCU Academic Transformation Lab, 2014). However, the meaning of this tagline and the intersection between connected learning and open education that it represents are deceptively difficult to define. Connected learning and open education are distinct fields of educational research, advocacy, and practice that evolved in different times, geographic regions, and professional sectors. Connected learning was organized in the late 2000s, emerging from mostly U.S., elementary and secondary educational interests (Connected Learning Alliance, 2015). Much of the research associated with it arises from sociology, digital humanities, and communication science fields, and its practice frequently focuses on instructional design for the informal learning spaces of adolescents (DML Research Hub, 2015). In contrast, open education was established during the widespread open and distance learning higher education initiatives of the 1970s. Its global presence is supported predominantly by educational technology and distance education research that focuses on the accessibility, sustainability, and scalability of educational resources (McConnell, Hodgson, & Dirckinck-Holmfeld, 2012).

Despite their differences, connected learning and open education are propelled forward from and by a digitally networked participatory culture. As such, they share core assumptions about the value of educational equality and access, digitally networked participation, self-determined and active learning, and authentic and relevant learning experiences (Ito et al., 2013; Veletsianos & Kimmons, 2012). The intersection VCU seeks to explore lies within these core

assumptions. This section explores what it might mean to provide "connected learning for a networked world" at the levels of theory, design, and practice. Connected learning and open education approaches will be described separately before the VCU approach is presented as a unique synthesis of the two.

Philosophical approaches. Connected learning and open education are considered approaches to teaching and learning rather than specific templates for instructional design (Ito et al., 2013; Pearce, Weller, Scanlon, & Ashleigh, 2010). While they share similar values, the two educational approaches apply these concepts differently and with different results. Matters are further complicated by the ill-defined nature of open education, which spans multiple facets of pedagogy and the academic profession; not all open educators share the same understanding of their field, even on such fundamental issues as the definition of "open" (Veletsianos & Kimmons, 2012). This section seeks to respect the differences between and within the connected learning and open education communities, while focusing on the nuances (shared and separate) that impact the VCU pedagogical approach the most.

Connected learning. In the late 2000s, the John D. and Catherine T. MacArthur Foundation funded the organization of a network of research, educational, and advocacy organizations called the Connected Learning Alliance. Its purpose was to design and advocate for the use of digital technologies in ways that improved educational equity and opportunity for all young people (Connected Learning Alliance, 2015). Citing the large body of educational literature linking student engagement to retention and success, the network's research branch, Digital Media Lab (DML) Research Hub, defined its task in terms of improving student engagement in academic environments. Previous research demonstrated that engaged students feel a sense of belonging and perceive their education as relevant to their current and future goals; thus, DML Research Hub

focused its efforts on developing inclusive learning environments that foster these qualities (Ito et al., 2013).

Connected learning scholarship characterizes inclusive instructional designs as those which facilitate diverse pathways to academic success and provide multiple entry points for student engagement or re-engagement along the way (Ito et al., 2013). It argues that diverse pathways to success emerge when educators and students begin to value, discuss, and incorporate student agency as well as student hobbies, passions, and peer activities into formal academic or professional environments. Connected educators help students explore, develop, and drive their own "learning lives," the compilation of informal and formal learning experiences that makes up the student's learner identity. They believe that the recognition and validation of these holistic learner identities lead more students to higher levels of engagement, sense of empowerment, and lifelong learning (Kumpulainen & Seton-Green, 2014).

Connected educators describe their approach as a form of progressive education for the digital age (Connected Learning Alliance, 2015). They cite Dewey (1916/1989) and Montessori (1912/2013) as inspirations who valued the pedagogical qualities of student choice, experience, and purposeful social interaction. Dewey framed experiential learning through a process of free inquiry; his students learned through designing, executing, and analyzing the results of their own experiments. These experiments were situated in the problems and practices of everyday living, because "every subject gives an opportunity for establishing cross-connections between the subject matter of the lesson and the wider and more direct experiences of life" (Dewey, 1916/1985, p. 191). Similarly, Montessori's (1912/2013) learning environments allowed students to move freely through a variety of concrete, authentic learning experiences in the presence of mixed-aged

classmates. The heterogeneous nature of social interaction provided opportunities for informal mentoring relationships to emerge, stimulating even greater discovery learning among all students.

Connected learning scholars are cognizant of and open to using digital technologies, even if they are not entirely dependent on them (Garcia et al., 2014). Ito et al. (2013) wrote that digitally networked spaces offer powerful opportunities for connected learning by supporting diverse avenues for creative self-expression; increasing access to information and additional learning experiences; and providing social support for more types of students, including those who historically have been marginalized or disadvantaged in formal academic settings. Therefore, digital technologies are seen as powerful, but neither essential nor driving, tools for connected learning.

Open education. The Open Education Consortium (2015) defines open education as "resources, tools, and practices that employ a framework of open sharing to improve educational access and effectiveness worldwide" (para. 2). Open educators are interested in all aspects of equitable and accessible education including the optimization of course locations, timing, formats, and costs of educational materials and programming (McConnell et al., 2012). The emphasis on sharing content correlates to the prominence of open educational resources (OER) in the research and development agenda of open education. In 2000, UNESCO formally defined OER as materials that are made available in the public domain or under an open license with the capacity for reuse, remixing, and redistribution (Yuan et al., 2008).

Since its inception, open education has been tied closely to digital technology as the pathway towards sustainable and scalable education (McConnell et al., 2012). Although the assumed relationship between open and digital has triggered recent criticism (e.g. Gourlay, 2014; Knox, 2013), the digital world remains the predominant environment for scholarship in open

education. The relationship between open and digital can be interpreted as historical and practical, but a philosophical connection also exists between the two. The connection is most explicitly displayed in the open education literature on emergence technologies. These open education scholars interpret technologies broadly to include all human-derived tools, from culture to pedagogy to digital networks. They build on the work of digital pioneers such as Engelbart (1963) who argued that humans and their technologies co-evolve, shaping even as they are shaped by each other. Thus, emergence technologies are those that co-evolve with the humans and the world around them. They exist in a perpetual state of "coming into being," shifting in concert with the realities around them. Emergence technologies are not necessarily new, but have not yet been fully researched or reached their assumed potential (Veletsianos, 2010). The open educators who study emergence identify digital networks and digitally-situated pedagogies as emergence technologies. They argue that the rapid and abundant information storage, retrieval, and flow through digital networks are altering human action, thought, and learning (Siemens, 2004). Therefore, the integration of the digital into formal learning environments is not optional, but instead an assumed requirement of higher education. Without it, formal learning environments would become irrelevant to the world in which it exists (White, Connaway, Lanclos, Hood, & Vass, 2015).

Many open educators draw from social constructivists as a theoretical basis for scholarship and practice (Couros, 2010). This umbrella term conveys a cluster of learning theories, pedagogical frameworks, and instructional practices that identify social interaction as a key catalyst for learning. Significant social exchanges for knowledge construction include relationships between individuals; interactions between individuals and cultures, societies, and institutions; and interfaces between individuals and socially derived tools such as language and

other technologies that allow for the documentation and sharing of thoughts (Bruner, 1966; Lave & Wenger, 1991; Vygotsky, 1980).

When connectivism was first described in the mid-2000s, some open educators began to use it to augment if not replace their social constructivist foundations. Connectivism was developed specifically for the networked learning found in digital spaces (Downes, 2006; Siemens, 2004). Connectivists argue that previous learning theories such as behaviorism, cognitivism, and constructivism fail to accommodate the rapidly shifting realities and organizational learning that takes place in networked societies (Siemens, 2004). They describe learning as a networked process on at least three levels: the physical neural network of dendrites and synapses, the internal conceptual network of schema and heuristics, and the external social network of human and non-human information sources (Downes, 2006). Drawing on chaos (Gleick, 1987) and actor network (Barbarasi, 2002) theories, connectivists believe that the creation, preservation, and utilization of information flow (i.e. "workflows") within each level of networks is more important than the specific content of learning. Therefore, pedagogical approaches should seek to help learners develop the capacity to make decisions about filtering, curating, and connecting pieces of information within the rapidly changing environment around them. Only then will students exhibit resiliency and innovation in the face of constant uncertainty of emergence (Siemens, 2004).

Design and practice. Because they are educational approaches rather than specific pedagogical strategies, connected learning and open education can be designed and implemented in a variety of ways. However, these experiences remain identifiable as such through the presence of key characteristics established in published frameworks and models. In the case of connected learning a formal pedagogical framework exists, published as part of the DML Research Hub's agenda for connected learning research and instructional design (Ito et al., 2013). In the case of

open education descriptions of open teaching (Couros, 2010) and connectivist-Massively Open Online Courses (c-MOOCs; Cormier, 2008) provide guidance for open educational practice. This section reviews these frameworks and guidelines and provides examples of how they are sometimes applied.

Connected learning. In 2013, DML Research Hub published a pedagogical framework for connected learning (Figure 2), consisting of three learning principles and three design principles. Core learning principles emphasize the diverse spaces in which youths learn, while the design principles identify specific approaches or strategies for inspiring deeper, more engaged learning. The learning principles, which include "interest-powered," "peer culture," and "academically oriented," are phrased to remind educators how the individual spheres of learning can be tapped to enhance overall learning. Interest-powered refers to the correlation between student engagement and learning activities that relate to a student's personal interests, hobbies, or other "fun" activities. Peer culture encourages educators to remember that peers are influential sources of information and feedback. Finally, academically oriented reminds educators of the overall goal of their inclusive and connected instructional designs: to channel student-centered activities into learning experiences with academic, professional, and civic merit (Ito et al., 2013).

The design principles, which include "production centered," "shared purpose," and "openly networked," refer to experiential, social, and networked learning, respectively. In production centered activities, students actively produce things or experiences for an authentic audience or that meet a real identified need. Shared purpose refers to the power of learning communities, which are collaborative work groups that share a common purpose or goal. These groups work best when participants have heterogeneous skill sets or levels of expertise so that informal mentorships can emerge across a variety of related topics (Wenger, 2000). Ito et al. (2013)

present both of these through a digital lens, highlighting the potential uses of digital space for self-expression and social interaction. However, of the three design principles, openly networked is the closest aligned to digital pedagogies, because it refers to the ability of open digital tools to increase learner access to more diverse information sources across settings (Ito et al., 2013).

Ito et al. (2013) clearly states that connected learning does not have to take place in digital environments. Nevertheless, connected learning scholars, including Ito et al. (2013), use digital learning spaces almost exclusively to discuss the openly networked design principle in practice. Most frequently, it is described in the context of personal learning networks (PLNs), a connectivist-based approach to online learning that empowers students to foster or maintain social networks across decentralized digital platforms (Downes, 2007). PLNs can be described in terms of the people, digital platforms, or workflows that create them (Cormier, 2010). Figure 3 provides a basic representation of a student's PLN through the lenses of people and platforms.

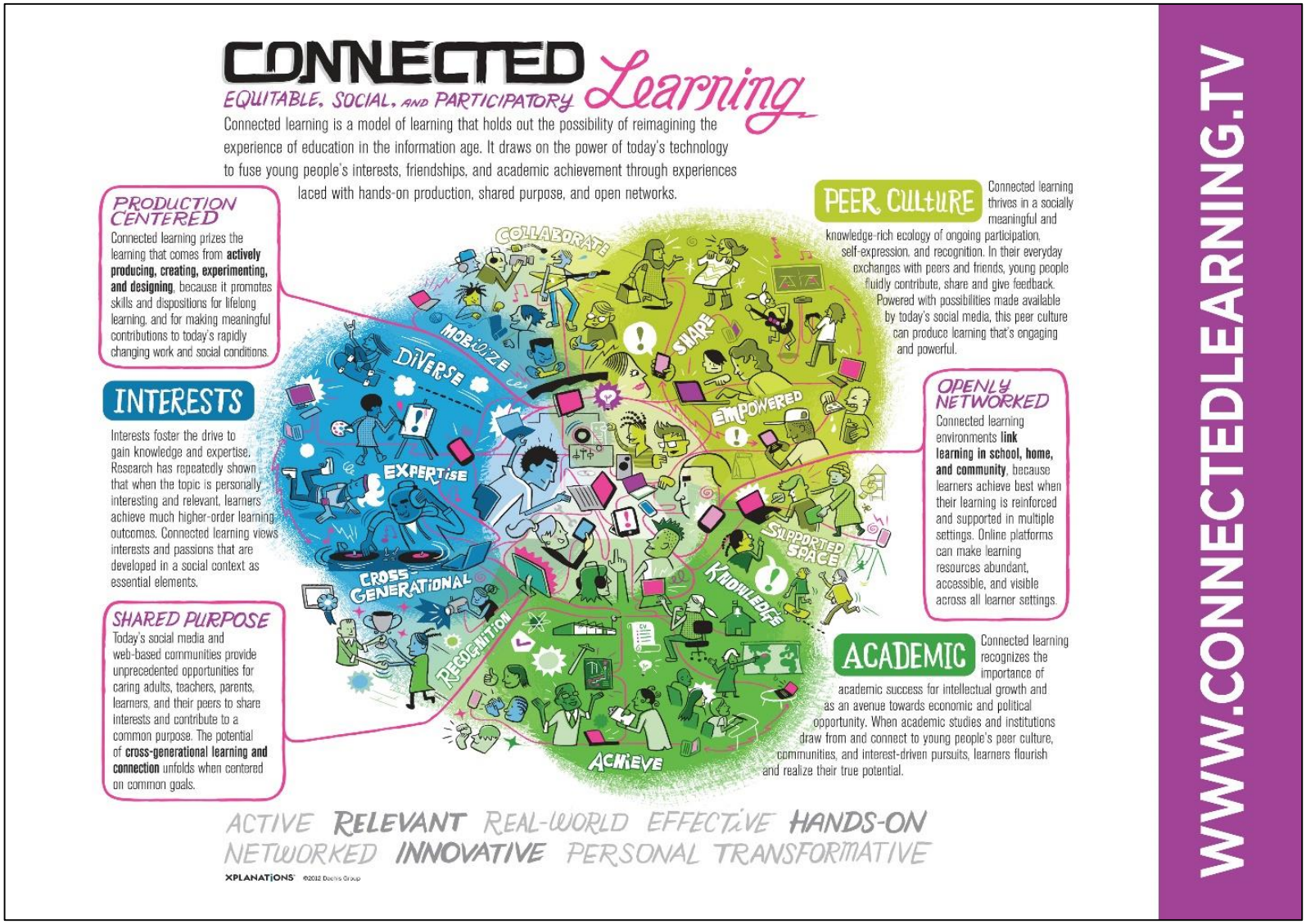


Figure 2. Connected Learning framework, as described by the Connected Learning Alliance. Licensed under Creative Commons Attribution 3.0 (http://creativecommons.org/licenses/by/3.0)

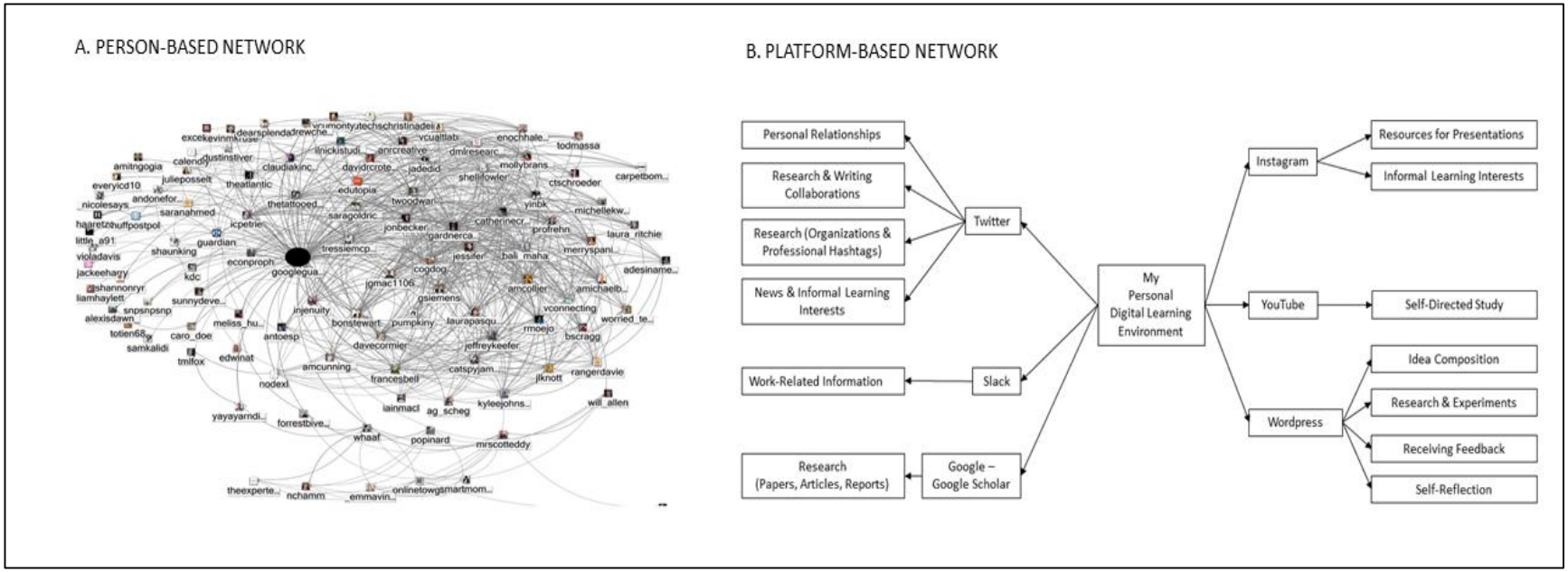


Figure 3. Personal learning network through two lenses. On the left ("A") a sociogram derived from a social network analysis demonstrates the relationships between a student (designated by the large black dot) and other participants on the social media platform, Twitter. On the right ("B") the same student represents her pedagogical use of multiple digital platforms.

PLNs differ from learning management systems because they are student- rather than course-focused and represent connections across a variety of formal and informal learning contexts ("openly networked"). Because the PLN belongs to the student rather than the educational institution, the social and knowledge capital developed through the network remain with the student between courses and after graduation (Cormier, 2010). Connected learning scholars are particularly interested in PLNs as opportunities for students to connect with people from different contexts. These social networks provide connected educators, mentors, and interested peers with the chance to broker learning opportunities, or introduce students to other people who can provide learning experiences, social connections, or pertinent information and knowledge (Ching, Santo, Hoadley, & Peppler, 2015).

Open education. Unlike connected learning, open education does not have a single published pedagogical framework. However, there are two complimentary constructs commonly used to inform open education practice. The first, open teaching, emphasizes the advocacy aspect of open education by describing methods through which instructors can promote openness and open values with their teaching. Open teachers model the use of open educational resources and open source tools when feasible. They also talk with students about open licensing, open digital scholarship, and the value of collaborative gift cultures for the purpose of establishing the value of transparent, collaborative, and social learning (Couros, 2010).

The second construct consists of the pedagogical strategies still emerging from c-MOOCs. The first c-MOOC took place in 2008, conceived and implemented by the scholars who first described connectivism, Siemens (2004) and Downes (2007), and supported by the University of Manitoba in Canada. Although it was not the first large online course or open online course, *Connectivism and Connected Knowledge* (CCK08; http://cck11.mooc.ca/) was one of the first to

combine academic credit with an openly networked learning environment. Over 2200 participants engaged in CCK08 learning activities, 24 of which were tuition-paying, credit-seeking University of Manitoba students. According to its instructors, the course was "not simply about the use of networks of diverse technologies; it [was] a network of diverse technologies" (Downes, 2008, para.2). Initially, CCK08 involved the use of three digital platforms: a course website that housed course materials and documents, announcements, and an aggregated course blog post feed (what would be called a "bloggregate" at VCU); individual student blogsites; and an open source application that facilitated collaborative concept mapping. By the end of the course, students and instructors had added ten additional digital platforms, such as an openly sourced learning management system and wiki space, to facilitate learning activities that the students conceived of themselves (Fini, 2009). CCK08 continued to run through four iterations and spawned many similarly designed courses across a variety of audiences and educational sectors. Downes eventually designated courses with this design as "c-MOOCs," to differentiate them from the "x-MOOCs," which were developed by organizations such as Coursera and EdX and possessed a more traditional, content-driven instructional design (Bates, 2014).

C-MOOCs were conceptualized to help students improve digital fluency, grow their PLNs, and establish digital workflows that facilitate information filtration, critique, organization, and repurposing (Siemens, 2004). The (not uncontested) assumption of c-MOOCs is that students will begin to develop digital mindsets and practices when they are surrounded by too much content distributed across too many platforms for anyone to master (Kop, 2011). Instructors scaffold the development of the necessary dispositions and skills by designing learning activities that involve the following:

- *Establishing a personal learning network (Engaging).* Learners are often asked to establish a digital presence if they do not already have one. Typically, this includes a personal blog site and at least one other social media account to use for completion of course activities. These accounts belong to the learners and can be used outside or beyond the context of the course for the purpose of sustaining a personal learning network (Dede, 2009; Downes, 2006; Kop, 2011).
- *Curating, critiquing, and organizing data (Aggregating).* Learning activities require students to access, organize, and retrieve web-based information. The quantity of information available encourages them to create personal strategies to perform this work, including but not limited to using RSS feeds, bookmarking, or tagging, or similar annotation systems (Dede, 2009; Downes, 2006; Kop, 2011).
- *Connecting or coordinating concepts over space, time, and spheres of learning (Remixing).* Typically, learners engage in reflection and sensemaking activities on personal blogs. Synchronous or asynchronous discussion takes place as comments on blog posts, discussion forums, social networking forums such as Facebook or Twitter, or wiki spaces (Dede, 2009; Downes, 2006; Kop, 2011).
- *Transforming data into new products (Repurposing).* Learners create new products based on the data they collect. Sometimes these products take the form of traditional essays or research papers, but more frequently they include the production of videos, images, podcasts, animation, music, or other forms of creative expression so that students are encouraged to develop transmedia literacy skills (Dede, 2009; Downes, 2006; Kop, 2011).

- *Sharing new products with the personal learning network (Feeding Forward).* Learners share learning products with others through effective use of their personal learning networks (Dede, 2009; Downes, 2006; Kop, 2011).

Putting it all together: The VCU connected course. Like all connected learning and open education learning experiences, the VCU connected course is highly situated and molded by the needs and conditions of the institution, instructors, and students. However, these courses embody an underlying set of values, strongly reminiscent of those found in progressive education, social constructivism, and connectivism. VCU connected courses are guided by the connected learning framework, the principles of open teaching, and the experiences of c-MOOC designers. Yet, the nature of the VCU context – the fact that VCU is seeking an institution-wide approach for inclusivity, relevance, and meaningfulness in a formal, higher education environment – makes it distinct from exemplars.

Philosophical approach. VCU faculty have blended the educational approaches of connected learning and open education to promote their own version of educational equity and accessibility, active and social learning, and digitally networked participation. The VCU approach aligns with connected learning and its focus on improving student engagement through more compelling, inclusive, and relevant learning experiences for more students. It interprets educational relevance through both connected and open lenses: courses should facilitate the integration of informal and formal learning and recognize the co-evolutionary, emerging, and augmenting qualities of digital networks and technologies. VCU emphasizes digital learning as active, social, creative, and authentic learning and encourages students and faculty to elevate their digital fluency in terms of developing personal learning networks and digital workflows for the purpose of lifelong learning in a digital age.

Course design. Like c-MOOCs, the VCU design has evolved and continues to evolve with practice. The first VCU connected course took place in the summer of 2014. *UNIV 200: Inquiry and the Craft of Argument* (known more widely as "Thoughtvectors") was an eight-week long, academic credit-bearing, open course that aimed to promote digital engagement and writing skills through study of new media and Internet history. Ninety-five VCU undergraduates were formally enrolled across six sections of the course. They joined over 500 open participants in course activities that included engaging with OER, Internet pioneers (via open video communication platforms), and group discussion via blogging and tweeting activities. The students had personal websites, which were networked together (via RSS feed into a bloggregate) at the section and course levels (Gogia, 2015).

Since Thoughtvectors, more than a dozen connected courses have been designed and implemented at VCU. From these experiences, shared themes related to pedagogical strategies and tools have taken shape. Table 1 represents these strategies in the form of a classification system that aims to help VCU instructional designers talk about connected courses with interested faculty. The first row represents the minimum criteria required to be called a VCU "connected course." Beyond the first row, the columns operate independently from each other. While the range of "minimum" to "more" implies a value judgement, it is only meant to assess the level of "connectedness" and not the overall quality of the course; the instructor, resources, students, learning goals, and discipline of study all play roles in finding a desired level of connectedness. For a variety of reasons, some courses fit better with higher levels of connectedness than others.

As demonstrated in Table 1, VCU connected courses can be described along five related yet distinct spectra:

- *Online presence*. To be classified as a connected course, the Internet must play some role in formal learning activities, in ways in which the instructor can observe and provide feedback on a student's digital practice. At minimum, a course must be "web-enhanced." Courses with higher levels of online presence carry labels of "hybrid," "blended," or "fully online."
- *Openness.* Connected courses model open practices along a spectrum. At baseline, the course syllabus and documents (i.e. information about the schedule, learning activities, and rubrics for assessment) should be made public. Mid-level courses are more inclusive, using open educational resources and open source tools as much as possible. The most open courses have mechanisms for concomitant open enrollment, similar to Thoughtvectors or CCK08.
- *Digital expression.* Connected and open educators value creative digital expression. At VCU, students in connected courses are required to blog, mostly in public, though students always have the choice of using pseudonyms, making some posts private, or completing other, non-connected courses. The remainder of the column speaks to the inclusion of learning activities that require increasingly complex levels of digital expression.
- *Participation.* Active and social learning are important. The levels in this column relate to increasingly time-intensive, digitally-situated, and socially complex forms of communication. At baseline, students provide peer-feedback on blog posts. Mid-level courses require students to participate in crowdsourcing activities or more intensive forms of social interaction. In these settings, students must demonstrate digital expression beyond the act of commenting.

Table 1.

Proposed VCU connected course design framework

CONNECTED COURSE	ONLINE PRESENCE	OPENNESS	DIGITAL EXPRESSION	PARTICIPATION	STUDENT AGENCY
Minimum Criteria	Web-Enhanced	Course syllabus & documents housed on public website	Students blog publicly	Students comment on each other's blog posts	Students retain ownership of course materials and learning products (individual & group) after the course
	Hybrid & Blended	Required materials (e.g. readings, digital tools) are open access/sourced.	Students are asked to use multimodal expression in their blog posts	Students work together to curate the web (crowdsourcing)	Students contribute to the course learning materials
			Students are asked to generate their own multimodal creations in their blog posts	Students engage in synchronous or partially synchronous class discussion (e.g. Twitter, Facebook, Discourse)	Students are able to adapt learning activities & products to their personal learning goals
More Connectedness	Fully Online	Open participant course enrollment is encouraged	Students are asked to create and demonstrate digital workflows across digital platforms	Students engage in collaborative projects	Students participate meaningfully in their own assessment

Courses with higher levels of digital participation are also more likely to engage students in cooperative or collaborative learning with more or more diverse groups of people. Highest levels of connected participation involved the formation of formal affinity groups to work towards collaborative projects. Often times these projects not only require students to negotiate more complex social interactions, but also more digital platforms as they move between process of curation, discussion, and creation.

- *Student agency.* Student agency refers to student ownership over the learning products, experience, and performance evaluation. In every connected course, students maintain possession of built-up knowledge and social capital; students maintain their own blog, and since all course materials are maintained on a public website, they can access any collaborative knowledge construction after the course is over. Mid-level courses require students to actively contribute to the educational resources of the course (usually through crowdsourcing or collaborative processes) and employ "interest-powered" strategies of connected learning. Finally, highly connected courses require students to practice self- and peer-assessment in ways that will advance their reflective and critical thinking skills while making them responsible for their own learning.

Pedagogical activities: Blogging. The only pedagogical activity that must be incorporated in a VCU connected course is public blogging. Blogs have been defined as a "diary of thoughts, ideas, and innovations…which is published on the Internet" (Goyal, 2012, p. 1). Like paper-based reflective writing, public blogging allows students to engage with and reflect on course content,

process, and their personal reactions to either or both. However, it also offers several uniquely digital affordances for learning.

- *Public writing.* When students write in public, they engage more fully with the concept of writing for an audience. Furthermore, the commenting feature of blogging allows for peer as well as instructor feedback on work (Deng & Yuen, 2011).
- *Embedded, multimodal expression.* Blogging allows students to embed images, video, animations, audio tracks, and other documents into their writing. This provides additional opportunities for creativity, illustration, metaphor, imagery, and development of aesthetic sensibilities (Yancey, McElroy, & Powers, 2012).
- *Hyperlinking.* Hyperlinks connect the main content of the post with other web documents to provide source, background, or supportive information (Gao, Li, and Zhang, 2012). In the context of e-portfolios, Yancey (2004) found that as students order and re-order, link, unlink, and relink their learning points and accomplishments, unexpected patterns and connections emerge across academic achievements, professional pursuits, and personal interests.
- *Categories and tags.* Tags and categories are organizing systems that allow bloggers to label, order, or filter and provide options building narrative and forging connections across posts (Efimova & DeMoor, 2005.)

Pedagogical activities: Tweeting. The use of Twitter is a common but not required element of the VCU connected course. Twitter is a public digital platform that supports microblogging, a short form of blogging that allows for abbreviated expressions of ideas, opinions, or events. Participants can microblog, or "tweet" up to 140 characters in text, video, images, or hyperlinks (Twitter, 2014). Tweeting as back channel form of communication has been documented in a wide

range of social contexts from natural disasters to sporting events (Black et al., 2012). In educational contexts, tweeting often facilitates similar back channel action, inviting sustained and synchronous student interaction, providing documentation of ongoing learning processes and events, and encouraging participation, reflection, and collaboration (Gao, Luo, & Zhang, 2012). Symbols, abbreviations, lingo, annotation systems, and other socially negotiated norms have emerged within Twitter in part because of its strict limitations on the use of text.

Table 2 offers a select guide to the main structural components and annotation systems found in Twitter. A digital annotation is a type of discourse device that contextualizes, directs, or comments on the main body of the content (Cousins, Baldonado, & Paepcke, 2000). Because they play a significant role in how learners interact with each other on Twitter, certain annotations warrant further description.

- *Hyperlinking.* Hyperlinks work the same in Twitter as they do on blogging platforms, although they can look different. Depending on the content of the hyperlink, the digital device being used to view Twitter, and the specific type of Twitter application (e.g. desktop or mobile), hyperlinks may look like visible urls or embedded documents. Research from social media and business analytics research suggests that users employ hyperlinks in tweeted discussions to support arguments, provide additional information, or offer examples (Black et al., 2012).
- *Mentioning.* When tweeters "mention" other users by adding their Twitter handles to a tweet, it not only deploys the tweet to the Twitter stream for all followers to see, but also signals the mentioned users (in their notification column) that they were mentioned. Honeycutt and Herring (2009) found that as many as 90% of mentions indicated a desire

for social interaction, with mentions being much more likely to initiate threaded discussions than tweets without mentions.

