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Exploring Forum Dynamics in a Chinese MOOC: A Longitudinal Probabilistic Social Network Analysis [1]

Jingjing ZHANG[a*] & Maxim SKRYABIN[b]
[a]*Faculty of Education, Beijing Normal University, China*
[b]*Department of Higher Mathematics, ITMO University, Russia*
*jingjing.zhang@bnu.edu.cn

Abstract: This study attempts to answer the fundamental question of how the overall nature of relations in a network affect the network's potential to foster or inhibit the different forms of social learning. The study adopts longitudinal probabilistic social network analysis to identify the patterns and evolution of relationships formed in a MOOC discussion forum. Three network effects – homophily, network closure, and preferential attachment – are used to explore the dynamics of the discussion networks formed in the MOOC forum. Understanding the formation of the network of relationships will allow us to explore how social learning takes place and in turn improve the online learning experience in MOOCs.

Keywords: MOOC, network dynamics, social learning analytics, SIENA

1. Introduction

A massive open online course (MOOC) is an online course aimed at large-scale interactive participation and open access via the web (Daniel, 2012). In addition to traditional course materials, MOOCs provide interactive user forums that build learning communities for students and professors alike. Although MOOCs have a longer history, with roots in the better-known distance education movement, in 2012, they broke onto the educational scene as a new online teaching and learning phenomenon. This resulted in the New York Times dubbing 2012 "The Year of the MOOC" (Pappano, 2012).

Learning via MOOCs is a quickly rising global tide, and Chinese students have enthusiastically plunged into the new wave of MOOC learning (W. Wang, 2013). MOOCs' rapid development has aroused great scholarly attention. Studies have generally focused on three aspects: 1) introductory studies on the MOOC curriculum model and definitions, characteristics, application modes, and case studies (Li & Wang, 2012; P. Wang, 2013); 2) the impact of MOOCs on the reform of traditional classroom instruction and higher education (Zhang, Hong, & Wen, 2013; Zhu, 2012); and 3) applications of MOOCs in education (Waard, et al., 2011). In addition, some researchers have begun to focus on quality standards and the systematic quality assessment of MOOC curricula (Rossi & Mustaro, 2013).

Despite the significant attention paid to MOOC delivery systems, little attention has been devoted to what is happening in MOOC forums. Specifically, there is a dearth of research on the impact of forum discussion on Chinese MOOC learners. In China, up to now, only a few studies adopted social network analysis to understand the activity patterns of MOOC forums. The studies (e.g. Xu et al, 2015) that utilize social network analysis to explore interactions tend to use data from one time point on characteristics of the networks, implicitly assuming that the MOOC forums are stationary or in equilibrium conditions. There is no study that explicitly measures and analyzes network dynamics in China.

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Because of the unique "spirit of collectivism" in Eastern Asian educational tradition and culture, Chinese learners display different learning methods, learning habits, and even ways of thinking compared to their Western counterparts (Wang, 2013; Watkins & Biggs, 1996, 2001). Chinese learners tend to seek out group learning and follow group leaders to enhance the learning process. This presents a challenge for the traditional Chinese learner, given that most MOOCs and their corresponding learning communities use English as a lingua franca, complicating the search for a MOOC learning community. Using data collected from a Chinese MOOC course and applying probabilistic social network analysis, this study seeks to rigorously measure the dynamic mechanism by which discussion networks are formed among MOOC participants.

2. Network Concepts and Hypotheses

This study focuses on explaining how the network configurations and actor covariant form and reshape the structure of the interactions in a MOOC discussion network. Three network effects – homophily, network cohesiveness, and preferential attachment – are chosen to explore the discussion networks in a Chinese MOOC.

Network cohesiveness was measured by reciprocity and transitivity. Reciprocity is a very important measurement of mutual relationships in network settings. This metric is studied on the dyadic level through the process of dyad census. It is evident that students who are actively engaging in forum discussions are likely to receive more feedback from peers, and to develop their thinking further. The transitive relationship, in which A connects to B, B connects to C, and A also connects to C, may be more conducive to social learning, as participants are more likely to receive stimuli from multiple peers as the desired information diffuses through a network (Todo et al., 2013). Reciprocity as well as transitivity are likely to lead to network cohesiveness.

- *Hypothesis 1 (H1)*: The discussion network tends to become more cohesive.

