Enhancing Peer Influence in STEM Learning and Engagement through Social Media Interactions using Network Science Principles

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Abstract:

This Work in Progress (WIP) research presents a framework to explain the usefulness of social media datasets of student interactions that can be retrieved through Twitter, a publicly available social media platform. Traditional datasets have limited capacity to adequately capture student communication strategies and analyze student interactions with such details and coverage. As such, social media datasets, enriched with student activity information over time, will be useful to capture student perception on various STEM topics covered in class and identify ways to facilitate active learning. The major focus of this research is towards understanding how STEM students are socially influenced online, while communicating course topics and interacting in their respective cohorts. The proposed framework of this research will help future studies to craft targeted information dissemination strategies for various student groups based on their online social network characteristics, activities, and interactions on how students' react to what others post in social media on a related topic. By applying network science principles, this research demonstrates how to (i) define properties and growth of student interaction networks; and (ii) classify student activities, perception and learning behaviors from individual and group dynamics. The proposed framework not only expands our knowledge of student online interaction dynamics, but will also result in better understanding of how students' express diverse concerns on a given STEM topic and how to harness and embed such information for enhancing engagement and peer influence. The peers not only include instructor and the students taking the course, but also subject matter experts, alumni, faculty, senior students among others.

Background, motivation and related work:

The primary focus in the study of large-scale complex networked systems is to comprehend the dynamic interdependence between the network topology and the function of network agents. This distinctive interdependence has important consequences on the robustness and resilience of real networks as they respond to random failure, targeted attacks or any other external perturbations [1]. This has emerged in the domain of *Network Science* that provides an interdisciplinary perspective to the study of real networks having complex, irregular and versatile topology [2-4]. This knowledge of the coupled dynamics between network structure and function has manifold applications in various fields including infrastructure systems, supply chain and logistics, biology, social and financial systems, information and communication networks, and many others [3, 5, 6]. This joint association of network structure with the entities also allows the experiment of highly dynamic behavior of the network agents that exist and interact within the complex architecture. Some promising research questions related to complex network systems may include: (a) *how do interactions between network agents (nodes/vertices) help to develop new ideas or information while disseminating through the network?* (b) *is there any threshold at which the information dissemination becomes a global cascade?* (c) *what is the rate and extent at which the information disseminates?* The answer to these questions can be found in many empirical studies of real world systems, such as, disease transmission [7, 8]; transmission of computer viruses [9, 10]; collapse in financial systems [11], failures of power grid [12, 13]; information diffusion through social networks [14], and many others. Many new network concepts, properties and measures have been developed by running experiments on large-scale real networks. A number of statistical properties and unifying principles of real networks have been identified from these studies. Significant amount of research efforts have helped to develop new network modeling tools, reproduce the structural properties observed from empirical network data, and design such networks efficiently with a view to obtaining more advanced knowledge of the evolutionary mechanisms of network growth [15]. Many real networks possess interesting properties unlike random graphs indicative of possible mechanisms guiding network formation and ways to exploit network structure with specific objectives [3].

The emergence of online social media such as Facebook, Twitter etc. have created ubiquitous social environments. Users can interact with such systems by being friends with others, updating statuses, posting interesting links, mentioning other users in their statuses or posts, commenting or liking others' posts, privately communicating with their connections and in many other ways depending on the type of the system. User interactions within these systems help to construct a network of user relationships representing links of direct social influence. In such a network, two users are connected if they interact with each other or establish a friendship between them. Thus a *social interaction network* can be defined as a network of nodes and links, where nodes consist of the users of a particular online social media system and links are established if two nodes have some form of interaction between them. An individual's connections and activities in a social interaction network enable us to understand the social influence on real world actions. Such knowledge is invaluable for predicting human actions in the real world through a social network amplification [16, 17]. User activity in social media has shown its prevalence in recent years, for instance every second over 143K tweets are being generated on Twitter [18].

