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Examining Collaborative Knowledge Construction in Microblogging-Based Learning Environments

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Abstract

Aim/Purpose	The purpose of the study is to provide foundational research to exemplify how knowledge construction takes place in microblogging-based learning environments, to understand learner interaction representing the knowledge construction process, and to analyze learner perception, thereby suggesting a model of delivery for microblogging.
Background	Up-and-coming digital native learners crave the real-time, multimedia, global-interconnectedness of microblogging, yet there has been limited research that specifically proposes a working model of Twitter's classroom integration for designers and practitioners without bundling it in with other social media tools.
Methodology	This semester-long study utilized a case-study research design via a multi-dimensional approach in a hybrid classroom with both face-to-face and online environments. Tweets were collected from four types of activities and coded based on content within their contextual setting. Twenty-four college students participated in the study.
Contribution	The findings shed light on the process of knowledge construction in microblogging and reveal key types of knowledge manifested during learning activities. The study also proposes a model for delivering microblogging to formal learning environments applicable to various contexts for designers and practitioners.
Findings	There are distinct learner interaction patterns representing the process of knowledge construction in microblogging activities ranging from low-order to high-order cognitive tasks. Students generally were in favor of the Twitter integration in this study.

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Recommendations for Practitioners	The three central activities (exploring hashtags, discussion topics, and participating in live chats) along with the backchannel activity formulate a working model that represents the sequential process of Twitter integration into classrooms.
Impact on Society	Microblogging allows learners omnichannel access while hashtags can filter the global noise down to meaningful bytes of information to target formal and informal learning. When shared amongst global users for participatory communication, it gives access to collaborative knowledge. This study gives practitioners and designers a working model to leverage microblogging and connect to their tech-savvy learners for more connected learning.
Future Research	Future research may include experiments of this proposed model for delivering microblogging in: prolonged studies; compared to other microblogging methodologies; in non-hybrid delivery models such as asynchronous-only; in other academic or professional disciplines; or in other educational age ranges.

Keywords	knowledge construction, social media, microblogging, Twitter

INTRODUCTION

Knowledge construction is the active process of making meaning by interactions with novel information from instructors, peers, content, and/or the environment which is interpreted uniquely based on the existing knowledge of the learner (Bruner, 1990; Jonassen, 1991; Merrill, 1991; Savery & Duffy, 1996). From both cognitivist and constructivist perspectives, a key goal of student learning is to achieve higher-order thinking, which is a key component of knowledge construction as evidenced through its renegotiation, organization, justification, integration, reflection, and internalization of information resulting in original outcomes (Chi, 2009; Jonassen, 1991). For a time, research into knowledge construction focused primarily on the individual processes due to its need to build upon historical context unique within the mind; however, the elements of social collaboration and autonomy in concert with relatedness have always existed (Bereiter & Scardamalia, 1989; Lebow, 1993; Vygotsky, 1978). In recent years, research has moved away from this individualistic perspective making collaborative knowledge construction an area of prime interest for educational researchers and practitioners largely due to the rapid emergence of collaborative constructive platforms and social delivery mechanisms along with the ready-adoption of these platforms and mechanisms by digital native learners (T. Anderson, 2008a; Cuban, 2001; Lu, Hao, & Jing, 2016; Selwyn & Stirling, 2016).

Among many tools available to be integrated into collaborative learning environments for knowledge construction (Dawley, 2009; Gao, Zhang, & Franklin, 2013; Kimmerle, Moskaliuk, Oeberst, & Cress, 2015; Lan, Tsai, Yang, & Huang, 2012), microblogging tools such as Twitter have gained mounting popularity and attention (Gao, Luo, & Zhang, 2012; Ricoy & Feliz, 2016; Shabgahi, Shah, & Cox, 2013; Tang & Hew, 2017). Microblogging is a type of lightweight online application that allows a burst of multimedia content to be published and shared with others worldwide on the web (Java, Song, Finin, & Tseng, 2007). Research has reported its benefits and potential in allowing instant feedback and comments alongside the main channel of instruction or information (Kimmons & Veletsianos, 2016; Li & Greenhow, 2015; Luo, 2015, 2016), promoting interaction and engagement (Domizi, 2013; Luo, Smith, & Cheng, 2016; Munoz, Pellegrini-Lafont, & Cramer, 2014), and boosting academic achievement (Junco, Elavsky, & Heiberger, 2013; Kassens-Noor, 2012; Van Vooren & Bess, 2013). Nevertheless, studies that specifically address the process of knowledge construction in the context of microblogging tools have been limited. In this study, we aimed to establish evidence of higher-order thinking through knowledge construction during microblogging activities in a hybrid classroom with both face-to-face and online environments via a case-study research design. This paper begins with a review of the literature on microblogging applications in education, as well as the learning theories, frameworks, and models to understand the knowledge construction process from both theoretical and empirical lenses. We then employ the framework drawn from extant research literature to thoroughly examine data collected from microblogging-supported environments across multiple learning activities. The results and discussion section provides detailed findings, including the proposition of a working model of Twitter integration in classrooms. The last section of the paper sheds light on the contribution of the paper and provides recommendations for future practitioners and researchers regarding knowledge construction in a microblogging-specific context of learning.

LITERATURE REVIEW

To better understand the process of collaborative knowledge construction in microblogging-based learning environments, we provide a review of literature on microblogging use in education, related learning theories, and current empirical studies involving knowledge construction, while looking for frameworks to understand types of knowledge and learning activities and the models to examine learner interaction in knowledge construction.

MICROBLOGGING USE IN EDUCATION

Microblogging applications as a broadcast medium were founded on text-based, SMS-sized posts of information to the user's profile initiating immediate sharing worldwide for the purpose of relating concurrent activities (Java et al., 2007). Modern microblog users enjoy omnichannel access through website interfaces, SMS, or mobile devices and post a patchwork of self-made or shared multimedia content including static and GIF graphics and videos (Murthy, Bowman, Gross, & McGarry, 2015; Vavoula, Sharples, Rudman, Meek, & Lonsdale, 2009).

The instant and participatory communication afforded by microblogging tools provides considerable opportunities to be integrated by instructors and designers to meet the disparate needs of various learners in both formal and informal contexts (Chen & Bryer, 2012; Gao et al., 2012; Luo & Franklin, 2015; Tang & Hew, 2017). Given the unique attributes of microblogging tools and mounting popularity of these tools among digital natives, researchers believe microblogging holds great potential to be integrated across varying educational contexts to support both individual and collaborative learning (Gao et al., 2012; Krutka, Nowell, & Whitlock, 2017; Luo, Dani, & Cheng, 2016; Ricoy & Feliz, 2016; Rohr, Costello, & Hawkins, 2015; Shah, Shabgahi, & Cox, 2016). In face-to-face classroom settings, backchanneling, which means to maintain a real-time communication channel on the side of the primary instructional activity, is a common form of microblogging's educational use in order to enhance audiences' participation and engagement in a live event (Kim et al., 2015; Kimmons & Veletsianos, 2016; Kimmons, Veletsianos, & Woodward, 2017; J. Li & Greenhow, 2015; Tomlinson et al., 2017). In online learning environments, instructors use microblogging tools to facilitate discussions and reflections of the course content, as well as for building a learning community among participants from a course (Agherdien, 2011; Ricoy & Feliz, 2016; Wright, 2010). In terms of learning outcomes, a few experimental design studies also evidenced that Twitter can positively impact the recall of course content (Blessing, Blessing, & Fleck, 2012) and test scores (Junco et al., 2013; Junco, Heiberger, & Loken, 2011; Van Vooren & Bess, 2013).

In a recently published systematic review, Tang and Hew (2017) summarized six ways of using Twitter in education: (a) capture and representation, which refers to using Twitter to record media and data in order to document or showcase ideas and activities; (b) communication, which refers to using Twitter for sharing, exploring, and outreach purposes; (c) collaboration, which refers to using Twitter to work together on a project to solve a common problem; (d) class organization and management such as posting class announcements; (e) reflection as a part of self-assessment; and (f) assessment as evaluation activities conducted among members of a class (the instructor and students, and/or among students themselves). The studies above present a wide range of use of microblogging tools in various contexts within education. Conversely, some studies also reported that some students believe that the interaction on Twitter is superfluous and Twitter may restrict in-depth thinking due to its 140-character limit (Kassens-Noor, 2012; Prestridge, 2014). It is unclear how students construct knowledge in a Twitter-supported environment on an individual or group level and why students' experiences differ. Therefore, more research was recommended in this area (Tang & Hew, 2017).