- *Retweets.* Retweets (indicated by the use of "RT" or through the use of the RT button, which automatically adds the "RT") copy and deploy another user's tweet through the network of the retweeter. Although retweeting is a form of signal amplification, research suggests that it can indicate a variety of motivations, including the desire to propagate information, announce a listening presence in a conversational space, allow other followers to follow a dialogue, return or gain favor, or offer positive feedback (Black et al., 2012; boyd, Golder, & Lotan, 2010; Huang, Thornton, & Efthimiadis, 2010).
- *Hashtags.* When tweeters use hashtags (#) in front of a topic, phenomenon, or event, the tweet is aggregated to a timeline devoted to all tweets that include that hashtag. This facilitates discussion around a subject among Twitter users regardless of follower-following status (Huang et al., 2010). In educational contexts, a predetermined course hashtag allows all students to participate in course-related discussion, similar to that found in other online discussion forums.

Table 2.

Introductory guide to Twitter

Twitter Symbol	Twitter "Lingo"	Meaning
Structural Components		
@	Handle	The identification or account name of the tweeter (e.g. @GoogleGuacamole). Accompanied by an avatar (image) of the user's choosing
--	Profile	Customizable page that allows the tweeter to share (usually autobiographical) information and avatar. Tweeters use this page to access a record of their own tweets as well lists of other users that follow them, users they follow, and lists of tweets they favorited
--	Followers	The other users who chose to follow the Tweeter. Followers will see all the tweeter's tweets in their streams.
--	Following	A list of the users the tweeter has chosen to follow. All of these users' tweets will appear in the tweeter's stream.
	Timeline	The dynamic "home" of the tweeter, showing in real time the tweets of those who the tweeter follows. The timeline is also known more informally as the tweeter's stream.
	Notifications	The alert page that notifies tweeters when their tweets are favorited, retweeted, or receive a reply. Also informs tweeters when other users "follow" them or "mention" them in a tweet. Some tweeters choose to have their notifications forwarded to email accounts
Annotation Systems		
#	Hashtag	The tweeter constructs a tweet that includes a hashtag followed by text (e.g. #vcudiglit15 or #dissertationproblems). All tweets that include the "hashtag" are aggregated on separate pages so that users can follow a stream of tweets about this topic. In academic environments, hashtags are often used to indicate course (e.g. "Thoughtvectors") or conference names (e.g. "ELI2015").
	Retweet (RT)	The tweeter shares another user's tweet with his/her followers. They may edit the tweet prior to retweeting it. Notification is automatically sent to the original tweeter that the retweet occurred.
--	Hat Tip (HT or Via)	The tweeter acknowledges where (typically another user) he/she received the information or link that he/she is about to share with followers.
@	Mention (MT)	The tweeter constructs a tweet that includes the Twitter handle of another user. The tweet is public and appears in the tweeter's stream, but it also appears in the mentioned user's notification column, increasing the possibility that he or she will see it.
Other User Actions		
	Direct Message	The tweeter contacts another user privately. These messages are curated in the "Message" page, similar in function to the "Notifications" page.
	Favorite	The tweeter acknowledges a tweet in his or her stream without adding additional comments. The "favorited" tweet is not shared with the favoriter's followers (in other words, the signal is not amplified), but the original tweeter is automatically notified that the tweet was favorited. The favorited tweet is also saved to the favoriter's favorite list.
	Reply	The tweeter replies directly to a tweet of another user. Replies are public, showing in the twitter streams of the original tweeter and those who "reply."
--	Follow	The tweeter adds another user to their list of followers. The followed user's tweets now show up in the stream of tweeter who followed them. Tweeters can also "unfollow" other users to remove their tweets from their streams.

Learning that Matters

The VCU connected course is intended achieve more meaningful learning and higher levels of student engagement by helping students develop learning identities, personal learning networks, and digital workflows. As illustrated in Figure 4, students engage in this sort of learning through connectivity: forming connections with people and across concepts, space, and time in digital spaces. The idea of learning through connection is neither new nor particularly radical. In fact, connection is the basis of social constructivist and cognitivist theory and a synonym for transfer of knowledge. This section delves further into the conceptualization of connection – with people and across concepts, space, and time – as a synonym for learning, linking it to a diverse selection of learning models, theories, and data-driven pedagogical practice.

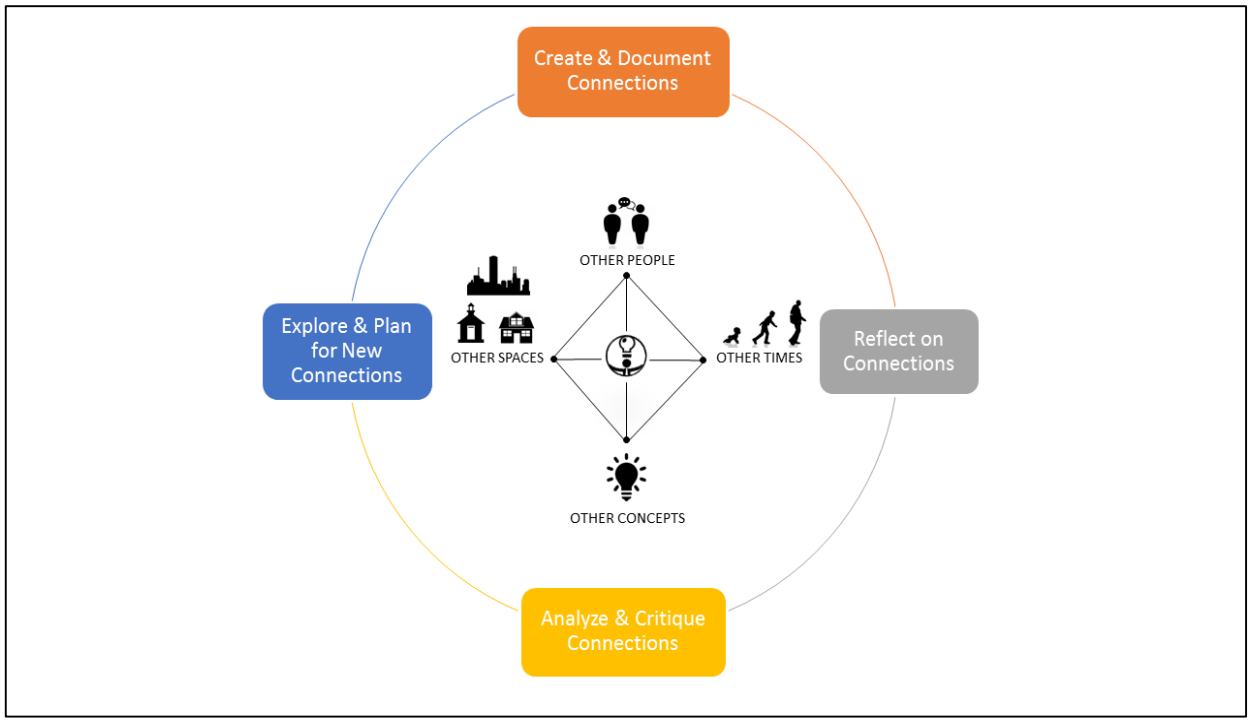


Figure 4. Connectivity as learning. This model of connectivity includes three rings. The central ring holds the learner and her current ideas, experience, and opinions. The middle ring represents what the student is attempting to connect with that current experience. Finally, the outer ring demonstrates the steps required to engage in the pedagogical act of connection. They represent a close adaptation of Kolb's model for experiential learning (2014).

Connection as a learning process. The pedagogical nature of connecting can be conceptualized in terms of Kolb's (2014) theory of experiential learning. Drawing from the work of Dewey, Vygotsky, Lewin, and Piaget, Kolb argues that learning is a continual, holistic, and creative process grounded in experience in and with the world. He describes learning as a cycle of encountering new experiences, making reflective observations, developing abstract conceptualizations, and experimenting to test these abstractions. Learning can be initiated at any site within the cycle. Since it was first published in 1971, the Kolb model has been used successfully in educational practice and research across a diverse range of disciplines including but not limited to business, healthcare, social services, and education (Kolb & Kolb, 2005). Connectivity draws on the same theoretical foundations as the Kolb model for experiential learning and follows the same cycle: learners document and reflect on their connections, explore them for larger meaning or purpose, consider how that meaning might inform next steps, and use that information to take further steps towards their learning goals.

Learning by connecting with people. Connected learning and open education strategies are rooted in social constructivism and therefore value social interaction as a form of learning. Interpersonal interaction can take a variety of educational forms. Learners might observe and imitate others in their environment and then adjust their behavior based on positive and negative reinforcement (Bandura, 1977). They might engage with instructors in more formalized learning, characterized by such approaches as explicit instruction, facilitation of self-discovery, or modeling of desired behaviors (Bandura, 1977, Bruner, 1966, Vygotsky, 1980). They might also engage with peers who drive learning through the implicit and explicit feedback of peer cultures (Ito et al., 2013) or participate in a variety of formal and informal learning communities (Lave & Wenger, 1991).

The pedagogical relationships within peer-based learning communities can be described in terms of collaboration or cooperation, though there is general consensus that these concepts overlap and student activity might shift rapidly between them (Dillenbourg, 1999). In general, collaboration implies that group members share similar levels of respect or status within the community, perform the same actions, and work towards a common, negotiated product or endpoint. The quality of interaction related to collaboration is not counted in the frequency of contact but rather in the influence the contact has on each group member's cognitive processes (Dillenbourg, 1999). In contrast, cooperative groups are less likely to value equality and uniformity among members; rather, they maintain individual perspectives, purposes, and goals within shared context and stream of collective activity (Morgan & O'Reilly, 1999; Stahl, 2005; Whatley & Bell, 2003). They divide up the work and tend to value the quantity of proffered effort as well as quality of the contribution (Stahl, 2005).

Students also learn when they interact with people who do not share their values, perspectives, or similar life experiences (Slavin, 1990). Connections with "the other" have the potential to trigger transformative learning through the process of creating a disorientating dilemma, reflection, and discourse (Mezirow, 1991). Even if transformative learning does not occur, the experience of engaging with diverse groups of people offers glimpses of that which was not previously known to exist. As Wenger (2000) described:

> There is something disquieting, humbling at times, yet exciting and attractive about such close encounters with the unknown, with the mystery of 'otherness:' a chance to explore the edge of your competence, learn something entirely new, revisit your little truths, and perhaps expand your horizon. (p. 84)

Finally, students learn from engaging with others as an audience. The constructionist approach, characterized by Harel and Papert (1991), does not emphasize collaborative knowledge construction as much as intrapersonal development in the presence of others. Constructionists suggest that students faced with performing or creating a product for an audience will learn more deeply because they must externalize their thoughts for the purpose of sharing them. Once thoughts are made explicit, they can be studied, refined, and made sharper through the process (Ackermann, 2001).

Learning by connecting concepts. Learning takes place when students are able to connect new concepts to previously established knowledge. When learners are able to make meaning from previously unconnected information, the creative act transforms the information, the learning experience, and the learner. Downes (2007) described transformation of information into knowledge in terms of a trail of falling dominos; the wave of energy created by the falling dominoes is extrinsic but innately related to the individual dominos. In another metaphor, he suggested that the transformed information is like a television image that conveys far more than its pixelated parts. Bruner (1996) describes the impact of information transformation in this way:

> To be able to go beyond the information given to figure things out is one of the untarnishable joys in life. One of the greatest triumphs of learning (and of teaching) is to get things organised in your head in a way that permits you to know more than you "ought" to. And this takes reflection, brooding about what it is that you know. The enemy of reflection is the breakneck pace. (p.129)

Finally, Meyer and Land (2003) describe the connection of concepts as a passage through a series of thresholds that facilitate a movement from superficial to more complex understanding of information. These concepts, which are found in all disciplines and stages of education, are portals

that open up new and previously inaccessible ways of thinking about something (Meyer & Land, 2003). The passage through the threshold is irreversible; once students achieve understanding they will not or cannot return to their previous, more simplistic understanding (Cousins, 2006).

The pedagogical nature of connecting concepts can also be considered in terms of schema theory. The organization of information into models, or schema, allows for increased memory formation, storage, and retrieval. New experiences are tested against previously held knowledge through a process of pattern recognition. When similar patterns are found, the new experience is added to the selected schema. Either the model (accommodation) or the perception of the new experience (assimilation) is adjusted to make the connections complete and the memory formed (Gruber & Voneche, 1977).

Schema theory informs number of widely accepted pedagogical models, including Vygotsky's (1980) zone of proximal development (ZPD). Vygotsky wrote that effective learning occurs when instructors build on what students already know, introducing new materials that are just beyond the student's current understanding. In doing so, students are able to move in a stepwise progression towards a deeper understanding. Bruner (1960) developed a programmatic strategy for scaffolding called the spiral curriculum, in which students revisit topics iteratively and with more complexity over time and in every turn. Ausubel (1968) created the advance organizers specifically to enhance schema formation and information retention. These materials, given to students prior to class, emphasize how new information can be abstracted, organized, and connected to previously learned information to form a big picture of the topic of interest (Ausubel, 1968). Finally, concept maps, a derivation of the advanced organizer, encourage students to visualize learned concepts (usually in graphs that include boxes and connecting lines) in terms of their relationships with each other. Concept mapping not only encourages pattern formation and

recognition, but can be used as an evaluation tool, for identifying correct and incorrect ideas held by students (Novak & Canas, 2008).

Learning by connecting through space and time. The phrase, "connections across space and time" is synonymous with transfer; it means that students are able to connect their current thinking or experience with experiences that have taken place in other situations, contexts, or time periods. Many argue that the goal of education is to support the transfer of school learning across space and time to contexts and scenarios beyond the classroom. Transfer, or connection, is an active process of pattern recognition, schema retrieval, application, reflection, and adjustment. The more robust the schema – the more connections and diverse examples that lie within – the faster, more creative, and more expert the transfer of knowledge will be (Bransford et al., 2000).

The ability to transfer is enhanced when students are able connect situated experiences and facts with abstract principles, organizing categories, and cross-disciplinary relationships. For example, when environmental conditions change students who learn the abstract principles behind archery will be more successful than those who only practiced shooting a target. Second, emphasizing similarities and differences between scenarios or items enable students to engage in pattern recognition. For example, stressing the interactions between anatomy and physiology rather than teaching each in isolation allows medical students to create more flexible models of how different human bodies will respond to diverse scenarios. Finally, students transfer knowledge more effectively when they have engaged with the material in a variety of contexts. Proven techniques include having students explore a variety of contexts for examples or instances, develop solutions to a problem across diverse conditions, or hypothesize how the information might be useful in different contexts (Bransford et al., 2000).

Metacognitive knowledge, defined as "knowledge of cognition in general as well as awareness and knowledge of one's own cognition," increases a student's ability to transfer knowledge without explicit prompting (Anderson, Krathwohl, & Bloom, 2001, p. 29). Metacognitive knowledge can be divided into reflection (the understanding of cognition), and reflexivity (the ability to act on the reflection). Ideally, students are able to reflect on their own learning, diagnose strengths and weaknesses, identify and apply strategies for improvement, and assess their own performance. When students perform these tasks independently, they tend to assess themselves for the ability to transfer knowledge and make any required adjustments to be successful (Bransford et al., 2000).

Putting it all together: Learning goals for connectivity. Every connected course is different, so to suggest a common list of learning goals might signal the type of one-size-fits-all instructional design that VCU seeks to avoid. Furthermore, courses generally have more than one type of learning goal. Although connected courses seek to promote connectivity, it is safe to assume all stakeholders, including students, hope to develop other dimensions of learning and knowledge as well. Nevertheless, connectivity lends itself to concrete expression in terms of what students should be doing through the duration of a connected course. These connectivity-based learning goals are described in Table 3.

Table 3.

Proposed learning goals for VCU connected courses

INTEGRATIVE THINKING – DIGITAL FLUENCY	CONNECTIVITY	*Students form, document, and reflect on connections between their opinions, ideas, and experience and:* • Course readings, discussion, or other materials. • The opinions, ideas, and experience of others in the learning community. • Images, videos, audio files, or other non-text based media. • Their own previous knowledge, thinking, or experience from other classes, professional, or informal learning environments.
		Students engage in networked participatory activity by: • Interacting in course-related discourse with others in the learning community. • Valuing diversity of perspective by reaching out to or responding to different members of the learning community. • Contributing relevant resources (curated and created) to the learning community.
		Students develop their digital workflows by: • Creating personal approaches to curating, organizing, and sharing thoughts, information, and resources. • Researching, cultivating, and engaging with a personal learning network across or within digital platforms. • Exploring strategies for amplifying a signal (someone else's or their own) in digitally networked environments.

Meaningful Assessment for a Digital Age

Classroom assessment of student performance is one of the oldest, most visible, and expected forms of educational assessment in higher education. Its presence has a powerful impact on how and what students learn (Boud, 2000). Knight (2002) established that students take course activities and learning more seriously if they are graded. Furthermore, Entwistle (1996) wrote: "The single strongest influence on learning is surely the assessment procedures…even the form of an examination question or essay topics set can affect how students study…" (p. 111-12). Therefore, student assessment must not only take place, but it must align with underlying epistemologies, curriculum, and instructional practices if it is to support the desired learning outcomes, dispositions, and behaviors (Knight, 2002).

If VCU faculty aim to promote student connectivity in connected courses, they must establish and align their learning objectives, activities, and assessments to do so. Currently,

assessment in digital, higher education learning spaces tends to focus on content acquisition, which is inconsistent with the nature of connective learning, an active process of documentation, reflection, analysis, and creativity. This section will briefly review the current state of assessment in online, higher education environments before discussing themes for reform and the assessment practices found in open and connected learning environments. Finally, it will draw on these sources as well as what has already been described of course context and the pedagogical act of connecting to propose a potential strategy for assessing connectivity in VCU connected courses.

Assessment in higher education. When compared with the development, validation, and impact studies of standardized tests, examinations, and other quantifiable and quantifying instruments, non-standardized classroom assessment receives relatively little attention in the educational assessment literature (Angelo & Cross, 1993; Boud, 2000). A systematic review of "online," "distance," "e-learning," "digital," and "networked" classroom assessment in higher education settings reveals that most research focuses on the impact of course format (online, hybrid, or blended) on student experience or their performance on content-based, end-of-course exams (for examples across academic disciplines, see Fox & Medhekar, 2010; Kemm & Dantas; Porter, Pitterle, & Haney, 2014). The assessment protocols (i.e. the end-of-course exams) in these studies are a means to the end rather than the focus of the research itself. While these articles do not provide detailed descriptions of assessment instruments, most imply that they test students using some combination of multiple choice, short answer, matching, or essay questions, graded by instructors and completed by students in isolation from any resources but themselves. However, the brevity of the discussion around the assessment instruments used in these studies is telling; it suggests an underlying assumption among the researchers – and possibly even the academic fields

they represent – that student content acquisition and recall as demonstrated through traditional testing formats are unquestioned indicators of the learning they are trying to achieve.

Traditional assessments of content acquisition (i.e. quizzes and tests) represent a philosophical and pedagogical conundrum for open and connected educators, because they treat knowledge construction as a measureable, static product rather than a dynamic process. They rarely assess social learning or integrative learning across courses or contexts (Cheng, et al., 2013; Kumpulainen & Sefton-Green, 2014). Furthermore, traditional assessments can hamper learning designs that allow for student choice, because they assume students learn the same information and arrive at the same endpoints at the completion of a course (Downes, 2007). Finally, because most traditional classroom assessments are developed and graded by instructors, they fail to promote self-assessment and -regulation (Boud, 2000; Cheng et al., 2013).

Digital age assessment reform. In 2010, the Joint Information Systems Committee (JISC; U.K.) published a report calling for reform of classroom assessment so that it might align better with emerging digital participatory cultures and digital pedagogies (Davies, 2010). It emphasized that evidence of content acquisition is no longer enough to ensure that students will be successful in the digital age. Instead, digital age assessments must: capture learning as a process as well as an outcome; support self-reflection, -assessment, and -regulation; and leverage the power of peer-to-peer learning and feedback (Davies, 2010). Although Davies (2010) synthesized the call for assessment reform into a single report, similar arguments run throughout the digital pedagogical literature (e.g. Cheng et al., 2013; Buckingham-Shum & Ferguson, 2012) and beyond (e.g. Boud, 2000; Pring, 2015). Together, these scholars call for meaningful approaches to digital age assessment that are integrated, sustainable, and scalable.

Integrated assessments. Integrated assessment is that which is integrated into the everyday behaviors of instructors and students, capturing the process of learning including the false starts, personal struggles, and collateral learning that take place before the student achieves a finalized, polished endpoint (Katz & Chard, 1996). Progressive educators call this process awareness, and they assess student progress by collecting evidence of learning in the form of art, writing, performance, and recorded social interaction (Edwards, 2002). In other educational environments, process awareness translates to formative assessment. In a review of 250 peer-reviewed articles and book chapters, Black and Wiliam (1998) concluded that efforts to provide high quality formative assessment produced significant learning gains as measured by comparative performance on summative assessments. Effect sizes in these studies ranged from 0.4 to 0.7. Although all students demonstrated evidence of improved learning in the presence of high quality formative assessment, traditionally lower-achieving students exhibited the most improvement.

Formative assessment becomes a pedagogical tool when it promotes reflection (Black & Wiliam, 1998). Multiple learning theories, including active (Fink, 2013), experiential (Kolb, 2014), and transformative (Mezirow, 1991) learning theories integrate reflection into the cycle of learning. Arendt (1971) describes reflective practice as a "stop and think." Bergson (1913/2001), Schon (1983), and Csikszentmihalyi (1990) suggest that individuals must document if they want to understand and replicate (or not replicate) their actions in the future, because they are not necessarily aware of what they are doing while they are doing it. The process of reflective self-assessment helps students diagnose their strengths and weaknesses while nurturing questioning behaviors and critical stances (Schon, 1983).

Sustainable assessments. The educational ethic of promoting ongoing, continuous, or lifelong learning is well established (Dewey, 1916/1985; Lindeman, 1926/1989). The ability to

assess – to question, engage with, and assign value to information, knowledge, and learning activities – is an essential component of self-directed learning. Therefore, sustainable assessments, or those that meet the needs of the formal educational environment while establishing the dispositions and behaviors required for future self-regulation and assessment, are desirable (Boud, 2000; Davies, 2010). Sustainable assessment is most frequently associated with self- and peer-evaluations. A growing body of literature suggests that when properly scaffolded, self- and peer-assessment provide results similar in quality to instructor-generated feedback. Therefore, it may offer a scalable alternative to instructor assessment particularly in larger classroom settings (DeWeaver, Van Keer, Schellens, and Valcke, 2009; El-Mowafy, Kuhn, & Snow, 2013; Matheson, Wilkinson, & Gilhooly, 2012).

Self- and peer-assessments have pedagogical implications. Self-assessment particularly in the form of self-documentation encourages students to engage again with the content and process of learning. Malaguzzi (1993) observed that students often engage with the material differently when they are assessing that which is already completed, moving towards a deeper level of understanding. Self- and peer-assessment may also enhance students' ability to absorb and act upon the formative feedback they receive in learning environments. Although Black and Wiliams (1998) identified formative feedback as a powerful learning tool, not all formative assessment is equally effective. Kluger and DeNisi (1996) found that the presence of formative feedback could actually hamper learning in certain situations, suggesting that qualitative and moderating factors exist. Sadler (2010) suggested students cannot absorb and utilize formative feedback without sufficient working knowledge of the fundamental concepts teachers employ when providing it. The intensive use of formative peer- and self-assessment as a pedagogical strategy encourages deeper student engagement with academic content and structure, develops evaluative knowledge

and skills, and begins to reduce dependence on an instructor to provide feedback (Sadler, 2010). Therefore, Nicol (2010) concluded that self-assessment should become an explicit rather than implicit form of formative assessment so that students might improve their ability to assess or recognize quality and then justify their assessment to others.

Scalable assessments. The value of scalability has always been central to digital learning (Veletsianos & Kimmons, 2012). It also important in higher education where institutions are being asked to do more for more students with less funding. In these situations, faculty need efficient yet still meaningful ways to assess student work (Davies, 2010). As more campuses invest in digital infrastructure for everything from course registration to student services to learning management systems, interest in academic and learning analytics has increased (Siemens & Long, 2011). While academic analytics focus on the administrative functions of higher education (e.g. student enrollment, faculty productivity), learning analytics focus specifically on acts of teaching and learning. Learning analytics is a quickly growing, interdisciplinary field of digital research that applies the methodologies of business intelligence and data mining to educational contexts and research agendas (Siemens, 2012). As they become more sensitive, specific, and available, learning analytics applications are being promoted as scalable formative assessment tools that enhance personalization of education in college and university settings (Clow, 2013).

Open and connected assessment strategies. Although they tend to take different (if overlapping) approaches, connected learning and open education scholars are dedicated to evaluating and assessing connectivity by documenting student connections within and across networks of people and ideas. Maintaining their close connection to progressive education, many connected learning scholars advocate for the use of e-portfolios (Kumpulainen and Sefton-Green, 2014). E-portfolios are personalized sets of web-based materials, collected across formal and

informal learning experiences and pieced together through connective narrative, for a particular purpose and audience. Typically, e-portfolios take the shape of a public or private blogsite maintained by the student. Common audiences for student e-portfolios include but are not limited to the student, peers, family, instructors, and future employers. Yancey (2004) found that e-portfolios facilitated integrated learning while enabling students to develop a sense for connections, reflectiveness, and intellectual community.

Open educators tend to look at assessment through the lens of digital technologies and scalability, leading to growing interest in and relationship with the field of learning analytics (Siemens & Long, 2011). Learning analytics are grounded conceptually in digital traces. Digital traces are the connective tissue of the network, "not made of nylon thread, words, or any durable substance" but a trail "left behind some moving agent" (Latour, 1996, p. 132). When students click through webpages, create content, and add hyperlinks, digital platforms automatically capture evidence of the activity. These "traces" become descriptions, which, when reconstructed appropriately, flesh out possible relationships existing in any given moment. Digital scholars argue that act of tracing stimulates self-reflection and pattern recognition; establishes a tangible product for mutual consideration and planning; and documents interaction so that it becomes an account, story, or explanation of process (Latour, 2005; Rice, 2011).

Learning analytics capitalize on the automatic collection and storage of digital traces to inform evaluation of student engagement, time on task, and learning comprehension. Analytics implies more than analysis; the field aims to develop methods for data interpretation ("analysis") as well as ways to manipulate the data to help visualize, display, or otherwise apply the data towards decision-making. Much of the current learning analytics research capitalizes on the large and complex data sets captured by university learning management systems. Researchers use these

data to create predictive models that identify students who display at-risk behaviors. The information is visualized in dashboards within the learning management system, alerting instructors, students, or other stakeholders that intervention might be required (Siemens & Long, 2011).

Buckingham Shum and Ferguson (2012) questioned the ethical integrity of some approaches to learning analytics, citing the questionable use of digital traces, which are "potentially noisy data," in the context of mathematical algorithms that are protected by commercial licensing and therefore have not undergone widespread review or critique. The authors offer an alternative approach to the use of digital traces, moving away from the development and study of individualizing, algorithmically motivated feedback systems to what they called social learning analytics. Social learning analytics is a subset of learning analytics meant to capture, organize, and demonstrate the inherently social, open, and connective aspects of networked participatory learning. Buckingham Shum and Ferguson (2012) offer five promising research methodologies for the study of digital traces in online learning spaces. Of these, social network analytics and discourse analytics have already been applied to classroom assessment and will be discussed here.

Social network analytics (SNA). Social network analytics involves making decisions based on the metrics and visualizations derived from social network analysis (SNA). SNA is a strategy for investigating social structures that was developed in sociology but has been successfully applied in many fields including anthropology, biology, political science, economics, social psychology, and education (Knoke & Yang, 2008; Otte & Rousseau, 2002). It is best used to answer questions about patterns in relationships or interactions between or within communities, potential causes of group dysfunction, ways to enhance group cohesion or effectiveness, and routes

of information or any other sort of transmission through and between communities (Cheliotis, 2013). Directed network analyses are performed when the origin and destination of the interaction (known as an "edge") are significant, for example, when investigating transmission of information or diseases. Undirected network analyses are performed when the directionality of interactions are less meaningful, such as when tracing friendship relationships (Wasserman & Faust, 1994).

SNA generates graphs or sociograms to describe the nodes (objects or people) and the edges (ties, interactions, or relationships) that make up a network (Wasserman & Faust, 1994). They can be viewed and interpreted in dynamic, real time or as static points in time (Dawson et al., 2011b). Typically, nodes and edges are depicted as points and lines, respectively. When a network is directed, edges are displayed as arrows pointing in the direction of the interaction; otherwise, lines without arrows indicate an undirected analysis. Color, shapes, and style of the lines also can be used to convey additional information about the nodes or edges. For example, line thickness might indicate how many interactions have taken place between nodes (Wasserman & Faust, 1994).

SNA produces metrics that characterize performance at the level of the network (sociocentric) or individual node (egocentric). Indicators of network size, density, and clustering have been used to describe the presence of community (Dawson, 2008) and cohesion (Reffay & Chanier, 2003) in online discussion forums. However, much SNA-based educational research focuses on information and resource exchange within online courses at the individual student level (examples include Haythornthwaite, 1999; Jimoyiannis, Tsiotakis, & Roussinos, 2013; Moolenaar, 2012; Shea et al., 2013); these studies describe the distribution and qualities of power among students in terms of degree, betweenness, and closeness centrality.

Degree centrality indicates the number of interactions between one node and the others within a network. Nodes with high levels of degree centrality often represent popular or busy hubs for information exchange (Faust, 1997). In directed networks, degree centrality is further subdivided into in- and out-degree to indicate the number of incoming and outgoing transmissions, respectively. Betweenness centrality is the frequency with which individuals bridge the cliques or clusters that occur naturally within human networks. Nodes with high betweenness centrality are gatekeepers, positioned to control flow of information and resources across the network (Dawson, 2010). Although degree centrality is often reported in studies as a descriptive indicator of student engagement, betweenness centrality may be a better indicator of student success. In one undergraduate course, Cho, Gay, Davidson, and Ingraffea (2007) found that student betweenness centrality correlates positively with final grades as well as a general openness towards exploration

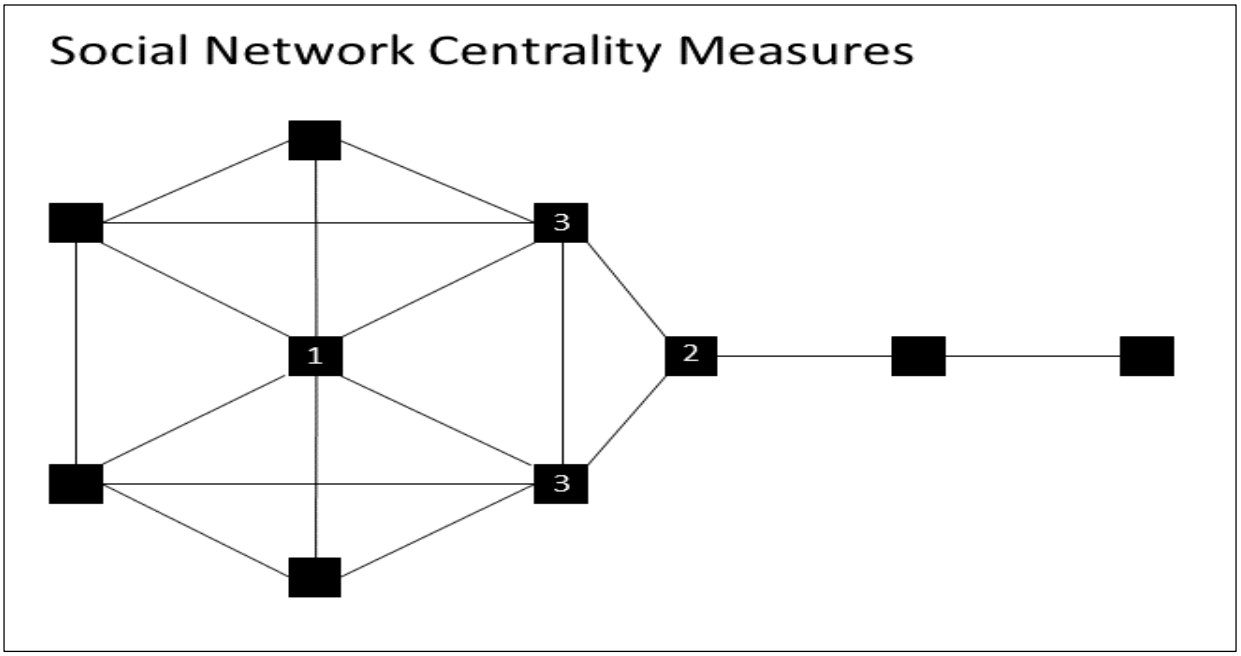


Figure 5. Social network centrality. Student #1, with the largest number of edges, has the highest degree centrality. Student #2 acts as a bridge between the large cluster of students and several outliers, and therefore has the highest level of betweenness centrality. Students #3 have the highest closeness centrality because they are the most closely connected to the most people in the network. Adapted from "Social network analysis: A brief introduction," by V. Krebs. Retrieved from: http://www.orgnet.com/sna.html

and willingness to learn. Finally, closeness centrality measures the degree of relationships an individual node formed with the network as a whole. It includes eigenvector algorithms that use overall network degree centrality and tie strength to judge the individual's overall importance within the broader network structure (Faust, 1997). Figure 5 offers a graphic representation of the most commonly reports forms of centrality.