Social network analysis (SNA) can explore an individuals' social tie, network density and strength. SNA allows students to examine how they participate in informal atmosphere by equal participation [19]. More recent studies have demonstrated how SNA could benefit the understanding of peer influence [20, 21]. One of the greatest challenges in academic settings has been to maintain student interest in a particular course and their persistence [22]. Some studies focused on how social networks and online social media can benefit STEM related activities [23-25]. Malik et al. (2018) explored social media (Twitter) based activism campaign to examine engineering diversity factors. Intersectional self-expressions on Twitter were examined during a hashtag activism campaign for engineering diversity [26]. Le et al. (2019) developed a framework to use social media data for workplace learning by analyzing cybersecurity related tweets. The research provided a structure that describes how data can be developed by using descriptive, material, and network analysis to help professionals learn. Findings depicted that most of the tweets covered multiple subjects and used three or more hashtags; the popular users were not automatically the most powerful (based on retweets) based on follower counts; companies and other organizations had the highest number of followers, but the most retweeted were the individual users who were the experts in their field. Besides, infographics were the main content of popular tweets and the overall sentiment of cybersecurity related tweets were found negative as many hashtags tweet represented current threats [27]. A thorough small-scale review of research study was presented on networked learning in teacher communities for continuous professional development (CPD) by using virtual learning environment (VLE) [28]. "National Engineering

Week” was monitored using Twitter data to understand the engineering community engagement [29].

Despite the growing need to harness large scale online social interactions to enhance peer influence in STEM learning and the emerging advancements in network science, the empirical literature is inconclusive how social media can serve as a social and catalytic learning and information sharing gateway for STEM students and professionals through social media platforms and how to quantify such peer influence. The proposed research is one of the first few studies in the literature that proposes a holistic framework to enhance peer influence in STEM learning and engagement through social media interactions using network science principles.

