Investigating the Developmental Trajectory of Critical Thinking in Online Discourse among College Students: An Epistemic Network Analysis

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Abstract: Critical thinking is regarded as one of the core thinking skills in the 21st century. This study intends to investigate the developmental trajectory of critical thinking in the online discourse. In this study, 27 participants who were enrolled in an undergraduate course on instructional system design generated 724 discussion notes. Each student was given a critical thinking test at the beginning of the course, and the students were divided into high and low achievement groups based on the results. An epistemic network analysis is adopted to analyze their critical thinking behaviors in the online discussion. The results show that the epistemic network graphs of the two groups of students were significantly different, and varied at different stages of the online inquiry. Findings of this study have significant implications on designing activities for engaging college students in critical thinking and productive knowledge building discourse.

Research objectives

As one of the core skills in the 21st century, critical thinking (CT) is very important for personal growth, social progress, and world development. Cultivating students' critical thinking has become an important topic in the field of education (Peng & Deng,2017). Critical thinking is the process of analyzing and evaluating thinking to improve thinking, which involves many practical activities. Studies have shown that collaborative learning can significantly promote critical thinking (Loes & Pascarella, 2017). It is suggested that engaging students in knowledge building discourse could effectively facilitate the cultivation of critical thinking (Bereiter, 2002). In recent years, online discussions born in computers and Internet technologies have also become a way to develop critical thinking.

Researchers have used content analysis to examine critical thinking in online discussions (Beckmann & Weber, 2016). The codings can be further analyzed by using social network analysis, semantic analysis, or data visualization analysis, etc. Although these methods could demonstrate patterns or connections of the coded data, it is difficult to fully and dynamically present the characteristics and changes of learners' cognitive network structure. Epistemic Network Analysis (ENA) can be adopted to quantify the online discussions generated by the learners during the interactive process (Andrist, Collier, Gleicher, Mutlu, & Shaffer, 2015). And it forms a dynamic network model to represent the structure between the learner's behaviors and characterizes learners' cognitive characteristics. In this study, ENA is adopted to understand the characteristics and changes in students' critical thinking in a comprehensive and dynamic way.This study aims to analyze the online discourse of college students within one semester. ENA is used to explore the differences between high- and low-level groups in terms of critical thinking, in search of ways to cultivate critical thinking in an online learning environment.

Theoretical framework

Critical thinking

The concept of critical thinking can be expressed in a variety of definitions, depending on one's purpose. For example, in Paul and Elder's (2019) definition, critical thinking is the process of analyzing and assessing thinking to improve it. However, whatever the definitions are, the concept of CT has the same essence. The American Psychological Association offered a widely accepted definition of CT: judging in a reflective way what to do or what to believe. It can be traced back to Ennis' definition in 1985, which refers critical thinking as reflective and reasonable thinking that is focused on deciding what to believe or do. Ennis also noted there are creative activities covered by this definition and CT is a practical activity because deciding what to believe or do is practical activities. For college students, critical thinking is indispensable in the process of their learning processes. Learning how to cultivate critical thinking and put it into practice will enable students to quickly learn to

understand, analyze, explain, apply, innovate and other knowledge construction and internalization methods. Therefore, it is very important and necessary to cultivate and assess students' critical thinking.

Online collaborative learning

With the development of the Internet, people began to pay attention to the critical thinking in online collaborative learning. Bullen (1998) believes that curriculum design and implementation is one of the factors that influence learners' participation in collaboration and critical thinking in online learning community discussions. Leng and Huang (2019) adopt a combination of quantitative analysis and qualitative analysis to study the critical thinking of college students in online collaborative projects, the results show that online collaborative projects can improve the critical thinking level of college students. These studies have shown that online collaborative learning can effectively enhance the critical thinking of college students, but how to more deeply understand the characteristics and changes of college students' critical thinking still needs further exploration.

Epistemic network analysis

A team of the University of Wisconsin Madison Campus developed a method called ENA to assess learner performance, though which researchers can identify patterns of relations among discourse elements of coded data (Andrist, Collier, Gleicher, Mutlu, & Shaffer, 2015). Although there has been a growing interest in applying ENA in analyzing students' cognitive connections during collaborative learning (Shaffer et al., 2009), researches on investigating the developmental trajectory of critical thinking in online discourse are few. In this study, ENA is used to understand the characteristics and changes of students' critical thinking in online collaborative learning.