Learning Theories

The conceptual framework of knowledge construction is deeply rooted in both social cognitivist and constructivist theory. In the realm of social cognitivist theory, learners acquire knowledge and skills that they attain from the external environments and internalize them within their own minds through schema construction (Bandura, 2011). Within the cognitive domain, researchers proposed various models to examine learning outcomes and identify the different kinds of learning and various types of knowledge learned by a learner (Reigeluth & Moore, 1999).Constructivism theorists consider learning to be the active process of making meaning from experiences and interactions by applying one's personal, historical understanding to the current experience (T. Anderson, 2008b; Bruner, 1990; Dewey, 1916; Smith & Ragan, 2005). This requires the learners to operate at a higher cognitive level and gives them the responsibility in learning to arrive at a self-chosen position which they consider justifiable based on their own personal interpretations (Cunningham, 1991; Jonassen, 1991; Oeberst, Kimmerle, & Cress, 2016; Richey, Klein, & Tracey, 2011). Evidence of learning comes from how learners elaborate upon information and handles complex problems which challenge their current understanding (Ertmer & Newby, 1993), which gives researchers the opportunity to examine the process of knowledge construction by evaluating interactions made by learners.

Frameworks to Understand Types of Knowledge and Learning Activities

Bloom's Taxonomy of Educational Objectives is a classic framework for the examination of learning objectives and outcomes (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956). The original taxonomy encompasses all hierarchical categories within the cognitive domain concerning high-order thinking, namely, (a) knowledge, (b) comprehension, (c) application, (d) analysis, (e) synthesis, and (f) evaluation. The recently revised taxonomy (L. W. Anderson & Krathwohl, 2001) saw the need to isolate cognitive processes as a dimension unique from the knowledge dimension of educational objectives. The cognitive process dimension resembles the original taxonomy by illustrating the hierarchical levels of learning (now updated to (a) remembering, (b) understanding, (c) applying, (d) analyzing, (e) evaluating, and (f) creating), while the knowledge dimension provides a way of identification of different types of knowledge acquired: factual, conceptual, procedural, and metacognitive. By isolating knowledge as a unique dimension with four objective characteristics, knowledge can now be more easily examined as an independent outcome and measured against the cognitive process dimension (L. W. Anderson & Krathwohl, 2001). Researchers have applied Bloom's Taxonomy and its revised version extensively to understand the types of knowledge and learning activities across various settings and through different technologies (P. C. Lin, Hou, Wang, & Chang, 2013; Thompson, Luxton-Reilly, Whalley, Hu, & Robbins, 2008).

J. R. Anderson's (1986) knowledge classification divided knowledge into declarative knowledge and procedural knowledge. Declarative knowledge is known as the verbal or factual knowledge stored in memory, which can only be learned through memorization and tends to be static. Procedural knowledge concerns the type of knowledge that provides step-by-step instruction regarding how to perform a particular task.

Chi (2009) provides a conceptual framework further differentiating learning activities between the learner as being (a) active, (b) constructive, or (c) interactive. The framework proposed a testable hypothesis, articulating that *interactive* activities (referring to activities that enable students to jointly create knowledge) are superior to *constructive* (constructing outputs), which are both superior to *active* (doing something physically) activities. This framework applies well to overt activities such as Twitter and other microblogging environments because of their externalized outputs; in this case, tweets. Chi (2009) noted that knowledge construction in interactive and constructive activities can be measured by the production of additional outputs (elaborations/ideas that are beyond the provided information), whereas being active is engaging with the material and may only be summarizing it or attending to existing knowledge.

Models to Examine Learner Interaction in Knowledge Construction

Early researchers interested in computer conferencing environments adopted a social constructivist approach to develop frameworks to examine learner interaction at various stages of knowledge construction. Gunawardena, Lowe, and Anderson (1997) developed an *interaction analysis model* to depict the hierarchical phases in the co-construction of knowledge. The five phases for analysis are comprised of (a) sharing/comparing of information, (b) discovery and exploration of dissonance, (c) negotiation of meaning, (d) testing and modification, and (e) agreement and applications. Kanuka and Anderson (1998) reviewed and condensed the five-phase model to only two as they found much of the conversation transcripts in their research lacked the sequencing necessary to construct knowledge, and novel ideas were not being challenged: (a) social interchange (not social constructivism) and (b) social discord and knowledge construction. They categorized content in which views remained unchanged as merely social interchange and left interactions involving negotiation and the exchange of novel information to the second category. Pena-Shaff and Nicholls (2004) created an instrument to capture the interaction and meaning construction process which consists of 11 categories: (a) questions, (b) reply, (c) clarification, (d) interpretation, (e) conflict, (f) assertion, (g) consensus building, (h) judgment, (i) reflection, (j) support, and (k) other. This list provides a holistic and meaningful framework to understand how learning occurs in bulletin board-mediated online discussion learning environments.

In recent years, Blooma, Kurian, Chua, Goh, and Lien (2013) analyzed learner interaction in knowledge construction by reviewing knowledge, cognitive processes, and social dimensions in micro-collaborations with a social question answering (SQA) tool study. They employed the L. Anderson and Krathwohl (2001) revision of Bloom's Taxonomy to examine the knowledge and cognitive processes. The social dimension includes four elements – (a) affective, (b) interactive, (c) cohesive, and (d) argumentative – each with multiple indicators used for coding purposes. The authors claim this dimension's focus is on "community commitment and co-construction of knowledge" (p. 113). Influenced by Dillenbourg and Schneider's (1995) eight mechanisms of collaborative learning and the coding scheme of Pena-Shaff and Nicholls (2004), Gao (2013) examined learner interaction in a social annotation learning environment: a study resulting in six categories of interaction to represent students' knowledge construction process (See Table 1). X. Li and Cox (2016) developed their own knowledge construction process model upon evaluating technical support community forums after separating out problem description and non-constructive posts from the knowledge construction posts. They defined these posts to be "directly related to building new knowledge to solve technical questions and problems" (p. 1051), which included (a) initiation, (b) idea proposal, (c) refinement, (d) evaluation and testing, and (e) resolution.

The above review of learning theories and conceptual frameworks and models served as a guide to analyze our data collected from microblogging-based learning environments. In particular, the conceptual frameworks and coding schemes of Gao (2013) and Blooma et al. (2013) were of key importance for the data analysis of this current study due to the similar nature between Twitter's interactive and microblogging capabilities and the qualities outlined in their frameworks and coding schemes.

Purpose of the Study

Despite the continuing research effort, limited research consideration has been dedicated to understanding how microblogging tools such as Twitter facilitate and support the process of knowledge construction without being amassed with other social networking sites such as Facebook or

YouTube. Such blanket association refutes that social networking sites (SNS) all have different design considerations, which can be seen by comparing any of the above collaborative knowledge construction research studies. The frameworks to analyze the transfer of knowledge, the environments of learning, and the models of delivery all vary from one tool to the next and as such microblogging, too, has considerations which are unique. Therefore, the purpose of the study is to provide foundational research to exemplify how knowledge construction takes place in microblogging-based learning environments, to understand learner interaction representing the knowledge construction process, and to analyze learner perception, thereby suggesting a model of delivery for microblogging. The following questions were crafted to guide our research:

1. What was the process of knowledge construction in microblogging-supported activities represented by learner interaction?
2. What types of knowledge were manifested in microblogging-supported learning activities?
3. How did students perceive the effectiveness of using Twitter for knowledge construction?

METHODS

PARTICIPANTS

This study utilized a case study research design via a multi-dimensional approach to analysis (Yin, 2008). Twenty-four college students aged 19 to 22 from a core requirement course at a large Midwestern university in the United States participated in this study. Among these students seventeen were female and seven were male. Nearly 80% of these students self-identified themselves as an intermediate or advanced technology user, yet only 23% considered themselves an *early adopter* of technology while the majority considered themselves *pragmatists* (requiring assurances that the technology is going to work before adoption).

INSTRUCTIONAL CONTEXT

The course was primarily administered online with only three face-to-face meetings over the 14-week semester. Students were expected to become acquainted with a wide variety of emerging Web 2.0 technologies to develop or enhance classroom instruction. Being an exemplar of Web 2.0 technologies, Twitter was incorporated in this class for students to experience its educational use through varying means. In the three face-to-face sessions (Weeks 1, 7, and 14), microblogging was adopted as a backchannel to allow comment and feedback during lectures and presentations. Three online microblogging-focused activities consisted of (a) the exploration of educational Twitter hashtags (a word or phrase used to categorize or identify tweets on similar topics, usually preceded by a pound sign "#") utilizing the search function integrated in Twitter; (b) the discussion of topics relating to the course and readings as well as answering related questions-prompts from the instructor; and (c) active participation in a variety of synchronous live chat sessions. The live chat activity required students to participate in at least one-hour of a live chat session of their choice concurrently among a group of other educators (peers and experts for the learners in the study) online. Students were asked to minimally post one tweet per week, but they were encouraged to converse with their instructor and peers on Twitter beyond what was prescribed by the required instructional activities.