Homophily, a term coined by Lazarsfeld and Merton (1954), refers to the tendency of individuals to associate with those similar to themselves. A network with a high degree of average homophily among actors is likely to disseminate information and (tacit) knowledge fast, i.e., the actors have a better source for learning (Cross et al., 2001). In this study, teaching staff (including instructors and teaching assistants (TAs)) and students are considered as two distinct groups of participants in MOOCs. To understand what role instructors play toward encouraging social interaction and supporting learning in MOOCs, as well as whether students can act as learning companions to assist learning, it is very important to unravel the interaction between students and instructors in MOOC practices.

- *Hypothesis 2 (H2)*: There is a tendency toward an increasing volume of interactions between students.

Outdegree popularity is a measure of how "uneven" the distribution of centrality is in a network. Centrality is an actor-related measure and can be defined in different ways that all relate to the "importance" or "power" of an actor in a network. Highly centralized networks appear to be conducive to the efficient transmission of information (Crona and Bodin 2006), as the central actors play an important role in delivering messages. These central actors, on the other hand, could manipulate the communications in networks.

- *Hypothesis 3 (H3)*: Participants who are actively involved in forum discussions are likely to become even more engaged.

3. Context of the Study

In 2013, Tsinghua University launched its new learning portal XuetangX to host local MOOCs as well as courses from a consortium of leading universities world-wide. XuetangX, powered by the open source platform edX, aims to increase Chinese students' access to quality education, while transforming universities' campus-based learning. A social science course, one of the first courses to be launched at XuetangX, was studied in this research. The course began in Spring 2014 and ran for about several weeks. More than 10,000 learners registered for this course. As one of the most popular MOOCs in China, the course was offered again in 2015. The instructor for this course has taught the

course at Tsinghua University over a number of years. Two TAs joined the course, responsible for releasing course information and answering questions asked by students in the discussion forum.

Compared to the first release of other Chinese MOOCs at XuetangX, this course has a rather popular discussion forum where students can ask questions answered by others. In total, 5464 discussion messages were posted online, in which 217 are original posts, 2553 are replies to the original posts and 2481 are comments on the replies. These messages generally include enquiries on exercises, course materials, and the logistics of the course. Students also use the discussion forum as a platform to report their own study and seek social activities. Some of them left feedback on the course on the discussion forum.

4. Methods

The probabilistic analysis was performed by employing stochastic actor-driven models defined and evaluated with the program Simulation Investigation for Empirical Network Analysis (SIENA) (http://www.stats.ox.ac.uk/~snijders/siena/) jointly with the StOCNET graphical interface package (Snijders, 2011; Steglich, Snijders & West, 2010). The objective function, which is used in this research, depends on two types of effects: structural effects and covariate effects. The structural effects capture endogenous network mechanisms. In this research, the following structural effects were used:

- *Reciprocity* is represented by the number of reciprocated ties (measure of mutuality). Reciprocity estimates the probability of user B replying to A, given that A has replied to B.
- *Transitive triplets or transitivity* is represented by the number of ties to actors who are the friends of friends (measure of network closure, i.e. transitivity estimates the probability of user A replying to C, if A has replied to B and B has replied to C).
- *Outdegree popularity (also known as activity of alter)* is defined by the sum of the outdegrees of the others to whom the actor is tied (measure of activity attraction, i.e. actors who have already received many replies are likely to be replied to by others).

Unlike structural effects, the covariate effects estimate the network dynamics based on exogenous factors, e.g. role of actors. In this research, one dyadic constant covariate effect (*same role*) was used. The student role was coded as 0 and the non-student role (i.e., instructor and TA) was coded as 1.

As per the availability of the timestamp, the evolving network was split into six periods; each period has an approximately equal number of messages (i.e., posts, replies and comments). The Jaccard indices for two sequential periods were calculated, varying from 0.529 to 0.892. This means that network dynamics of six periods is "smooth" enough, which justifies the use of six periods as appropriate in this study. Each period contained ties from previous ones, i.e., all network changes are upward. This is natural because interactions within MOOCs are very asynchronous and replies to messages can occur several periods later.

5. Results

5.1 Descriptive Statistics of the Network

In this MOOC course, 1915 participants posted 5251 messages in total, in which 217 are original posts, 2553 are replies to the original posts and 2481 are comments to the replies. On average, each discussion thread attracted 23 replies and comments. The instructor led 26 discussion threads, replied to 17 messages, and commented on 91 messages. TAs posted two messages, replied to 24 messages and commented on 134 messages.

