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# Identifying and Comparing Interaction Features of Different Topic Categories in Online Learning Discussions Supported by Danmaku

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**Abstract:** With its interactive features, danmaku, a live-chat functionality allowing viewers to post messages right on the screen while watching videos, has numerous potentials of enhancing online learning interaction. In this paper, danmaku data generated by learners in one lecture of a high-school math course was retrieved. Coding based on content analysis was conducted to identify the interaction relationship, social network was then modeled, and results were compared between co-learner presence and idea exchange discussions. It was found that co-learner presence and idea exchange discussions showed differences in conversation structure, network topology and high-degree nodes. This study enhances the understanding of the interaction in MOOC learning facilitated by danmaku and provide evidence and basis for making use of danmaku discussions to better facilitate learning interaction.

**Keywords:** MOOCs, danmaku, online video learning, learning interaction, collaborative learning, content analysis, social network analysis

## 1. Introduction

Fig. 1 shows an example of danmaku, a system where user-generated messages are stored and displayed at their delivery timestamp along the MOOC video timeline and appear as moving subtitles on the screen when the video is played. This functionality originated in Japan in animation watching and got popular with teenagers and young people in Asia (Zhang & Cassany, 2019). Then, it was gradually introduced from animation watching to MOOC learning due to its interactive essence. It was found in an investigation that 76% of the students enjoyed this novel tool in their learning (Hu et al., 2017).

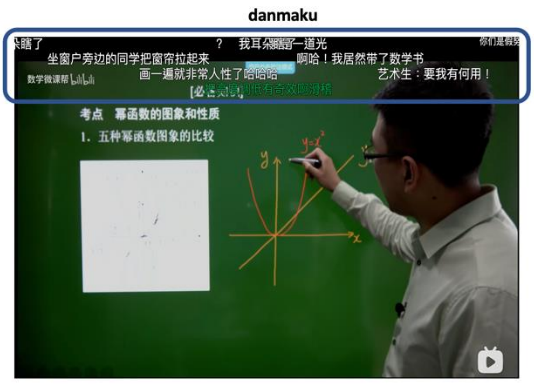


*Figure 1.* A Screenshot of a Math MOOC Lecture Supporting Danmaku Functionality.

Over the recent years, social network analysis has been used in MOOC-learning research to reveal characteristics of interaction relationship (e.g., Joksimović, et al., 2016), analyze the text features and network characteristics (e.g., Dowell et al., 2015), or explore the correlation between interaction network and learning performance (e.g., Houston et al., 2017). However, these studies focused on traditional forum discussions instead of danmaku discussions. In addition, existing danmaku research mainly analyzed its usage in entertainment video and a few studies about learning began to explore the potential and effect of using danmaku in learning (e.g., Chen et al., 2019; Zhang et al., 2019). Although they confirmed the effectiveness of danmaku in supporting learning, a clear picture of the features and mechanisms of the learning interaction facilitated by danmaku have not been drawn yet.

To address this gap, this study aims to explore and identify the interaction feature and pattern implemented via danmaku in MOOC learning. Since previous studies found different topic categories (different sub-forums and learning content related or not) showed different patterns in MOOC-forum interaction and participation (Gillani & Eynon, 2014; Poquet & Dawson, 2016; Wise & Cui, 2018), it was hypothesized that similar effects also exist in MOOC-danmaku discussions but show different features as a "co-viewing" experience can be created by danmaku (Sun et al., 2018). Consequently, this study aims to answer the following research question:

RQ: What differences do the different topic categories show in conversation structure, network topology and core nodes in the learning discussion supported by danmaku?

## 2. Methods

### *2.1 Data Source*

This study focused on a grade-10 math video lecture about quadratic function and data in this video was obtained from bilibili.com, a popular video portal. In total, 2,435 messages were collected and cleaned.

