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Exploring design principles of bot-supported collaborative learning: The role of chatbots in regulated group discussions

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Abstract: Regulation of collaborative learning involves the use of regulatory skills and strategies across various aspects including cognition, metacognition, emotion, motivation, and social interaction. Chatbots have been used to facilitate group discussions in computer-supported collaborative learning. However, little is known of the extent to which chatbots may assume the roles of certain agents involved in group discussion and the impacts of this on the collaboration process. This study thus explored learning experiences in which chatbots facilitate group discussions to understand how chatbots do or do not facilitate the various facets of collaboration by fulfilling their assigned roles. This study then categorized the perceived roles and functions of chatbots in relation to social regulation into three different thematic categories and suggested design principles of bot-supported collaborative learning.

Introduction

The coronavirus outbreak has forced educational institutions to abruptly convert their synchronous in-person classes into either synchronous or asynchronous online learning regardless of the class types (Dhawan, 2020). These unexpected and precipitous changes in learning environments required both teachers and learners to adjust to the new modes of interaction. Platforms for online communication in education or industries, including ZOOM, Canvas, Metaverse, and Slack, have been integrated into online learning environments to facilitate interactions among classroom participants. Although supporting interactions in online learning is one of the most extensive research strands in computer-supported collaborative learning (CSCL), there remains a substantial discrepancy among studies of the effectiveness of CSCL (Kreijns et al., 2003). Among various attributions is the lack of design considerations of social interaction (Kreijns et al., 2003) and of regulated learning at both the individual and social levels (Järvelä et al., 2015).

The ability to effectively interact with group members to construct a shared understanding (Kirschner et al., 2008) and to regulate learning processes individually or collectively plays a pivotal role in successful collaborative learning (Järvelä & Hadwin, 2013). Given the combined importance of interactive and regulated online learning, researchers have recently focused on the use of emerging technologies to help regulate learning processes in online collaboration (Järvelä et al., 2015). Using chatbots as facilitators in online group discussions has been suggested as one effective use of technologies in CSCL (BSCL; Huang et al., 2021; Kim et al., 2020). However, little attention has been given to how chatbots can support learners to build knowledge effectively while regulating their processes collectively during online group discussions. As this lack of consideration may be partially due to the lack of design principles for BSCL, empirical research is needed to establish design principles of chatbots as discussion facilitators. To address this need, this study developed a chatbot prototype, named 'FACIL', to facilitate group discussion in problem-based learning contexts, and collected and analyzed the qualitative data of group discussion transcripts and student interviews. Based on the findings of group regulation and student perceptions of the roles and functions of FACIL in these chatbot-facilitated group discussions, this study then suggested design principles for BSCL. To guide the exploration of design principles, this study focused on the following research questions:

1. How do students socially regulate their learning processes in BSCL?
2. How do students perceive the roles and functions of FACIL in their collaboration processes?
3. What design principles can be suggested for BSCL?

Social regulation in online group discussion

Regulation of collaborative learning involves three types of regulation processes: self-, co-, and socially shared regulation (Järvelä & Hadwin, 2013). *Self-regulation* in collaborative learning refers to individual learners' effortful use of (meta-)cognitive, emotional, social, and motivational strategies during the collaboration (Schunk & Zimmerman, 2012). By contrast, learners can offer supports to facilitate their peers' regulated learning (i.e., *co-regulation*). Learners can also take joint control of group task processes by monitoring, and reflecting on their (meta-)cognition, emotion, motivation, and interactions collectively with other group members. In such *socially shared regulation*, they share the responsibility for regulating the learning processes (Järvelä & Hadwin, 2013).

In collaborative learning, group discussion may enable learners to identify "what they know, and indeed what they do not know… it does not necessarily lead them to what they are supposed to know" (Laurillard, 2002, p. 158). Reflecting on their learning processes and identifying what they still need to know is difficult and thus need to be either supported or trained (Hadwin et al., 2010). In addition, emotional (e.g., confusion and frustration) and motivational (e.g., disengagement with group work) challenges often emerge during the process of social regulation (D'Mello & Grasser, 2012). Unfortunately, however, little research sheds theoretical or practical light on the use of educational technologies to support aspects of learning other than cognition (e.g., metacognition, emotion, social interaction, and/or motivation) for collaborative groups (Järvelä et al., 2015). Thus, investigating technology-enhanced collaborative learning experiences regarding the regulation of learning via social interaction is necessary to construct design principles of CSCL technologies.