DATA COLLECTION

Student tweets published on Twitter and an end-of-course survey were collected. Participants' tweets were collected using Twitter Archiving Google Spreadsheet (TAGS) v5, a Google Drive developer's texting mining tool to quickly and easily capture content from Twitter's API. TAGS was preconfigured to archive and save Tweets automatically in real-time. Participants ended the last class by answering an online survey via Qualtrics. A total of 22 of the study's 24 students participated in the survey. Students were asked to share their perceptions of the Twitter integration and whether they achieved any knowledge gain owing to their use of Twitter. They rated three statements regarding how Twitter helped them construct their knowledge on a five-point Likert-type scale ranging from strongly agree to strongly disagree. The statements were followed by an open-ended question requiring students to justify their ratings and provide written comments.

Data Analysis

Prior research has measured knowledge construction through text analysis of the learning product artifacts, such as blog posts and online discussion forum posts (Kimmerle et al., 2013; Lan et al., 2012; Oeberst, Halatchliyski, Kimmerle, & Cress, 2014). The analysis of interaction has often been used as an indicator of knowledge construction (Gunawardena et al., 1997). As was outlined in the Literature Review, prior researchers have developed multiple different coding schemes to measure this interaction. For the analysis of interaction in our data, we decided to evaluate two coding schemes: one for an in-depth view of the interaction (utilizing Gao's *Coding Scheme for Types of Interaction*, (Gao, 2013, p. 79)), and the second as a limited scope of the elements of knowledge construction (utilizing Blooma et al.'s *Dimensions, Elements, and Indicators of the Integrated Framework* (Blooma et al., 2013, p.112)).

In this study, we chose a single tweet as a unit of analysis. Critical in coding is the idea of contextualizing each tweet in a conversation, as many tweets were associated with adjacent tweets and can only be coded in reference to those connected tweets. As Pena-Shaff and Nicholls (2004) noted, one message/tweet could be coded into various categories or a single category, depending on how this single message is being interpreted in the thinking processes demonstrated in the text. We kept this note in mind and applied it to our coding process. The links of tweets containing URLs were also reviewed to contextualize the ultimate purpose of the tweet for coding purposes.

Learner interaction using Gao's coding scheme

To examine the process of knowledge construction represented by learner interaction, the lead researcher first began coding participants' tweets by comparing them with Gao's (2013) coding scheme. Beginning with the existing coding scheme in Gao's study (See Table 1) to conduct the first round of analysis, tweets collected from all weeks were read and coded and the categories and indicators were revised as needed. The researcher then fine-tuned the categories using a detailed line-by-line coding process. New, unanticipated categories emerged as the researcher assessed and categorized the data and, therefore, were added to the existing coding scheme. As more categories were generated, the researcher went back to the existing coding schemes in previous studies related to Gao's, such as Pauschenwein and Sfiri's (2010) and Naaman, Boase, and Lai's (2010), to eliminate unnecessary categories and combine them into new meaningful codes. A modified coding scheme was established after the researcher's examination of tweets in the non-live chat activities (See Table 2). When it came to the live chat activity, the researcher noticed that not all codes from the pre-established coding scheme could be applied to those tweets due to the different nature of online communication (asynchronous versus synchronous). Therefore, another modified coding scheme was created exclusively for tweets generated in the live chats activity (See Table 3). During this phase in which the coding scheme was developed, modified, and finalized, two additional senior researchers acted as peer debriefers, examining the coding and discussing with the lead researcher to reach consensus on the coding. After finalizing coding, we calculated the percentage and numerical numbers of tweets belonging to each code. We also interpreted the distribution of tweets in combination with an analysis of student surveys, including the open-ended questions. Twitter username and course hashtags shown in the tweets were replaced with xxxxx to retain anonymity.

Table 1. Gao's coding scheme for types of interaction

CATEGORIES	BEHAVIORS
Self- reflection	Learners reflect on and interpret what they have
Elaboration/ clarification	Learners build upon an existing comment by adding supporting examples and justification
Alternative/ complementary proposal	Learners offer a complementary or alternative view
Internalization/ appropriation	Learners paraphrase the concepts/ideas presented by their classmates or acknowledge learning something new
Conflict/ disagreement	Show disagreement or conflicting opinions
Support	Learners express agreement without further explanation, establish rapport, or share feelings

Note: Reproduced table with permission (Gao, 2013, p. 79)

Table 2. A coding scheme for non-live chat tweets

CODES	DESCRIPTIONS	EXAMPLE OF TWEET
SR-self-reflection	Acknowledge learning new knowledge and recognize its significance	Twitter is very significant for discussions and thought! Interested to see how it works for #xxxx
EL-elaboration	Expand learning content, build on existing comments by sharing thoughts and/or show examples	@xxxxx I completely understand. I think there is definitely an age barrier for certain types of technology #edtech
AP-alternative proposal	Offer alternative perspectives	I like the polls but if I didn't know the answer I would just wait for others to answer
IT-internalization	Paraphrase the concepts/ideas, synthesize ideas, showing an application and/or transformation of concepts/ideas	Using clickers in the classroom would be a good way to involve everyone in class discussions or to check for understanding
SP - support	Express agreement, establish rapport, or share similar feelings with none/little elaboration	Very energetic presentation!
DA - disagreement	Show disagreement or conflicting opinions	You need to be careful of subliminal messages in visual media. Even some kids' media reinforces gender and racial stereotyping
SL-socialization	Greet and be acquainted with one another	@xxxxx Hi! What's your major?!
RS - resources sharing	Share information, media, and other resources related to course content	How Do I Use Twitter's Suggestions For Who To Follow? http://t.co/6YlvWpiYys

CODES	DESCRIPTIONS	EXAMPLE OF TWEET
CB - conversation building	Back-and-forth questions and replies to reach discussion of the course-related content	@xxxxx What do you think are some of the best practices of using graphics and videos?
DC - discussion of coursework	Discuss course assignments, share links to their assignments	I know it's late, but does anyone need an extra group member for our projects for tomorrow? Let me know!
TD - technical difficulties	Report technical difficulties	Anyone having troubles typing in the form? I have a small space to write a lot.
OT- off task	Irrelevant tweets, not focusing on the course content, tweets posted by outsiders	Finally got my #xxxx Twitter set up! A little late...

Table 3. A coding scheme for live chat tweets

CODES	DESCRIPTIONS	EXAMPLE OF TWEET
SR-self-reflection	Acknowledge new knowledge and recognize its significance	I saw one app for the ipad that zoomed in on a mouth as it made certain sounds, I thought it was really cool #slpchat
EL-elaboration	Expand learning content, build on others' comments by sharing thoughts and/or show examples	@xxxxx You can fit in whatever standards you need to around a topic, letting them choose just makes it more collaborative #rechat
AP-alternative proposal	Offer alternative perspectives	Although technology in the classroom is great, so students can't act mature enough to stay focused. #edchat
IT-internalization	Paraphrase the concepts/ideas, synthesize ideas, showing an application and/or transformation of concepts/ideas	Never put someone down for their opinions. Open minds are key to this profession. #edchat
SP - support	Express agreement, establish rapport, or share similar feelings	@xxxxx I completely agree with you on this and can see where you're coming from. #edchat
DA - disagreement	Show disagreement or conflicting opinions	@xxxxx I'm not sure if I completely agree with that. I think that is a generalized statement #edchat
SE - self-expression	Express themselves, show emotions and feelings, share thoughts about themselves	only 17 minutes in and I am so overwhelmed by #edchat I'm hoping this gets better!
SL - socialization	Connect and network with other	xxxxx, Ohio University undergrad, AYA Earth and Space science major #mdedchat

Types of knowledge via Blooma et al.'s coding scheme

Similar to Gao's coding scheme, Blooma et al.'s coding scheme (2013) was developed for forum-type online environments with social knowledge construction via micro collaborations. Blooma et al.'s coding utilizes three dimensions: (a) knowledge, (b) cognitive process, and (c) social. As our study focused on examining knowledge construction, we did not feel cognitive process needed to be extrapolated from knowledge as we are examining only the outputs of the process and not the cognitive processes themselves. However, we did recognize the need for keeping the social dimension due to the social nature of Twitter. Our modified version of Blooma et al.'s dimensions, elements, and indicators of the Integrated Framework appears as Table 4. Utilizing the elements and indicators of their framework in the strictest sense might place nearly all tweets within the social category; however, Twitter is a *social medium* and as such users are inclined to use social framing statements as they express their purpose or in the context of continuing a conversation thread. Therefore not all tweets with an emotional expression are strictly a *social* coded Tweet. The purpose of the tweet in total and within context must be taken into account. As an example, the tweet: "*Hey #xxxxx, it's been cool learning from the links y'all shared. My note: #edreform is full social info related to the classroom. Love it*" contains a specific fact framed in social elements; the assignment was to research and share hashtags for educators and the shared hashtag specifically contains social information for classroom educators placing it into the *knowledge-factual* code. Elements within the tweet such as the initial compliment to the group and *"love it"* are a part of utilizing a social medium and not the ultimate purpose of the tweet. In coding the tweets collected this time, a separate coder was utilized from the previous coders once the coding scheme was agreed upon.