Research questions

Based on the above introduction, we mainly want to discuss two questions in this study: (a) Is there any difference between the high-level group and low-level group in critical thinking? If yes, what are the main differences as reflected by the online discourse? (b) What is the developmental trajectory of critical thinking in the high-level group and low-level group at different stages?

Research design

Participants

Participants were a class of students who enrolled in a course named Instructional system design from a university in Shanghai. 27 students were involved in this study (male: female = 4:23). They were divided into 9 groups and conduct project-based learning to design a course with the use of technology. Before the course stated, students filled a questionnaire on critical thinking, CCTT-Z critical thinking skill to measure their critical thinking level. The questionnaire included 52 objective multiple-choice questions with a total score of 52 points. According to the average score of each group, the group with the highest score and the group with the lowest score were selected (max=40.43; min=31.65; mean=36.20). The two groups are named high-level group and low-level group. At the end of the course, they were to complete the instructional design of a unit, including introduction of each lesson in the unit, multi-media content and how technologies are used in the lessons. To achieve this goal, students worked in groups and share ideas in an online discussion forum. The whole online collaborative learning processes lasted for 3 months and went through three stages as designed by the course teacher, which were background research (P1), unit preparation (P2) and peer critique (P3).

Research tool

ENA is a method based on cognitive framework theory to visualize and analyze the network relationships between learners' individual and groups' cognitive processes by constructing a dynamic network model.

Coding scheme

Murphy's (2004) framework is adopted as the coding scheme for critical thinking. It's an instrument to support thinking critically about critical thinking in online discussions. Murphy divides critical thinking into five processes: Recognize, Understand, Analyze, Evaluate, Create (to be referred to as R, U, A, E, C for short). According to these five processes, we design a coding scheme corresponding to critical thinking. Where null means that the content to be encoded does not belong to any of the above five encodings.

Data sources

To explore the differences between the high-level group and the low-level group, this study encodes each discussion post in three stages in two groups in one semester and the ENA is adopted for analysis. Two researchers coded all 724 posts with a consistency factor of alpha=0.932. Each discussion post will be encoded as one of six codes. After coding, take out the posts of students in high-level group and low-level group. A total of 90 posts in the high-level group and 85 posts in the low-level group were selected for analysis, and a series of data processing was performed in the webENA. Through the comparative analysis of the data of high group and low group, we can explore the differences of critical thinking cognitive network between the two groups.

Results

RQ1: The differences between high-level and low-level group in critical thinking

It can be seen from Figure 1 that the confidence intervals for the high-level and low-level groups are completely independent, indicating that there is a significant difference in critical thinking between the two groups. As can be seen in Figure 1a, for the processes of critical thinking (R, U, A, E, C), there are 6-7 strong connections, showing that the processes of critical thinking involved in the high-group project are comprehensive and extensive, and different critical thinking processes interact more.

It can be seen from Figure 1c that although there are connections in the low-level group, but only 3 processes (A, E, and U) are strongly connected. And the R and C are weakly connected with other processes, indicating that there are less coexistence and interaction between the critical thinking processes involved.

Figure 1b shows the superposition of cognitive networks of the high-level group and low-level group. For the connection of a certain two nodes, if the connection strength of high-level group is greater than that of low-level group, then the connection of the two nodes in the superposition will be shown in red (red represents high-level group, blue represents low-level group), otherwise, the connection will be shown in blue, and the greater the difference is, the thicker the line of the connection, the darker the line color of the connection.

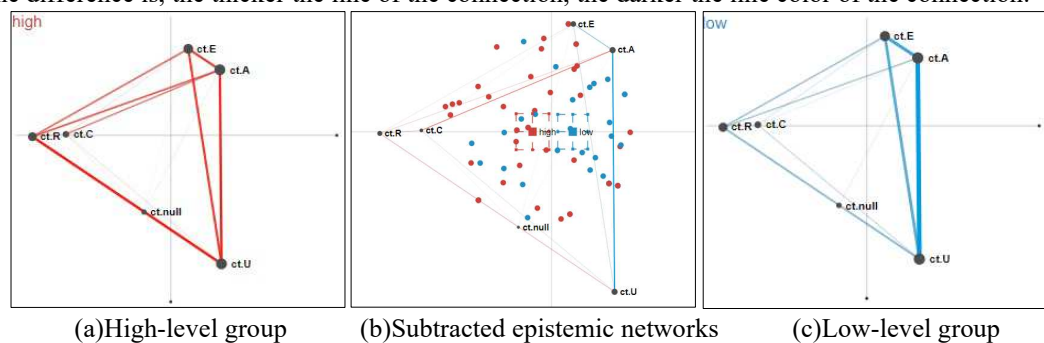(a)High-level group   (b)Subtracted epistemic networks   (c)Low-level group

