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# Exploring college students' cognitive processing patterns during a collaborative problem-solving teaching activity integrating Facebook discussion and simulation tools

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ABSTRACT

Simulation and manipulation play vital roles in teaching procedural knowledge in science, technology, engineering, and mathematics (STEM) education. However, most studies in these fields have only focused on learning effectiveness rather than on students' collaborative problem-solving (CPS) processes and cognitive processing patterns in problem-solving activities. This paper aims to analyze learners' cognitive processing patterns in a CPS teaching activity that integrates Facebook discussion tools and simulation-based teaching software. The participants in this study included 45 students from the College of Management at a university in northern Taiwan. These students took an elective course titled "Introduction to the Network." This study used a quantitative content analysis (QCA) to code the online discussions and to explore the represented cognitive levels. Next, a lag sequential analysis (LSA) was conducted to analyze the coding results of the QCA to assess the behavioral patterns during the discussion process. The results indicate that students' network troubleshooting abilities improved over the course of the study. The learners' discussion patterns and cognitive levels during the activity are analyzed and discussed here. Differences in sequential cognitive processing patterns were found between the "discussion-centered" and "manipulation-centered" groups. The findings of this research may serve as a reference for instructors of STEM classes when integrating social networking services (e.g., Facebook) and CPS when designing virtual learning activities to improve learning effectiveness and increase cognitive levels.



## 1. Introduction

Simulation and manipulation play vital roles in teaching procedural knowledge, especially in science, technology, engineering, and mathematics (STEM) courses. Simulation-based learning is a teaching approach that provides students with simulated situations and environments for learning (Jonassen, 1996). This approach enables students to use their procedural knowledge in a relatively safe, low-cost environment that resembles reality (Carabaneanu, Trandfir, & Mazilu, 2006; Oortwijn, Boekaerts, & Vedder, 2008). This teaching method may promote students' procedural knowledge through a "learning by doing" process (Anderson, 1983).

Currently, this simulation-based teaching approach is commonly implemented in college classes and business settings to improve the skills of students and employees (Liu & Su, 2010; Salas, Wildman, & Piccolo, 2009; Vincent, 1976). With this approach, many real-life problems can be solved. For example, although network troubleshooting skills are critical in university network courses, budget constraints may make it difficult for colleges to purchase the necessary network devices (e.g., routers) for students to practice these skills. Moreover, learner errors may lead to additional costs for repairs. Therefore, less costly instructional simulation software is recommended for networking instruction. Additionally, in real-life network troubleshooting, issues are usually complicated and are the result of numerous factors. For example, when an office worker cannot access the Internet, the network engineer must analyze the possible causes and then communicate and work with the system engineer, the layout engineer, and the user to solve the problem. Currently, even in small- and medium-sized enterprises, engineers are asked to resolve network problems as quickly as possible, and the network engineer must be trained in efficient, logical thinking and teamwork. Therefore, the simulation of a real collaborative

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problem-solving (CPS) environment in a teaching activity may encourage students to learn by doing and to help them transfer what they have learned to real-life situations.

The prevalence of social networking services (SNSs), particularly the use of Facebook, has recently been reported to have positive effects on students' learning (Kabilan, Ahmad, & Abidin, 2010; Lin, Hou, Wang, & Chang, 2013; Wu, Hou, & Hwang, 2012). Barbera (2009) indicated that students exhibited more collaboration and interaction in online learning when using Facebook than when using common e-portfolio software. Wang, Woo, Quek, Yang, and Liu (2012) investigated the use of Facebook groups as a learning management system (LMS), and they found that students were satisfied with the basic functions of Facebook groups and believed that Facebook was helpful in online learning. Mazman and Usluel (2010) also suggested that Facebook is not only a social-networking platform for students but may also be a flexible online learning environment.

From the perspective of constructivism, "knowledge is actively built up by the cognizing subject" (Glasersfeld, 1995, p.51). Therefore, students' practical training in STEM education through reflective thinking in problem-solving tasks may facilitate their learning as they actively construct procedural knowledge in their schemas. Moreover, learners can solve problems and construct knowledge collaboratively during peer interactions through CPS strategies (Nelson, 1999). In summary, with the collaborative discussion environment of Facebook, which emphasizes social interaction with simulation software as a manipulation tool for problem-solving, we expect that the quality of students' problem-solving abilities and their acquisition of procedural knowledge will be enhanced.