Social network analytics explore the validity or interpretation of SNA metrics while simultaneously developing tools, protocols, or data visualizers that help instructors, students, and other stakeholders use SNA for program evaluation, performance assessment, or other aspects of decision making. Dawson and colleagues have done the most work in this area, prototyping and testing a social network extraction tool called the Social Network Adapting Pedagogical Practice (SNAPP). SNAPP extracts student data from discussion forums held in university learning management systems and visualizes them through third party software applications to perform social network analyses that are potentially appropriate for student assessment and program evaluation (Dawson, 2010).

Dawson (2010) used SNA as a formative assessment strategy for illuminating "at-risk" behavior and predicting student performance (i.e. course grades) in an entry-level chemistry course taught at a large Canadian university. The study assumes that learning is a social process and that the investigation of learning should involve identifying and characterizing the social networks involved. The author extracted student engagement data from the LMS that facilitated online learning activities and housed online resources throughout the course. Student participation in online learning activities was not mandated but was actively encouraged by the instructor. Standard statistical analysis showed significant differences between degree centrality of the peer-

to-peer networks developed by high- and low-performing students (as defined through their final grades).

Dawson, Macfadyen, Lockyer, and Mazzochi-Jones (2011a) used SNA to investigate the ability of medical school admissions criteria at an Australian medical school to predict levels of student engagement in a social learning environment during the first two years of study. Admissions is influenced significantly by student grade point average and standardized test performance, and the authors hypothesize that these competitive and performance-based measures will not predict success in the social learning environment cultivated through recent reforms in the medical school curriculum. Student data from the learning management system was extracted and visualized through social network analysis software and centrality metrics were generated. There was no correlation between student admission scores their levels of engagement in social learning practices.

Dawson, et al. (2011b) used SNA to assess student engagement and creativity in first year medical students at an Australian university. Student data was extracted from the LMS, which is used extensively in the facilitation of required online learning activities, including peer-peer and -instructor discussion. Student creativity was operationalized as social networking and brokering agility and measured through degree, closeness, and betweenness centrality metrics. The SNA was compared with results from a learning disposition questionnaire meant to quantify the level of perceived student creative capacity. Results indicate a moderate relationship between self-perceptions of creativity and degree centrality ($r = .334$, $p < .01$) and betweenness centrality ($r = .338$, $p < .01$). Correlation between survey results and closeness centrality was not significant.

Discourse analytics. Discourse analysis originated in linguistics and communication studies as a qualitative research method for exploring discourse devices. Discourse devices are

socially negotiated expressions, conventions, structures, or processes that add meaning beyond the main content of the message (Ferrara, Brunner, & Whittemore, 1991). Examples include the use of emoticons (affective responses); quoting messages before responding to them (interactive responses); and the explicit use of user names when replying or commenting (cohesive responses; Haythornwaite et al., 2000; Kanuka & Anderson, 2007b). Educational researchers routinely investigate the use of discourse devices in asynchronous and synchronous online learning environments; for example, Lapadat (2007) found that students and instructors use them to establish community, create coherent scholarly discussions, and negotiate agreements and disagreements throughout the course.

Some educational researchers are developing applications for discourse analytics in learning management systems. Oshima et al. (2012) developed open source software called Knowledge Building Discourse Explorer (KBDeX) that combines SNA and discourse analytics to study learner interactions in LMS-based discussion forums. In the same study, they report that analysis of student interactions with KBDex yielded similar results to a traditional qualitative content analysis of an undergraduate level discussion-based online course. Later, Matsuzawa et al. (2014) used KBDeX for formative, student self-assessment in a discussion-based online undergraduate-level information technology course. Their findings suggest that students who use KBDeX to reflect on their collaborative efforts show higher end-of-course preferences for collaborative learning than those who did not.

Pulling it all together: Assessing connectivity. VCU is conducting a massive pedagogical experiment that involves exploring, remixing, and repurposing the principles and practices of open education and connected learning to create an innovative approach to higher education, one that promotes real and distinctive learning, learning that matters, generalizable learning for digital

fluency and integrative thinking, and connected learning for a networked world. This experiment includes a large scale (yet highly customizable), university-supported (yet public and open) digital blogging platform. This platform has facilitated the development of VCU connected courses, where students learn by engaging in open digital scholarship. While the courses have a mandatory blogging focus, many also encourage or require students to participate in public discourse on social media platforms such as Twitter.

Like every VCU course, connected courses have their own content areas and program- or discipline-driven learning goals. However, they also carry the expectation that students will work towards a sense and practice of connectivity. The hope is that students will consistently attempt to connect their course-related thinking, learning, and experience to something larger, such as an emerging learner identity, a personal learning network, or impassioned engagement with a real-world problem or audience. Furthermore, instructors hope students will learn to leverage the affordances of the web to enable their learning processes of documentation, reflection, analysis, and experimental action.

If connected courses are to succeed in promoting student connectivity, they must create connectivity-based assessments. The preceding work of progressive, connected, and open educators suggests that this means assessing student performance through processes of documentation: capturing and reflecting *with* students on the connections they are making within and across networks as they are being made. The field of social learning analytics suggests that digital traces may offer real-time, scalable documentation of student activity that can be used to help students examine and reflect on their own connectivity; in doing so, particularly when the connectivity is scaffolded and situated within a personally meaningful learning goal, students may demonstrate higher levels of engagement and knowledge transfer.

This study proposes to capitalize on the digital annotation devices of blogging and tweeting as a means to capture student connectivity in ways that are scalable, flexible, and amenable to self- and peer-assessment. Specifically, it will study student use of hyperlinks, embedded materials, mentions, and hashtags as those which have been studied in other fields and been shown, at least preliminarily, to have connective qualities (Black et al., 2012; Honeycutt & Herring, 2009; Huang et al., 2010). The social media and social learning analytics literature has already linked digitally traced mentions and hyperlinks to listed connectivity-based learning goals. This study is not a repetition or a direct extension of these studies, but rather an adjacent work that has been inspired by them. Although this study will not link the use of annotation devices to other, traditional indicators of student learning and success, it will begin to describe the pedagogical potential and implications of annotation devices in the VCU connected course context, so that further research steps can be taken to tie it all together. It will also demonstrate how these digital traces might inform meaningful forms of assessment that provide opportunities for formative feedback, guided reflection, peer- and self-assessment, and self-regulation. These assessment strategies will be organized and presented as the prototype for an assessment toolkit meant to assist VCU faculty as they continue to design and implement connected courses.

Chapter 3

This study focused on the use of annotation devices in course-related blogging and tweeting as potential indicators of connectivity in VCU connected courses. The ultimate goal of the study was to create an assessment toolbox that offers faculty an array of digital strategies meant to assist in the documentation of students making connections with other people and concepts across disciplines, contexts, and time. While this study was directed towards a very real and concrete institutional need, its exploratory design reflected the emergent state of digital pedagogy research and development. It was not driven so much by discrete and fixed research questions as by the idea of a question, which was: How do course participants use annotations during course-related blogging and tweeting, and can this information be used to inform student assessment?

Study Design

This retrospective, descriptive, mixed methods study aimed to provide straightforward and "largely unadorned…answers to questions of special relevance to practitioners and policy makers (Sandelowki, 2000, p. 37). As illustrated in Figure 6, it employed convergent, mixed research methodologies to engage an area of inquiry, which was divided into the following strands:

- How do learners use annotation devices, specifically hyperlinks, embedded images, mentions, and hashtags, while engaging in course-related blogging and tweeting?
    - How does their use vary across different connected courses and instructional designs?
    - How does their use relate to connectivity-based learning goals?

- How can documentation of student annotations be generated, translated, and displayed in ways that are meaningful and practical for student feedback and assessment? Specifically, how does student annotation and its documentation:
    - Differ between students to create a spectrum of student performance?
    - Lend itself to a pedagogical assessment toolkit including analytic assessment dashboards, rubrics, assessment criteria, and digital graphic visualizations?
- How do these assessment strategies conform to published recommendations for 21st century digital assessments?

Applying a mixed methods approach to these inquiry strands was essential to provide a more complete answer than could be provided by either qualitative or quantitative analysis (Creswell & Plano Clark, 2011). Since little is known about student use of annotations in course-related blogging and tweeting, exploratory qualitative and quantitative analyses was used to address the first strand of inquiry. The two methodological approaches are equally important, interactive, and mixed during the analytical and interpretive phases of the study, which represent the second and third strands of inquiry.

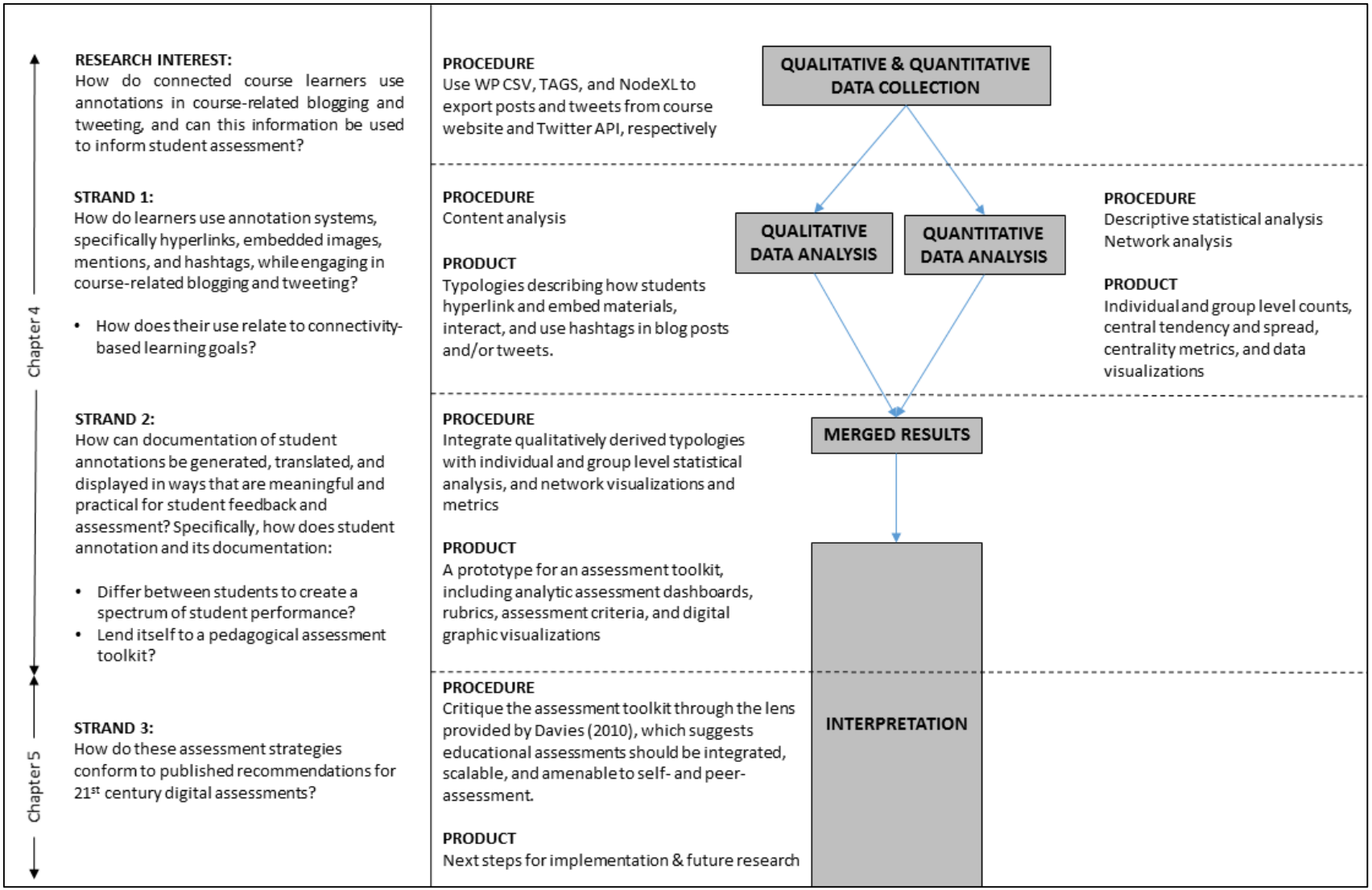


Figure 6. Study design.

Study Context

In the summer of 2015, Virginia Commonwealth University offered five fully online courses that met the minimum VCU connected course qualities as outlined in Table 1 (Chapter 1). The courses varied across disciplines, intended student populations, and instructional designs, but represent an authentic range of courses for which any proposed assessment toolkit would have to conform. Data for this study was collected from four of the five courses. The fifth was excluded because the course website was not hosted by the VCU campus publishing platform (Ram Pages), making data retrieval more complicated than data from the other courses. The four courses involved in the study were designated CC, CAM, SOC, and VT. Table 4 provides a summary of their defining connected qualities, identified through a content analysis of the course websites.

Course CC. CC was a graduate level research elective taught by two instructors and completed by ten academic credit-earning VCU students. No students withdrew after the initial add-drop period or failed to complete the course. The course syllabus and documents were housed on a public course website, and all required educational materials and digital tools were openly and freely available. The instructors actively encouraged participation by individuals ("open participants") who were not enrolled at VCU and would not receive academic credit. These individuals were recruited through social media, personal and professional networks of the instructors, and digital- and print-based advertising media. Open participants were able to enroll in the course via the course website. Although they did not receive grades or formalized instructor feedback, their blog posts were aggregated by the course RSS feed and included in the bloggregate alongside student and instructor posts.

Table 4.

Overview of course settings

COURSE LABEL	STUDENT LEVEL	ONLINE STATUS	LEVEL OF OPENNESS	DIGITAL EXPRESSION	PARTICIPATION	STUDENT AGENCY
CC	Graduate	Fully Online	Course documents and required learning materials were openly accessible. Open participation was actively recruited.	Students blogged publicly. They were required to create and integrate multimedia products into posts. Students were required to tweet as part of graded, structured Twitter-based learning activities.	Students were required to curate and crowdsource web-based information and engage in synchronous online discussion.	Students retained ownership of learning products, contributed to the course learning materials, adapted learning activities, and engaged in formal self-assessment.
CAM	Undergraduate		Course documents and required learning materials were openly accessible. Open participation was possible but recruitment was limited.	Students blogged publicly. They were encouraged but not required to create or integrate multimedia products into their posts. Students were encouraged but not required to tweet. There were no structured, graded Twitter-based learning activities identified.	Students were incentivized to comment on each other's blogs.	Students retained ownership of learning products, contributed to the course learning materials, and adapted learning activities.
VT	Undergraduate		Course documents and some required learning materials were openly accessible. No mechanism for open participant registration identified.	Students blogged publicly. They were required to create and integrate multimedia products into posts. Students were encouraged but not required to tweet. There were no structured, graded Twitter-based learning activities identified.	Students commented, crowdsourced web-based information, and engaged in synchronous online discussion.	Students retained ownership of learning products, contributed to the course learning materials, adapted learning activities, and engaged in formal peer assessment.
SOC	Undergraduate		Course documents were openly accessible, but assigned readings required the purchase of a textbook. No mechanism for open participant registration identified	Students blogged publicly. They were encouraged but not required to create or integrate multimedia products into their posts. Students could choose to earn participation points through tweeting, but it was not required. There was only one structured, ungraded Twitter-based learning activity identified	Students were incentivized to comment on each other's blogs. They were also required to complete collaborative writing projects.	Students retained ownership of learning products, contributed to the course learning materials, and adapted learning activities.

CC students were required to establish individual, public blogsites as well as Twitter and Diigo accounts so that they might complete learning activities. These activities included listening to expert panel discussions via open videoconferencing, curating relevant web resources and contributing them to a group Diigo account; participating in synchronous Twitter-based class discussions, and blogging. Blogging assignments not only included reflective and course topic-driven prompts, but also digital "makes" that encouraged students to express abstract course concepts through multimodal digital literacies. Students responded to blog prompts through the lens of their own research interests. Weekly, hour-long "Twitter chats" framed the majority of CC learner tweeting. In these chats, instructors tweeted out course-related questions at timed intervals and the group engaged each other in related discussion. Students were required to attend six of the eight Twitter chats. Attendance was documented through completion of a pre-discussion self-assessment that gauged their preparation for the discussion.

Course CAM. CAM was an undergraduate level general education elective taught by one instructor and completed by 19 credit-earning VCU students. At least one student withdrew from or failed to complete the course. The syllabus and materials were housed on a public course website. Students developed their own reading lists based on personal interests and curation of the web. Students earned points towards a final grade by blogging and commenting on other student blog posts. The instructor provided a variety of blogging prompts from which to choose, each designed to trigger research, reflection on personal experience, and/or interdisciplinary thinking. The inclusion of multimedia elements was encouraged but not scaffolded, modeled, or required for completion of the course. Students were encouraged to tweet with the course hashtag, but the activity was neither required nor structured through learning activities. Formal self- or peer-assessments were not included in the course design. Although open participation was possible

(through an enrollment page on the course website), active recruitment was minimal and no open participants overtly participated in the course.

Course VT. Course VT was an undergraduate general education elective taught by one instructor and completed by five credit-earning VCU students. At least one student withdrew or failed to complete the course. The syllabus and learning activities were housed on a public course website. While access to the web-based course readings was limited by copyright restrictions, all digital tools needed to complete learning assignments were freely and publicly available. Learning activities included curating web sources for a crowdsourced, public reference collection; reflective blogging; commenting on other participant posts; completing digital "makes;" participating in private, unrecorded, video-conferenced class discussions; and completing an individualized web-based project. Formalized peer assessment was integrated into the final project. Twitter discussion was modeled but not scaffolded or required. There was no mechanism available for open participants to formally enroll in the course.

Course SOC. Course SOC was an undergraduate foundations course taught by one instructor and completed by 26 credit-earning VCU students. The course syllabus and learning activities were housed on a public course website, but a commercial textbook was required to complete weekly readings and assignments. Learning activities included blogging, participating in online discussion, completing an individualized written or video project; and engaging in a collaborative blogging project. Students blogged on a combination of instructor-generated prompts and student-identified news stories or events. Creative, multimedia expression in blog posts was encouraged but not scaffolded or modeled. Class participation was defined as tweeting or commenting on other student blogs, although the format of or instructor expectations around Twitter discussion could not be clearly identified in a review of online course materials. Formal

self-assessments did not appear to be included in the course design. While there was no mechanism to allow open participants to enroll in the course, the instructor subscribed to a variety of active, well-established, discipline-specific blogs to populate the course bloggregate with relevant perspectives from beyond the classroom.

Study Population

The course settings allowed for different types and levels of participation. Participants were broadly defined as those who: (1) wrote blog posts specifically for the class and that were aggregated by the course RSS feed for the course bloggregates; (2) tweeted using the course hashtag; or (3) a combination of course-related blogging and tweeting. As illustrated in Table 5, four types of participants existed within the course settings:

- **Instructors and assistants**. Each course had an official instructor of record who also participated in varying levels of course blogging and tweeting. Course CC had two instructors as well as a small group of assisting staff and graduate students who were designated as assistants. These assistants, a group that included the current study's researcher, played semi-formalized roles in recruiting, engaging, or troubleshooting for open participants and students on Twitter. While Course SOC did not include assistants the instructor subscribed to a number of relevant blog sites that automatically populated the course bloggregate with professional quality posts. These posts modeled appropriate blogging technique and provided additional information, much like an instructor or assistant would do.

Table 5.

Participant type and activity by course

		STUDY COURSES			
		CC	CAM	VT	SOC
	 **INSTRUCTORS & ASSISTANTS**	Two instructors & three assistants contributed: **1689 Tweets - 30 Blog Posts**	One instructor contributed: **108 Tweets - 0 Blog Posts**	One instructor contributed: **347 Tweets - 30 Blog Posts**	One instructor subscribed to approximately a dozen outside blogs. Together, they contributed: **133 Tweets - 633 Blog Posts**
STUDENT-PARTICIPANTS	 **ENROLLED STUDENTS**	Ten students contributed: **1416 Tweets - 214 Blog Posts**	19 students contributed: **79 Tweets – 184 Blog Posts**	Five students contributed: **124 Tweets - 112 Blog Posts**	26 students contributed: **341 Tweets – 353 Blog Posts**
	 **OPEN PARTICIPANTS**	Four open participants contributed: **251 Tweets - 57 Blog Posts**	There were no open participants in this course.	There were no open participants in this course.	There were no open participants in this course.
	 **OTHER PARTICIPANTS**	189 other participants contributed: **719 Tweets - 0 Blog Posts**	Ten other participants contributed: **39 Tweets - 0 Blog Posts**	12 other participants contributed: **24 Tweets - 0 Blog Posts**	14 other participants contributed: **71 Tweets – 0 Blog Posts**

- **Students.** Students were formally enrolled, VCU-affiliated students taking the course for academic credit. They completed all or most of the assignments with the expectation of receiving formalized feedback and grades for their work.
- **Open participants**. Open participants were individuals who took advantage of open course policies to complete at least some of the blogging and tweeting activities. They registered for the course and had their blogsites linked to the course bloggregate. They did not pay for the course, receive formalized feedback, or academic credit for their participation. Although CC and CAM websites had processes in place for open participation, CC was the only course in the study that included contributions from open participants.
- **Other participants.** Other participants were individuals whose participation was limited to tweeting with the course hashtag. An analysis of Twitter profiles, the content of course-related tweets, and other publicly available information allowed most of these participants to be identified and separated into two primary groups: academic participants (e.g. faculty, staff, or students from VCU or other higher education institutions) and community participants (e.g. community-based individuals who had overt professional connections to the subject matter being discussed in the course).

Sampling Procedures

The analyses performed for this study are based on the content and metadata of tweets and blog posts aggregated through Twitter API and RSS feeds, respectively. Every tweet and post submitted by every participant between the official start and end dates of the courses were collected through the automated processes described below. Decisions on which posts and tweets to analyze were made based on this hierarchy of questions:

1. Given the purpose of the study and the characteristics of the analysis being performed, which participants' contributions should be examined?
2. Within that sampling framework, is it feasible to include every available tweet or post, given the nature of the analysis and the time and resources available to the researcher?
3. If every tweet or post cannot be sampled, what selection within that sampling framework makes sense, with the understanding that the sample will be expanded if data saturation or thematic redundancy has not been achieved (Lincoln & Guba, 1985)?

Preliminary analysis suggested that instructors and their assistants tweeted and blogged to provide group feedback, make course-related announcements, and model appropriate practice. These motivations seemed different from those of the learners and the course and might have skewed results away from "learner" practices, because, in some cases, instructors contributed significantly more than students. Therefore, instructor and assistant contributions were excluded from all analyses except social network analysis, since this analysis requires comprehensive data to be meaningful. After instructors and assistants were excluded, a sampling framework of "student-participant" or "learner" (defined as enrolled students, open participants, and other participants) remained. CC was the only course that included open participants and had an appreciable number of other participants. Since these individuals appeared to blog and tweet with similar motivations as enrolled students (if at lower frequencies), their work was included in the relevant analyses to increase variation within the sample.

Table 6 describes the sample frames and size by course, source, and analysis type. All Twitter data from student-participants were analyzed. Similarly, all blog post data from CAM and VT students were analyzed, but the high volume of SOC and CC posts precluded full-sample analysis. Time-delineated sampling was used identify posts submitted by SOC students and CC

students-participants during the third, seventh, and eighth weeks of the course. Data from the seventh and eighth weeks of these courses included final projects and summary posts; posts from the third week were included to capture any changes in annotation that might occurred over time.

Data Collection

Blog posts from the course websites were collected and exported as comma-separated values (CSV) files using WP CSV, a WordPress plugin that imports and exports posts and pages from WordPress supported websites. Extracted data included the timestamp, author, title, content, url, tags, and categories of each post. Hyperlinked and embedded materials were identified and isolated from other blog post content manually through a standard copy-and-paste process.

Tweets that included designated course hashtags were collected for the duration of the courses. Twitter Archiving Google Spreadsheet (TAGS; Hawksey, 2014) and NodeXL (Smith et al., 2009) were used to collect data automatically from the Twitter API. TAGS collected the timestamp, content, author, retweet and reply status of each tweet in a prospective and continuous manner. NodeXL, a Microsoft Excel template with network graphing capability, collected tweet timestamps, authors, and content in a retrospective, "snapshot" fashion. NodeXL also automatically identified and isolated hyperlinked urls, mentions, and hashtags. Comprehensive data collection was ensured by importing data from the Twitter API via NodeXL every seven days. A detailed description of the processes used to prepare data for analysis is located in Appendix A.

Data Analysis

Exploratory data analysis requires a certain "attitude, a flexibility, and a reliance on display" (Tukey, 1980, p 23). In that spirit, four types of data (hyperlinks, embedding codes, mentions, and hashtags) from as many as four participant types in four course settings were studied through three analytic lenses: descriptive statistical analysis, content analysis, and network

analysis. Not every combination of factors was analyzed; sampling frames, as described above, were set around what was reasonable as well as what would best serve to respond to the strands of inquiry outlined previously in the chapter. Table 6 provides an overview of the analyses, data types, participant types, and sampling frames that were pursued.

The analyses were organized through eight separate Microsoft Excel workbooks, one for each course and data source (blog posts or tweets). Blog-related spreadsheets included timestamps, post authors, post content, and the isolated hyperlinked or embedding urls. Tweet-related workbooks included spreadsheets by annotation and analysis type. Each spreadsheet included timestamps, authors, tweet content, and the isolated annotation type. Student-participants were assigned identification codes, which indicated their course, participant type, and a unique identification number. Tweets (n = 5343) and posts (n = 1613) were counted and organized by timestamps, participant type, and sampling frames were applied.

Table 6.

Sampling framework by analysis by course

ANALYSIS	DATA TYPE	DETAILS OF ANALYSIS	SAMPLE SOURCE	SAMPLED POSTS & TWEETS[a]				
				CC	CAM	SOC	VT	TOTAL
Content Analysis	Posts	Type, source, communicative impact of hyperlinked and embedded materials		93	184	102	117	496
	Tweets	Type, source, and communicative impact of hyperlinked materials Communicative impact of hashtags		2386	118	412	126	3066
Descriptive Statistics	Posts	Number of hyperlinks Number of embedded materials Number of broken hyperlinks		93	184	102	117	496
	Tweets	Number of hyperlinks Number of mentions Number of hashtags Number of broken hyperlinks		2386	118	412	126	3066
Network Analysis	Posts	Visualization of hyperlinked sources		93	184	102	117	496
	Tweets	Visualization, network and centrality metrics for social interactions (e.g. mentions)		4075	226	545	497	5343

[a] CC and SOC blog posts represent those written by the designated sample source for Weeks 3, 7, and 8 of the course. VT and CAM blog posts represent all those written by the sample source. CC was the only course to include open participants. All tweets from the designated sampling sources were included for all courses for all analyses.

Content analysis. Content analysis is a systematic, replicable research method that reduces large amounts of text-based data into an efficient number of representative themes or categories (Weber, 1990). Hsieh and Shannon (2005) identified three distinct approaches to content analysis, including conventional, directed, and summative analysis. Conventional analysis involves deriving coding categories directly from the text, while directed analysis incorporates theory or relevant research in the initial coding process, and summative content analysis involves extracting keywords or content before interpreting how they are used within the text. This study employed summative content analysis to evaluate how student-participants incorporated hyperlinks and hashtags into their coursework.

Student-participant blog posts were sampled (496 of 920 possible posts) across study courses, yielding 1,186 hyperlinks for analysis. Student-participant tweets (n = 3066) yielded 431 hyperlinks for analysis. The same procedure was followed for analysis in both contexts. The urls were followed, and the hyperlinked and embedded materials were documented. Over time, categories surrounding types and sources emerged and a typology was established. Then the placement of hyperlinks and embedded materials within the post was studied. Categories for the communicative impact of hyperlinks and images were added to the typology. Communicative impact refers to how the reader perceives the purpose of the hyperlink or embedded materials, or how they impacted the reader experience.

Hashtags were also isolated from student-participant tweets. Once course-related hashtags were removed, 135 "additional" hashtags remained. A search for these hashtags was performed through Twitter and Google search engines. Once any broader context (i.e. historical, cultural, or community-based meaning) was established, the content of the hashtags was analyzed in the context of the tweet, themes documented, and descriptive categories developed.

Network analysis. Network analysis generates visualizations (sociograms) and metrics to document the interactions between people, objects, or people and objects. NodeXL was used to perform two different types of network analysis. The first analysis, which documented the social (mention-driven) interactions within the four courses, was inspired by the social network analytics research described in chapter two. Sociograms and network-level metrics, including density, diameter, and edge and self-loop frequencies, provided comparable metrics across the study courses. Centrality metrics, including in-degree, out-degree, and betweeness centrality, were generated for individual students within the community. The second analysis was inspired by the discourse analytics research described in chapter two. Sociograms were used to identify relationships between students and their web-based information sources.

Ethics of Study

Internet-based research, whether defined as that which studies Internet-related phenomena or that which uses the Internet to collect or analyze data, is a new practice. As more researchers explore virtual activity and behavior, unique ethical tensions have emerged within the field. Virtual contexts blur delimitations between data and personhood. For example, the avatars might be considered data, a behavior manifested by a separate, physical human, or a separate virtual person who may or may not reflect all or some of the physical person who created them (Markham & Buchanan, 2012).