Chatbots as facilitators in online small group discussions

To support various aspects of collaborative learning, there have been many attempts to use chatbots as facilitators for successful collaboration. Chatbots have played a wide range of roles in online group discussions. One role is the facilitation of learners' collaboration and interaction during learning processes. For example, chatbots can facilitate learners' communication and monitor online collaborative processes (Bahja et al., 2020). Chatbots can also assist in time management (Kim et al., 2020) and improve learners' attention and engagement during the learning process (Neto & Fernandes, 2019).

Another role chatbots can perform is supporting the regulation of learners' emotional states during learning. For example, Lee et al. (2020) examined the effects of self-disclosure of chatbots on learners' mental states and found that chatbots' conversational styles may influence learners' intimacy levels and relationship closeness, depending on the contexts and types of tasks. They also identified that chatbots increased learners' perceived intimacy, enjoyment, and satisfaction with their learning environment by providing a dialogue to facilitate interaction with course content and reduce the transactional distance (Huang et al., 2021).

In some cases, chatbots replaced human learners and played the role of a colleague or tutor in small group discussions. Chatbots provided guidance and feedback with no time constraints (Huang et al., 2021) and facilitated the distributed participation of learners in group discussions and debates. Kim et al. (2020) reported that learners perceived the chatbot as one of their group members with a specific role in the discussion such as a manager, facilitator, or assistant, among others. These functions induced the participation of passive participants and alleviated the burden on human leaders.

As such, researchers utilized these responsive features to facilitate the online learning process. However, little is known of the extent to which chatbots may assume the roles of certain agents involved in group discussion and the impacts of this on the collaboration process in various aspects (e.g., (meta)cognition, emotion, interaction, and motivation). Since collaboration is more likely to succeed when each agent maintains an awareness of the team and tasks in which they are engaged based on mutual trust (Fransen et al., 2011), a careful investigation is needed to understand the degree to which chatbots facilitate various facets of collaboration in group discussion learning experiences by fulfilling their assigned roles.

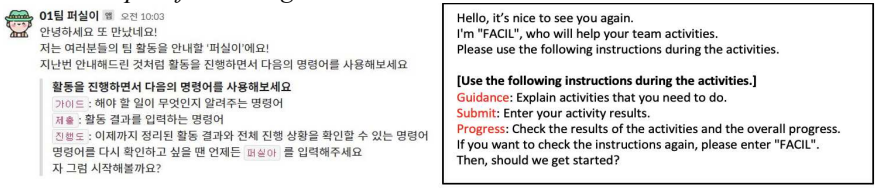
Research design and methods

This study was conducted in a general education course 'Technology for Innovation' at a large private university in South Korea. Students explored the definition, current trends of Digital transformation, and solved case-based problem-solving using cases of applying AI, Big data, and block chain to industrial fields. The Bot-Supported Collaborative Learning (BSCL) sessions were offered using Slack, the communication platform, during the four weeks. 58 students enrolled in the BSCL sessions (34 students were female and 24 students were male).

Development of FACIL

Figure1

An Example of a Message From FACIL



A prototype of educational chatbot, FACIL, was developed using Python slackclient which enables Slack users to implement the chatbot prototype within their chatrooms. Some major functions of FACIL are, to name a few,

delivering (a) instructional messages that contain learning contents and activity procedures, (b) responsive messages that respond to predetermined keywords or encourage inactive learners, (c) requests that ask students for different ideas or challenges, and (d) allowing learners to view their progress, submit their answers and call for instructors by predetermined commands (see Figure 1).