Table 4. A coding scheme for knowledge construction by tweets

CODE	DESCRIPTIONS	EXAMPLE OF TWEET
KF – knowledge-factual	Knowledge of terminology Factual details and elements	#xxxx Lesson learned. Keep track of class Twitter posts as they occur and not two days later. They can really get lost. :)
KC – knowledge-conceptual	Classification and categorization Generalizations Knowledge of theories	# xxxx It is a good integration of social media and technology in a classroom in a way that can be very appealing to students.
KP – knowledge-procedural	Criteria for determining when to use appropriate procedures Relates to content Knowledge of techniques Knowledge of methods Knowledge of subject-specific skills	Is there a way to pause the answers so no one answer the majority answer
KM – knowledge-meta-cognitive	Prior knowledge Orientation to instruction Strategy towards learning Self-regulation of learning Error-checking	# xxxx - ers, Share your thoughts and questions with project-based learning in #FLedchat
S – social	Expressions of emotion Use of humor Self-disclosure Quoting others Complimenting, cohesive looping Consensus building	weird being in face to face class right now!

Enhancing Trustworthiness, Validity, and Credibility

We employed several strategies to enhance trustworthiness and safeguard the rigor of this case study research. We used triangulation (Newman & Hitchcock, 2011; Patton, 2002), member checks (Maxwell, 2009), and research reflexivity (Nastasi & Schensul, 2005). We modified two existing coding schemes to triangulate the meaning making of student tweets. An external investigator browsed approximately 200 sample tweets and conversed with the lead researcher about how to best code the tweets into a particular category due to the potential ambiguity of meaning existing in the tweets. Member checks were performed with student participants via emails and verbal inquiries during office hours to ensure the correctness of information collected. We kept reflexive notes and journals prior to and during the process of the data collection, analysis, and interpretation phase, making researchers' own bias and assumptions transparent and open to ourselves and others, ultimately aiming to increase credibility and validity of the study.

Results and Discussion

Over the course period, 944 tweets were collected in total, among which 837 tweets were collected from three online activities and 107 were collected from face-to-face backchannel activities. Figure 1 shows the volume of tweets across the three different online activities.

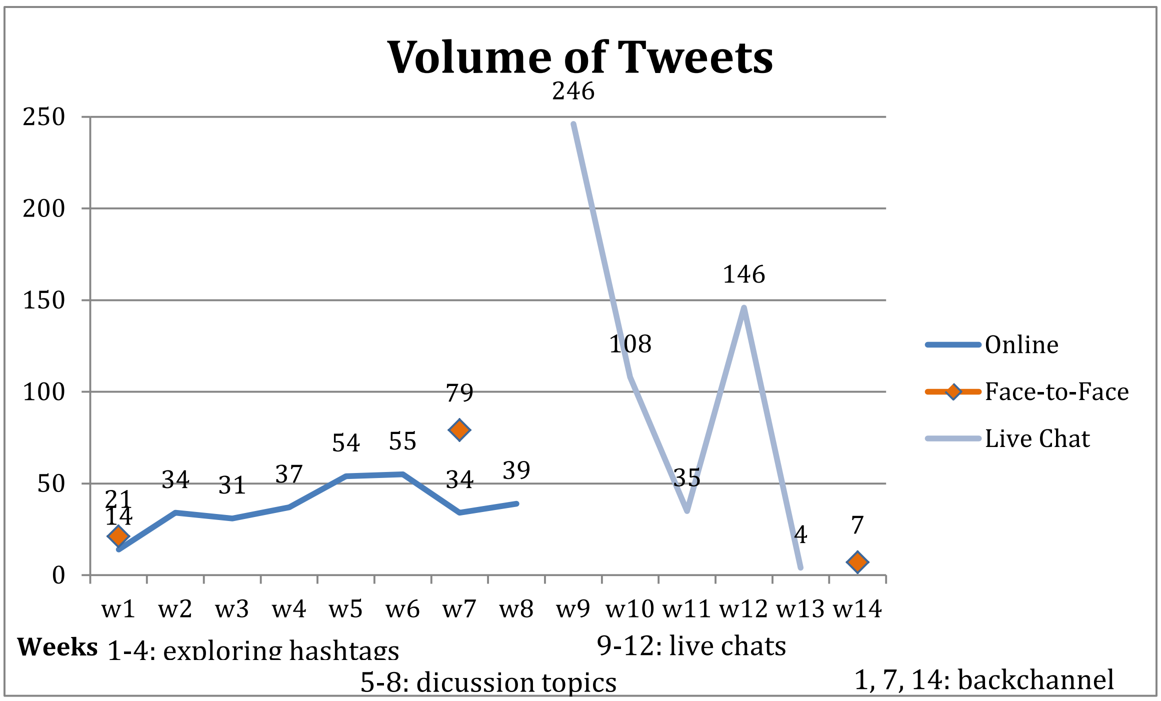


Figure 1. Volume of tweets over 14 weeks of three different online activities

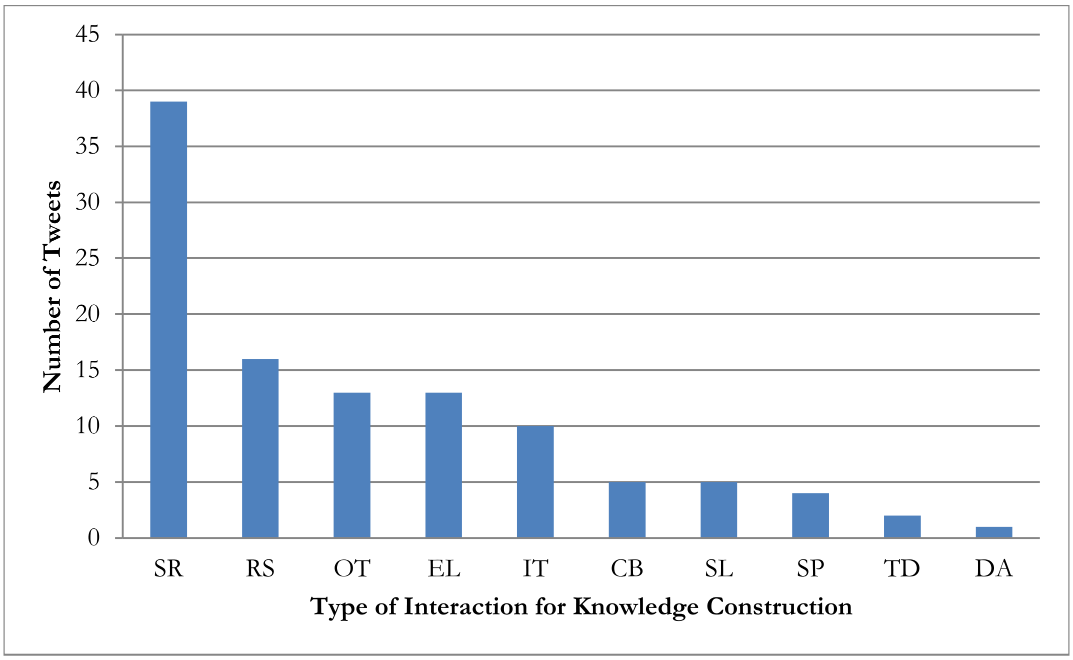
Knowledge Construction Process

We organized this section by the four different activities used in both face-to-face and online learning, followed by a synthesized result. Overall we found that the knowledge construction process in face-to-face environments seemed to be relatively different from that of online environments.

Exploring hashtags

The distribution of various types of interaction during the exploring hashtags activity is demonstrated in Figure 2, showing the percentage and the number of tweets within each category, respectively.