### *2.2 Tie Definition*

In this study, interaction ties between learners through the danmaku messages in the video were defined into two categories: the directed tie where the message explicitly replied or referred to the preceding message (Joksimović et al., 2016; Kellogg et al., 2014) and the undirected tie where the learner simply sent relevant messages to participate in a group conversation of a certain topic (Jiang et al., 2014).

### *2.3 Content Analysis and Classification*

Content analysis and subsequent manual coding were conducted and three coders familiar with danmaku participated in identifying and classifying the discussion topic and interaction tie.

First, we figured out the events triggered by video content as the context where danmaku discussions were situated since danmaku is one kind of event-based communication (Zhang & Cassany, 2020). Second, different topics of the danmaku discussions situated in those video-content events were located. Third, all the messages were checked in their relevance to each topic, the replying relationship and the temporal order based on their delivery timestamp. Thus, different rounds of discission achieved through danmaku were identified.

Two coders worked independently. After finishing coding, a third coder worked with the first two together to resolve the mismatch by using the majority-rule approach. Finally, the kappa coefficient of 0.76 and 0.88 was obtained for the classification of undirected and directed ties, respectively. Both values show substantial agreement (Viera & Garrett, 2005).

Although a variety of detailed topics were talked about in this lecture using danmaku, an obvious tendency was that many learners cared about the presence of others or themselves in the process of learning the lecture with the status of not seeing each other visually. The importance of social presence (Garrison, 1999) has been recognized by researchers in the formation and development of online learning groups (e.g., Kear, 2010). Of different elements composing social presence, co-presence was defined as the feelings of mutual awareness as well as inclusion and connection to a community (Biocca et al., 2003). Adopting this definition, we categorized the co-presence messages. In addition to the discussion about co-presence, learners also exchanged other general information. As a result, two general topic categories in all the messages were identified: 1) co-learning presence where learners tried to find and express the presence of others and themselves or their inclusion in a group of similar identities such as grade level, hometown and learning performance at school; 2) exchange of ideas in which knowledge information and emotional thoughts were communicated.

### 2.4 Network Modeling

The node list for the network was extracted from the danmaku message data. Although senders of the messages are all anonymous, each sender could still be represented by their encrypted user id. The edge list for the network was identified and mixture of directed and undirected edges was used based on the tie definition de-scribed in Section 2.2 and by manual classification in Section 2.3. Then, the two lists were imported into R and unweighted networks were modeled using the igraph package. Degree of all the nodes (the number of neighbors that a learner interacts with) were computed.

## 3. Results and Interpretation

### 3.1 Content Analysis

In total, of all the 2,435 danmaku messages, 1,203 and 315 messages achieved 44 and 57 rounds of undirected and directed discussions among learners, respectively while 917 messages were isolated expressions. Table 1 shows the structure of messages and rounds in the two discussion topic categories.

Table 1. *The Structure of Messages and Rounds in Each Discussion Topic Category*

| | Co-learner presence | Exchange of ideas |
|---|---|---|
| Average word number in each message | 4.7 | 10.8 |
| Average message number in each round | 7.57 | 20.3 |
| n of messages in directed discussions | 294 | 21 |
| n of messages in undirected discussions | 24 | 1,179 |
| n of interaction rounds | 42 | 59 |

According to the result, on average co-learner presence discussions usually used very limited number of short messages in each round while much larger number of longer messages appeared in exchange of ideas. This was probably resulted from another finding here that co-learner presence was mainly implemented by directed interactions and exchange of ideas was mostly achieved through undirected discussions, as Table 1 indicates. Since no function of replying to others' messages, such as the 'reply to' button, is provided in danmaku and all messages move across the screen and then disappear, learners need to use some techniques to explicitly respond to others' messages to complete the directed interaction and they have to do it quickly. In such scenarios, only part of all the viewers could make it and their words tended to be concise.

Besides, the topic of discussion for co-learner presence and idea exchange were different, which also explains the above-mentioned difference in message number and length. The starting message of each round in co-learner presence discussions often straightforward asked for co-learner presence information and could be easily provided by using simple words without extending the conversation. For example:

- Is there anybody watching?
- Yes.