Data analysis

This paper used an exploratory case study method (Yin, 2009) to describe and identify the perceived roles and functions of FACIL in relation to students' social regulation of the collaboration processes in BSCL. The text records of group discussions and the video recordings of student interviews were collected. The second and third authors viewed all the text records of group discussions and interviews to identify students' regulatory efforts and behaviors that were either explicitly shown in the discussion transcripts or described during the interviews. In addition, the perceived roles and functions of FACIL were examined by examining participants' answers to the relevant interview questions (e.g., "Can you describe your experience you had with FACIL during the discussion?" and "What supports do you feel that you got from the FACIL during the discussion?"). The authors categorized the perceived roles and functions of FACIL in relation to social regulation into three different thematic categories and suggested design principles of chatbots to improve their performance as facilitators for each category.

Findings

Three themes of students' perceptions of the roles and functions of FACIL in relation to their regulation of collaboration processes were identified through the analysis: (a) relieving the (meta)cognitive burden of mutual performance monitoring, (b) relieving the emotional burden of requiring further exploration during the group task, and (c) encouraging the engagement of all group members by relaxing tensions and alleviating embarrassment. This paper presents the first representative theme in detail and a summary of all themes in Table 1 due to the limited space. All themes will be discussed in further detail at the conference.

Relieving (meta)cognitive burden of mutual performance monitoring

Social regulation of learning

For successful regulated learning in problem-solving contexts, students are required to have a shared understanding of the knowledge, strategies, and/or responsibilities needed to complete the task. The holistic regulation of mutual performance demands a high degree of (meta-)cognition, so external supports are needed to reap the benefits of CSCL (Fransen et al., 2011). In this study, FACIL offered information of content knowledge (in the form of case studies) and procedures students should follow. In addition, FACIL provided responsive reactions during each sub-discussion: information about the overall progress, degree of participation of each member, subgoals to achieve, and task requirements, as well as facilitating messages, were provided either upon request or based on the predetermined conversation algorithm. In interviews after the classes, students reported that FACIL was helpful because it provided references of collaborative processes that group members might have otherwise overlooked. Moreover, students mentioned that they were satisfied with the guiding role performed by FACIL because they did not have to spend additional time and effort to establish team rules for performance monitoring. However, some cases were identified in which students followed the guidance provided, but jumped to a conclusion without sufficient discussion. Indeed, one group member mentioned that their group had little interaction regarding the topic as they were focused only on providing answers to the questions asked by FACIL. Suggested design principles to address these issues are listed in Table 1.

Table 1

A summary of the identified themes and suggested design principles

Themes: Perceived roles of chatbots	Aspects of regulation	Issues in regulation of learning	Suggested design principles
Relieving the (meta)cognitive burden of mutual performance monitoring	Cognition and metacognition	1. Students jumped to a conclusion without sufficient discussion 2. Students did not collaborate but cooperated while unaware of others' work 3. Students only responded to goal-directed comments	1. Implement a role assignment activity: split the task into several subtasks, analyze the nature of each subtask, set roles, and then implement a role-assignment activity before presenting the guidance for each subtask

Relieving the emotional burden of requiring further exploration during the group task	Emotion, motivation and social interaction	4. Students hesitated or refrained from requesting further exploration 5. Students felt awkward in challenging others' ideas	2. Systematically and logically pre-determine an algorithm to facilitate the processes of challenging and rebutting for rich interactions
Encouraging the engagement of all group members by relaxing tensions and alleviating embarrassment		6. A small number of students dominated the discussion process 7. Students seldom encouraged others to engage in the task	3. Help learners to become aware of their interaction processes and deliver encouraging messages for distributed participation and mutual trust

Discussion

The use of chatbots as facilitators of online small group discussions offers potential benefits, including improving the effectiveness of online collaborative problem-based learning, when the chatbots are carefully designed for social interaction and regulation. Chatbots can support students' regulatory processes in group discussions by performing various roles to relieve (meta)cognitive, emotional, motivational, and interactional impediments to the group discussion. Based on the identified roles of and issues with chatbots acting as facilitators, this study suggests design principles that encompass the multifaceted nature of regulated collaborative learning, which has previously been neglected (Järvelä et al., 2015).

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