Previous research has seldom discussed simulation-based teaching activities that integrate CPS strategies and explore students' cognitive processes. Furthermore, most CPS studies only discuss students' overall learning effectiveness (e.g., Noroozi et al., 2012) without exploring their problem-solving strategies and patterns of behavior related to cognitive processing. Therefore, this study aims to use lag sequential analysis to examine learners' behavioral patterns because such analysis helps to visualize the sequential patterns of students' cognitive behaviors in group discussions (e.g., what type of behavior immediately follows a certain type of behavior) and has been used in many digital learning studies (Bakeman & Gottman, 1997; Hou, 2010; Wu et al., 2012). Moreover, students may have peer discussions and manipulate the simulation-based tools for learning in CPS activities. Discussions and manipulations are two key behaviors in CPS activities, and different students may use different strategies to manage the time devoted to each of these two behaviors. For example, some groups may apply a "discussion-centered strategy" and develop procedures and solutions through thorough discussions. Other groups may apply a "manipulation-centered strategy" and focus on manipulation in which they gradually find the optimal solution by discussing the instantaneous feedback obtained from numerous repeated manipulations. Each of the abovementioned CPS time-allotment strategies has particular characteristics and limitations. An important research issue is to examine how instructors intervene and lead these two types of groups with different strategies to facilitate students' cognitive processing.

This study uses Facebook groups as a CPS task discussion environment and pairs it with Packer Tracer simulation software to create a simulated CPS learning environment. The study investigates CPS tasks for complete network troubleshooting by placing students in different groups. The advantages and limitations of this teaching method are analyzed, and the characteristics and differences of the sequential cognitive processing patterns for the discussion-centered and manipulation-centered groups are then discussed. Accordingly, this study focuses on the following research questions:

1. Does students' learning improve after they engage in simulation-based CPS learning activities? If so, to what extent?
2. What patterns of behavior related to cognitive processing do students exhibit in their online discussions within simulation-based CPS learning activities?
3. What are the differences in behavioral patterns between discussion-centered and manipulation-centered groups in terms of cognitive processing?

## 2. Research design

### 2.1. Participants

The participants in this study included 45 college students enrolled in an "Introduction to the Network" course at a university in northern Taiwan. The course aimed to teach basic networking concepts and to develop students' network troubleshooting abilities. There were 31 (69%) male and 14 (31%) female participants. The instructor administered a pre-test one week before the learning task. Next, the instructor divided the participants into heterogeneous groups based on their pre-test scores because many researchers (e.g., Johnson & Johnson, 1996; Swing & Peterson, 1982) have suggested that the use of heterogeneous grouping in a collaborative learning mode promotes learning effectiveness. Moreover, Webb, Nemer, Chizhik, and Sugrue (1988) found that groups that include members with both low and high learning abilities demonstrate greater learning gains than groups of only members with low learning abilities. Therefore, this study adopted *S-shaped heterogeneous grouping*, and each group showed similar degrees of heterogeneity. There were 11 groups, and each group was made up of three to five students.

### 2.2. Procedure

This study was conducted based on the CPS and simulation-based instructional approach. The teaching activity for the network troubleshooting course was performed with Packet Tracer, a network simulator, and Facebook groups. All participants attended a 16-week networking course. In the first 13 weeks, the instructor introduced the networking concepts and the manipulation of the simulation tools to ensure that the students learned the same course content and had similar prior knowledge. In the 14th week, a pre-test for the study was administered, and in the 15th week of the course, the main simulation-based CPS teaching activity was presented during a 2 h class period. Upon entering the computer classroom, participants were divided into several groups and were informed that they could only discuss the activity with the members of their group. To avoid compromising objectivity and to ensure control of the experimental situation, the instructor did not intervene in the group discussions during the activity.

The teaching activity in this study was designed based on the following procedure:

1) Before the students engaged in the given network troubleshooting tasks, the instructor explained the network troubleshooting problems and the goals of the tasks to the students.
2) The instructor grouped the students based on the pre-test scores administered in the 14th week such that each group was heterogeneous. There were 11 groups in total, and each group was made up of three to five students.
3) All of the groups were given the same network troubleshooting task (i.e., solving a network connection problem in a company) on Packet Tracer. At the beginning of the task, each student could operate and test the network environment on a computer. The instructor provided each group with an online learning sheet. This sheet explained that students could have problem-based discussions within their group's private Facebook group (each group used one private Facebook group). Because students were not allowed to change seats in the class, students did not sit face-to-face with their group members. Therefore, they had to communicate with each other through Facebook as an online CPS environment.