As a group, Internet researchers tend to question the assumptions of the biomedical ethical model in the context of the virtual world, a place in which humans participate by knowingly and publicly publishing work (Kanuka & Anderson, 2007a). However, virtual contexts challenge traditional definitions and perceptions of public and private domains. Research indicates that people who publish their thoughts to the Internet may operate in public but maintain strong

perceptions of privacy, demand proper contextualization of their information, or expect some retention of ownership over their data even if it is not copyrighted material (Markham & Buchanan, 2012). Furthermore, digital traces of what are otherwise fleeting social interactions exist, and they create permanent, concrete grounds for public scrutiny. Laws, rules, norms, and etiquette surrounding digital traces are either nonexistent or newly emerging, leaving some individuals and populations more vulnerable than they should be in a fair and just society (Kanuka & Anderson, 2007a). Therefore, a growing number of Internet researchers are moving towards the ethical stance that it is ethically unsound to treat all visible data found on the Internet as public domain, without consideration of the individual who created or published it (Markham & Buchanan, 2012).

However, traditional models of informed consent are not always feasible in Internet-based environments; for instance, establishing consent through participant signatures could be an insurmountable barrier to some types of research. Digital networks are expansive and typically eclectic. A series of retweets and mentions can touch thousands of people within hours in ways that may or may not be relevant to the research questions at hand. Finding and consenting all those involved for the purposes of research that de-identifies data and is irrelevant to the individual not only wastes the researcher's resources but might be considered invasive by network participants (Markam & Buchanan, 2012).

Internet research frequently involves de-identified data, but a sound ethical approach requires researchers to acknowledge that most digital information can be traced back to the originator despite attempts to de-identify it. With this in mind, course participants were notified of the study and provided with an opportunity to opt out through a link from their course websites to a website designed by the researcher that provided information on the study, contact information, and instructions on opting out of the research (http://rampages.us/clresearch). No participant opted

out of the study and all study protocols were approved by the VCU Internal Review Board (IRB Study Protocol HM20004202).

Chapter 4

This chapter is divided into two sections that correspond to the first two strands of inquiry described in chapter three. The first section focuses on how students use blogging and tweeting annotations in connected courses. Findings are described at a course level, so that general trends can be identified and the impact of course context might be considered. Furthermore, it proposes classification systems, or typologies, for organizing, describing, and quantifying student annotations. The second section employs the findings of the first to develop a prototype of an assessment toolkit consisting of analytic assessment dashboards, rubrics, and digital graphic visualizations for blogging and tweeting applications. Individual student data is used to illustrate the use of the assessment toolkit, thereby demonstrating the capacity of the data to be stratified in ways consistent with performance assessment. Important findings are summarized within the chapter, but a complete report on the statistical analysis of annotation use at a course level is located in Appendix B. A comprehensive report of student-level findings can be found in Appendix C. The sociograms of mentioning activity (e.g. social network analysis) for each course is located in Appendix D.

How Learners Used Annotations in Connected Courses

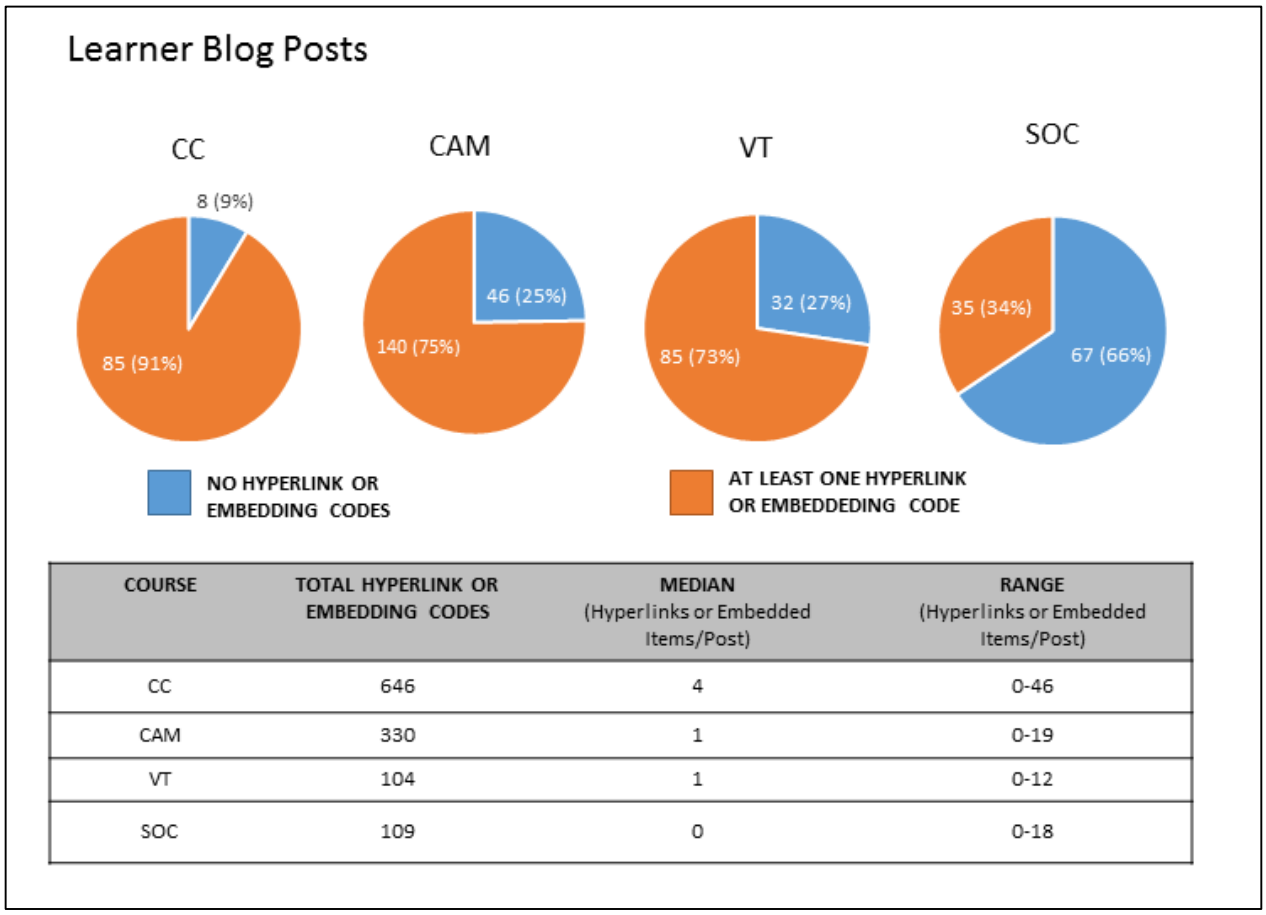
In the span of two overlapping, eight weeklong summer sessions, approximately 282 people contributed 1613 blog posts and 5343 tweets to the four courses included in the study. They inserted thousands of hyperlinks, embedded images, mentions, and hashtags into their work with diverse results and impact. To better understand how learners employed annotation systems, 496

posts and 3066 tweets were sampled and their annotations extracted. This section reviews the findings of content, statistical, and network analyses that were performed on these data and summarizes them in the form of course-level typologies and graphic visualizations.

Annotations in blog posts. Of the 496 student-participant blog posts sampled, 345 (69%) included at least one hyperlink or embedded image, which allowed for the analysis of 1186 hyperlinks and embedded images. Embedded images, videos, animated .gifs, or audio files made up roughly one third of the sample, while the remainder were text-based hyperlinks to other web-based documents. Although hyperlinks and embedded materials are technically different (embedded materials are copied, stored, and visualized within the body of the post, while hyperlinked materials remain in their original context), they yield similar html code when extracted from blogging platforms. Therefore, they were analyzed together as this was more technically feasible than teasing them apart. The vast majority of hyperlink and embedding codes (97%) yielded at least some analyzable information; less than 2% (n = 23) of links were broken or otherwise inaccessible. An additional 14 (1%) links could not be followed because students privatized or deleted blog posts after the data had been collected but before analysis took place.

As Figure 7 demonstrates, hyperlinking and embedding took place with different distributions across the courses. CC students hyperlinked and embedded with the highest frequency. Although this could be attributed to a variety of factors, CC was a graduate level course, and students typically wrote longer and more formal posts than the undergraduates. Furthermore, they were required to blog literature reviews that accounted for almost all posts containing more than 25 hyperlinks.

With the exception of embedded images, which will be discussed below, hyperlinking and embedding codes consistently yielded three types of information: the type, source, and content of hyperlinked or embedded materials. This information in combination with the placement of the hyperlink or embedded material within the blog post led to the development of themes for describing communicative impact of the hyperlinked or embedded material. Types, source, and communicative impact of hyperlinking and embedding codes were categorized, aggregated, and listed in Table 7. Figure 8 contrasts frequencies of each classification across the study courses.



COURSE	TOTAL HYPERLINK OR EMBEDDING CODES	MEDIAN (Hyperlinks or Embedded Items/Post)	RANGE (Hyperlinks or Embedded Items/Post)
CC	646	4	0-46
CAM	330	1	0-19
VT	104	1	0-12
SOC	109	0	0-18

Figure 7. General annotation use in blog posts. While CAM and VT statistics represent student annotations from all eight weeks of blogging, CC and SOC represents weeks three, seven, and eight; therefore proportional statistics controlled for number of posts are more significant than total numbers.

Table 7.

Typology for hyperlinking and embedding in blog posts

TYPE	
Articles & Papers	Academic literature of scholarly outlets; grey literature of government, professional, and research organizations; published work of the popular news and media organizations. Typically formatted for downloading or printing.
Webpage Information	Information contained on a webpage, typically not formatted for downloading or printing. Typically geared towards a public or consumer audience and are less likely to contain references or in-text citations. Also includes online dictionaries and encyclopedias.
Blog Posts	Short works of one or a small group of authors sharing personal experience or a point of view. Self-published, not formatted for downloading.
Course Materials	Information on the course website.
Images & Videos	Pictures, videos, and animated gifs.
SOURCE	
Academic Journals & Conferences	Academic journals and conference proceedings.
News & Magazines	News, periodicals, and other popular media outlets.
Organizational Websites & Blogs	Government, industry, and nonprofit organizations typically associated with "grey literature," public policy, professional certification and governance, research, or business.
Course Website	Course website.
Course Participants	The work (i.e. blogsite, posts, or tweets) of other participants in the course, including instructors, students, or open participants.
Self	Work produced by the author of the post; typically previous blog posts, tweets, or other learning products.
Social Media Platforms	Digital sites with primary function of supporting crowdsourcing, curation, commenting, and co-creation, e.g. YouTube, Wikipedia, and Twitter.
Other Digital Platforms	Digital sites with primary function of supporting multimodal creativity such as graphic design, photograph annotation and editing, or audio recording.
COMMUNICATIVE IMPACT	
Providing Course Context	Provides background information or explanation by linking to course website or other information about the course. Refers to hyperlinks only.
Providing Personal Context	Provides background information by linking to their previous work or other information about their lives. Refers to hyperlinks only.
Describing	Defines or gives background, or additional information. Refers to hyperlinks only.
Citing or Referencing	Citing and referencing as recommended by a style guide. Refers to hyperlinks only.
Providing Additional Resources	A reference meant to provide additional information, but it may or may not have been used to inform the post. Refers to hyperlinks only.
Illustrating	Offers an example or illustrates a point. Refers to hyperlinks and embedded images.
Aesthetics	To add aesthetic value to a post. Refers to embedded images only.
Linking to Learning Products	To connect to or display completed assignment, when students were tasked with making images, audio recordings, or using google docs or other digital platforms.

Types and sources of materials. As demonstrated in Figure 8, hyperlink use differed with participant level, course content, and instructional design. The graduate- and post-graduate learners of CC tended to hyperlink to articles, technical reports, policy papers, and web-based information from academic, government, and research or advocacy organizations. SOC undergraduate students frequently hyperlinked articles published in news outlets and popular media, consistent with their course content and blogging prompts. CAM students tended to hyperlink to consumer-oriented information provided on government or industry webpages, which the instructor associated with a shortage of appropriate academic sources. VT students rarely hyperlinked to text-based content (n = 23), but blog prompts were designed to stimulate multimodal expression and reflection rather than web-based research.

Almost every learner embedded at least one image or video. Embedded images presented an analytical challenge, because many source locations were obscured through the uploading process; the fact that many learners failed to properly credit images exacerbated the problem. The unsourced images, which account for 17% of the entire sample, contribute the "unknown" material sources seen in Figure 8 and Table 19 (Appendix B). Table 8 outlines the types and frequencies of images and videos embedded into student posts across courses. Embedded images included photographs, edited photographs, graphics, and infographics, tables, and charts. Edited photographs referred to those transformed through post-production editing, such as that seen with collages or memes. Graphics included cartoons, clip art, and typographic-based designed, in contrast to infographics, which were specific graphic representations of research-related data**.** Finally, embedded videos were identified as animated .gifs, entertainment (e.g. music videos and movie or television clips), or informational materials.

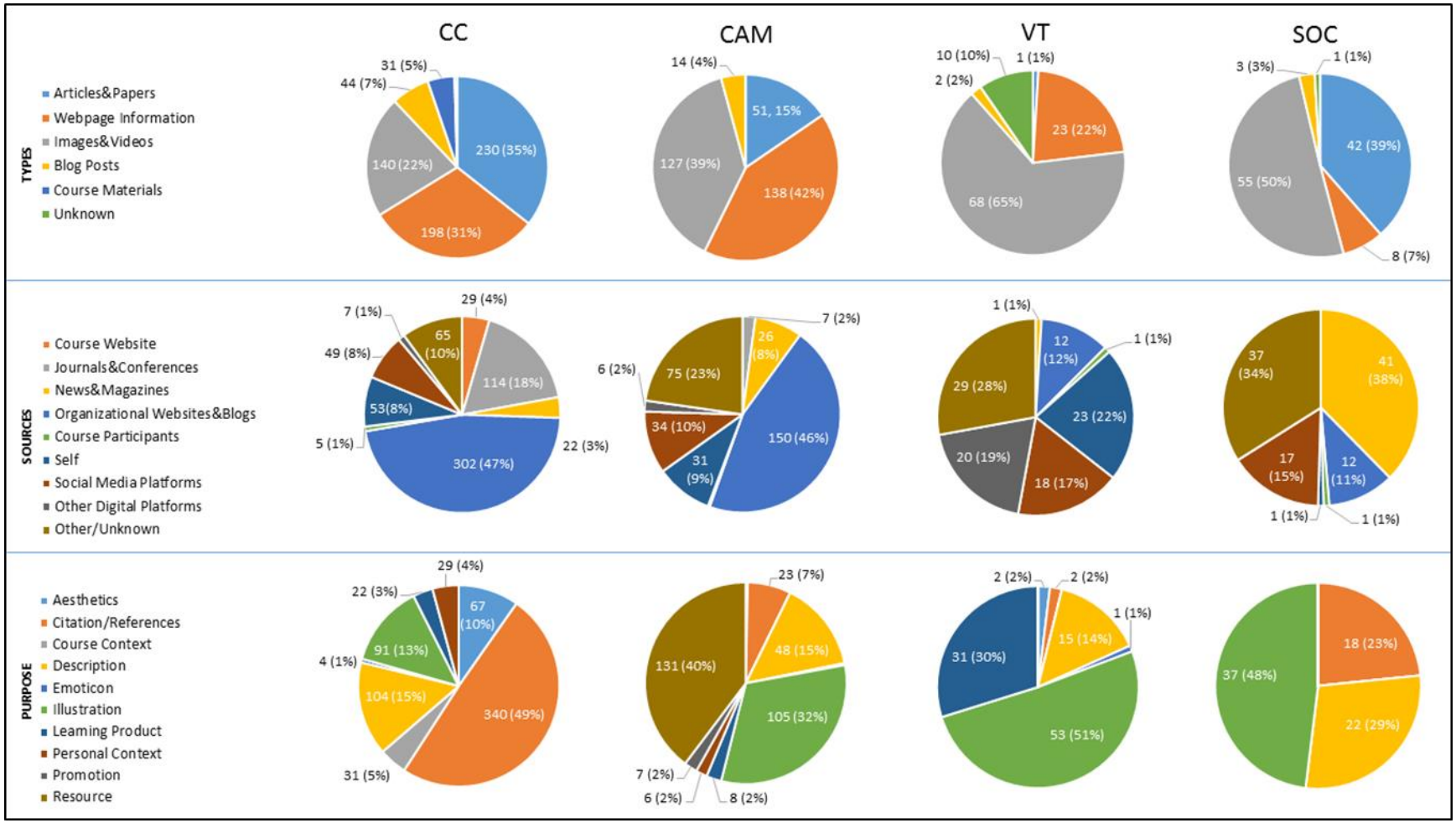


Figure 8. Specific hyperlinking and embedding practice in blogs. These data are based on sampled student-participant posts only.

Sixty percent (n = 39) of embedded videos were informational and consisted of recorded interviews, promotional videos, instructional "how-to" recordings, or Ted Talks. The presence of music videos and movie or television clips (n = 23; 37%) was often traceable to blog prompts asking student-participants to use these types of content as metaphors or illustrations of a course-related topic. Student-participants accessed videos almost exclusively from YouTube; only four videos (6%) from the sample were sourced from Vimeo or TedTalk.com. One VT student chose to embed animated .gifs (n = 2; 3%) to illustrate course concepts, including one she created on her own.

Self-generated images and videos (i.e. those created by the author of the post), were present at varying frequencies across courses. Several CAM students embedded their own photographs, but one student who demonstrated comparatively high levels of digital literacy routinely embedded self-generated videos, graphic elements, and photographs. VT and CC student-participants were required to incorporate their own image-based creations, including infographics, concept maps, and edited photography, into blog posts. The presence of these multimodal assignments is reflected in the number of learning products student-participants embedded or linked. After VT and CC student-participants were required to use digital creative tools to complete assignments, some continued to use those tools to illustrate their blog posts even when it was not required. The number of self-generated images reported in Table 8 is most likely underreported. If authors did not claim ownership in a caption, the content of the image or video, or the text of the post, the material was not counted as self-generated. In particular, CC learners embedded approximately a dozen illustrated quotations that may have been self-generated through the same graphic illustration applications they used to make infographics earlier in the course. However, these could not be confirmed as self-generated.

Table 8.

Characteristics of embedded images and videos in blog posts by course

	CC	CAM	VT	SOC
TOTAL IMAGES[a]	**110**	**128**	**56**	**39**
Photographs	17 (15%)	71 (55%)	18 (32%)	23 (59%)
Edited Photographs	12 (11%)	7 (5%)	7 (13%)	0
Graphics	66 (60%)	20 (16%)	28 (50%)	15 (38%)
Infographics, Tables, & Charts	15 (14%)	17 (13%)	3 (5%)	1 (3%)
Self-Generated Images	11 (11%)	24 (19%)	26 (46%)	0
TOTAL VIDEOS/GIFS	**30**	**13**	**13**	**6**
Music	8 (27%)	0	8 (61%)	1 (17%)
Movie & Television Clips	3 (10%)	0	3 (23%)	0
Informational	19 (63%)	13 (100%)	0	5 (83%)
Animated .GIFs	0	0	2 (15%)	0
Self-Generated Videos & .GIFs	0	2 (15%)	1 (8%)	0

[a]Percentages in table refer to percentage of total images and total video/gifs, respectively

Communicative impact of hyperlinks and embedded material. The type, source, content, and placement of hyperlink or embedded material codes created an effect within the blog post, which was defined as the communicative impact of the annotation. Like types and sources of the materials, the communicative impact classification system emerged from the process of content analysis. These categories and their frequencies are found in Table 7 and Figure 8, respectively. The findings suggest that learners hyperlinked documents and embedded images and videos with six communicative effects: to provide citations and references; to offer additional resources; to describe or define; to illustrate, provide examples, or for metaphorical effect; to connect the post to previous work; to connect the post back to the course assignment; or to add aesthetic appeal. Table 9 offers examples of these effects, but to protect student privacy the examples represent close rather than exact representations of student work.

- *Citations and references.* Students used hyperlinks to augment in-text citations and end-of-post references, consistent with the recommendations of commonly used style guides.

CC students did this frequently and across types of blogging assignments (n = 340; 49%); SOC students also employed this technique, but typically only in their formal, collaborative writing assignments (n = 18; 23%). Hyperlinked citations and references were isolated to a few CAM students (n = 23, 7%) and almost nonexistent in VT (n = 2, 2%).

- *Additional resources*. Rather than invoking standard academic citation styles, many CAM students offered hyperlinked resources at the end of the post (n = 141; 40%). Their hyperlinking practice differed from citing and referencing because it was unclear whether the hyperlinked resources had informed the main content of the post or if they were present merely to extend it. Similarly, CAM and VT students occasionally embedded informational videos at the end of their posts as an additional resource, prefaced by the phrase: "To learn more…."
- *Description.* Learners in all courses used hyperlinks to describe, define, demonstrate, or provide background information for statements in ways that functioned differently than standard citations, references, or additional resources. These hyperlinks were embedded directly into text without explicitly referencing a source. For example, learners might hyperlink a technical word or phrase to a Wikipedia article or an online dictionary that defined the word or phrase. Similarly, students added infographics, charts, and tables to augment the narrative of the post.
- *Illustration, metaphors, and examples.* Learners often illustrated products or organizations they discussed in their posts with visual representations, icons, logos, or video clips. Music videos, in particular, provided opportunities for metaphorical expression. In this sample of learner work, music videos and movie and television clips were always followed with an explanation of the metaphor or illustration the learner was trying to achieve.

- *Personal context.* Learners used hyperlinks to refer to their previous work, typically blog posts written earlier in the course. Sometimes this had the effect of showing how blog posts built on each other in a constructed process. This was particularly common in CC, where blogging prompts were designed to build on each other to create a learning product. In other cases, learners used hyperlinks to refer to posts where they had previously defined, described, or contextualized a concept, presumably so they did not have to do it again.
- *Course context.* CC students used links to the course website or course to provide context for why they were writing the post.
- *Aesthetics.* Although learners provided an explanation for embedded videos, they were much less likely to support embedded images with explanatory narrative. In many cases, images appeared to have little meaning beyond the development of a personal aesthetic. CC students tended to punctuate blog post sections with clip art. Some CAM and VT students routinely added attractive photographs to the top or the bottom of each post.

Table 9.

Examples of communicative impact in blogs

BLOG POST EXCERPT[a]	HYPERLINKED WORD or EMBEDDED MATERIAL	HYPERLINK/EMBEDDED MATERIAL TYPE & SOURCE	COMMUNICATIVE INTENT
Smith (2010) suggests that verbal and nonverbal communication can lead to increased...	Smith(2010)	Journal article	Citation
	Nonverbal	Slides published on a digital slide sharing platform	Description
If you would like more information on this topic, check out what these organizations have to say: National Institutes of Health	National Institutes of Health	Government-sponsored webpage designed for public consumption of research	Additional Resources
...this could be done Mad Libs style.	Mad Libs	MadLibs webpage	Description
Phenomenology would be one appropriate research approach. It has been used in similar studies in the nursing and allied health fields (Howard & Jeffries, 2014).	Phenomenology	Stanford Encyclopedia of Philosophy entry on phenomenology	Description
	Howard & Jeffries, 2014	Journal article	Citation
In last week's post, I proposed a list of questions that are meant to inspire my research for this course. This week...	Post	Previous post	Personal context
I am exploring this topic as part of this course..."	Course	Course website	Course context
 Barn raisings, still common in parts of the country, demonstrate the benefits of community by…In the picture….		Embedded image credited to a Wikipedia article (public domain)[b]	Illustration
 **Additional Questions**		Embedded image with unknown source	Aesthetics

[a] These excerpts are modeled after samples from learner blog posts. Exact phrasing was changed to protect the privacy of the original authors.

[b] Photo attributed to Alexander W. Galbraith, via Wikimedia Commons. Retrieved from: https://commons.wikimedia.org/wiki/File%3ABarn_raising_in_Lansing.jpg

Annotations in tweets. In terms of annotation use, tweets presented a richer and more complex field for analysis than blog posts. A heterogeneous population of enrolled students, open participants and other participants contributed 3066 (57%) of the 5343 course-related tweets. These tweets contained a higher concentration and more diverse array of annotations than blog posts. This study explored learner (that is, enrolled student, open participant, and other participant) use of hyperlinks, mentions, and hashtags.

As seen in Figure 10, each course supported different tweeting and annotation patterns. Unlike blog posts, which were sampled unequally across courses, all learner tweets and annotations were studied; therefore total number comparisons as well as proportionate use are meaningful. CC generated 2386 tweets and 2308 mentions, mostly during the structured Twitter chats students were required to attend weekly. Observation suggested that student-participants mentioned, or talked to each other, in almost synchronous conversation. SOC students, who were incentivized but not necessarily required to tweet, generated 412 tweets through unstructured and unscheduled activity. They interacted with each other at a lower frequency, but tended to include hyperlinked resources in their tweets. Tweeting in VT and CAM was voluntary. Although the VT instructor made a notable effort to engage students and model the activity by tweeting 347 times (70% of all VT tweets), neither cohort produced significant student-participant data.

Hyperlinks in tweets. Of the 3066 student-participant tweets analyzed, 524 (17%) included one hyperlink. No tweets contained multiple hyperlinks. Furthermore, no hyperlinks were broken or inaccessible. Three hyperlinks in CC tweets appeared to be irrelevant to the course and attributable to two Twitter bots working on the margins of the course community. Nine percent (n = 48) of the total hyperlinks led to images, videos, or animated .gifs, while the remainder connected the tweets to text-based web documents.

Of the learner tweets containing hyperlinks, 106 (20%) were simple retweets generated by CC (n = 73) and SOC (n = 33). As illustrated in Figure 9, simple retweets differ from edited retweets in that the learner does not annotate or add anything to the original message. Social media research suggests individuals retweet for a variety of reasons (boyd et al., 2010). The lack of learner-generated information in a simple retweet made it difficult to interpret. Therefore, simple retweets were excluded from content analyses. Edited retweets were retained because they included some sort of explanatory or descriptive addendum by the student-participant.

The types and sources of tweeted hyperlinked materials were similar to blogged hyperlinks, although the proportions of use changed significantly (Figure 11). Only SOC learners tweeted hyperlinks to news and popular culture articles at appreciable levels; VT, CAM, and CC learners tended to hyperlink to their own blog posts and learning products. Communicative impact also appeared to be different and the new categories are listed and defined in Table 10. Themes included: contribution, promotion, signaling, description, and reply context.

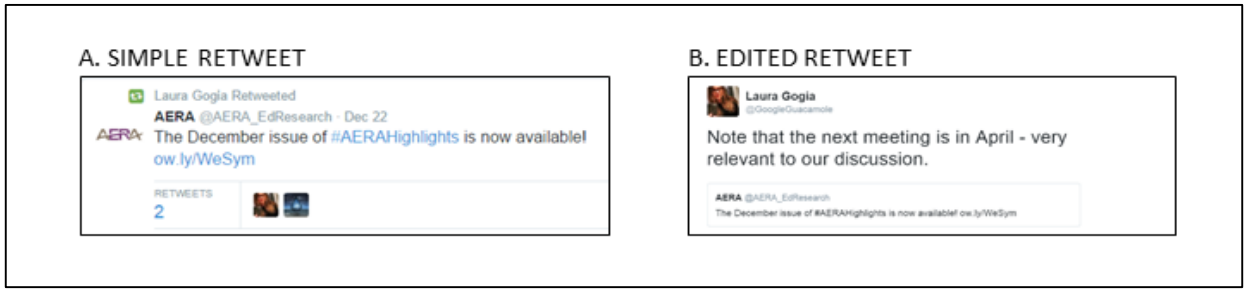
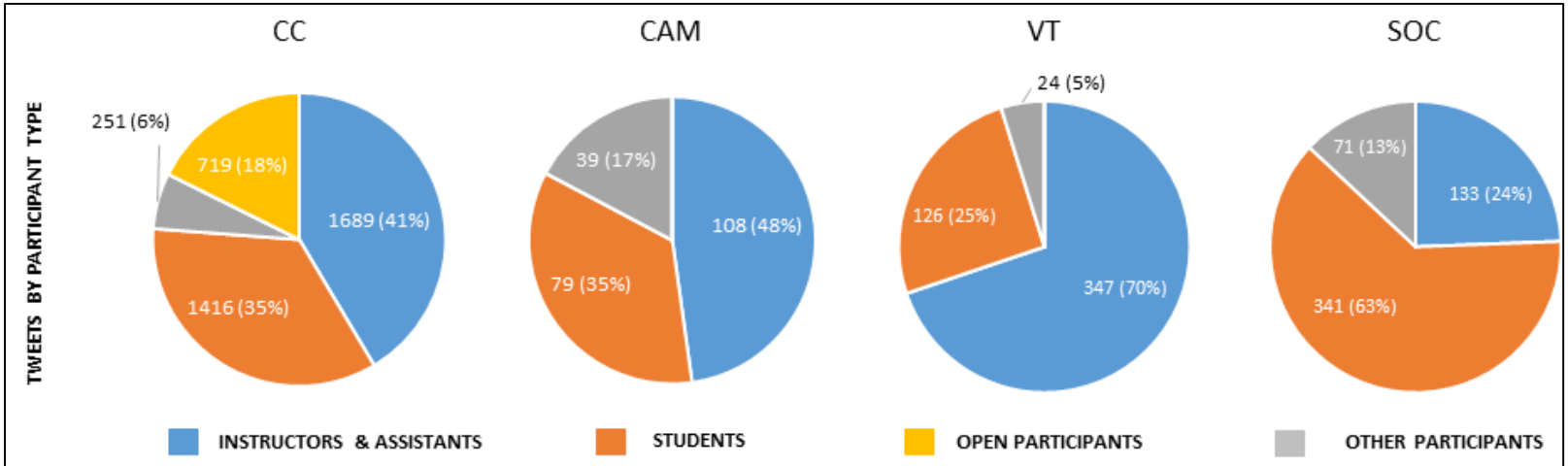


Figure 9. Simple versus edited retweet. The simple retweet ("A") shows how an individual ("Laura Gogia") simply retweets a message from another Twitter user ("AERA") to her followers without adding additional information. In the edited retweet ("B") the same individual retweets the same message, but adds a message of her own that reads: "Note that the next meeting is in April…." Simple retweets were excluded and edited retweets were retained for the hyperlink analysis.



COURSE	TOTAL TWEETS	TOTAL STUDENT-PARTICIPANT TWEETS	HYPERLINKS[a]	MENTIONS	HASHTAGS[b]
CC	4075	2386	248	2308	106
CAM	226	118	41	28	1
VT	497	150	62	106	2
SOC	545	412	173	266	26
TOTAL	5343	3066	524	2708	135

[a] Number of hyperlinks, mentions, and hashtags are based on student-participant tweets only. Instructor use of these annotations is not included.
[b] Excludes the designated aggregator course hashtags.

Figure 10. General annotation use in tweets.