5.2 Reciprocity, Network Closure, Homophily and Preferential Attachment

Table 1 presents the results regarding Hypotheses 1, 2, and 3. Structural effects such as reciprocity and transitivity are significant ($p < 0.001$) and the coefficients for them are positive. Moreover, these structural effects were included in other models (Model 2 and Model 3) and results for them are similar to what was obtained for Model 1, i.e. these results are very consistent. The reciprocity effect

is positive and significant. That means that there exists a tendency to create reciprocal links; for example, if the participant writes an original post, then he/she comments on or replies to this post. The "transitive triplets" effect was considered as a triadic-level effect. The positive transitivity effect means that actors prefer to create links with the rule "the friend of my friend is my friend". The positive effects of reciprocity and transitivity suggest that H1 was accepted – that is, the discussion network becomes more cohesive as participants contribute to the forum.

Table 1: SIENA estimation results.

Effects	H1 (Model 1)	H2 (Model 2)	H3 (Model 3)
Reciprocity	4.4197 (0.1304)	3.8991 (0.1875)	3.7338 (0.1818)
Transitivity	1.5132 (0.0799)	0.8713 (0.0918)	0.8516 (0.0968)
Same role	—	–4.5110 (0.0605)	—
Outdegree popularity (activity of alter)	—	—	0.0628 (0.0008)

H2 states that there is a tendency toward the increasing interactions between teaching staff and students. To test this hypothesis, the "same role" dyadic covariate was included in Model 2. Our findings show that same role is a significant covariate effect ($p < 0.001$) and its coefficient is negative. Thus, the network is considered heterophilic, i.e., participants do not have a preference for creating links with those similar to themselves. For example, students reply to the instructor and TAs.

In H3, the preferential attachment was tested with the outdegree popularity (earlier known as the activity of alter). In Model 3, the outdegree popularity effect is significant ($p < 0.001$) and its coefficient is positive but relatively small. This means that participants who are actively involved in forum discussions are likely to become even more engaging.

6. Discussion and Conclusion

In an attempt to understand how the overall nature of relations in a discussion network was formed in the setting of MOOC forums, a probabilistic social network analysis using the actor-based model was performed. This study is an empirical investigation of the network dynamics in a Chinese MOOC, which is essential to move the discussion on learning interactions inherent in a Chinese context forward.

The results of this study have shown that there is an increasing cohesiveness within the studied network, as participants tend to reply to the messages initiated by peers and connect to others in a transitive way. Participants are likely to become more selective when interacting with others. This reflects on the Chinese culture of creating small, cohesive groups in which Chinese students feel confortable residing. Interactions with peers in a rather open and large-scale space provoke more challenges for Chinese students.

Unlike previous studies (e.g. Kellog et al., 2014) that were conducted in a Western context, showing that MOOCs can be leveraged to foster robust learning networks and facilitate peer-supported learning, our study indeed demonstrates that Chinese students display different learning behaviors. In the studied discussion forum, Chinese students tend to respond to the instructor and TAs. They follow teachers' instructions to learn step by step. In a Chinese context, a teacher is highly respected by students, so students seek correct answers from the teachers. The discussion between teachers and students is regarded as an authentic learning process. Peer-supported learning has been recently introduced into Chinese classrooms, but the importance of peer-supported learning has not received sufficient attention. Nevertheless, in the studied network, the majority of Chinese students still tend to rely heavily on teachers, who are supposed to provide them the right answers to their inquires. In such a learning culture, MOOCs are undoubtedly vulnerable to criticism for their lack of learning support systems.

Preferential attachment is present in the studied networks, commonly referred to as "the rich get richer effect". In the studied networks, participants who are actively involved in forum discussions are likely to become even more engaged. On one hand, it is likely that some participants could manipulate the communications flow in the MOOC forum. If these participants drop out of the course, the discussions are likely to discontinue. Such a learning context is not a robust learning community, as

was illustrated in the work of Kellogg and his colleagues (2014). On the other hand, some participants might feel that their contribution was not well received by others in forum discussions. It is likely that their questions were not answered by others. To support their learning in MOOCs, intervention is required.

To conclude, this study adopted a probabilistic social network analysis to explore the network dynamics in a Chinese MOOC forum. The results of this study demonstrate that MOOCs present a challenge for traditional Chinese learners, given that there is a lack of learning support in MOOCs. Traditional Chinese learners have high expectations of using MOOCs as an alternative channel to interact with professors from elite universities. Due to the massive number of registered learners, it is difficult for instructors to interact with individual students on a one-to-one basis in MOOCs. Thus, in a Chinese context, it seems to be essential to promote openness by creating a peer-supported learning environment. This peer-supported learning environment might not be a Western-style robust learning community where learners, who are intellectually open and accept the possibility of change, are supposed to be willing to share ideas and help each other. In a Chinese MOOC learning environment, human or intelligent tutoring intervention is key to facilitate balanced interactions in MOOCs.

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