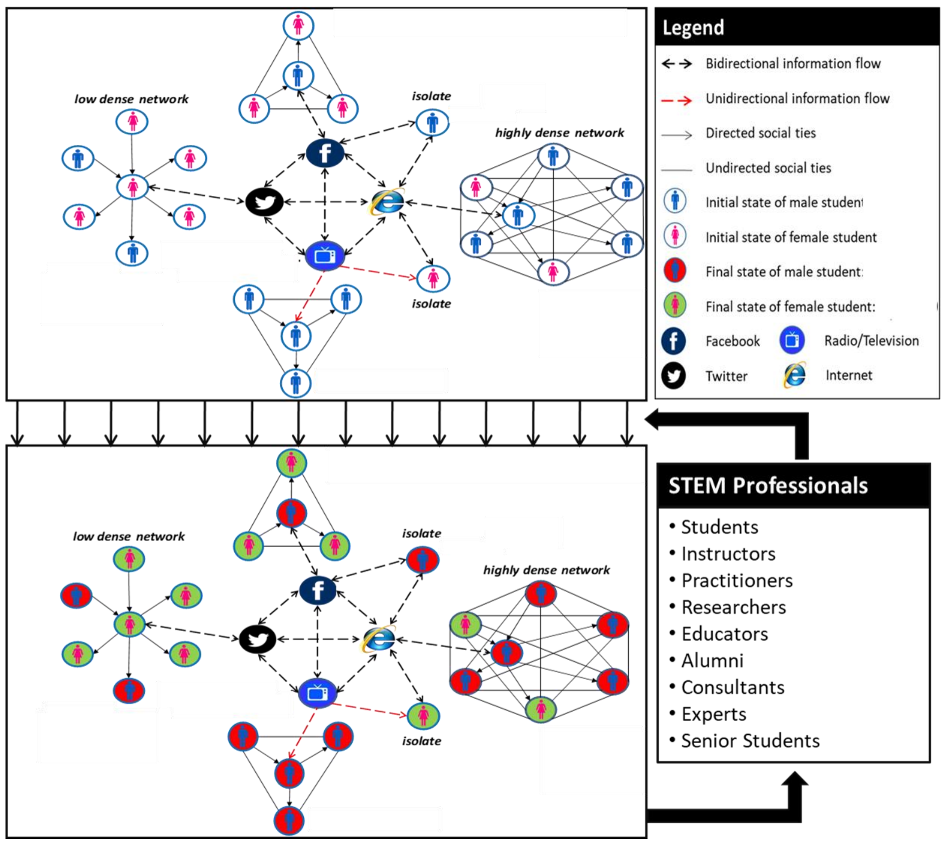

Figure 1: Conceptual Framework of Peer Influence in STEM Learning and Engagement

Research scope, merits and conceptual framework:

The major focus of this research is to explore how STEM students are socially influenced online, while communicating STEM course topics through social media platforms and interacting in their respective cohorts and experts in the online community. The research will explore network science principles [30-33] and data-driven techniques [34, 35] to (i) determine student perception and sentiments on a given STEM topic; (ii) define properties and growth of student interaction networks and maximize influence; and (iii) classify student activities, perception and learning behaviors from individual and group dynamics. The methodologies and findings of this research can help to (i) craft targeted information dissemination strategies for various student groups based on their online social network characteristics, activities, and interactions on how students' react to what others post in social media on a related STEM subject matter, (ii) expand our knowledge of student online interaction dynamics and how students' express diverse concerns on such topics, and (iii) identify how to harness and embed such information for enhancing engagement and peer influence. The peers not only include instructor and the students taking the course, but also subject matter experts, alumni, faculty, senior students among others (Figure 1). The proposed research will help us to minimize this information gap in the literature and enable developing more effective online student communication and learning approaches.

The conceptual framework of the proposed research incorporates STEM related information dissemination in a community setting. This includes network agents (such as students, instructors, researchers, practitioners, alumni, consultants, experts, senior students among others) who interact with each other based on their relationships and the information flow the network is determined by such interactions. Given the type of information being shared by a given agent, the research proposes to model how this information transmits from individuals to individuals and how these agents react to that particular STEM related topic, event or any related idea. Specifically, the research will model and analyze the information system by determining how the initial states (top box in Figure 1) of network agents change to a final state (bottom box) for a given type of STEM related information (bottom box in Figure 1). The proposed framework, based on highly integrated components, will add real value as it is not only generating data, analyses and results, more importantly, it is shaping a scalable methodology that can be applied to other informal learning settings.

Preliminary findings and future recommendations:

This research already experimented the proposed framework and retrieved datasets of student interactions available through Twitter in a fully online class of Construction Materials and Methods at the Florida International University in Spring, Fall 2019 and Spring 2020. The datasets include online students' interactions from students and their participation in five consecutive course deliverables. In order to enable and measure students' social interactions, several online participation deliverables were assigned so that the students' can post about what is being covered in class and also comment or react on what others have posted. These deliverables included student interactions on several topics covered in class such as (i) construction; (ii) delivery methods, drawings and specifications, zoning regulations, building codes, construction standards; (iii) soil types, properties, gradation, testing and exploration; (iv) concrete ingredients, making, placing and reinforcing concrete, sitecast and precast concrete, wood products, masonry; and (v) steel construction. Students were required to post any information of their choice (text, photo, video, website link or anything relevant) already covered in the class and comment or react to what others have posted including in-class students and external peers as shown in Figure 1. Students used several keywords (such as #bcn2210, #fiu, #construction) as hashtags and mentions to maximize peer influence. Course survey from Spring 2019 indicated that 34.72% of all students had an average experience with such online participation, while 41.67% and 19.44% mentioned good and delightful experience, respectively. The aim of this research is to demonstrate an opportunity to implement social media in STEM not only to foster student engagement, but also to support future interdisciplinary collaboration across all engineering fields. Further efforts should uncover the lessons learned from the preliminary experiments along with key insights and recommendations for transferring this novel pedagogy to other institutions and courses.

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