- *Contribution.* Most frequently (n = 182; 44%), learners appeared to tweet a hyperlink to contribute information to others within the cohort. Contributions differed in quality, from generalized to specific. SOC learners typically tweeted a news article to the entire community preceded by a comment such as, "Interesting article." In contrast, when CC learners hyperlinked they frequently combined it with a mention, linking the piece of information to a specific person who might find it most relevant.
- *Promotion.* Findings also suggest that learners hyperlinked to promote material (n = 176; 42%), usually the tweeter's own blog posts. Some CC learners also promoted course-related events. The simplest promotional tweets read: "Read my new blog post, [*hyperlink*]." However, some tweeters began to experiment with more complex promotional techniques such as adding a quote or image to illustrate the hyperlink.
- *Signaling.* In every course but VT, learners incorporated images that seemed to signal the tweeter's activity or mood (n = 29; 7%). Examples included selfies, animated .gifs, memes, or a photograph accompanied with explanatory text. Although signaling tweets were isolated to two or three CAM and SOC students, the practice was more widespread in CC, where learner interactions became increasingly informal over time.
- *Description and reply context.* The structured, synchronous CC class discussions seemed to trigger specific hyperlinking behaviors. Sometimes (n= 19; 5%), learners hyperlinked to webpages that seemed to provide more detailed definitions or descriptions of what was found in the content of the tweet, thereby transcending the 140 character limitation. Other times (n = 23; 6%), hyperlinks appeared to be artifacts of the threaded dialogues. These hyperlinks were designated "reply context," because they were generated when learners appeared to use edited retweets as a response mechanism.

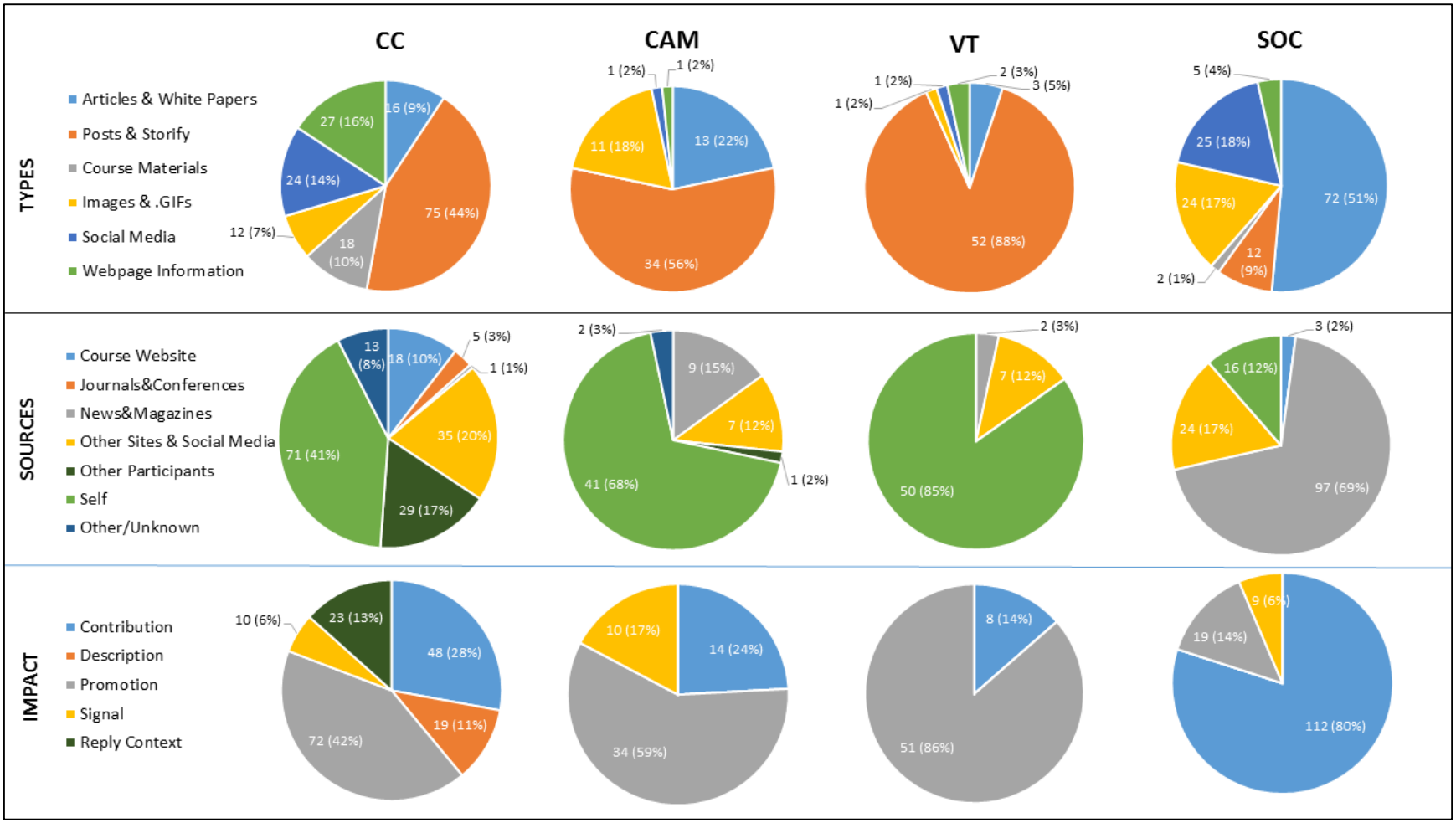


Figure 11. Specific hyperlinking practice in tweets. These data are based on analysis of student-participant tweets only.

Table 10.

Typology for hyperlinking in tweets

TYPE	
Articles & Papers	Academic literature of scholarly outlets; grey literature of government, professional, and research organizations; published work of the popular news and media organizations. Typically formatted for downloading or printing.
Webpage Information	Information contained on a webpage, typically not formatted for downloading or printing. Typically geared towards a public or consumer audience and are less likely to contain references or in-text citations. Also includes online dictionaries and encyclopedias.
Posts & Storified Narratives	Self-published, short works of one or a small group of authors sharing personal experience or point of view through narrative. Narratives published on Storify narratives are timeline-based stories created from curation of social media posts, such as tweets, Facebook posts, and blog posts.
Course Materials	Information on the course website.
Images & Gifs	Pictures, Videos, and Animated Gifs.
Social Media	Social media other than blog posts, typically tweets and Facebook posts. Includes quoted retweets.
SOURCE	
Academic Journals & Conferences	Academic journals and conference proceedings.
News & Magazines	News, periodicals, and other popular media outlets.
Other Sites & Social Media	Organizations typically associated with "grey literature," public policy, professional certification and governance, research, or business and popular social media platforms such as YouTube, Wikipedia, and Twitter.
Course Website	Course website.
Course Participants	The work (i.e. blogsite, posts, or tweets) of other participants in the course, including instructors, students, or open participants.
Self	Work produced by the author of the post; typically previous blog posts, tweets, or other learning products.
Other Digital Platforms	Digital sites with primary function of supporting multimodal creativity such as graphic design, photograph annotation and editing, or audio recording.
PURPOSE	
Describing	Providing definitions, background information, or context
Contributing	Sharing a resource or providing information- either generally or to a specific community member(s)
Promoting	Announcing the presence of a new blog post or finished learning product (almost exclusively their own) or a scheduled course event
Signaling	Announcing current state of mind or status
Reply context	Part of an open conversation; the conversationalists continue to include the link in the tweets as they converse without direct reference to it. Unclear whether the hyperlink is an artifact or present with a purpose

Mentions in tweets. Student-participants generated 2708 mentions in their 3066 tweets. Some tweets included more than one mention. Social network analysis (SNA), which is based on mentioning behavior, was used to generate sociograms and metrics to describe interpersonal activity among all participants (including instructors and assistants). Sociograms, located in Appendix D, suggest CC achieved robust networked communication, while the other courses remained fairly instructor-centered. As demonstrated in Figure 12, enrolled students in all courses tended to interact the most with their instructor or other enrolled students. CC students engaged open participants (n = 140, 9%) at similar frequencies as the open participants engaged them (n = 191, 34%), suggesting that the two groups were willing to converse with each other.

Hashtags in tweets. While every tweet included a course hashtag, 135 (5%) of the learner tweets included at least one additional hashtag. Some appeared only once, while others were used by multiple participants over time. Student-participant use of additional hashtags appeared to fall into three distinct categories, and are documented in Table 11. Community context hashtags were those associated with social movements or affinity groups that exist beyond the course, such as #blacklivesmatter and #dataviz. Course context hashtags appeared to refer to some aspect of the course including readings, discussion topics, student work groups, or learning activities. The most common type of hashtag seemed to add personal context, subtext, or metatext to tweets. They signalled a spectrum of conditions or personal status notes from positive (#epiphany) to neutral (#keepingitinteresting) to confusion (#pleasehelp, #confused).

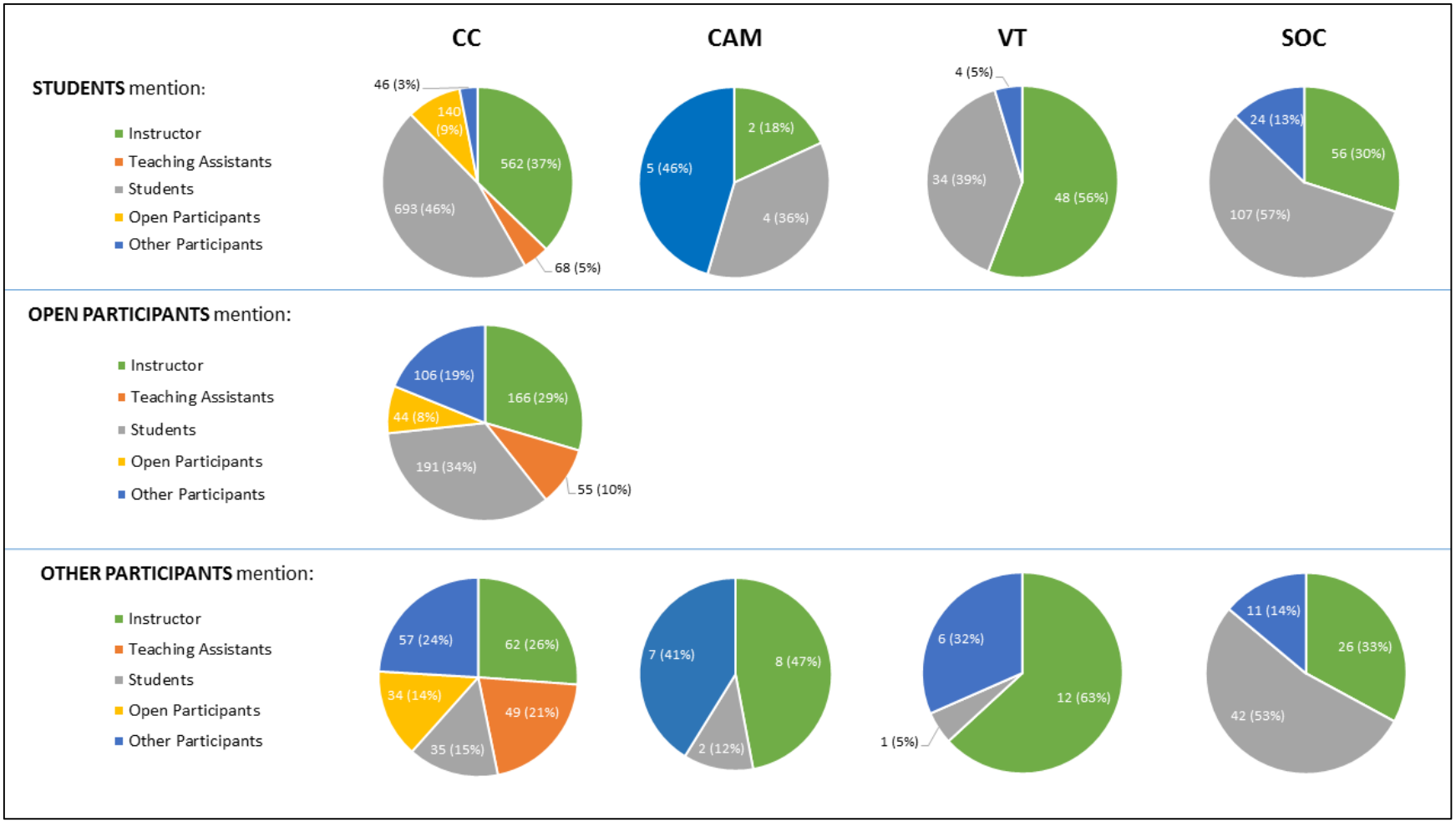


Figure 12. Mention practice.

Table 11.

Hashtags by course

		TYPE OF HASHTAG		
COURSE	**TOTAL HASHTAGS[a]**	**COMMUNITY CONTEXT**	**COURSE CONTEXT**	**PERSONAL CONTEXT**
CC	106	21	22	63
CAM	1	0	0	1
VT	1	0	1	1
SOC	26	3	7	16
Total	135	24 (18%)	30 (22%)	81 (60%)

[a]Excludes the aggregating course hashtags. These data represent student-participant contributions only.

Assessment Toolkit

The previous section described how student-participants used annotations in course-related blogging and tweeting. This section applies those findings towards the development of assessment strategies and tools for documenting student use of annotations in blogging and tweeting activities. It offers prototypes for assessment rubrics and criteria, analytical assessment dashboards, and potentially real-time student performance visualizations. Rubrics tie student annotation use back to the connective learning goals outlined in chapter two. The enrolled student data from CC, CAM, and SOC are inputted into analytic dashboards and graphic visualizations to demonstrate how these tools help stratify student performance and provide actionable feedback for student improvement. Although not all of the available student-level data are used here, comprehensive tables of these can be found in Appendix C. Figure 13 offers an overview of the assessment toolkit.

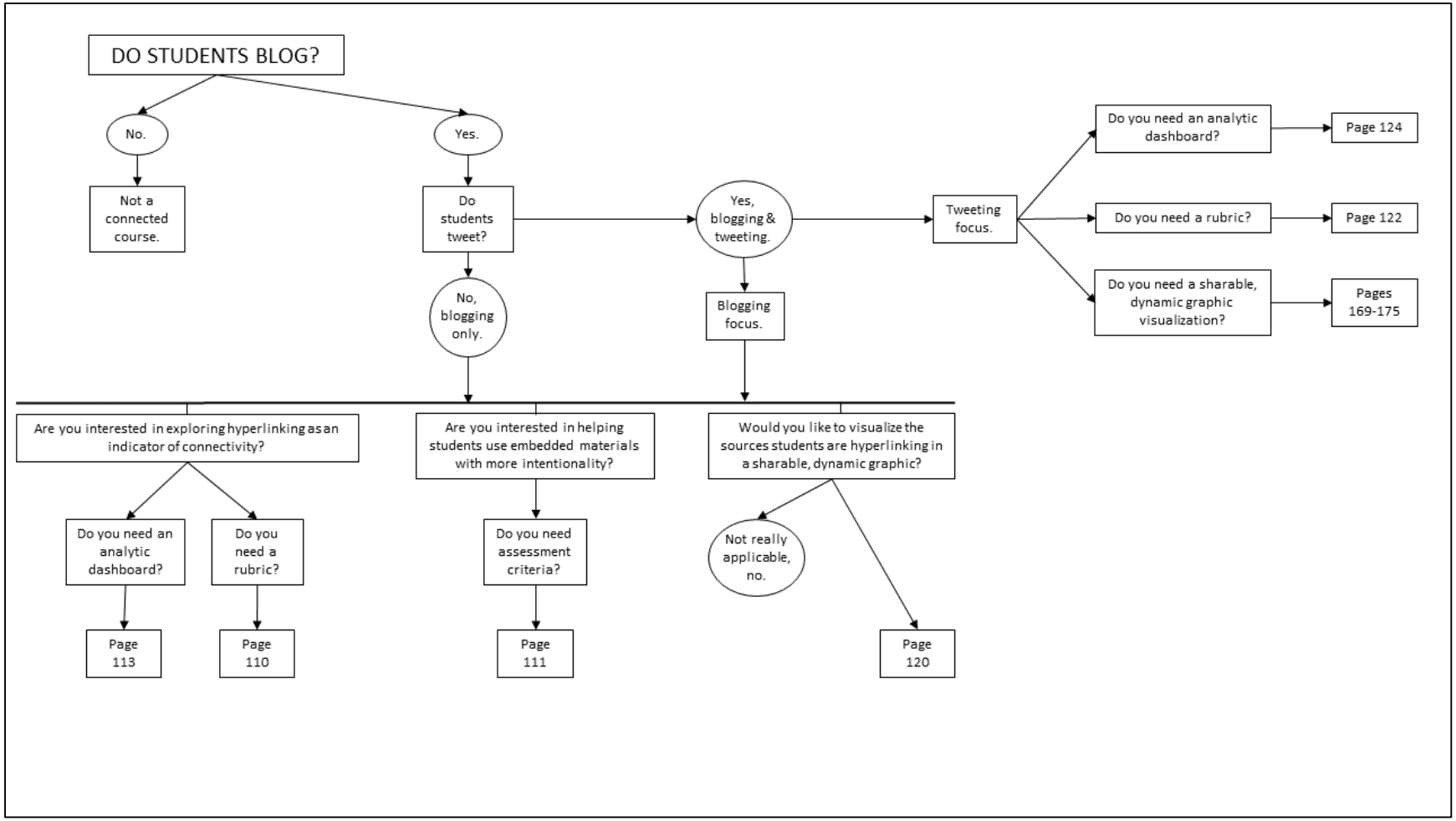


Figure 13. Proposed toolkit for assessing student annotation use in connected courses.

Blogging assessments. This study focused on blogged hyperlinks and embedded images because of their almost ubiquitous presence, essential connective qualities, and potential for automated extraction and visualization. The strategies offered here, which include rubrics, analytical dashboards, and potentially real-time graphic visualizations, are grounded in three evaluative assumptions, namely, that the quantity, digital mechanics, and communicative impact of student work matter when assessing it.

- *Quantity.* Although assessment cannot depend entirely on the number of posts, hyperlinks, and embedded images, this information is essential for establishing baseline understanding of student commitment and time on task. If posts have not been submitted and students have not attempted to document the links between ideas, then this form of connectivity cannot be assessed.
- *Digital mechanics.* While blog posts are not intended to conform to traditional academic writing standards, there are growing expectations that bloggers will exhibit precise and consistent hyperlinking and embedding technique, including proper use of alternative text and attribution. Just as a lack of posts and hyperlinks impacts assessment, broken or inaccessible hyperlinks, failure to give credit to image sources, and incomplete or improper embedding impedes the documentation and communicative impact of annotating.
- *Communicative Impact.* Content analysis suggested that students who used more and more varied hyperlinks made more and more diverse types of connections in their writing. Similarly, embedded materials had more impact when students made the reason for their presence clear. Therefore, communicative impact becomes the focus of blogging assessment.

Rubric for blogging. Rubrics are descriptive scoring protocols meant to guide the analysis of the products or processes of learning (Brookhart, 1999). They differ from checklists in that checklists indicate the presence or absence of elements only, while rubrics seek to describe levels or degrees of elemental presence (Moskal, 2000). Table 12 offers a rubric designed to capture student connectivity based on elements of quantity, digital mechanics, and communicative impact. It is grounded in the connectivity-based learning goals outlined in chapter two and the communicative intent typology presented earlier in this chapter.

Assessment criteria for embedded images. Embedded images offer a unique opportunity and challenge to faculty who seek to improve student connectivity and communicative impact. For reasons that have yet to be established, embedded images are common in student blog posts; even students who fail to use other annotation devices will embed a photograph or graphic element occasionally. However, the care with which images were embedded varied tremendously in the sampled blog posts. Many students failed to make explicit connections between images and their blog posts. Moreover, many failed to attribute images adequately or attend to universal design elements such as alternative text. However, students who embedded with intentionality used images to further their narrative or show deep and personal connections to the subject matter. Table 13 offers criteria for embedded images that can be shared with students and used in assessment. The criteria suggests that images should be properly attributed to be considered at all ("baseline requirement.")

Table 12.

Rubric for blogging

INDICATOR		NEEDS IMPROVEMENT	AVERAGE	EXEMPLARY
QUANTITY	**Quantity of posts**	Fewer than assigned	As assigned	More than assigned
	Quantity of hyperlinks and/or embedded materials	Rarely present	Consistently inserts one or two hyperlinks and/or embedded images per post	Consistently inserts more than two hyperlinks and/or embedded images per post
DIGITAL MECHANICS	**Proper hyperlinking**	Linked URLs often visible or not integrated into text. Broken or inaccessible hyperlinks frequently present.	Linked URLs mostly integrated and embedded in text. Broken or inaccessible hyperlinks occasionally present.	Linked URLs always embedded and integrated in text. Broken or inaccessible hyperlinks rarely present, if ever.
	Proper embedding	URLs to videos and images always visible in the text of the post rather than embedded.	URLs to videos and images occasionally visible in the text of the post.	URLs to videos and images rarely or never visible.
	Proper attribution and attention to universal design	Images and videos rarely captioned and credited. Alterative text never available.	Images and videos frequently captioned and credited. Alternative text sometimes available.	Images and videos properly captioned and credited, with alternative text available.
COMMUNICATIVE IMPACT (HYPERLINKS)	**Makes connections to personal experience or work**	Rarely links to personal blog posts or other learning products. Rarely if ever embeds self-generated images, videos, or multimodal forms of expression.	Occasionally links to personal blog posts or other learning products. Occasionally embeds self-generated images, videos, or multimodal forms of expression.	Consistently links to personal blog posts or other learning products. Often embeds self-generated images, videos, or other forms of multimodal expression.
	Makes connections to course concepts and materials	Rarely links to course materials or the work of classmates.	Occasionally links to course materials and the work of classmates.	Consistently links to course materials and the work of classmates.
	Makes connections to other disciplines and contexts	Rarely links to sources from other disciplines or contexts.	Occasionally links to sources from other disciplines or contexts.	Consistently links to sources from other disciplines or contexts.
	Demonstrates variability in connections made within posts	Rarely links or links only with one or two purposes (as described in the hyperlinking typology).	Shows some variation in linking patterns across and within blog posts.	Consistently shows variation in linking patterns across and within blog posts.
COMMUNICATIVE IMPACT (EMBEDDED MATERIALS)	**Demonstrates intentionality in embedding materials**	Never or rarely embeds multimodal forms of expression. AND /OR Materials are rarely integrated into or used to further the narrative of the post.	Occasionally embeds multimodal forms of expression. AND/OR Materials are inconsistently integrated into or used to further the narrative of the post.	Consistently incorporates multimodal forms of expression. AND/OR Materials are consistently integrated into and used to further the narrative of the post.

Table 13.

Criteria for assessing embedded images and videos

LEVEL	CRITERIA
CATEGORY 1 (BEST)	Student incorporates the image or video deeply into the narrative of the blog, using it to: • Further the narrative (e.g. a table, chart, or infographic that the student refers to or explains in the narrative) • Demonstrate a personal connection to the subject (e.g. a photograph, graphic, or video the student made themselves and explains in the narrative)
CATEGORY 2 (AVERAGE)	The student embeds an image or video that: • Provides additional information (e.g. a picture of an object or concept being explained in the narrative) • Makes an otherwise unstated theme explicit (e.g. a graphic illustration of a famous quotation that encapsulates the student's argument) • Inspires deeper questions (e.g. a satirical cartoon).
CATEGORY 3 (NEEDS IMPROVEMENT)	The student embeds an image or video that fails to serve any obvious purpose other than contributing to an aesthetic (e.g. an attractive photograph or clip art punctuating the post or sections within the post).
BASELINE REQUIREMENT	The student credits image or video source appropriately via caption, alternate text, or in the body of the text.

Analytic assessment dashboard for blogging. Analytic dashboards are visual representations of key student performance data meant to provide a historical account of what the student has done and suggestions for what the student might do to improve their performance in the future. The best dashboards are simple, using the least number of indicators to provide the most useful information (Hetherington, 2009). Therefore, an analytic dashboard for student blogging should: (1) include elements of quantity, digital mechanics, and the communicative impact of hyperlinks and embedded materials; (2) provide clear and actionable information on how students might improve their performance; (3) be mindful of time and resources required to collect the data to be inputted in the dashboard; (4) function across multiple course contexts; and (5) allow a practitioner to draw conclusions about student performance that are consistent with those drawn from a full content analysis of student work.

The analytic dashboard was developed and tested with CC and CAM enrolled student data. Quantity indicators included numbers of posts and annotations per post. Student annotations were divided into text-based and image-based materials to provide basic information about the types of

connections being made without requiring a comprehensive application of the blogging typology. The number of aesthetic images or videos ("Category 3" in Table 13, this chapter) addresses intentionality of embedded images, while broken or inaccessible hyperlinks offer insight on digital mechanics. Students are loosely clustered into groups exhibiting exemplary, average, and below average work. Student order within the groupings is not significant.

Dashboard example #1: CC students. Course CC required graduate level students to write a mixture of research-based and reflective blog posts interspersed with creative digital makes. Instructors tasked them with writing in ways appropriate for the general public, using openly accessible resources and augmenting their work with visual and interactive media. They provided some informal but explicit feedback on student use of hyperlinks and embedded materials during the course.

The sample of student work used to complete the analytic dashboard (Table 14) exhibits variation in annotation behavior. At the time of sampling, students should have completed eight or nine posts; some of the variation occurred because the sampling frame did not precisely match the assignment completion schedule. Exemplary student work included hyperlinked or embedded materials frequently, averaging seven to nine hyperlinks per post. In general, these students used fewer aesthetic images and had few if any broken links. Average student work included just as many hyperlinks and embedded images as exemplary students but did not demonstrate the same attention to digital mechanics. Two of the three students in the final grouping had fallen behind on completing assignments. Furthermore, they had neither the frequency nor quality of hyperlinking or embedding, suggesting that intervention or further review was required.

Table 14.

Analytic dashboard for student blogging - CC students

GROUPINGS	STUDENT ID	TOTAL POSTS	ANNOTATIONS/ POST	HYPERLINKS	EMBEDDED MATERIALS	CATEGORY 3 IMAGES/VIDEOS[a]	BROKEN HYPERLINKS
Exemplary	CC-S2	9	9	59	24	2	2
	CC-S3	8	7	54	4	1	0
	CC-S4	9	9	74	8	4	0
	CC-S8	9	7	53	11	5	0
Average	CC-S1	8	7	51	10	5	4
	CC-S5	9	8	58	18	8	3
	CC-S7	8	7	49	8	5	1
Needs Improvement	CC-S6	7	5	27	8	4	0
	CC-S9	7	7	40	10	9	2
	CC-S10	8	2	8	11	9	0

[a] Refers to criteria outlined in Table 7, in which Category 3 images are labeled "aesthetic," or bearing no communicative impact beyond contributing to an aesthetic.

To substantiate the stratification of student performance demonstrated in the analytic dashboard, the blogging typology was applied to three posts randomly chosen from students representing each grouping: CC-S4 (exemplary), CC-S1 (average), and CC-S10 (needs improvement). As shown in Figure 14, CC-S4 tended to incorporate more and varied annotations in each post, while CC-S1 integrated fewer annotations with more broken hyperlinks and Category 3 images. Finally CC-S10 hyperlinked and embedded with the least frequency, variability, and quality.

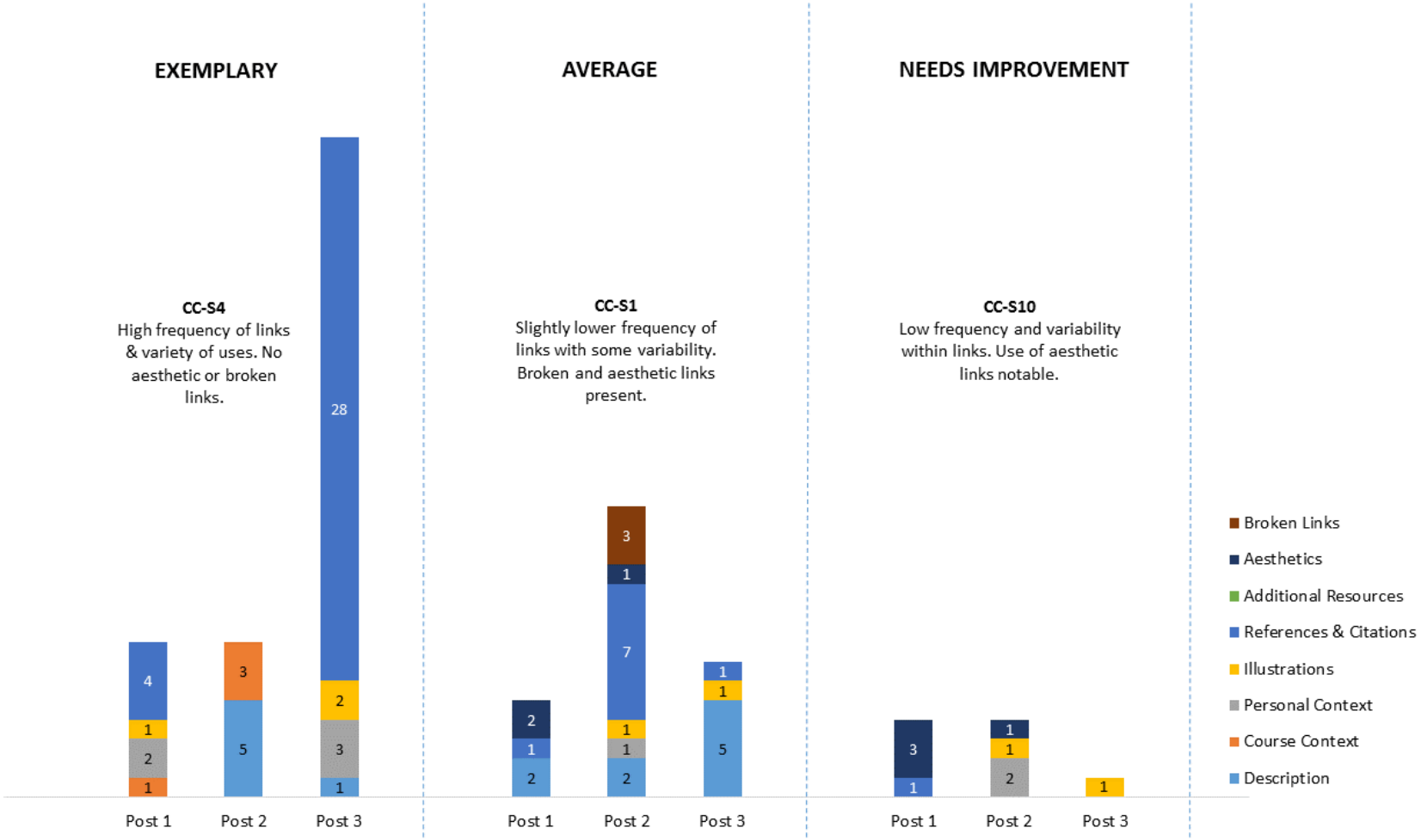


Figure 14. Typology-based assessment of CC student blogging.

Dashboard example #2: CAM students. CAM offered the most flexibility and required the most self-directed learning of all the study courses. Students engaged in independent research on broadly-defined topics, which included finding and reporting on their own information sources. Unlike CC students, who were instructed to use weekly posts to construct a multi-part project, CAM students were offered little structure on how posts should be written. A range of blog prompts were provided, many of which were intended to encourage students to connect research materials to their personal or academic interests. Students earned points towards their grade for blogging and writing comments on other student blogs. Therefore, not every student wrote the same number of blog posts.

The assessment dashboard (Table 15) demonstrates the broad spectrum of student performance seen in CAM. Exemplary students met expectations of performing independent research, using hyperlinks to share references and additional resources as well as to embed materials. Students in the average group tended to incorporate fewer hyperlinks per post and a higher percentage of aesthetic-based images; CAM-S2 demonstrates a different kind of average performance by incorporating a moderate number of hyperlinks but failing to integrate an appreciable number of images or videos. Students whose work needed to improve fell into two, distinct subcategories. Some students failed to hyperlink or embed any materials, while others engaged only in aesthetic-oriented embedding.