Or

- I am a grade-12 student?
- I am also in grade-12.

On the contrary, starting messages in idea exchange discussions usually sought for help with understanding key knowledge points or emotion and attitude communication which could be more complicated, thus requiring extra number of longer messages. For example:

- How did the teacher get the 4x?

- Because the formula $(a+b)^2 = a^2+2ab+b^2$ should be used with “a” replaced by “x + 1” and “b” by “1”.

- I am a bit confused about this.
- $\{(x + 1) + 1\}^2 = (x + 1)^2 + 2(x + 1) + 1^2 = x^2 + 4x + 3$
- …

Or

- I am fond of this teacher’s style! He gave concise but understandable explanations.
- I cannot agree with you more. Of all the courses I attended, this free one is most effective.
- Same with what I felt!
- Is he really so good? Maybe I can only know it if I pass the exam.
- …

### *3.2 Social Network Analysis*

As Fig. 2 indicates, the co-learner presence network (see Figure. 2a) consists of many independent small sub-networks while the idea exchange network (see Figure. 2b) is basically a large inter-connected network. This difference between the independence and interconnection depends on the number of shared nodes bridging different sub-networks (rounds of discussions) and may indicate that learners who joined the co-learner presence discussion participated in only few rounds of discussions whereas one learner in idea exchange discussions could took part in much more different rounds.

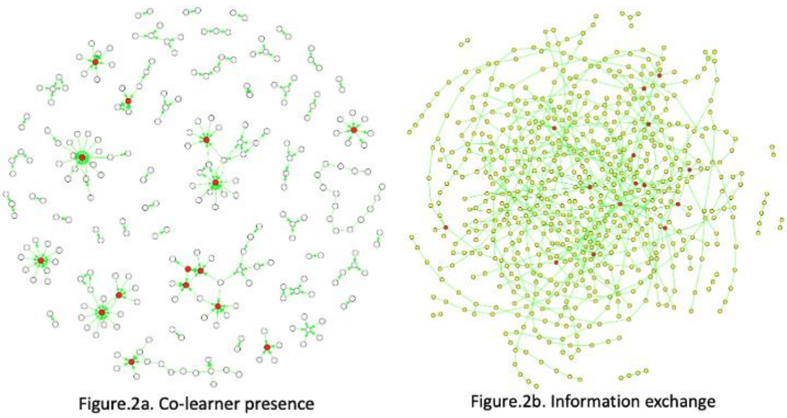


*Figure 2.* Social Networks Constructed for the Co-learner Presence and Idea Exchange Interactions.

The top 15 learners with high node degree in each network were highlighted with red in two networks, respectively. Table 2 reports the number of starting messages and percentage of other nodes connected through the starting message for the top 15 learners ranked by node degree in the two networks. In the co-learner presence network, it could be found that these high-degree nodes are cores of the small sub-network as most of them were starting message sender and therefore interacted with other learners who replied. This goes in consistency with the finding in Section 3.1 as very limited number of messages appeared in each round of discussion in co-learner presence interaction, thus achieving those independent small sub-networks. In total, 29 distinct learners appeared in the top 15 lists for the co-learner presence and idea exchange networks. Except for user “167dcd56” (highlighted in orange in Table 2) who stayed as the high-degree learner in both networks, the other 28 learners had high degree in only one of the two networks. It can be figured out that generally top learners in the two networks were different and that getting well connected in one network did not necessarily ensure good connectivity in the other. This is similar to the finding of Wise and Cui (2018) that high-degree MOOC learners in the content-related forum discussions were largely different from those in non-content discussions.