The knowledge construction process was predominantly self-reflection (36.1%), resource sharing (14.8%), and elaboration (12.0%). Our data showed that students were learning new information from searching for educational hashtags (i.e., *"#NCLB has a lot of interesting ideas and thoughts about NCLB #interesting*"), and they shared what they found and learned from this activity (i.e., *"#mathsjam is a great for not only people interested in math related games but shows great tools for educators and their students*"). Few students elaborated on their learning beyond sharing their findings and fewer students internalized the new knowledge through paraphrasing the tweets posted from the hashtag accounts or making inferences, conclusions, and/or hypotheses about what they learned from those hashtags (i.e., "*Online formats help shy kids participate, but definitely don't help them learn to be confident. How do teachers bridge that gap*?"). This result may also be explained in that for many students this was the first time they used Twitter for educational purposes; they were still in the stage of muddling through, which can be seen from the relatively sizable proportion of off-task (OT) tweets (12.0%) (i.e., "*I promised myself I would never get a Twitter. #edct2030 #Shame.*"). Learner interaction during this activity was rather limited and primitive as this was the first microblogging-based activity aiming to prepare students for a higher-level learning domain.

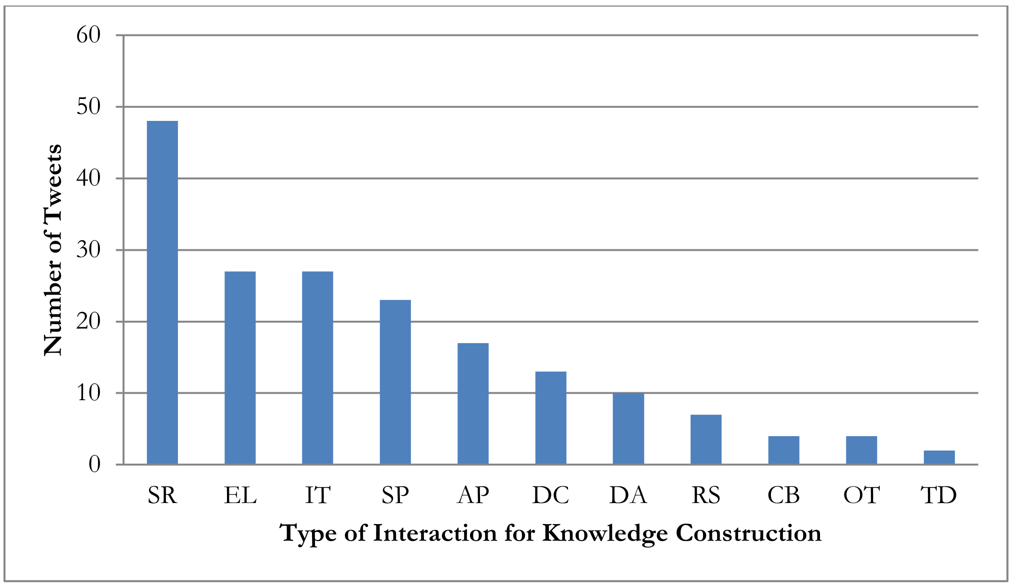


Note. SR = self-reflection, RS = resources sharing, OT = off task, EL = elaboration, IT = internalization, CB = conversation building, SL = socialization, SP = support, TD = technical difficulties, DA = disagreement.

Figure 2. Type of interaction in exploring hashtags by number of tweets

Discussion topics

During the succeeding four weeks when students were discussing course-related topics, our results showed that they seemed to reach a higher level in the knowledge-construction process compared to the Exploring Hashtags activity (See Figure 3). More high-level types of interaction appeared in this time span. The proportion of elaboration (14.8%) and internalization (14.8%) types of interaction slightly rose, as did alternative proposal (9.3%), support (12.6%), and disagreements (5.5%). Compared to the exploring hashtags activity, the discussion topics activity may have required a higher cognitive capability in that students were not simply asked to seek information and report the findings. The support (SP) (i.e., "*I agree! I've seen several ideas I can use in my future classroom.*") and disagreements (DA) (i.e., *"Using graphics can be great but sometimes I wonder if they could be a distraction."*) types of interaction, which showed a direct interaction between at least two students, substantially increased. This finding demonstrated that students in this activity also learned through agreeing to and debating with others, in addition to reflecting on their own learning. It may also imply a higher level of social cohesiveness concurring with Pena-Shaff and Nicholls (2004); participants in online discussion environments are more likely to acknowledge each other's' ideas, make reference to one another, and socially interact with one another as the learning period progresses. With an increased familiarity with Twitter's educational use over time, the amount of off-task tweets (2.2%) and tweets in relation to technical difficulties (1.1%) (i.e., "*Anyone having troubles typing in the form? I have a small space to write a lot.*") were subsequently dropped, as compared to the preceding four weeks (12.0% and 1.8%, respectively). The rise in Twitter literacy, both technologically and cognitively, seemed to help students to stay focused on reflecting on their own learning and constructing new knowledge.



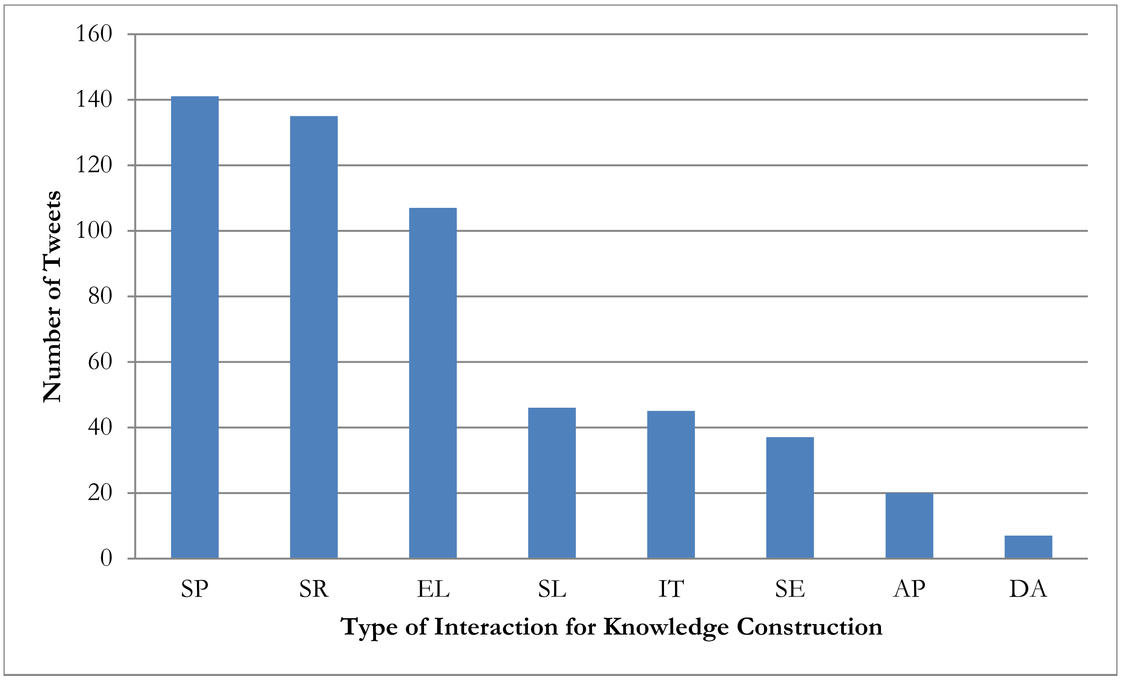
Note. SR = self-reflection, EL = elaboration, IT = internalization, SP = support, AP = alternative proposal, DC = discussion of coursework, DA = disagreement, RS = resources sharing, CB = conversation building, OT = off task, TD = technical difficulties.

Figure 3. Type of interaction in discussion topics by number of tweets

Live chats

As acknowledged previously, a different coding scheme was used to understand interaction patterns in live chats. Classification of tweets was modified due to the more casual and informal nature of learning interaction that occurred in synchronous chats. Tweets that were previously considered off-task (such as tweets that exclusively reflected feelings and emotions of the moment) were placed into a new category: self-expression (SE). Some other categories, including resource sharing (RS), discussion on coursework (DC), and technical difficulties (TD), were not applicable in live chat settings. Only SL (socialization) and the original six a priori codes from Gao's (2013) (SR, EL, AP, DA, IT, DA) were preserved.