Table 15.

Assessment dashboard for student blogging - CAM students

GROUPINGS	STUDENTS	TOTAL POSTS	ANNOTATION/ POST	HYPERLINKS	EMBEDDED MATERIALS	CATEGORY 3 IMAGES[a]	BROKEN LINKS
EXEMPLARY	CAM-S4	12	3	27	14	3	0
	CAM-S14	11	3	27	3	2	1
	CAM-S15	10	4	20	15	6	0
	CAM-S20	4	9	24	11	0	0
AVERAGE	CAM-S2	11	2	19	1	0	0
	CAM-S7	9	2	11	6	4	0
	CAM-S8	9	3	9	15	9	1
	CAM-S9	8	3	15	5	3	1
	CAM-S12	13	2	9	23	23	1
NEEDS IMPROVEMENT	CAM-S1	8	1	2	3	3	0
	CAM-S3	8	0	0	1	0	0
	CAM-S5	12	1	8	0	0	0
	CAM-S10	10	1	5	0	0	0
	CAM-S11	9	1	3	2	0	0
	CAM-S13	12	1	10	3	3	0
	CAM-S16	6	3	11	8	8	1
	CAMS-17	9	1	3	2	2	0
	CAM-S18	15	1	10	12	12	1
	CAM-S19	8	0	0	3	3	0

[a] Refers to criteria outlined in Table 7, in which Category 3 images are labeled "aesthetic," or bearing no communicative impact beyond contributing to an aesthetic.

The application of the blogging typology to CAM students, shown in Figure 15, confirms and augments the assessment offered by the dashboard. CAM-S20 represents exemplary performance, while CAM-S2 and CAM-S7 represent average and CAM-12 and CAM-S1 below average performance. Since CAM students wrote shorter, less complex posts than CC students, the student representatives' posts were combined to show overall trends rather than a post-by-post assessment.

CAM-S20 only wrote four posts, earning the rest of the required points by commenting on other student posts but generated as many hyperlinks as students who wrote ten and twelve posts. This student tended to research extensively and averaged more additional resources per post than other students. CAM-S20 also exhibited diverse hyperlinking and embedding patterns across posts, created original videos and graphics, and consistently made explicit connections between the embedded materials and the post narrative. A typical CAM-S20 post included an original embedded image or video that introduced a topic, a brief paragraph providing historical context (with description hyperlinks), a brief paragraph on mechanics or functionality of the topic (with a captioned illustration or infographic), and a list of hyperlinked additional resources.

CAM-S2 and CAM-S7 produced average work, but in different ways. CAM-S2 tended to write relatively long posts with more evidence of research; however, the student failed to make personal or interdisciplinary connections or explore multimodal forms of expression. Almost every CAM-S2 hyperlink related to an additional resource listed at the end of the posts. On the other hand, CAM-S7 exhibited a more diverse hyperlinking pattern but failed to engage in substantive research as indicated by relatively low numbers of descriptive, citation, and additional resource links.

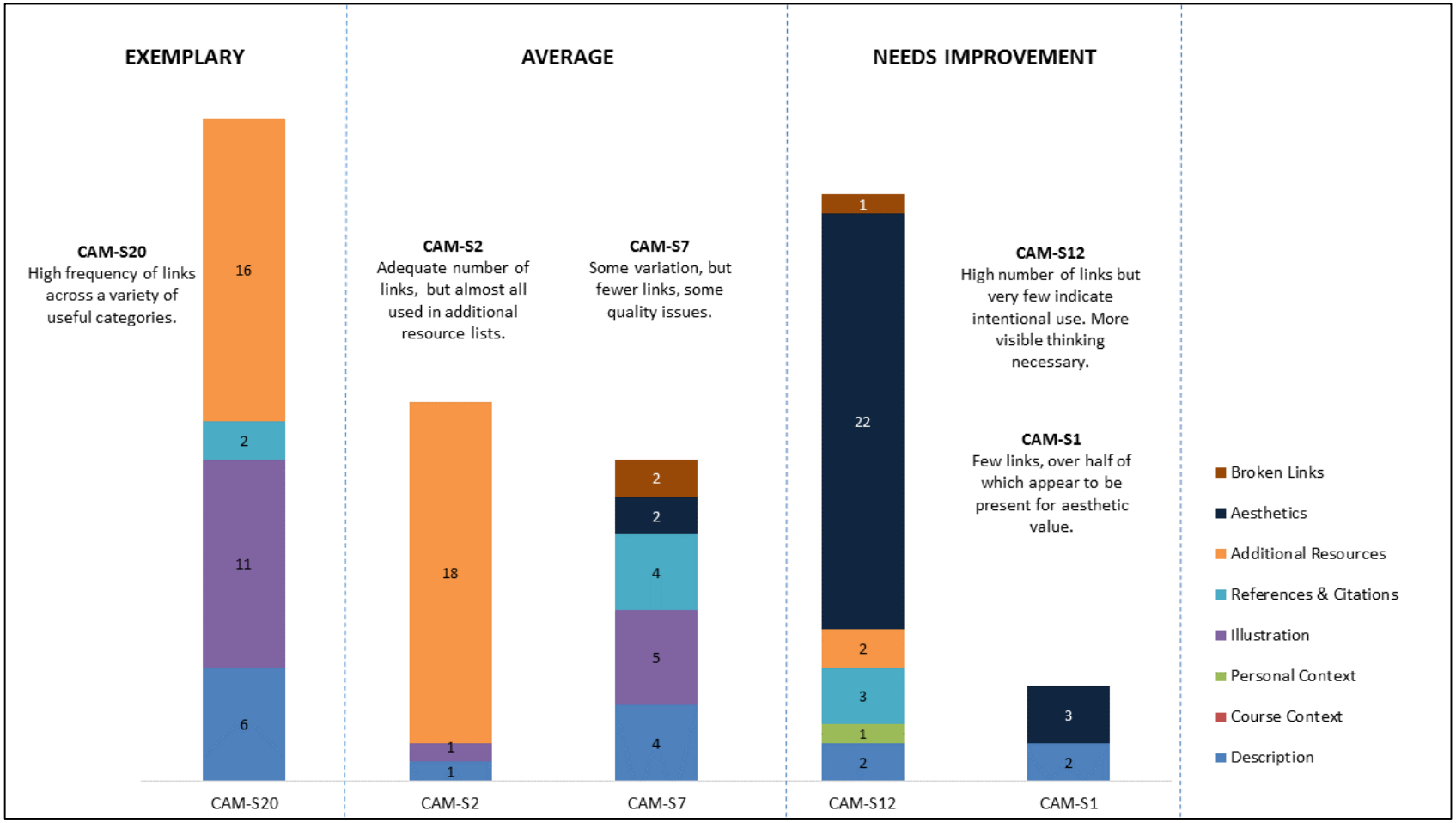
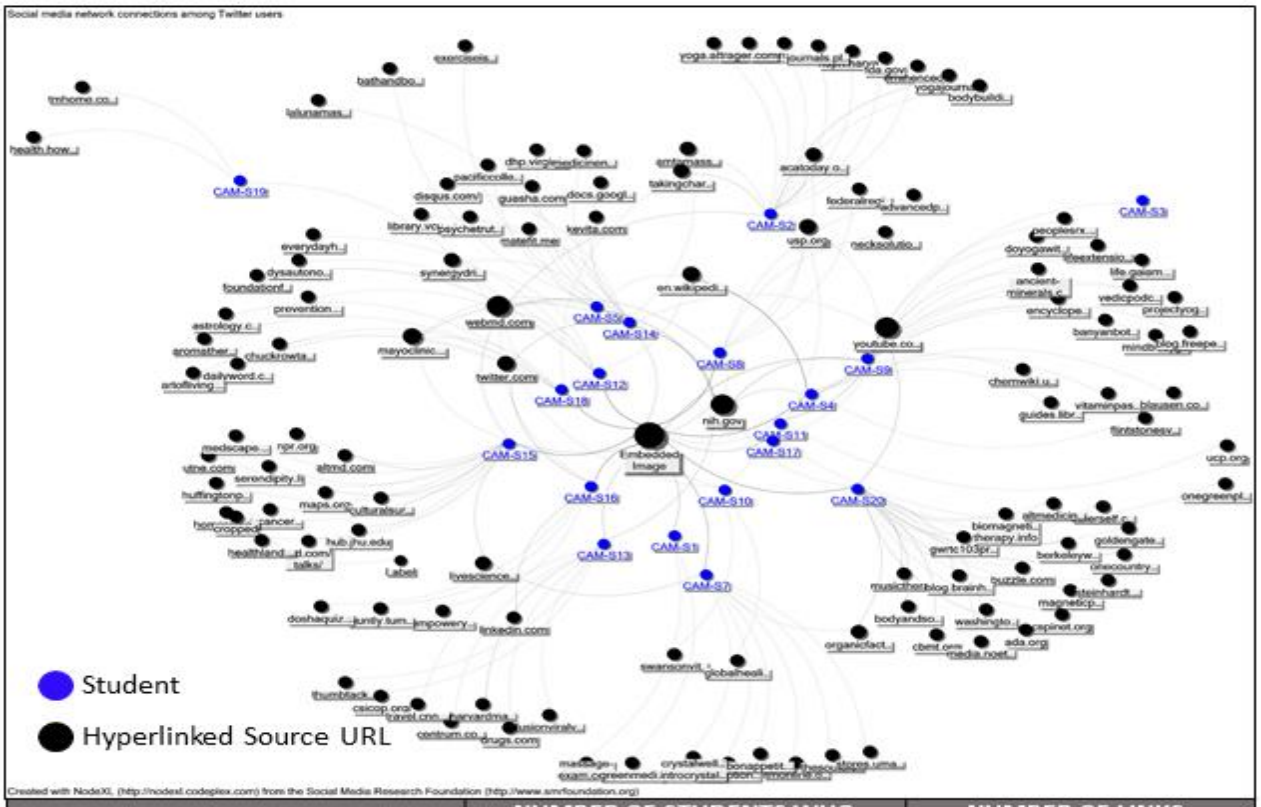


Figure 15. Typology-based assessment of CAM student blogging.

Finally, CAM-S12 and CAM-S1 reflect performance profiles that warrant further investigation and intervention. The former reflects the pattern of inserting one or more attractive images – usually unattributed and unreferenced photographs – at the beginning or end of the blog post. This pattern, seen frequently in undergraduate blogging, may demonstrate a general lack of attention to text-based linking as well as failure to fully integrate images into the narrative. CAM-S1 reflects a failure to hyperlink or embed, which could signal a variety of problems, including but not limited to a lack of commitment to the task, digital fluency, or understanding of the assignment.

Graphic visualizations. Although network analysis software applications such as NodeXL are often used to visualize social interactions (social network analysis), the software can be used to visualize any sort of relationship, including those mediated by hyperlinks and embedding html code. Although a visualization of how and what students choose to hyperlink is not relevant to every course setting, CAM students curated their own course content, drawing from web-based information sources in a field that has relatively few established and credible information sources. A digitally mediated, rapidly generated network visualization that can be shared with and interpreted by students may offer opportunities to discuss critical consumption of web-based information. Figure 16 shows students (in blue) and their hyperlinked sources (in black). Embedded images were aggregated and url file names removed so that trending information sources could be more easily identified. Network analysis indicated CAM students linked to more than 121 different government, nonprofit, for-profit, and media organizations. Three students generated 20 hyperlinks to Wikipedia. Less than half of students linked to what the instructor considered the most credible information sources available, suggesting discussion of information sources may have been warranted.



TOP MATERIAL SOURCES	NUMBER OF STUDENTS WHO LINKED-EMBEDDED	NUMBER OF LINKS-EMBEDS
Embedded images	15	120
NIH.gov	8	21
Wikipedia.org	3	20
WebMD.com	8	13
YouTube.com	8	13
Twitter.com	3	6
USP.org	4	4

Figure 16. Network analysis of relationships between CAM students and their hyperlinked sources in blog posts. Students are indicated by their study I.D. numbers. The size of the nodes indicates degree centrality, or the number of interactions in which that node is engaged.

Tweeting assessments. This study focused on three tweeting annotations, specifically, hyperlinks, mentions, and hashtags. Hashtags were not included in the assessment toolkit because they were used relatively infrequently by a limited number of students and their use (while compelling in terms of additional research) did not necessarily align with connectivity-based learning goals. This section offers rubrics, analytic dashboards, and graphic visualizations based on indicators of quantity and communicative impact. Digital mechanics play less of a role in tweets. While broken hyperlinks could be documented, none were found in the sample suggesting that the indicator may be less useful in this context than in blogging.

Rubric assessment for tweeting. The prototype for a tweeting rubric (Table 16) draws from the connectivity-based learning goals listed in chapter two and tweeting typology found earlier in this chapter. Although quantity indicators are not currently represented in the rubric, rows and criteria could be added based on the instructor's preferences and instructional design. For example, instructors could specify a certain number of tweets per day or week or attendance at a certain number of course-related Twitter events. The rubric focuses on communicative impact of hyperlinks and mentions, addressing the networked participatory activity and some of the digital workflow elements of the connective learning goals.

Table 16.

Rubric for tweeting

INDICATOR		NEEDS IMPROVEMENT	AVERAGE	EXEMPLARY
COMMUNICATIVE IMPACT (HYPERLINKING)	**Makes connections to own learning products**	Rarely hyperlinks to own blog posts/learning products.	Inconsistently hyperlinks to own blog posts/learning products.	Consistently hyperlinks to own blog posts/learning products.
	Make connections to course events or other participants' learning products	Rarely hyperlinks to others' blog posts/learning products.	Inconsistently hyperlinks to others' blog posts/learning products.	Consistently hyperlinks to others' blog posts/learning products.
	Experiments with introductory techniques for promoting hyperlinked materials	Limits introduction of hyperlinked materials to the title or author of the post.	Occasionally but inconsistently experiments with "hooks" to introduce hyperlinked materials OR Limits introduction to a generalized or vague phrase of encouragement (such as "Interesting read.")	Consistently experiments with promotional techniques and introductory hooks, such as the intentional use of mentions, hashtags, images and .gifs, compelling quotes, or personalized critique.
	Attempts to use hyperlinks to stimulate discourse or contribute to the learning of others	Never or rarely offers targeted, relevant information to specific community members based on their expressed interests or needs.	Occasionally offers targeted, relevant information to specific community members based on their expressed interests or needs.	Consistently offers targeted, relevant information to specific community members based on their expressed interests or needs.
COMMUNICATIVE IMPACT (MENTIONS)	**Engages classmates and instructors in dialogue**	Rarely mentions or responds to mentions from other students or instructors.	Occasionally mentions or responds to mentions from other students or instructors.	Consistently mentions or responds to mentions from other students or instructors.
	Engages other members of the community in dialogue	Rarely mentions or responds to mentions from community members	Occasionally mentions or responds to mentions from community members.	Consistently mentions or responds to mentions from community members.
	Timeliness	Fails to respond to mentions in a timely manner. Never sustains a partially synchronous dialogue.	Occasionally takes more than a day to respond to mentions. Rarely able to sustain a partially synchronous dialogue	Consistently responds to mentions within a day or less. Occasionally able to sustain partially synchronous dialogue.

Analytic assessment dashboard for tweeting. An analytic dashboard was developed and tested with CC and SOC enrolled student data. Quantity indicators included number of tweets, hyperlinks, and mentions. Student hyperlinks were divided into self- and other-sourced materials, because these indicators are easily identified without content analysis. Additionally, self-sourced materials were almost always associated with self-promotion while other-sourced materials were almost always associated with some sort of contributory behavior to the group. Although neither of these behaviors are inherently good or bad, students should attempt to balance them as part of communication diversification. Betweenness centrality was included as a social network metric with previously demonstrated pedagogical merit (Dawson et al., 2011a, 2011b).

Dashboard example #1: CC students. CC was the only study course that required students to engage in structured, weekly, discussion-focused tweeting. The quality and quantity of tweeting was not graded during the course. Instead, students were given participation credit if they completed short self-assessments about their readiness before every Twitter chat. Alternative assignments were available for students who could not attend the scheduled chats. Use of alternative assignments may have corresponded to decrease in quantity of tweets, particularly if the student completed more than one. These alternative assignments were not taken into account in the following assessment.

As Table 17 indicates, CC students either excelled at tweeting or they did not. Students who did well tweeted more frequently, displayed a mix of self- and other-sourced hyperlinks in their tweets, and interacted more frequently and with more diverse sets of people. Those who were less engaged averaged fewer tweets and demonstrated less balanced blends of self- and other-sourced hyperlinks. Although some in the third grouping generated reasonable numbers of

Table 17.

Analytic assessment dashboard for tweeting - CC students

GROUPINGS	STUDENT IDS	TOTAL TWEETS	HYPERLINKS			MENTIONS	
			TOTAL HYPERLINKS	SELF-SOURCED	OTHER-SOURCED	TOTAL MENTIONS	BETWEENNESS CENTRALITY
EXEMPLARY	CC-S4	230	10	4	6	211	1510
	CC-S7	226	19	12	7	220	2171
	CC-S8	274	16	8	8	311	1885
AVERAGE	CC-S9	150	9	5	4	157	718
NEEDS IMPROVEMENT	CC-S5	88	6	1	5	56	118
	CC-S2	63	5	4	1	30	156
	CC-S3	104	3	1	2	139	97
	CC-S1	121	1	0	1	44	77
	CC-S6	94	4	0	4	92	66
	CC-S10	156	15	15	0	244	13

mentions (e.g. CC-S3 and CC-S10), they had lower betweenness centrality, suggesting they limited their interactions to a small number of people. Only one student (CC-S9) fell between the two groups by exhibiting exemplary practice patterns at lower frequencies. This student was known to have completed at least one alternative assignment suggesting that the lower frequencies might need to be adjusted for accurate representation.

The tweet typology and mention analysis were applied to four students representing exemplary (CC-S8), average (CC-S9), and below average (CC-S2 and CC-S10) performances. Figure 17 demonstrates that all students had mention-centric tweeting practice, consistent with the course-level data presented earlier in the chapter. However, CC-S8 exhibited a more frequent and diverse hyperlinking pattern than the other students (although all CC students hyperlinked at low levels). This student also engaged a variety of participant types, which was captured through the frequency analysis as well as betweeness centrality (1885). CC-S9 tweeted in similar patterns as CC-S8, but at lower frequencies. CC-S10 and CC-S2 needed to adjust their practice but in different ways. CC-S10 tweeted and mentioned as frequently as CC-S9 but with significantly less diversity,

hyperlinking only to promote their own work and with the lowest betweenness centrality (13) of the group. CC-S2 failed to engage in tweeting, mentioning, or hyperlinking at appreciable levels at all.

Dashboard example #2. SOC students. Although SOC tweeting was incentivized with participation points, it was neither required nor structured. As the SOC assessment dashboard in Table 18 indicates, many students failed to tweet enough for meaningful assessment, and no student approached anything close to the levels of tweeting, hyperlinking, and mentioning seen in CC. However, SOC-13 and SOC-S6 tweeted more than most of their classmates. These students not only tweeted more frequently, but also incorporated more balanced approaches to hyperlinks and mentions into their practice. In the case of these two students, network visualizations of hyperlinks and mentions can be combined to show interesting nuances in tweeting practice (Figure 18). For example, SOC-S13 tended to hyperlink directly to the webpages of online popular news and culture sources, such as *USA Today*, *Entertainment Weekly*, and *Huffington* Post. In contrast, SOC-S6 engaged with content through Twitter, hyperlinking to articles and posts tweeted from other Twitter users and information sources such as *Elite Daily* and *Sociological Review.* While SOC-S13 conversed with students and instructors, SOC-S6 interacted with a broader range of Twitter users.

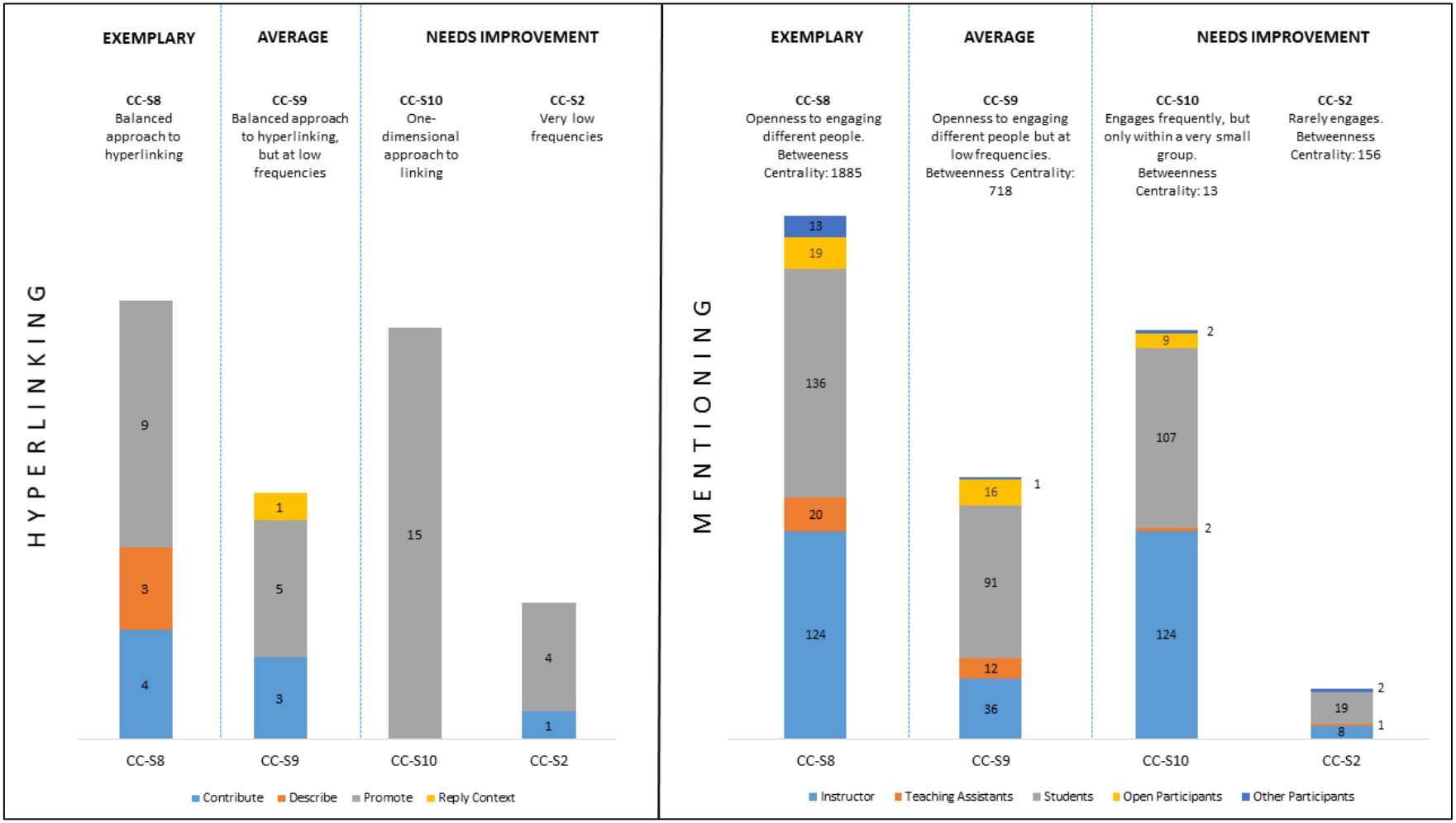


Figure 17. Typology-based assessment of CC hyperlinking and mentioning in tweets.

Table 18

Analytic assessment dashboard for tweeting – SOC students

GROUPINGS	STUDENTS	TOTAL TWEETS	HYPERLINKING			MENTIONING	
			TOTAL HYPERLINKS	SELF-SOURCED	OTHER-SOURCED	TOTAL MENTIONS	BETWEENNESS CENTRALITY
AVERAGE	SOC-S13	36	12	2	10	23	101
	SOC-S6	27	7	1	6	44	947
NEEDS IMPROVEMENT	SOC-S1	15	11	2	9	7	289
	SOC-S10	17	4	0	4	4	320
	SOC-S11	15	6	0	6	0	1
	SOC-S12	18	6	1	5	17	180
	SOC-S24	18	7	1	6	12	100
	SOC-S25	16	4	1	3	10	149
CANNOT ASSESS	SOC-S2	10	1	0	1	9	9
	SOC-S4	12	11	0	11	0	283
	SOC-S3	2	0	0	0	1	0
	SOC-S5	4	2	0	2	1	8
	SOC-S7	6	3	2	1	8	263
	SOC-S8	6	3	0	3	10	116
	SOC-S9	0	0	0	0	0	0
	SOC-S14	9	6	0	6	5	239
	SOC-S15	9	6	0	6	3	4
	SOC-S16	1	1	0	1	0	0
	SOC-S17	5	2	0	2	5	165
	SOC-S18	7	0	0	0	0	37
	SOC-S19	11	8	0	8	11	14
	SOC-S20	12	7	0	7	0	60
	SOC-S21	0	0	0	0	0	0
	SOC-S22	0	0	0	0	0	0
	SOC-S23	13	6	0	6	3	6
	SOC-S26	7	2	1	1	12	148

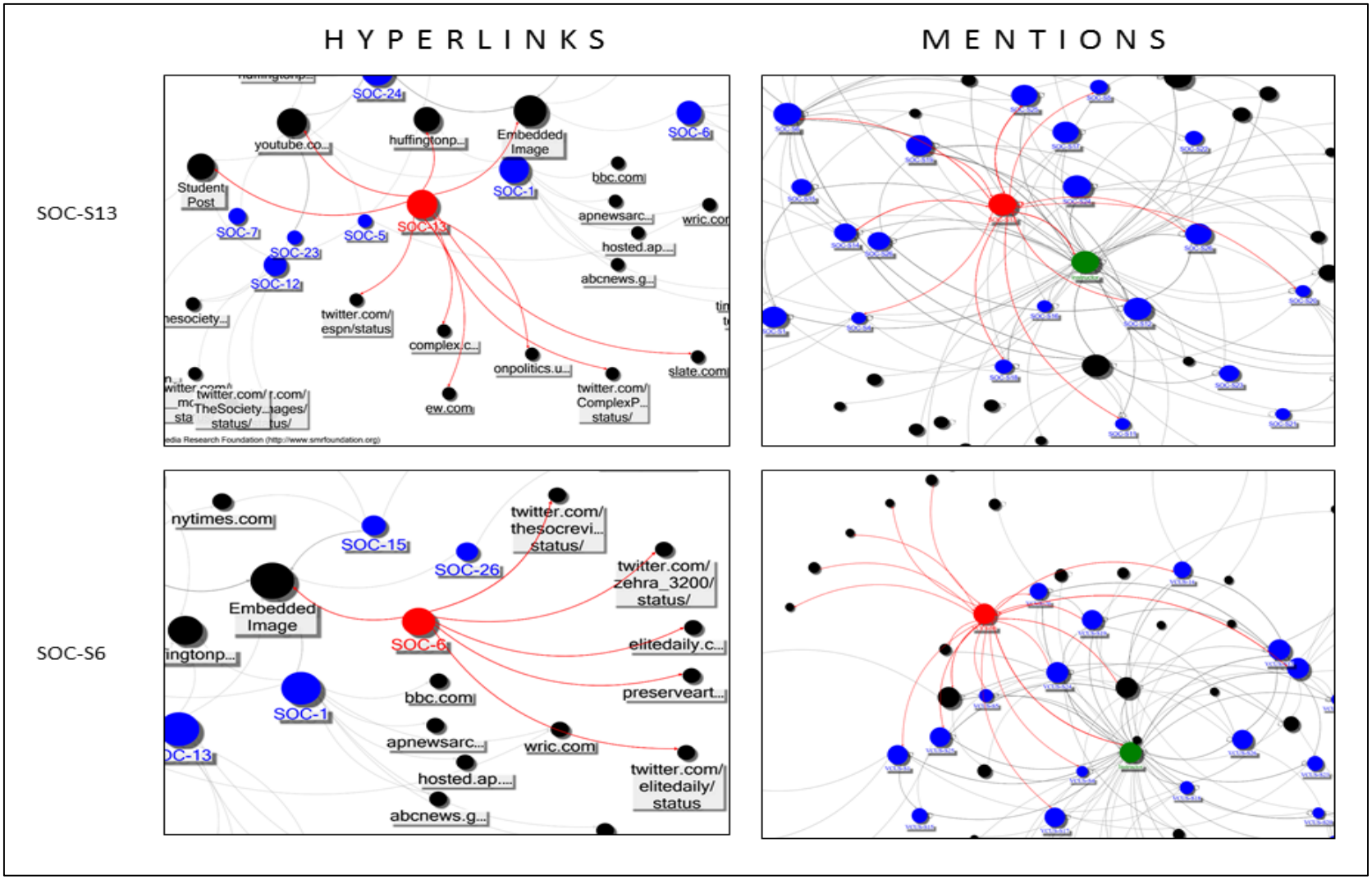
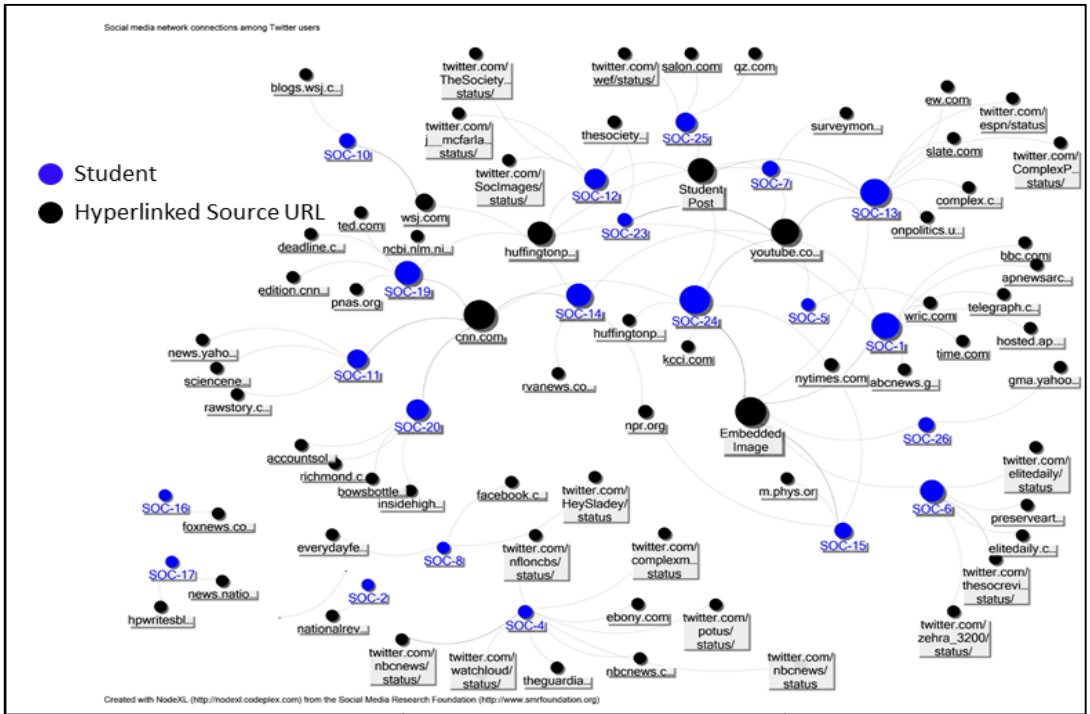


Figure 18. Sociogram assessment of two SOC students' tweeting.