Table 2. *Top 15 Learners with the Number of Starting Messages They Sent and Percentage of Other Nodes Connected through the Starting Message in All the Connected Nodes of the Learner*

| Rank | Co-learner presence | | | Idea exchange | | |
|---|---|---|---|---|---|---|
| | User ID | ① | ② | User ID | ① | ② |
| 1 | cd7e6fec | 2 | 73% | cbd6d772 | 2 | 33% |
| 2 | d4160a6a | 1 | 100% | 87a33001 | 0 | 0% |
| 3 | *167dcd56* | 2 | 87% | ff6b175a | 0 | 0% |
| 4 | a7fa6872 | 1 | 60% | 19bbfa53 | 0 | 0% |
| 5 | 875320b | 1 | 100% | 651617da | 0 | 0% |
| 6 | aaa4e453 | 2 | 50% | 8aabf982 | 0 | 0% |
| 7 | c24718f6 | 1 | 50% | 49079dc1 | 0 | 0% |
| 8 | 8a45564e | 1 | 100% | *167dcd56* | 0 | 0% |
| 9 | a7ae6d97 | 1 | 57% | 3045389f | 0 | 0% |
| 10 | 72d5b521 | 1 | 43% | 3e1c35ea | 1 | 40% |
| 11 | 220d53f8 | 0 | 0% | 5ab1b637 | 0 | 0% |
| 12 | 2c5749fd | 1 | 100% | 1156fbf6 | 0 | 0% |
| 13 | 3e8f3c7f | 1 | 100% | 155628fd | 0 | 0% |
| 14 | 7bec74e8 | 1 | 83% | 1bb84137 | 0 | 0% |
| 15 | 4b9051ab | 1 | 100% | 2f4abb28 | 0 | 0% |

① refers to the number of starting messages sent by the learner in any round of discussions
② refers to the percentage of nodes connected by the starting messages in all the connected nodes of the learner.

In addition, for 13 out of the 15 high-degree nodes in the co-learner presence network, at least half of all the other nodes connected with them were tied through the starting message. In contrast, only two out of the 15 learners sent starting messages and most of the ties between them and their connected nodes were not implemented through the starting message. This shows that sending starting messages (e.g., asking if co-learners exist or sharing the date of watching the lecture) which can initiate a round of discussion could help achieve interaction with other learners in co-learner presence network. This can be probably explained by the herding effect in danmaku since viewers could be easily affected by observing others' danmaku messages and leading messages stimulated subsequent ones (He et al., 2017). However, how connectivity formed in the idea exchange discussions still requires further research.

## 4. Conclusion

This is a very timely study as the whole world is still in pandemic now and online learning are playing the most crucial role it ever has. Learning videos supporting danmaku are getting popularity in MOOCs and danmaku is serving as a tool for achieving learning interaction. This study offered insight into how learners interacted differently in the co-learner presence and idea exchange discussions in a math MOOC lecture and the resultant findings in topic categories, conversation structure, network topology and core nodes could shed light on how to make full use of danmaku to improve MOOC learning interaction between learners. For example, as many learners used danmaku for co-learner presence interaction, the course instructor can intentionally harness social presence cues during the lecture to help learners engage more with their peer learners. In addition, since interaction on co-learner presence and idea exchange showed rather different patterns, MOOC portals can adjust the interface and functionality accordingly to better meet different needs of learners in online video learning.

Besides, Leng et al. (2016) found that danmaku video did improve students' learning outcomes in a small-sample eye-gaze experiment whereas how danmaku helps learners implement interaction needs more research, especially in the non-experimental environment. This paper identified the active effect of danmaku on conducting the co-presence and idea exchange interaction in an online math lecture. Since previous studies found interactions correlate with learning experience and performance (e.g., Houston et al., 2017), findings here could suggest the potential of danmaku in influencing both the experience and outcome.

However, this is a pilot study about one math lecture and is limited to a small facet of the danmaku-supported learning interaction. Further research is necessary to present more aspects of how danmaku shapes learners' communication and influences their learning performance. For example, lots of isolated messages which failed to realize interaction with others were identified in this research and they will be studied later to explore the reason for the failure.

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