Our data showed that students were able to reach a high level of collaborative knowledge construction in synchronous live chats (See Figure 4). Self-reflection (25.0%) (i.e., "*There are so many different websites that offer free project based learning examples and ideas #FLedchat*") was demoted as the second largest type of interaction, while support (26.1%) (i.e., *"@xxxxxx @xxxxxx i completely agree! it's important to be connected in all ways not just technology! #edchat*") became the most predominant type. These findings again showed a higher level of interactivity compared to other activities. Instead of posting tweets simply to share their own thoughts, more students sought to interact with other professionals who joined the same chat synchronously. Notably, most participants of the live chats with whom students interacted were not their instructor or classmates, but professionals with whom they had never spoken. However, this switch in subjects of communication did not affect the interactivity of such discussions. Interestingly, even though the overall interactivity was much higher than other settings, two types of interactions, the proportions of AP (alternative proposal) (i.e., *"@xxxxx I wonder if it deals with a generation gap. I feel that more people from our generation will be open to staying connected #edchat*") and DA (disagreements) (i.e., "*Being connected online is not the only way to connect with students. #edchat*"), remain consistently low. This finding concurs with the prior research on computer-mediated learning, suggesting a low rate of disagreement type of interaction in online discussion environments (Jeong, 2003; Pena-Shaff & Nicholls, 2004).

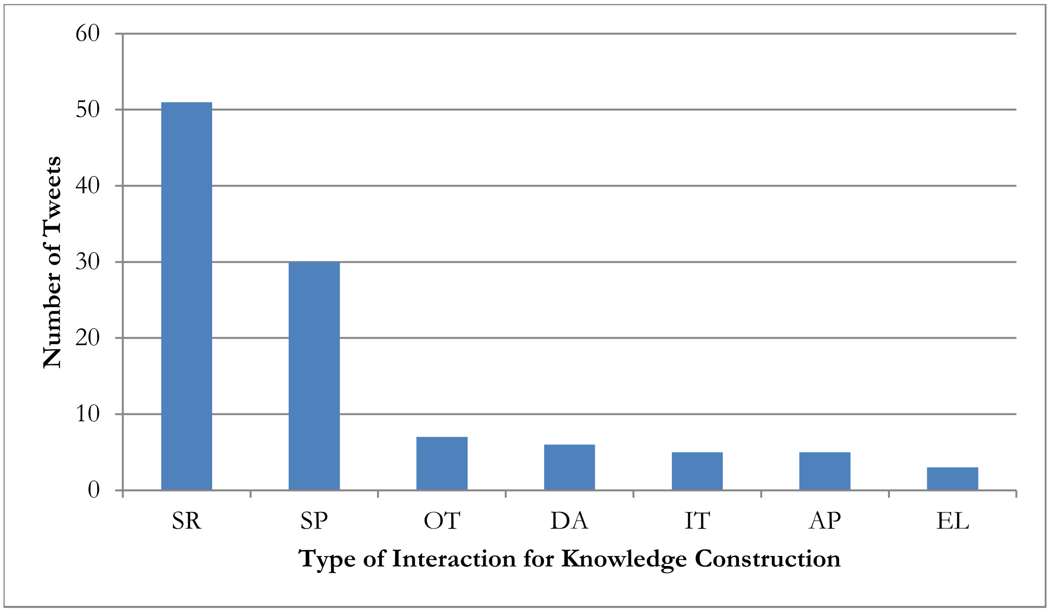


Note. SP = support, SR = self-reflection, EL = elaboration, SL= socialization, IT = internalization, SE = self-expression, AP = alternative proposal, DA = disagreement.

Figure 4. Type of interaction in live chats by number of tweets

Backchannel

We found that in the backchannel activity self-reflection (SR) was more dominant compared to the online environments, forming almost half (47.7%) of the total types of interaction (See Figure 5). Most self-reflection type of interaction (i.e., "*I've always enjoyed using clickers in the classroom. It's nice to be involved in a presentation.*") was in the form of acknowledging the importance of the subject of learning. Reflective questions also prevailed and were prevalent in face-to-face meetings, primarily aiming to seek further information from lecturers in the moment (i.e., "*What is typically the size of an average online class*?"). Support (SP) takes the form of showing positive feedback to the presenter or lecturer (i.e., "*I've never seen LearnBoost, so I'm glad you guys did your presentation on it so I can learn more about it.*"). Since this type of interaction occurred in face-to-face environments where participants were familiar with one another as well as at the presence of one another, support became more common than it was in online discussion environments. This may be explained that since people are less likely to create tension in the face of each other, showing support and positive feedback is always much more common than critical and negative feedback. What is also noteworthy is that off-task tweets were more common in face-to-face settings. One possible reason is that students are apt to digress from the learning topic when social networking tools and cell phones are easy to reach in face-to-face environments. This finding echoes with prior researchers noting the possibilities of creating distraction being one common drawback of using social networking tools like Twitter (Gao et al., 2012; P. C. Lin et al., 2013; Luo, 2016; Luo & Gao, 2012).

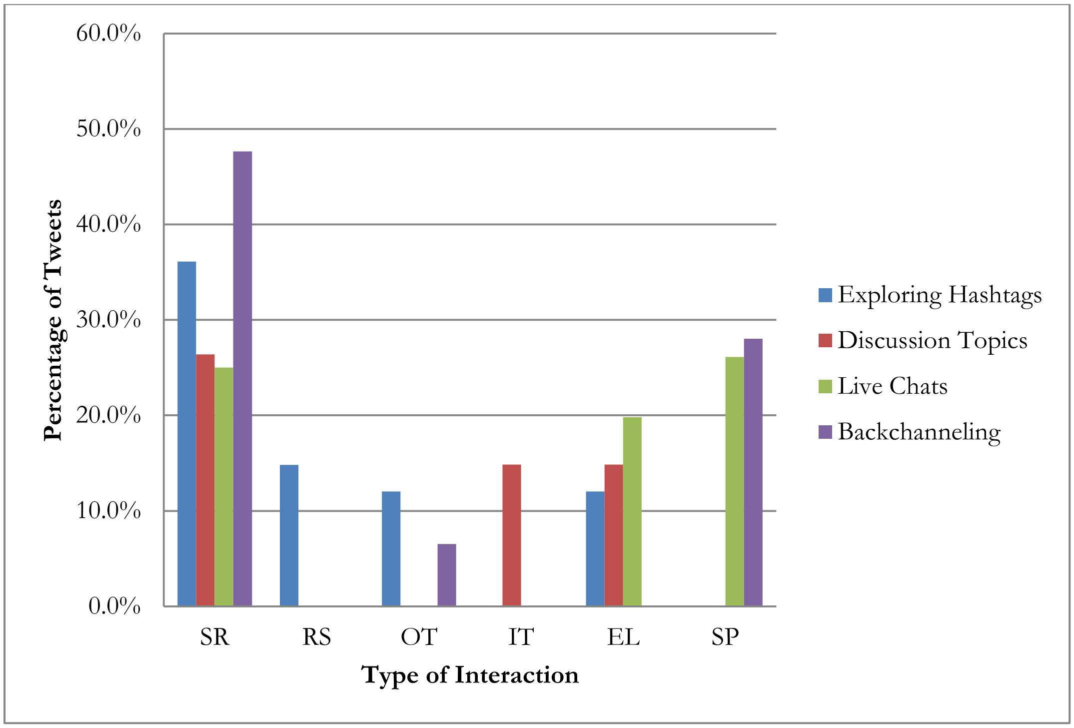


Note. SR = self-reflection, SP = support, OT = off task, DA = disagreement, IT = internalization, AP = alternative proposal, EL = elaboration.

Figure 5. Type of interaction in backchannel by number of tweets

Comparison of the top three types of interaction between the four activity types

Comparing the top three types of interaction between the four activity types based on the percentage of tweets in each interaction demonstrates the different dominances and similarities of the types of interaction between the activities. All four activities had self-reflection in their top three types of interactions showing self-reflection as a gateway to all knowledge construction through microblogging. In microblogging where self-reflection is placed into a generated output publicly seen it becomes a self-disclosure which Blooma et al.'s (2013) SQA coding scheme categorizes as a social activity; this is important to note in Figure 7. Figure 6 can be used to further illustrate the process of knowledge construction as the learner builds through the phases of activities where each activity has its own strengths after self-reflection: they begin with resource sharing, move into elaboration and internalization, continue with support and further internalization, and come back to self-reflection.



Note. SR = self-reflection, RS = resources sharing, OT = off task, IT = internalization, EL = elaboration, SP = support.