Graphic visualizations for tweeting. Tweeting lends itself to social network analysis. Course sociograms such as those located in Appendix D provide digitally-mediated, real-time, automated visual representations of social interaction. These relationships are translated into centrality metrics that provide descriptive quantification of student interaction. While betweeness centrality has been incorporated into the analytic assessment dashboard, centrality metrics for every SOC and CC student is also found in Appendix D.

Similar to blogged hyperlinks, tweeted hyperlinks can be visualized through network analysis. The analysis may be useful in Course SOC, where content analysis suggested that students focused their tweeting activities on contributing relevant articles to a collective pool of resources. The process of analysis matched that used for the blogged hyperlinks of CAM students. As the sociogram in Figure 19 demonstrates, SOC students hyperlinked across 70 resources with some emphasis on popular news sources such as CNN and Huffington Post. While SOC students engaged in some self-promotion as indicated by links to student blog posts, it was not the primary activity of the group. The varying size of student nodes suggests the wide range in student participation in this activity. Students with the largest nodes (e.g. SOC-24, SOC-1, and SOC-13) have the highest levels of degree centrality, which indicates higher numbers of links between the student and sources.



TOP MATERIAL SOURCES	NUMBER OF STUDENTS WHO LINKED-EMBEDDED	NUMBER OF LINKS-EMBEDS
Twitter.com	16	19
Embedded Images	6	13
YouTube.com	7	13
CNN.com	5	11
Student Posts	5	6
HuffingtonPost.com	5	5

Figure 19. Network analysis of relationships between SOC students and their hyperlinked sources in tweets. Students are indicated by their study I.D. numbers. The size of the nodes indicates degree centrality, or the number of interactions in which that node is engaged.

Chapter 5

Chapter four offers a discussion of how a heterogeneous group of students, spread across four VCU connected courses that took place over the summer of 2015, used digital annotation devices in their course-related blogging and tweeting. Typologies of use emerged from this study, which then were compared to the connectivity-based learning objectives and applied in the development of assessment tools including rubrics, dashboards, and digitally mediated graphic representations. This chapter critiques this process and its results, honing in on two questions that remain unanswered. The first refers to the relationships between digital annotation, connectivity, and student learning. While the assessment strategies described in chapter four document student annotation use, do they also capture connectivity? More importantly, do they document learning? The second question refers to the alignment of the toolkit with published 21st century assessment criteria (Davies, 2010). In other words, does the toolkit promote integrated, sustainable (i.e. self- and peer-), and scalable assessments? Chapter five seeks to answer these questions while also situating the assessment toolkit within the classroom assessment literature and offering potential avenues of future research.

Learning, Connectivity, and Digital Annotation

The relationship between learning, connectivity, and digital annotations is complex, and its full description is outside the scope of this study. The assessment literature discusses learning as a process and a product with social, individual, and blended qualities (Paavola, Lipponen, & Hakkarainen, 2004; Salomon, 1996; Stahl, 2005; Strijbos, 2011). This study frames learning as a

multi-step, experiential process that takes place with and among other people. Specifically, it assumes that the act of making connections across concepts, people, space, and time ("connectivity") is a form of learning.

The findings outlined in chapter four do not capture the experiential process of connective learning in its entirety, because the study was not designed to provide evidence that students made connections intentionally, reflected on them, and progressed in their learning because of them. However, the purpose of this study was not to explore the relationship between connection and learning, nor was it to provide evidence for the model of connectivity. Rather, it was intended to explore digital annotation devices as a potential means to document student connections. The study makes the argument that a digital annotation is a form of reification: a concrete product that also denotes the socially constructed process of its creation. Examples of reified products include words, tools, concepts, methods, stories, and documents developed in and by a community of practice (Wenger, 2000). The findings of this study suggest that digital annotations shared in blog posts and tweets are similar to the words documented in a community of practice; they both provide physical evidence that an event took place while also representing the process by which the event unfolded. Digital annotations represent connections, and if we are to assume that making connections across concepts, people, space, and time is part of a pedagogical act, then we can conclude that digital annotations might be used to document as least some aspects of learning.

Documentation as a Form of Assessment

Classroom assessment has a number of purposes, including providing feedback and support for students, gathering diagnostic information to help in planning and decision-making, maintaining records of student activity for external stakeholders (such as parents, administrators, and funders), and informing instructional and curricular adjustments and evaluation (Wilson,

1996). These purposes can be organized loosely into assessment of learning, for learning, and as learning. The first, assessment of learning, refers to the majority of classroom assessment that takes place in higher education: summative assessments that sort students into relative performance groups and provide reportable symbols (i.e. grades) meant to inform the student and external stakeholders of student achievement. In contrast, assessment for learning refers to a descriptive process that shifts the emphasis from summative to formative, thereby illuminating current status, diagnosing strengths and weaknesses, and informing decisions around the next steps in the learning process. Assessment as learning is a subset of assessment for learning that seeks to develop students' metacognitive skills by inviting them to carry out the description, diagnosis, and sense making related to their own formative assessment (Earl, 2013).

Progressive educational approaches such as Reggio Emilia and Montessori emphasize the close relationship between learning, documentation, and assessment, arguing that "in the process of learning through documentation, we become aware of that learning and its value; we assess it" (Rinaldi, 2004; p. 1). Assessment for and as learning requires instructors to accurately understand, apply, and communicate knowledge of their students, assignments, and desired learning goals in the context of the course and the larger educational agenda. They spend considerable time curating, interpreting, and helping students make meaning around learning artifacts such as portfolios, writing, art, videos of performance, recordings of social interactions, or similar. Finally, they implement assessments that spotlight "learning intentions" of students, making connections in student thinking explicit for the purposes of providing students with feedback, assisting them with self-reflection, and planning future action (Clarke, 2001).

However, acts of connection-making in the physical world are often fleeting, uncoordinated, and undocumented (Kimble & Hildreth, 2005). They can require a significant

amount of instructor resources to document, interpret, and report. For example, Clarke (2001) recommends that faculty use highlighter pens to mark any connections they find when reading student essays. Strategies such as these become problematic in the context of large class sizes and higher education.

In contrast to physical world connections, digital connections leave an automated and automatically documented trail if students choose to make them. Hyperlinks indicate connections across web based documents. Embedded materials can indicate connections across modalities. Mentions indicate connections between people. Hashtags can do all of these things. When integrated into a larger educational belief system, the documentation and interpretation of digital annotations allow instructors to move beyond the conceptualizations and limitations of the physical world and into a more digital approach to getting things done. In short, the assessment strategies offered in chapter four can be considered a digital augmentation Clarke's (2001) highlighting pen; the collection, exploration, and visualization of digital annotations offer an open window into the types of connections students are making in their work.

Potential for Integration

As with any set of tools, the quality of the assessment toolkit is impacted deeply by how and where it is implemented. One can suspect (and research) that the act of making connections has more pedagogical power when it is integrated into instructional designs that explicitly value, discuss, and help students practice connection-making. In these scenarios, assessments of connection-making are likely to have more meaning and a closer relationships with learning.

The study findings suggest that connected course designs and learning activities can support the types of connections (across concepts, people, space, and time) that we desire students to make. However, it is important to note that the courses included in this study were highly

variable in their pedagogical commitment to student connectivity. Of the four course settings, only CC engaged students explicitly with the concept of digital connection as pedagogical practice and digital annotation as pedagogical tools. These students received some informal feedback on their hyperlink use and were asked to reflect on their tweeting practice as visualized by social network analysis. However, none of the courses included connectivity-based learning goals or formal assessments of student connectivity. At this point, it is unclear if the students involved in the study would have performed better (i.e. made more, more varied, and more powerful pedagogical connections) or learned more deeply if annotation-focused assessments had been integrated into the course design. If connectivity-based learning goals were adopted, discussed with students, scaffolded through learning activities and with meaningful assessment, it may be possible to link annotation use with student learning with more confidence.

Potential for Sustainability

When Boud (2000) introduced the concept of sustainable assessment, he defined it as self- and peer-assessment for the purpose of development metacognitive and critical thinking skills necessary for lifelong learner. This definition feeds into the concept of assessment as learning, the subset of assessment for learning in which the documentation is interpreted and applied by the students for themselves (Pring, 2015). The assessment strategies described in chapter four are designed to support scaffolded and independent self- and peer assessment. Students can apply the rubrics and dashboards to their own work as easily as faculty can. Furthermore, the data and technology required to create data visualizations are as accessible to students as to faculty.

However, like the integration of annotation-centric instruction and assessment, the implementation of self- and peer-assessment takes a commitment and some bravery on the part of the instructor: a commitment of time, because students must be taught how to properly assess work

before they do it, and bravery, because allowing students to assess classwork requires the relinquishing some of power, control, and responsibility (Pring, 2015). Only one of the four connected courses (VT) included a formalized, graded, peer-assessment component. If self-assessment is to be a meaningful pedagogical exercise, it must be presented as meaningful (Hanrahan & Isaacs, 2001). Future research should include piloting of these tools with students as part of an integrated approach to connectivity-based teaching and learning, with cross comparisons made across instructor-, peer-, and self-implementation.

Potential for Scalability

When aspects of assessment can be automated, as the collection and visualization of student use of digital annotations can be, we begin to consider their potential for scalability (Davies, 2010). The assessment strategies offered in chapter four tend to present documentation in terms of quantification for the purposes of promoting an automated assessment process. For example, the visualizations are those which can be created quickly through the use of commonly accessible network analysis software. The dashboards emphasize things that can be counted quickly: the number of connections to concepts, the number of embedded images, the number of mentions, and similar. There are attempts to translate quality into terms of quantities: betweenness centrality captures how well students diversify their mentions, a comparison of the number of self-sourced hyperlinks to the number of other-sourced hyperlinks suggests a picture of how well students balance self-promotion with their contributions to the group, and the percentage of category three images to the total number of embedded materials suggests something about the care with which students incorporated multimodality into their work.

The workflows developed for the purpose of this study are described extensively in Appendix A. However, not all of the workflows were as automated as one would desire. The

1186 hyperlinks and embedding codes were extracted by hand from student blog post content (captured automatically but en bloc with the WP CSV Plugin). This manual step in the workflow was the reason for the restrictive sampling frames placed on Course CC and SOC (only posts from the third, seventh, and eighth weeks were analyzed). The cut-and-paste procedure that was undertaken would be too time intensive for a single instructor in a large classroom setting, unless the work was crowdsourced to students as part of a self- or peer-assessment exercise. Furthermore, the software application that was used for a majority of the network analysis, NodeXL, has recently transitioned from an open source to a not-for-profit pay model, a move that could potentially limit its accessibility to students and faculty. However, since this study was completed alternative approaches to the extraction of hyperlinked and embedded materials have been developed are available for VCU faculty. Furthermore, other open source network analysis applications are available, and new streamlined digital workflows related to mentions are already being developed.

Limitations and Next Steps

The limitations of this study can and should be framed in two ways: limitations of the assessment strategies outlined in chapter four and limitations of the study design, methodology, and implementation. Regarding the assessment strategies, it is important to note that what is presented in chapter four – the rubrics, dashboards, and approaches to data visualization – are only prototypes. Not only do they require additional piloting and adjustment, but they are purposefully generalized. Classroom assessments must be adapted for the priorities of specific students and faculty in a specific course environment. The rubrics, objectives, criteria, and dashboards described throughout this study are meant to be remixed, edited, and adjusted so they might be seamlessly integrated into the course design and context.

Furthermore, the assessment strategies described are not intended to be a comprehensive approach to assessment of student learning in VCU connected courses. Rather, they should be considered in terms of a larger assessment system – one that takes into account the need to document learning in terms of product and process, individual and social learning, and the different learning objectives and goals associated with each course. Courses have multiple learning objectives that reflect the need for students to develop disciplinary-based expertise, professional skills, and intellectual dispositions; it only stands to reason that course instructors would need different strategies for assessing student progress as related to the different desired outcomes.

Finally, even as this study attempts to develop automated processes for the quantification of student connections, it is not the intention of the researcher to suggest that all student assessment should follow a model of automated quantification and counting. As stated above, student learning should be assessed in terms of a system of approaches. The purpose of automating some aspects of assessment is to free the instructor for the more meaningful, more qualitative, and more human aspects of teaching and learning, including assessment.

From the position of traditional educational research, the limitations of this study are numerous and diverse. From a post-positivist perspective, the sampling procedures and the heterogeneity in participants, participation, and course implementation are all worrisome. From a constructivist perspective, the lack of student voice, limited attempts at triangulation, and the researcher-generated judgements about student activities are also worrisome. As discussed in chapter one, this study is admittedly messy, its findings overtly impermanent, and design representative of work done in a time of rapid change and highly variable conditions. Furthermore, the purpose of this study was to develop alternative assessment strategies, which is an inherently valuating and judgmental process. The limitations of the study as seen from either research

paradigm should not be considered limitations as much as opportunities for improvement in future studies.

One of the limitations of this study was its failure to include student input in the development of the blogging and tweeting typologies. "Communicative impact" is important, because students must be able to express their connections so that others can comprehend them (for reasons outlined by Harel and Papert, 1991). However, "communicative intent," or the student's motivation behind making the connection, is much more indicative of the learning that has occurred. This limitation also indicates a next step in future research, namely that students should be interviewed or surveyed their thought process before, during, and after digital annotation use.

I have already alluded to another important next step in this research agenda: These assessment approaches need to be fully integrated and piloted in authentic course settings designed to promote connection as a valued and explicit form of learning. Once these courses are established with committed instructors, connectivity-based learning goals, learning activities, and integrated assessments, more sophisticated research can begin to take place along a myriad of channels. For example, instructor and student experience needs to be addressed. Learning activities need to be designed and evaluated. The relationships between annotation use and student learning need to be addressed, as do the relationships between digital literacy, digital fluency, and connective learning, and integrative thinking. Understanding of hashtag use could be fleshed out. Connections between annotation use, connection making, acts of student reflection, and levels of student engagement can be explored. Furthermore, the assessment toolkit needs to be refined, with more streamlined workflows in place.

Final Thoughts

Latour (2005) captured the challenge of assessment well: "To describe, to be attentive to the concrete state of affairs, to find the uniquely adequate account of a given situation, I myself have always found this incredibly demanding" (p. 144). Latour was correct. What began in a simple exercise of data visualization grew into a tangle of overlapping research questions that challenged and required clarification around big foundational concepts: assessment, instruction, course design, and even learning. More than a standard research project, this work represents a design project in which creativity and insight are combined and translated to solve an identified problem or need. Design decisions were made, but ultimately many of these assumptions remain untested, waiting for the next phase(s) of research. In other words, this particular dissertation research does not have capstone properties, nor does it plug a small hole in the literature or provide many definitive results or conclusions. Rather, this is an idea book, full of early thoughts as well as convergent and divergent opportunities for design, redesign, and additional research. It marks a beginning, not an end. To be continued…

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Appendix A.

Data Cleaning

Documenting data cleaning procedures is important when the process is being considered for use by faculty in a student assessment context. The data cleaning procedure for this study is documented in Figure 20. These points must be stressed to others engaging in the process:

- While WP CSV appeared to provide an accurate and comprehensive list of posts, neither NodeXL nor TAGS are perfect in their collection from the Twitter API. Both databases should be considered excellent approximations, but the count of student tweets should be considered a range, not an exact representation.
- Manually extracting hyperlinks from the content of individual posts for the purposes of counting and following them was a rate limiting step.
- In understanding how to manipulate NodeXL data for analysis, it is important to remember it is designed for social network analysis. The template automatically creates separate columns for the tweet senders (Vertex 1) and the intended tweet receivers (Vertex 2). If the tweet did not include a mention, the name of the tweet sender will also be placed in the Vertex 2 column. If the tweet included two or more mentions, it will be duplicated so that each mention will gain its own space in the Vertex 2 column. Therefore, for retweet, hyperlink, and hashtag analyses, the data must be exported to a standard Excel file and the duplicate rows removed. An accurate mention list requires the removal of tweets for which Vertex 1 and Vertex 2 columns have the same name.

- NodeXL templates do not allow editing of vertex names; data cleaning must take place in standard Excel files. NodeXL easily imports and exports to standard Excel files.
- Timestamps, which are documented to sub-second times, provide the fastest way to recognize duplicates and should be kept in the analysis for their usefulness in data manipulation, even after the dates of interest have been isolated.

NodeXL is case sensitive; this becomes problematic when tweeters fail to capitalize their mentions consistently, because the numbers of tweets received (Vertex 2) will become diluted over multiple names (e.g. @Username and @username). This affects individual centrality metrics. The problem is easily avoided by exporting data to a standard Excel file, where a formula can be applied to make all data the same case.

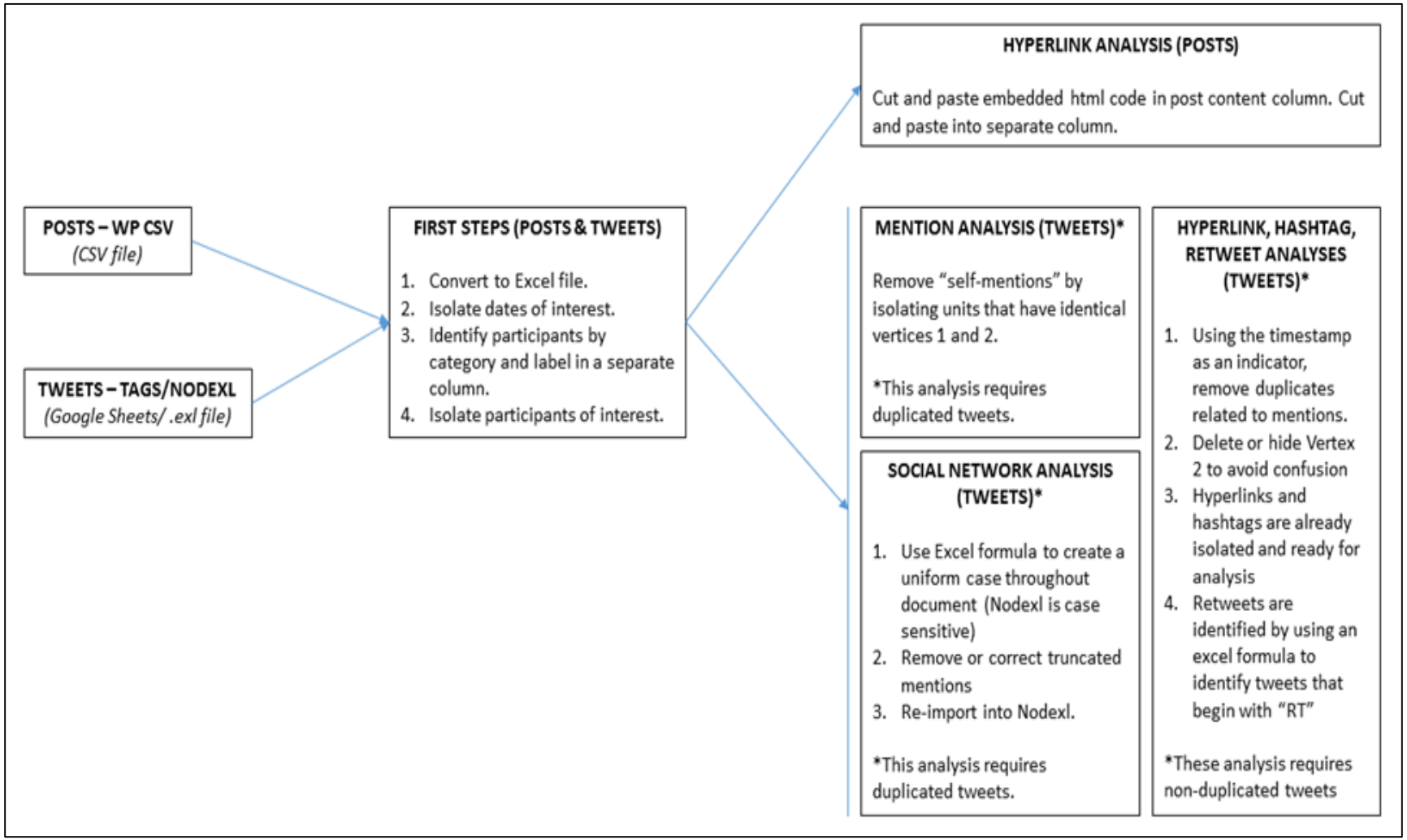

Figure 20. Data cleaning procedure.

Appendix B.

Student-Participant Annotation at the Course Level

Table 19.

Hyperlinking and embedding analysis - Blog posts

	CC	CAM	VT	SOC
SAMPLED POSTS	**93**	**186**	**117**	**102**
Posts w/ Hyperlinks or Embedding Codes	**85**	**140**	**85**	**35**
Number Hyperlinks and Embedding Codes	**659**	**336**	**108**	**109**
Inaccessible Hyperlinks[a]	**13**	**6**	**4**	**0**
HYPERLINKS AND EMBEDDING CODES ANALYZED	**646**	**330**	**104**	**109**
Median (Hyperlinks-Embeds/Post)	**4**	**1**	**1**	**0**
Range (Hyperlinks-Embeds/Post)	**0-46**	**0-19**	**0-12**	**0-18**
TYPE OF MATERIAL				
Articles & Papers	**230 (35%)**	**51 (15%)**	**1 (1%)**	**42 (39%)**
Blog Posts	**44 (7%)**	**14 (4%)**	**2 (2%)**	**3 (3%)**
Course Materials	**31 (5%)**	**0**	**0**	**0**
Images & Videos	**140 (21%)**	**127 (38%)**	**68 (63%)**	**55 (50%)**
Webpage Information	**198 (30%)**	**138 (41%)**	**23 (21%)**	**8 (7%)**
Unknown[b]	**3 (0%)**	**0**	**10 (9%)**	**1 (1%)**
SOURCES OF MATERIAL				
Academic Journals & Conferences	**114 (17%)**	**7 (2%)**	**0**	**0**
Course Website	**29 (4%)**	**0**	**0**	**0**
Gov't & Organization Websites& Blogs	**302 (46%)**	**150 (45%)**	**12 (11%)**	**12 (11%)**
News & Magazines	**22 (3%)**	**26 (8%)**	**1 (1%)**	**41 (38%)**
Other Course Participants	**5 (1%)**	**1 (0%)**	**1 (1%)**	**1 (1%)**
Other Digital Platforms[c]	**7 (1%)**	**6 (2%)**	**20 (19%)**	**0**
Other/Unknown[d]	**65 (10%)**	**75 (22%)**	**29 (27%)**	**37 (34%)**
Self	**53 (8%)**	**31 (9%)**	**23 (21%)**	**1 (1%)**
Social Media Platforms	**49 (7%)**	**34 (10%)**	**18 (17%)**	**17 (16%)**
COMMUNICATIVE IMPACT OF MATERIAL				
Additional Resource	**0**	**131 (40%)**	**0**	**0**
Aesthetics	**25 (4%)**	**1 (0%)**	**2 (2%)**	**0**
Citation/References	**340 (53%)**	**23 (7%)**	**2 (2%)**	**18 (17%)**
Course Context	**31 (5%)**	**0**	**0**	**0**
Description	**104 (16%)**	**48 (15%)**	**15 (14%)**	**22 (20%)**
Emoticons	**4 (0%)**	**1 (0%)**	**1 (1%)**	**0**
Illustration	**91 (14%)**	**105 (32%)**	**53 (51%)**	**37 (34%)**
Learning Product	**22 (3%)**	**8 (2%)**	**31 (30%)**	**0**
Personal Context	**29 (4%)**	**6 (2%)**	**0**	**0**
Promotion	**0**	**7 (2%)**	**0**	**0**

[a] Includes broken links or links that otherwise do not lead where they should, based on the context in which it was applied
[b] Occurred when student-participants privatized blogs or posts after data was collected but prior to analysis
[c] Applications and software that promote creativity (e.g. graphic design, audio and video recording) as primary focus
[d] Embedded images that provided no indication of source

Table 20.

Hyperlinking analysis - Tweets

	CC	CAM	VT	SOC
STUDENT-PARTICIPANT TWEETS	**2590**	**122**	**151**	**430**
Tweets with Hyperlinks	**248 (10%)**	**65 (34%)**	**62 (41%)**	**173 (40%)**
Hyperlinks	**248**	**65**	**62**	**173**
Retweeted Hyperlinks	**73**	**5**	**3**	**33**
Irrelevant Hyperlinks[a]	**3**	**0**	**0**	**0**
TOTAL HYPERLINKS ANALYZED	**172**	**60**	**59**	**140**
TYPE OF MATERIAL				
Articles & White Papers	**16 (9%)**	**13 (22%)**	**3 (5%)**	**72 (51%)**
Blog Posts & Storify	**75 (44%)**	**34 (57%)**	**52 (88%)**	**12 (9%)**
Course Materials	**18 (10%)**	**0**	**0**	**2 (1%)**
Images & Animated .GIFs	**12 (7%)**	**11 (18%)**	**1 (2%)**	**24 (17%)**
Social Media	**24 (14%)**	**1 (2%)**	**1 (2%)**	**25 (18%)**
Webpage information	**27 (16%)**	**1 (2%)**	**2 (3%)**	**5 (4%)**
SOURCES OF MATERIAL				
Academic Journals & Conferences	**5 (3%)**	**0**	**0**	**0**
Course Website	**18 (10%)**	**0**	**0**	**3 (2%)**
News & Magazines	**1 (1%)**	**9 (15%)**	**2 (3%)**	**97 (69%)**
Other Websites & Social Media Platforms	**35 (20%)**	**7 (12%)**	**7 (12%)**	**24 (17%)**
Other Course Participants	**29 (17%)**	**1 (2%)**	**0**	**0**
Self	**71 (41%)**	**41 (68%)**	**50 (85%)**	**16 (11%)**
Other/Unknown	**13 (8%)**	**2 (5%)**	**0**	**0**
COMMUNICATIVE IMPACT				
Contribution	**48 (28%)**	**14 (23%)**	**8 (14%)**	**112 (80%)**
Description	**19 (11%)**	**0**	**0**	**0**
Promotion	**72 (42%)**	**34 (57%)**	**51 (86%)**	**19 (14%)**
Reply Context	**23 (13%)**	**0**	**0**	**0**
Signal	**10 (6%)**	**10 (20%)**	**0**	**9 (6%)**

[a] These hyperlinks appeared to be irrelevant to the course, introduced by Twitter bots. There were no broken or inaccessible hyperlinks in this data set.

Table 21.

Mention analysis - Tweets

		PARTICIPANT WHO IS MENTIONED							
	PARTICIPANT WHO MENTIONS	**Instructors**	**Teaching Assistants**	**Students**	**Open Participant**	**Academic Participants**	**Community Participants**	**Other**	**Total Mentions**
CC	Students	562 (37%)	68 (5%)	693 (46%)	140 (9%)	17 (1%)	21 (1%)	8 (1%)	1509
	Open Participants	166 (30%)	55 (10%)	191 (34%)	44 (8%)	32 (6%)	60 (11%)	14 (2%)	562
	Academic Participants	39 (25%)	40 (25%)	20 (13%)	26 (17%)	22 (14%)	6 (4%)	4 (3%)	157
	Community Participants	15 (39%)	3 (8%)	3 (8%)	5 (13%)	4 (11%)	5 (13%)	3 (8%)	38
	Other	8 (19%)	6 (14%)	12 (29%)	3 (7%)	2 (5%)	2 (5%)	9 (21%)	42
	TOTAL	**790**	**172**	**919**	**218**	**77**	**94**	**38**	**2308**
CAM	Students	2 (18%)	--	4 (36%)	--	1 (9%)	4 (36%)	0	11
	Academic Participants	8 (47%)	--	2 (12%)	--	5 (29%)	1 (6%)	1 (6%)	17
	Community Participants	0	--	0	--	0	0	0	0
	Other	0	--	0	--	0	0	0	0
	TOTAL	**10**		**6**		**6**	**5**	**1**	**28**
VT	Students	48 (56%)	--	34 (40%)	--	0	1 (1%)	3 (3%)	86
	Academic Participants	5 (56%)	--	1 (11%)	--	2 (22%)	0	1 (11%)	9
	Community Participants	4 (100%)	--	0	--	0	0	0	4
	Other	3 (43%)	--	1 (14%)	--	2 (29%)	0	1 (14%)	7
	TOTAL	**60**		**36**		**4**	**1**	**5**	**106**
SOC	Students	56 (30%)	--	107 (58%)	--	13 (7%)	9 (5%)	2 (1%)	185
	Academic Participants	26 (36%)	--	37 (51%)	--	9 (12%)	1 (1%)	0	73
	Community Participants	0	--	0	--	0	0	0	0
	Other	0	--	7 (88%)	--	0	0	1 (13%)	8
	TOTAL	**82**		**151**		**22**	**10**	**3**	**266**

Appendix C.

Student-Participant Annotation Practice at the Student Level

Individual assessment was limited to enrolled students who were the only participant type required to complete all assigned work with the expectation of a graded assessment. Neither VT nor CAM students generated enough tweets or tweet-related annotations to make individual assessment of Twitter data meaningful. Therefore, tweet analysis was limited to CC and SOC students. Student identification codes consist of the course designation (e.g. CC students begin with "CC") followed by a random identification number.

Table 22.

Hyperlinking and embedding analysis - Blog posts

STUDENTS[a]	POSTS	HYPERLINKS & EMBEDS[b]	HYPERLINK-EMBED/ POST	RANGE	TEXT-BASED HYPERLINKS	IMAGES & VIDEOS	AESTHETICS[c]	INACCESSIBLE LINKS[d]
CC-S1	8	57	7	5-34	51	10	5	4
CC-S2	9	81	9	1-18	59	24	17	2
CC-S3	8	58	7	0-46	54	4	1	0
CC-S4	9	82	9	0-32	74	8	4	0
CC-S5	9	73	8	0-15	58	18	8	3
CC-S6	7	35	5	0-5	27	8	4	0
CC-S7	8	56	7	1-18	49	8	5	1
CC-S8	9	64	7	0-23	53	11	5	0
CC-S9	7	48	7	1-15	40	10	9	2
CC-S10	8	19	2	1-15	8	11	9	0
CAM-S1	8	5	1	0-2	2	3	3	0
CAM-S2	11	20	2	0-4	19	1	0	0
CAM-S3	8	1	0	0-1	0	1	0	0
CAM-S4	12	41	3	1-19	27	14	3	0
CAM-S5	12	8	1	0-2	8	0	0	0
CAM-S7	9	17	2	0-5	11	6	4	0
CAM-S8	9	23	3	0-4	9	15	9	1
CAM-S9	8	19	3	1-5	15	5	3	1
CAM-S10	10	5	1	0-2	5	0	0	0
CAM-S11	9	5	1	0-2	3	2	0	0
CAM-S12	13	31	2	0-8	9	23	23	1
CAM-S13	12	13	1	0-4	10	3	3	0
CAM-S14	11	29	3	0-6	27	3	2	1
CAM-S15	10	35	4	1-14	20	15	6	0
CAM-S16	6	18	3	0-6	11	8	8	1
CAM-S17	9	5	1	0-1	3	2	2	0
CAM-S18	15	21	1	0-2	10	12	12	1
CAM-S19	8	3	0	0-2	0	3	3	0
CAM-S20	4	35	9	1-16	24	11	0	0

[a] Analysis includes only enrolled students. It does not include students who withdrew or failed to complete the course. Student Identification number consists of the course designation followed by a randomly assigned number.