Figure 1. CT mean networks of each group and their subtracted network

It can be seen from the subtracted network of Figure 1b that the high-level group is significantly stronger than the low-level group in the processes C-A (Create-Analyze) and R-U (Recognize-Understand), and the low-level group is stronger in U-A (Understand-Analyze).

Overall, the difference between the two indicates that the use and interaction of the critical thinking processes embodied in the high-level group discussion is more complicated. This reveals the difference between high-level group and low-level group when applying critical thinking.

RQ2: The developmental trajectory of critical thinking in high-level and low-level group at different stages

With the deepening of the online discussions, the difference in the critical thinking of high-level college students and low-level college students can be judged by the centroid of the CT epistemic network graph change, as shown in Figure 2. Figure 2 shows the change track of cognitive network centroid in the high-level group and low-level group in three stages respectively.

As can be seen from Figure 2a, the discussion of the high-level group is significantly different in the three stages of the centroid (the confidence intervals do not coincide at all). The three stages of the discussion have different task themes, and gradually deepen from the first stage (P1) to the third stage (P3), and the project design is also perfected. This suggests that the high-level group was biased in applying critical thinking in three stages, each using different critical thinking processes. It can be seen from Figure 2b that the low-level group has a concentrated center of mass in the three stages, and there is no significant difference between them, indicating that the low-level group is similar to the critical thinking processes used in different stages of project design.

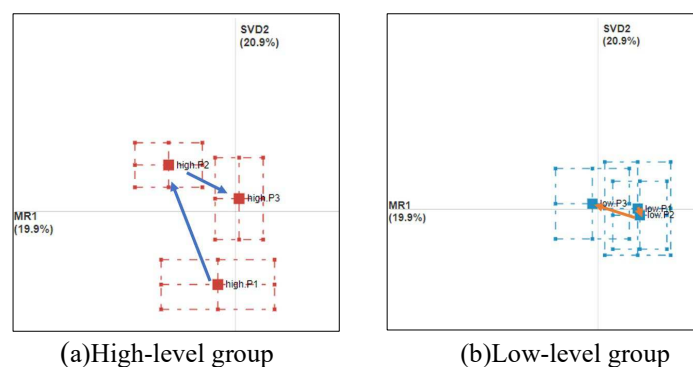(a)High-level group   (b)Low-level group

Figure 2: CT epistemic network graphs between different groups at different stages.

Through the above analysis, we can find that the cognitive network of high-level group in three stages can clearly reflect their critical thinking process in different stages, which is exactly the task of the corresponding stage. Generally speaking, we can know that 1) there are significant differences in the CT cognitive network graphs of high-level group at different stages, while the low-level group has no significant differences at different stages. 2) Two groups have different trajectories of development. The high-level group can use different critical thinking processes at different stages and have different emphasis and connection to solve different problems. However, there are no obvious changes and differences in the low-level group at different stages.

Conclusion

Firstly, this study explores the differences in ENA of critical thinking between the high-level group and low-level group students in an online collaborative discussion environment. The results show that there is a significant difference in the CT epistemic networks between the two groups. Secondly, in different stages, the epistemic networks of two groups have different development trajectories. Regarding the relationship between students' project scores and critical thinking scores, it is expected that critical thinking can influence the quality of project design, and the interactions in the online discussion forum also promote the development of critical thinking. Finally, this study also provides new ideas and directions for critical thinking research. The results show that the application of ENA in critical thinking research can effectively analyze the differences between high and low groups in critical thinking, and provide suggestions for the cultivation of critical thinking. Of course, how to better provide suggestions for the cultivation of critical thinking according to the results of ENA still needs further research.

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