Figure 6. Importance of interaction type by activity using top three percentages

TYPES OF KNOWLEDGE

In combining tweets from all activities (exploring hashtags, discussion topics, live chats, and backchannel) and using our modification of Blooma et al.'s (2013) SQA coding scheme (See Table 4), 50.4% of tweets fell into the social dimension (see Figure 7). Indicators of the social dimension within a tweet did not result in a social encoding unless it was the purpose of the tweet (i.e., "*Weird to be using twitter in class eeeh, I kind of like it!*"). Many of these tweets contained compliments and cohesive loops for the purposes of consensus building, which is a common communication tactic in SNS (Lafuente, 2016). It can be argued that the purpose of these tweets is not to construct knowledge as they do not present a novel idea or opportunity for irritation to self-truth required to build something new (Chi, 2009; Oeberst et al., 2016), but their importance in learning cannot be overlooked as they establish the collaborative learning environment which enables the co-construction of knowledge to take place. It was concluded in the SQA study that micro-collaborations do include knowledge building and critical thinking along with social acceptance and community agreement (Blooma et al., 2013).

Within the knowledge dimension, knowledge-metacognitive (KM) was the element with the most tweets at 15.3%. This aligned with what we found utilizing Gao's (2013) coding scheme (see Table 1); students sought interaction as they self-regulated their learning (i.e., *"@xxxxx I'd never heard of Scribd before this. Have you used it in the past?*"), as well as oriented to instruction (i.e. "*An instructional video and lesson plan due in the same week really makes you focus on spending your time wisely.*"). This was followed closely by knowledge-conceptual (KC) which contained 15.1% of the tweets and knowledge-procedural (KP) with 14.0%. These elements, along with knowledge-factual (KF) at 5.2%, represent knowledge surrounding the content and its construction. KP and KF are both specific to the content, whereas KC represents general content knowledge and its construction. In our study, the KC element tweets occurred predominately during the discussion topics activity as students utilized theories to classify, categorize, and generalize the benefits (i.e., "*Graphics are a GREAT way to meet those multiple intelligences of your student! These really support visual and auditory learners!*"). The KP element had use across all activities as learners co-constructed knowledge around the learning content and its procedures, techniques, and methods (i.e., "*when designing graphics it will be helpful to use web-safe colors and to balance mage quality with file size.*"). Similarly, KF had varying activity use when learners were ready to share factual content, which was rarer in our study due to the nature of the content which is more opinion-based; however, there were some (i.e., "*Less than 20% of students are auditory learners, yet most educational content is lecture based. We need change in the classroom!*").

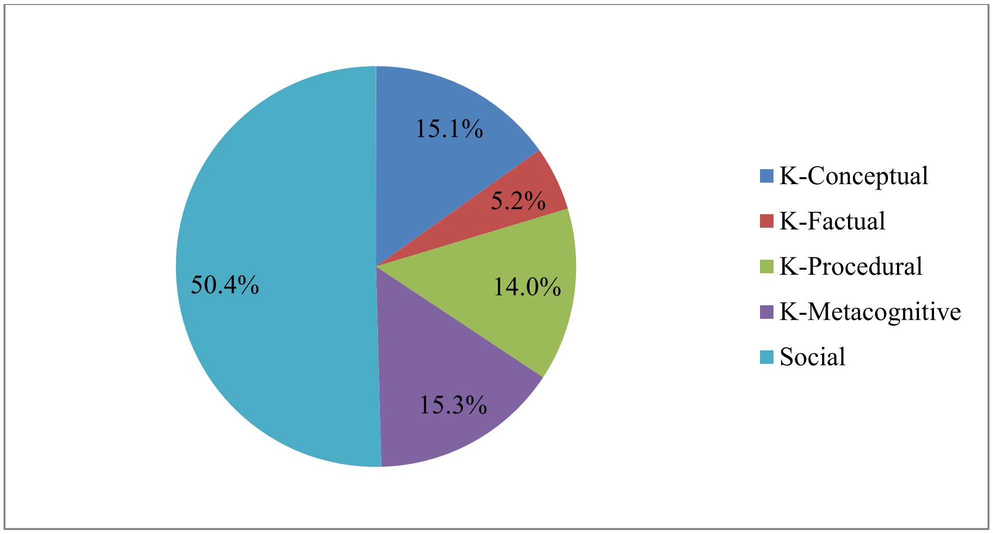


Figure 7. Knowledge construction dimensions combining all tweets

Student Perceptions

When asked if their knowledge on technology integration into education has grown due to the Twitter incorporation, 54% either strongly agreed or agree, while 32% remained neutral (Mean = 2.50, SD = 1.14). Students rated all activities relatively favorably. Table 5 displays the means and standard deviations of students' ratings on each item. Looking at the table horizontally, the backchannel activities helped them most with focusing on the learning topic. During guest lectures, Twitter played a strong role in helping to convey their own understanding. The exploring hashtag activity was considered most successful when it came to constructing their own learning.

Students were also asked an open-ended question: "Did the Twitter incorporation help you to learn more about issues in technology integration into education?" The majority of students reported that after this class they had gained new knowledge and experience regarding technology integration. They commented that they were exposed to new resources that they could use in the classroom and followed a lot of professionals who post things about technology. Five students particularly noted the benefits of getting involved in educational live chats and how they could see the potential of using it in the future. One also noted that, "I can see how it would benefit higher ed [education] students but I think there might be controversy if it's used with K-12."

Table 5. Means and SDs of student rating

	EXPLORING HASHTAGS	DISCUSSION TOPICS	LIVE CHAT	BACKCHANNEL-GUEST LECTURES	BACK-CHANNEL-STUDENT PRESENTATIONS
Focus on learning the topic	2.14 (0.94)	2.36 (1.18)	2.36 (1.40)	2.09 (0.92)	2.09 (1.11)
Express my own understanding	2.23 (1.11)	2.55 (1.14)	2.36 (1.40)	1.95 (1.09)	2.14 (0.94)
Construct my own learning	1.95 (1.00)	2.45 (1.14)	2.41 (1.33)	2.41 (0.96)	2.27 (1.03)

Note: 1 = strongly agree; 2 = agree; 3 = neutral; 4 = disagree; 5=strongly disagree

Implications: A Working Model of Twitter Integration in Classrooms

The above findings and discussion indicate that a composite of all the above-mentioned major activities could become a series of steps that could be taken into actual implementation of Twitter's classroom use. The three central activities (exploring hashtags, discussion topics, and participating in live chats), formulate a working model that represents the process of Twitter integration into classrooms. Though these activities were not initially designed to be hierarchical, a post-hoc analysis of these activities along with student feedback in the survey responses suggested that they seem to naturally build upon one another, which lends to a sequential working model that could potentially be employed by educational practitioners. The backchannel activity layers as another type of microblogging integration that might involve any one of these three forms of central activities. We recapitulated all four activities below coupled with pedagogical suggestions and recommendations.

Exploring Hashtags

Exploring hashtags is the fundamental activity that prepares students to attain a deeper understanding of Twitter's mechanics and functionality, transforming students' perspective from viewing Twitter as a purely social and personal tool to an educational and professional tool. In this activity, students will practice the acts of searching for a hashtag and sharing it by hashtagging their own tweet. The anticipated level of interactivity is relatively low in this stage, as the key of this activity is to familiarize students with the Twitter hashtag function and gain at least a preliminary idea of the educational aspect of Twitter. The instructor may guide students to interact with one another by commenting on each other's shared hashtags, but the major type of interaction is self-reflection that allows students to self-reflect on the hashtag learning process as shown in our research findings.

Serving as good models, we suggest the instructor should designate specific hashtags as exemplars for students to search as well as provide them some degree of flexibility so that they can search based on their own interests. These exemplary hashtags need to be preselected by the instructor in order to decrease the amount of possible noise contained in the tweets students search. Meanwhile, students should be asked to tweet what they have discovered from searching these educational hashtags (utilizing the designated class hashtag) so that the instructor can monitor this exploration process. Once the preselected hashtags are explored thoroughly by the students, the instructor can then provide a listing of hashtags with educational value (fully preselected, compiled of student-discovered tweets, or a combination thereof) and allow freedom for students to explore on their own. Caveats should also be given to students to inform them that they may encounter hashtagged tweets that have nothing to do with the hashtagged topic itself or have less educational value.

Discussion Topics

The main goal in the discussion topics activity is to train students into using the Twitter environment as a discussion forum to construct their understanding of learning topics, as well as to build trusting rapport among all class members. This is a stage in which students make considerable efforts to practice the act of writing a tweet to convey meaningful messages about their learning of content covered in the curriculum. Rudimentary as it initially seems, this activity requires a significant time and effort commitment to be able to convert habitual tweeting and SMS-sized texting practices (if any exist), or lengthy educational writing (as has been conditioned into students) into writing meaningful and in-depth content within the constraints of a microblog tweet.