[b] Does not include collaborative writing assignments (relevant to SOC only).

[c] Images that met criteria for "Aesthetics," established in Table 8.

[d] Includes broken or inaccessible links or those that lead to incorrect locations based on context.

STUDENTS[a]	POSTS	HYPERLINKS & EMBEDS[b]	HYPERLINK-EMBED/ POST	RANGE	TEXT-BASED DOCUMENTS	IMAGES & VIDEOS	AESTHETICS[c]	INACCESSIBLE LINKS[d]
VT-S1	23	9	0	0-1	8	3	1	2
VT-S2	21	21	1	0-4	4	18	3	1
VT-S3	25	33	1	0-12	17	16	6	0
VT-S4	23	27	1	0-5	6	22	18	1
VT-S6	20	17	1	0-4	5	12	5	0
SOC-S1	4	5	1	0-3	0	5	1	0
SOC-S2	6	11	2	0-6	3	8	0	0
SOC-S3	4	0	0	0	0	0	0	0
SOC-S4	5	1	0	0-1	0	1	0	0
SOC-S5	3	2	1	0-2	0	2	0	0
SOC-S6	4	0	0	0	0	0	0	0
SOC-S7	4	16	4	0-11	12	4	0	0
SOC-S8	4	0	0	0	0	0	0	0
SOC-S9	2	0	0	0	0	0	0	0
SOC-S10	3	0	0	0	0	0	0	0
SOC-S11	4	0	0	0	0	0	0	0
SOC-S12	3	7	2	0-4	4	3	1	0
SOC-S13	5	6	1	0-3	0	6	0	0
SOC-S14	6	7	1	0-4	2	5	0	0
SOC-S15	4	6	2	0-5	0	6	0	0
SOC-S16	4	5	1	0-4	0	5	0	0
SOC-S17	6	0	0	0	0	0	0	0
SOC-S18	4	0	0	0	0	0	0	0
SOC-S19	5	0	0	0	0	0	0	0
SOC-S20	5	2	0	0-1	0	2	1	0
SOC-S21	2	0	0	0	0	0	0	0
SOC-S22	4	0	0	0	0	0	0	0
SOC-S23	3	0	0	0	0	0	0	0
SOC-S24	5	6	1	0-3	6	0	0	0
SOC-S25	2	2	1	0-2	2	0	0	0
SOC-S26	1	1	1	0-1	1	0	0	0

[a]Analysis includes only enrolled students. It does not include students who withdrew or failed to complete the course. Student Identification number consists of the course designation followed by a randomly assigned number.

[b] Does not include collaborative writing assignments (relevant to SOC only).

[c] Images that met criteria for "Aesthetics," established in Table 8.

[d] Includes broken or inaccessible links or those that lead to incorrect locations based on context.

Table 23.

CC and SOC student hyperlinking and embedding - Tweets

[a] Analysis includes only enrolled students. It does not include students who withdrew or failed to complete the course. Student Identification number consists of the course designation followed by a randomly assigned number.

		TYPE			SOURCE				PURPOSE				
Students[a]	Total Hyperlinks	Documents, Posts, Informational Videos	Social Media	Images & .GIFs	Self	Other Participants	Course Website	Other	Contribute	Describe	Promote	Reply Context	Signal
CC-S1	1	0	1 (100%)	0	0	1 (100%)	0	0	0	0	0	1 (100%)	0
CC-S2	5	5 (100%)	0	0	4 (80%)	0	1 (20%)	0	1 (20%)	0	4 (80%)	0	0
CC-S3	3	1 (33%)	1 (33%)	1 (33%)	1 (33%)	2 (67%)	0	0	0	0	1 (33%)	2 (67%)	0
CC-S4	10	4 (40%)	4 (40%)	2 (20%)	4 (40%)	5 (50%)	0	1 (17%)	1 (10%)	1 (10%)	4 (40%)	4 (40%)	0
CC-S5	6	6 (100%)	0	0	1 (17%)	1 (17%)	0	4 (66%)	2 (33%)	3 (50%)	1 (17%)	0	0
CC-S6	4	2 (50%)	0	2 (50%)	0	0	0	4 (100%)	1 (25%)	1 (25%)	0	0	2 (50%)
CC-S7	19	15 (79%)	1 (5%)	3 (16%)	12 (63%)	2 (11%)	0	5 (31%)	2 (11%)	0	13 (68%)	2 (11%)	2 (11%)
CC-S8	16	14 (88%)	2 (12%)	0	8 (50%)	0	1 (6%)	7 (78%)	4 (25%)	3 (19%)	9 (56%)	0	0
CC-S9	9	8 (89%)	1 (11%)	0	5 (56%)	1 (11%)	0	3 (20%)	3 (33%)	0	5 (56%)	1 (11%)	0
CC-S10	15	15 (100%)	0	0	15 (100%)	0	0	0	0	0	15 (100%)	0	0

		TYPE			SOURCE				PURPOSE				
Students[a]	Total Hyperlinks	Documents, Posts, Informational Videos	Social Media	Images & .GIFs	Self	Other Participants	Course Website	Other	Contribute	Describe	Promote	Reply Context	Signal
SOC-S1	11	8 (73%)	0	3 (27%)	2 (18%)	0	0	9 (82%)	9 (82%)	0	0	0	2 (18%)
SOC-S2	1	1 (100%)	0	0	0	0	0	1 (100%)	1 (100%)	0	0	0	0
SOC-S3	0	0	0	0	0	0	0	0	0	0	0	0	0
SOC-S4	11	3 (27%)	8 (73%)	0	0	0	0	11 (100%)	11 (100%)	0	0	0	0
SOC-S5	2	2 (100%)	0	0	0	0	0	2 (100%)	2 (100%)	0	0	0	0
SOC-S6	7	2 (29%)	4 (57%)	1 (14%)	1 (14%)	0	0	6 (86%)	6 (86%)	0	0	0	1 (14%)
SOC-S7	3	3 (100%)	0	0	2 (67%)	0	0	1 (33%)	1 (33%)	0	2 (67%)	0	0
SOC-S8	3	1 (33%)	2 (67%)	0	0	0	0	3 (100%)	3 (100%)	0	0	0	0
SOC-S9	0	0	0	0	0	0	0	0	0	0	0	0	0
SOC-S10	4	4 (100%)	0	0	0	0	0	4 (100%)	4 (100%)	0	0	0	0
SOC-S11	6	6 (100%)	0	0	0	0	0	6 (100%)	6 (100%)	0	0	0	0
SOC-S12	6	3 (50%)	3 (50%)	0	1 (17%)	0	0	5 (83%)	5 (83%)	0	1 (17%)	0	0
SOC-S13	12	9 (75%)	2 (17%)	1 (8%)	2 (17%)	0	0	10 (83%)	9 (75%)	0	2 (17%)	0	1 (8%)
SOC-S14	6	6 (100%)	0	0	0	0	0	6 (100%)	6 (100%)	0	0	0	0
SOC-S15	6	3 (50%)	0	3 (50%)	0	0	0	6 (100%)	4 (67%)	1 (17%)	0	0	1 (17%)
SOC-S16	1	1 (100%)	0	0	0	0	0	1 (100%)	1 (100%)	0	0	0	0
SOC-S17	2	2 (100%)	0	0	0	0	0	2 (100%)	2 (100%)	0	0	0	0
SOC-S18	0	0	0	0	0	0	0	0	0	0	0	0	0
SOC-S19	8	8 (100%)	0	0	0	0	0	8 (100%)	8 (100%)	0	0	0	0
SOC-S20	7	7 (100%)	0	0	0	0	0	7 (100%)	7 (100%)	0	0	0	0
SOC-S21	0	0	0	0	0	0	0	0	0	0	0	0	0
SOC-S22	0	0	0	0	0	0	0	0	0	0	0	0	0
SOC-S23	6	6 (100%)	0	0	0	0	0	6 (100%)	6 (100%)	0	0	0	0
SOC-S24	7	7 (100%)	0	0	1 (14%)	0	0	6 (86%)	6 (86%)	0	1 (14%)	0	0
SOC-S25	4	3 (75%)	1 (25%)	0	1 (25%)	0	0	3 (75%)	3 (75%)	0	1 (25%)	0	0
SOC-S26	2	1 (50%)	0	1 (50%)	1 (50%)	0	0	1 (50%)	1 (50%)	0	0	0	1 (50%)

[a] Analysis includes only enrolled students. It does not include students who withdrew or failed to complete the course. Student Identification number consists of the course designation followed by a randomly assigned number.

Table 24.

CC and SOC student mentions - Tweets

STUDENTS[a]	TOTAL MENTIONS	WHO THEY MENTIONED						
		INSTRUCTORS	TEACHING ASSISTANTS	STUDENTS	OPEN PARTICIPANTS	ACADEMIC PARTICIPANTS	COMMUNITY PARTICIPANTS	OTHER
CC-S1	44	23 (52%)	1 (2%)	14 (32%)	5 (11%)	0	1 (2%)	0
CC-S2	30	8 (27%)	1 (3%)	19 (63%)	0	0	0	2 (7%)
CC-S3	139	42 (30%)	3 (2%)	89 (64%)	4 (3%)	0	0	1 (1%)
CC-S4	211	58 (27%)	12 (6%)	112 (53%)	19 (9%)	1 (0%)	9 (4%)	0
CC-S5	56	30 (54%)	1 (2%)	22 (39%)	2 (4%)	0	1 (2%)	0
CC-S6	92	40 (43%)	3 (3%)	44 (48%)	4 (4%)	1 (1%)	0	0
CC-S7	220	78 (35%)	14 (6%)	99 (45%)	19 (9%)	4 (2%)	3 (2%)	3 (2%)
CC-S8	311	124 (40%)	20 (6%)	136 (44%)	19 (6%)	7 (2%)	4 (1%)	1 (0%)
CC-S9	157	36 (23%)	12 (8%)	91 (58%)	16 (10%)	0	1 (1%)	1 (1%)
CC-S10	244	124 (51%)	2 (1%)	107 (44%)	9 (4%)	0	2 (1%)	0

[a] Analysis includes only enrolled students. It does not include students who withdrew or failed to complete the course. Student Identification number consists of the course designation followed by a randomly assigned number.

STUDENTS[a]	TOTAL MENTIONS	MENTION TYPE						
		INSTRUCTORS	TEACHING ASSISTANTS	STUDENTS	OPEN PARTICIPANTS	ACADEMIC PARTICIPANTS	COMMUNITY PARTICIPANTS	OTHER
SOC-S1	7	2 (29%)	--	3 (43%)	--	0	2 (29%)	0
SOC-S2	9	1 (11%)	--	8 (89%)	--	0	0	0
SOC-S3	1	0	--	1 (100%)	--	0	0	0
SOC-S4	0	0	--	0	--	0	0	0
SOC-S5	1	0	--	1 (100%)	--	0	0	0
SOC-S6	44	26 (59%)	--	11 (25%)	--	6 (14%)	1 (2%)	0
SOC-S7	8	2 (25%)	--	6 (75%)	--	0	0	0
SOC-S8	10	1 (10%)	--	9 (90%)	--	0	0	0
SOC-S9	0	0	--	0	--	0	0	0
SOC-S10	4	0	--	1 (25%)	--	0	3 (75%)	0
SOC-S11	0	0	--	0	--	0	0	0
SOC-S12	17	5 (29%)	--	10 (59%)	--	0	2 (12%)	0
SOC-S13	23	3 (13%)	--	20 (87%)	--	0	0	0
SOC-S14	5	2 (40%)	--	2 (40%)	--	1 (20%)	0	0
SOC-S15	3	2 (67%)	--	1 (33%)	--	0	0	0
SOC-S16	0	0	--	0	--	0	0	0
SOC-S17	5	0	--	4 (80%)	--	0	0	1 (20%)
SOC-S18	0	0	--	0	--	0	0	0
SOC-S19	11	2 (18%)	--	9 (82%)	--	0	0	0
SOC-S20	0	0	--	0	--	0	0	0
SOC-S21	0	0	--	0	--	0	0	0
SOC-S22	0	0	--	0	--	0	0	0
SOC-S23	3	1 (33%)	--	0	--	2 (67%)	0	0
SOC-S24	12	3 (25%)	--	4 (33%)	--	4 (33%)	0	1 (8%)
SOC-S25	10	1 (10%)	--	8 (80%)	--	0	1 (10%)	0
SOC-S26	12	4 (33%)	--	8 (67%)	--	0	0	0

[a] Analysis includes only enrolled students. It does not include students who withdrew or failed to complete the course. Student Identification number consists of the course designation followed by a randomly assigned number.

Appendix D.

Social Network Analysis

Social network analysis (SNA) captures interactions through visualizations (sociograms) and metrics. SNA can be performed in a number of digital and non-digital environments, including Twitter, where it identifies relationships in terms of who is mentioning whom. Therefore, SNA is a means for visualizing and describing mention use, at group (or network) and individual levels. Table 25 details relevant course-level metrics, including number of vertices (participants), unique and duplicate edges (interactions), and self-loops (the number of tweets that did not mention another person). None of the course communities were distinctive in terms of density (range 0.3-.5) or diameter (range 4-5). The appendix is divided by courses; each section provides the course sociogram. VT and CAM students did not produce enough Twitter data to warrant individual analysis, so centrality metrics are limited to CC and SOC enrolled students.

Table 25.

Network level metrics for course-related Twitter activity

COURSE	VERTICES	DENSITY	DIAMETER	UNIQUE EDGES	DUPLICATE EDGES	TOTAL EDGES	SELF-LOOPS	SELF-LOOPS/TOTAL EDGES
CC	228	.02	4	437	5404	5841	1341	.23
CAM	38	.03	5	46	86	132	75	.57
VT	38	.05	4	53	489	542	134	.25
SOC	75	.03	5	115	560	675	325	.48

Course CC

CC was the largest network in terms of number of participants and edges. CC participants were least likely to "self-loop," confirming previous findings that CC and VT students tended to engage specific individuals in dialogue rather than broadcasting general messages.

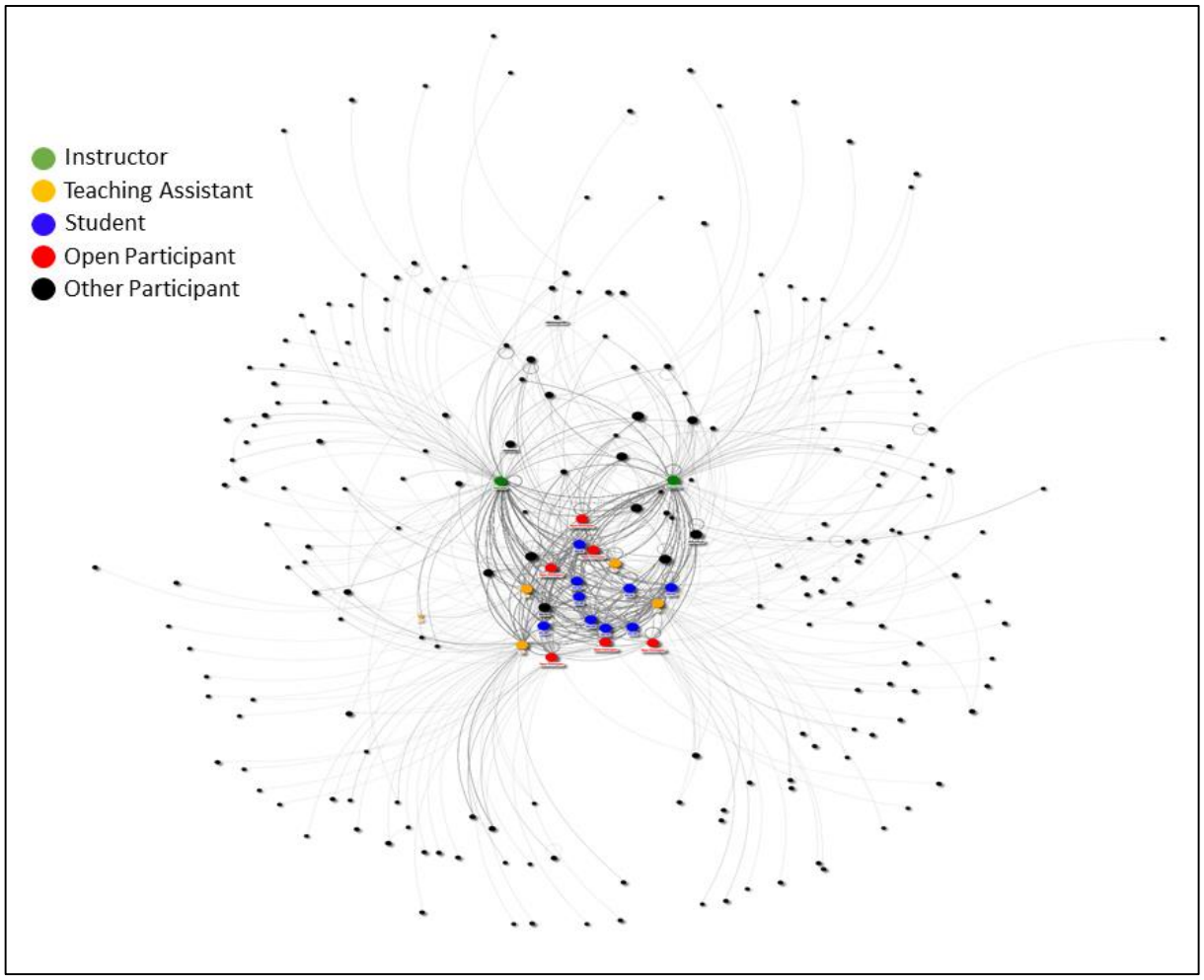

Figure 21. Sociogram of CC Twitter activity, based on SNA of all tweets containing the course hashtag.

Table 26.

Centrality metrics for CC enrolled students

STUDENTS	IN-DEGREE CENTRALITY	OUT-DEGREE CENTRALITY	BETWEENNESS CENTRALITY
CC-S1	22	17	77
CC-S2	22	13	156
CC-S3	22	17	97
CC-S4	29	29	1510
CC-S5	21	16	118
CC-S6	14	18	66
CC-S7	32	30	2171
CC-S8	27	31	1885
CC-S9	22	23	718
CC-S10	21	16	13

Course CAM

CAM had the least Twitter activity of the four courses. The community was instructor-centric. When students tweeted, they tended to "self-loop," meaning they were broadcast rather than using mentions to interact with specific people.

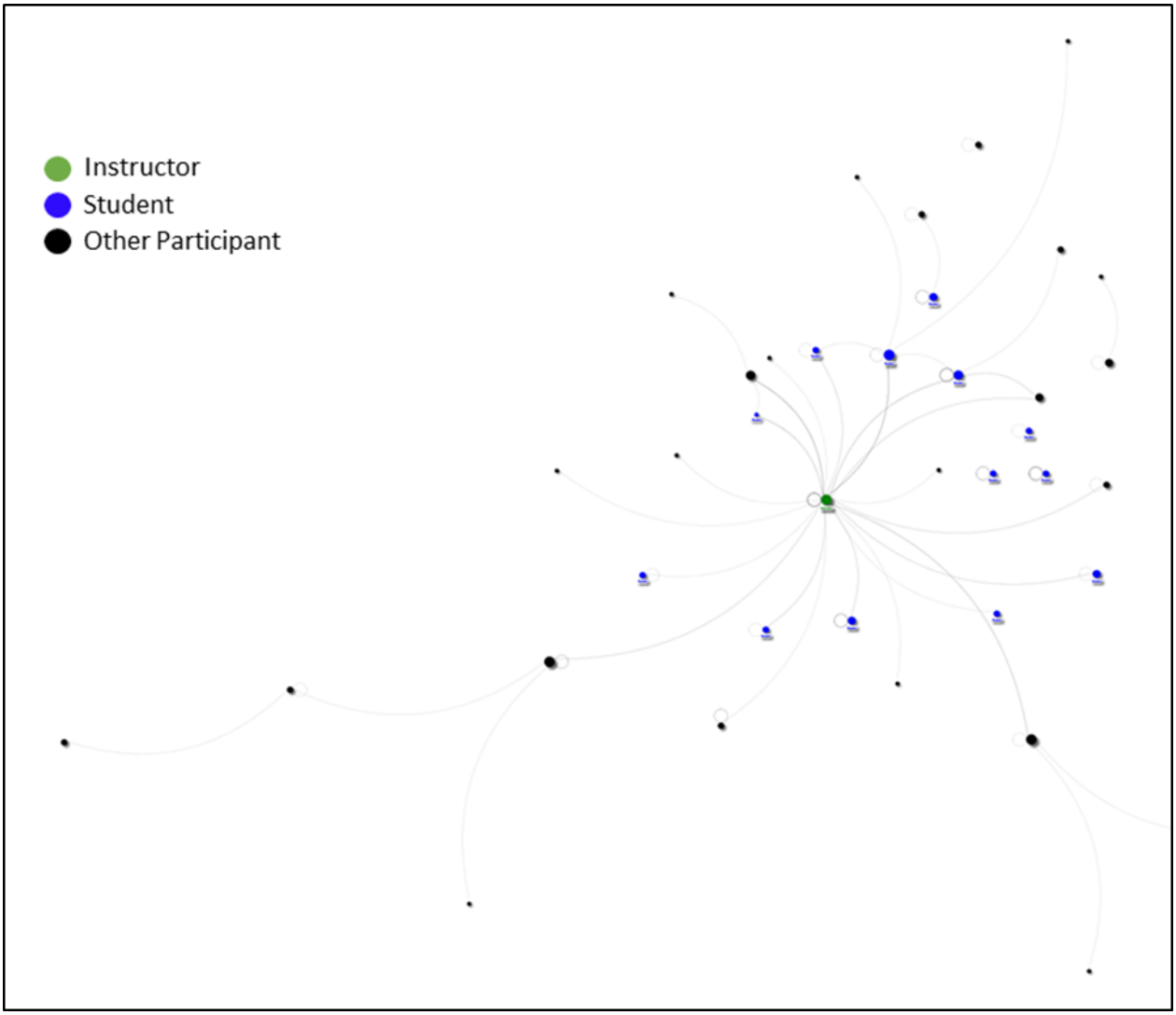

Figure 22. Sociogram of CAM Twitter activity, based on SNA of all tweets containing the course hashtag.

Course VT

VT had more Twitter activity than CAM, driven mostly by the efforts of the instructor, who contributed 70% of the tweets to the community. The proportion of self-loops seen in this group is relatively low, as many student tweeted directly to or in response to the instructor.

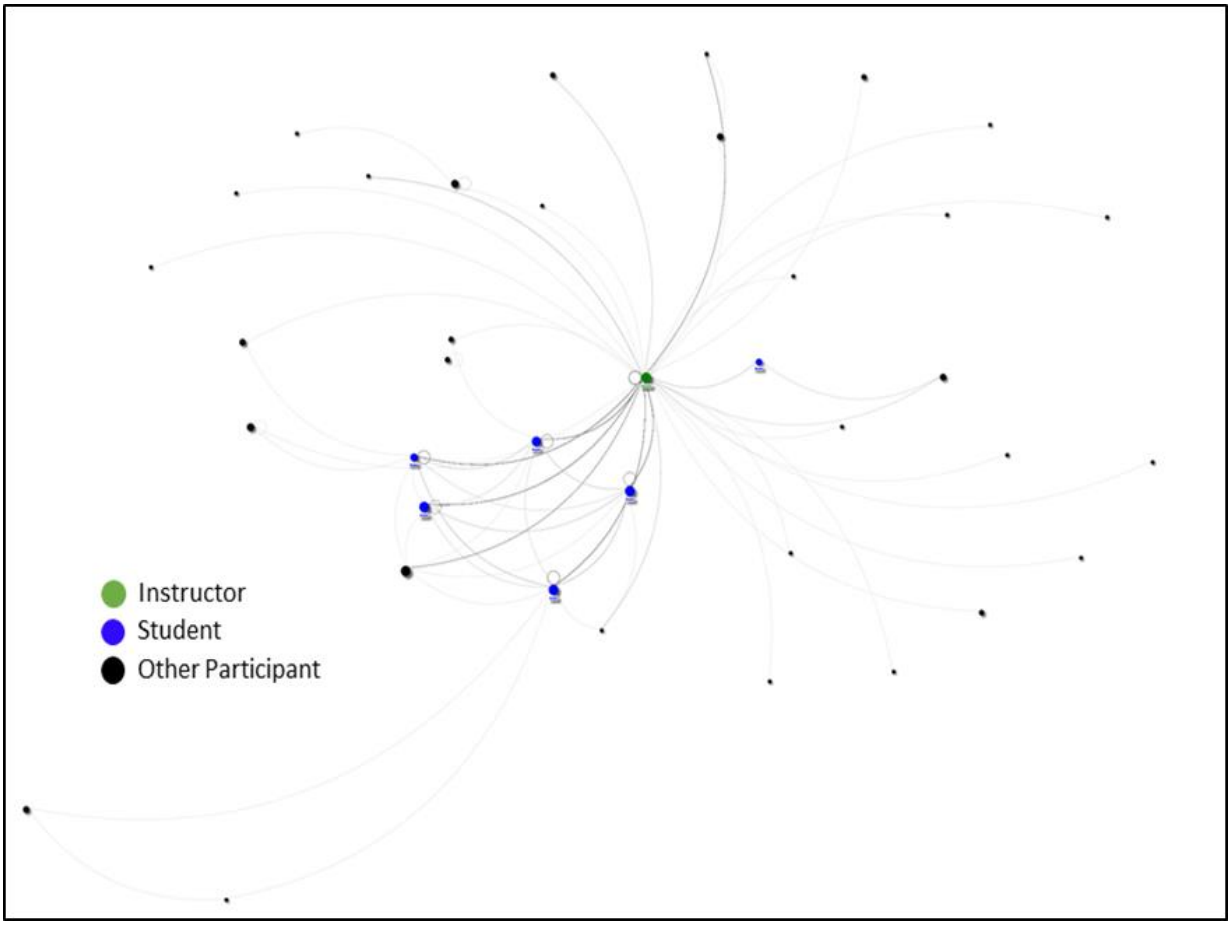

Figure 23. Sociogram of VT Twitter activity, based on SNA of all tweets containing the course hashtag.

Course SOC

SOC had the second most Twitter activity. Its incentivized but unstructured design resulted in an instructor-centric sociogram and significant number of self-loops. As discussed in chapter four, students tended to contribute hyperlinked materials to the group but less commonly engaged in threaded interaction associated with mentions.

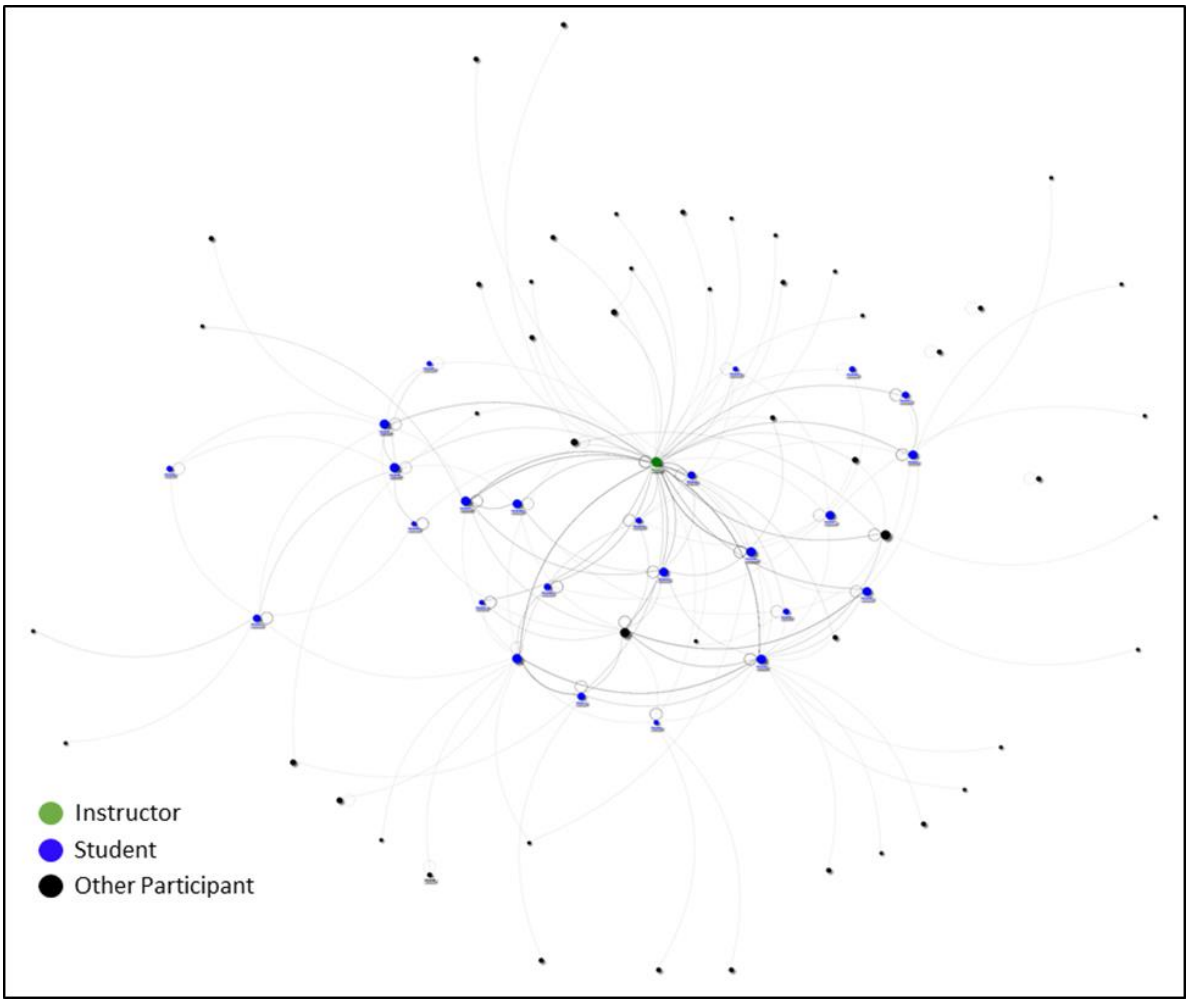

Figure 24. Sociogram of SOC Twitter activity, based on SNA of all tweets including the course hashtag.

Table 27.

Centrality metrics for SOC enrolled students

STUDENTS	IN-DEGREE CENTRALITY	OUT-DEGREE CENTRALITY	BETWEENNESS CENTRALITY
SOC-S1	4	6	289
SOC-S2	4	6	9
SOC-S3	3	2	0
SOC-S4	7	1	283
SOC-S5	5	2	8
SOC-S6	12	14	947
SOC-S7	4	8	263
SOC-S8	4	7	116
SOC-S9	2	1	0
SOC-S10	5	4	320
SOC-S11	4	1	1
SOC-S12	7	7	180
SOC-S13	6	11	101
SOC-S14	7	4	239
SOC-S15	4	3	4
SOC-S16	4	1	0
SOC-S17	3	6	165
SOC-S18	6	2	37
SOC-S19	6	6	14
SOC-S20	7	8	60
SOC-S21	4	1	0
SOC-S22	2	2	0
SOC-S23	4	3	6
SOC-S24	4	9	100
SOC-S25	5	6	149
SOC-S26	6	4	148