The instructor's guidance, including what types of discussion prompts are provided and how the process is modeled and scaffolded, is of extraordinary importance to the success of this activity. Prior research consistently placed an emphasis on the critical role of instructional guidelines in designing social media-enable learning environments (M. F. G. Lin, Hoffman, & Borengasser, 2013; Luo, 2015; Luo, Dani, & Cheng, 2016). Instructors should also facilitate in students fostering meaningful interaction with one another. To keep asynchronous discussions more methodic and ensure student interaction is to occur among predetermined class members, the instructor can structure the activity by grouping students into pairs or triplets. The instructor can impose timeliness by setting a time frame for each round of discussions to occur within a designated time period. For example, the first round of responses is required to be posted two days after the instructor posted the discussion question and at least two comments to each other's posts create the second round which is mandated within the succeeding three days. Alternatively, the instructor can hold synchronous chat sessions with the students (essentially a live chat but designated with a course-created hashtag to restrict the public from joining in) to expand the discussion on certain topics. A synchronous chat among class members can serve as an apt preparation for any succeeding massive-scaled live chat based on the similarities across all synchronous chats.

Live Chats

Participating in live chats with experts requires the highest level of Twitter proficiency as well as cognitive thinking in general. Since the live chat activity is the third stage in the working model, students are expected to be well prepared in regard to their technical proficiency level as well as their conceptual understanding of Twitter's educational value (Luo, Smith, & Cheng, 2016). The different levels of participation may depend on the characteristics of the distinct chats students choose to participate in. These characteristics encompass the pace of tweets posted, number of participants, and the topic to be discussed. Instructors may preselect less intense live chats for students or design warm-up activities to help them research the to-be-discussed topic ahead of time and think through what their opinions are on those topics (and possibly practice communicating them) before virtually participating in the live chat.

We believe that the instructor can introduce additional strategies and techniques for effectively participating in live chats. For instance, participants need to create a focused channel in which they can engage in expressing their own opinions, rather than being busy with keeping track of others' tweets. It is critical for participants to learn to interject their own thoughts while seeing others' conversations coming out simultaneously. There are third-party tools available that can assist with following feeds, hashtags, and channels if learners feel they need the assistance. Furthermore, participants should be selective in reading and posting tweets, rather than trying to keep up with all conversations/tweets that are pushed into the Twitter feeds. If one tries to read all tweets or have a conversation with everyone in the live chat, the experience will be inevitably overwhelming because it is impractical to understand and follow all strings of thought.

Backchannel

Our data showed that participation in Twitter as a backchannel in face-to-face classrooms is also of significant value to students. The purpose of setting up a backchannel may vary depending on the context of the activity, but it often takes on the role of: acknowledging the importance of the subject of learning, providing comments or critique, asking questions, or seeking further information on the subject matter. Similarly to other studies reporting students' non-participating and digression behaviors (Holotescu & Grosseck, 2009, M. F. G. Lin et al., 2013; Luo & Gao, 2012; Rinaldo, Tapp, & Laverie, 2011; Shah et al., 2015) our data suggested that irrelevant or off-task content may be more common in face-to-face settings as learners build social bonds with one another. We suggested instructors address promptness in responding to each other's tweets and help students remain focused in the backchannel activities through one of two options: (a) instructors may promote students microblogging as the presenter is giving his or her speech and simultaneously publish these posts on a classroom monitor, or (b) instructors may elect a five-to-ten minute timeframe where students are mandated to provide feedback and interact via microblogging.

Summary

Table 6 provides a visual scheme that highlights the three major stages of the working model for Twitter integration in classrooms. Note that this working model can be adopted on a micro-level as well as a macro-level. On a micro-level, instructors can adopt it when introducing a concept or topic, such as project-based learning or cyberbullying. The first stage has students search for hashtags with educational value on such topic(s). This is followed by stage two where students are engaged in asynchronous or synchronous discussions with only class members. In the third stage, the instructor can select pertinent live chats for students to join synchronously with experts, influencers, and subject matter experts/educators from all over the world. This integration model can be cyclical and iterative when more topics are introduced following this procedure. On a macro-level, instructors can plan for multiple sub-activities for each stage and continue this integration throughout an entire semester. In this approach, students will be more prepared in each stage and the effectiveness of such activity will be less contingent on students' interests, but it becomes a longitudinal intervention aimed to enhance the conventional classroom. Other activities such as backchannel use of Twitter can be carried on concurrently with the three key activities (See Figure 8).

Table 6. A working model of Twitter integration in classrooms

STAGE	ACTIVITY	GOALS	INTERACTIVITY	FOCUS IN THE KNOWLEDGE-CONSTRUCTION PROCESS
1	Exploring Hashtags	Prepares students to attain a deeper understanding of Twitter hashtag	Low	Self-reflection, resource sharing
2	Discussion Topics	Train students into using the Twitter environment as a discussion forum	Medium	Clarification, elaboration, internalization
3	Live Chat	Connect with experts worldwide and reach co-construction of knowledge	High	Alternative proposal, support, disagreement, co-construction of knowledge

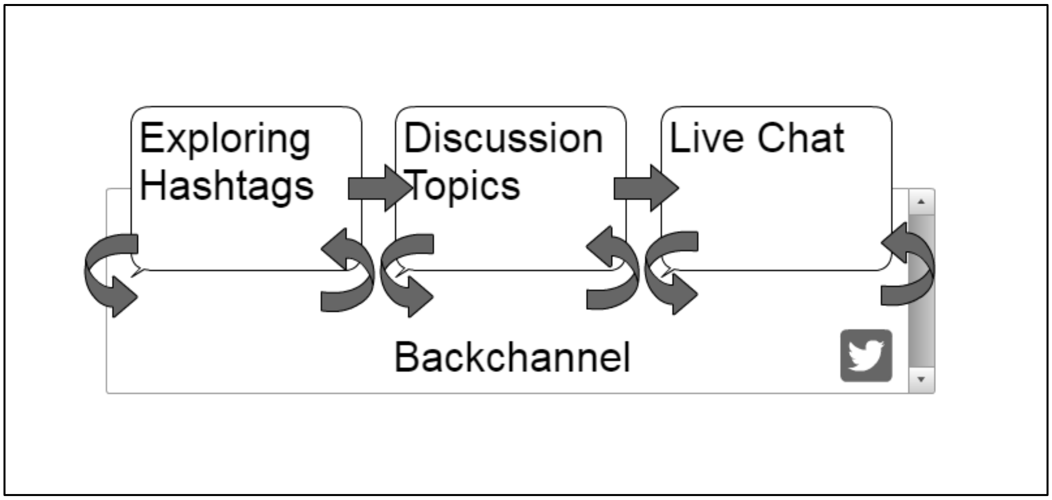


Figure 8. Timeline of a working model of Twitter integration in classrooms

CONCLUSION, LIMITATIONS, AND FUTURE RESEARCH

This study has sought to better understand the process of knowledge construction in microblogging-supported activities represented by learner interaction and types of knowledge manifested in microblogging-supported learning activities. Our results exhibit that there appears to be distinct learner interaction patterns representing the process of knowledge construction occurring across different activities. The hashtag exploration activity begins with a low-order cognitive task enriched by self-reflection via generated outputs (tweets) shared with the instructor and peers, preparing learners for future high-order knowledge construction. Discussions and backchanneling bridge the gap from low-order to high-order cognitive tasks and both could vary in their degree of learner interaction with peers, instructor, and content. While self-reflection remained highest across all different activities, elaborative, supportive, and internalization tweets became relevant during these activities as learners began to construct more openly with each other. Live chats represented the highest level of learner interaction and the greatest co-construction of knowledge. Social dimension of knowledge construction appears to be predominant and manifested across all activities. Metacognitive learning dimension falls in the second most dominant category, which represents their attention to prior knowledge and efforts in managing self-regulated learning. Student perception data from surveys corroborates previous findings, supporting the means in which microblogging tools can support and facilitate collaborative knowledge construction.

This study presents an initial effort in addressing knowledge construction in a microblogging-specific context of learning. Though various instructional activities were designed and examined in this study, the scope of analysis was limited within members of an undergraduate class over the course of only one semester. Owing to the small class size and the constrained case of such a class, results from this study may not necessarily transfer to other technological applications or to a large size class. We also acknowledge that only descriptive analysis was used in examining the content of tweets; therefore, advanced statistical methods such as sequential analysis are recommended to understand the directions of each type of interaction within the knowledge construction process. Future researchers may extend this study over different semesters or to other courses in a different discipline. The working model proposed within this study can be tested across different disciplines and domain contexts. It can also be tested in a traditional class, asynchronous, or purely online class versus the blended environment (which is this case study). Other rigorous methods such as experimental or quasi-experimental research designed to better control extraneous variables and compare the effectiveness of knowledge construction versus other technology-supported environments are also recommended for future researchers.

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