*ets research institute

DECEMBER 2024
RR–24-12

RESEARCH REPORT

Insights Into Critical Discussion: Designing a Computer-Supported Collaborative Space for Middle Schoolers

AUTHORS

Yi Song, Ralph P. Ferretti, John Sabatini, and Wenju Cui

ETS Research Report Series

Since its 1947 founding, ETS has conducted and disseminated scientific research to support its products and services, and to advance the measurement and education fields. In keeping with these goals, ETS is committed to making its research freely available to the professional community and to the general public. Published accounts of ETS research, including papers in the ETS Research Report series, undergo a formal peer-review process by ETS staff to ensure that they meet established scientific and professional standards. All such ETS-conducted peer reviews are in addition to any reviews that outside organizations may provide as part of their own publication processes. Peer review notwithstanding, the positions expressed in the ETS Research Report series and other published accounts of ETS research are those of the authors and not necessarily those of the Officers and Trustees of Educational Testing Service.

The Daniel Eignor Editorship is named in honor of Dr. Daniel R. Eignor, who from 2001 until 2011 served the Research and Development division as Editor for the ETS Research Report series. The Eignor Editorship has been created to recognize the pivotal leadership role that Dr. Eignor played in the research publication process at ETS.

ETS Research Report Series ISSN 2330-8516

ETS RESEARCH REPORT

Insights Into Critical Discussion: Designing a Computer-Supported Collaborative Space for Middle Schoolers

Yi Song[1], Ralph P. Ferretti[2], John Sabatini[3], & Wenju Cui[1]

1 ETS Research Institute, Princeton, New Jersey, United States
2 University of Delaware, Newark, Delaware, United States
3 University of Memphis, Memphis, Tennessee, United States

Collaborative learning environments that support students' problem solving have been shown to promote better decision-making, greater academic achievement, and more reasonable argumentation about controversial issues. In this research, we developed a technology-based critical discussion platform to support middle school students' argumentation, with a focus on evidence-based reasoning and perspective taking. A feasibility study was conducted to examine the patterns of group interaction and individual students' contributions to the critical discussion and their perceptions of the critical discussion activity. We found that more students used text-based communications than audio, but students who used audio collaborated with each other more frequently. In addition, student engagement in argumentative discourse varied greatly across groups as well as individuals. At the end of the discussion, most groups provided a solution that integrated both sides of the controversial issue. Survey and interview results suggest an overall positive experience with this technology-supported critical discussion activity. Using the insights from our research, we develop a conceptual dialogue analysis framework that identifies relevant skills under the argumentation and collaboration dimensions. In this report, we discuss our design considerations, feasibility study results, and implications of engaging students in computer-supported collaborative argumentation.

Keywords Argumentation; critical discussion; collaborative environment; computer-supported learning; dialogue analysis

doi:10.1002/ets2.12387

The ubiquitous and rapidly evolving technologies used in everyday life are having a transformative influence on teaching and learning (Brinkley et al., 2012; Dubé & Wen, 2022). Students are expected to learn to construct and evaluate arguments in various disciplines, such as the English language arts (ELA), history, science, and math (Council of Chief State School Officers, 2010). They are also expected to acquire the self-directed skills needed by informed citizens (International Society for Technology in Education, 2007) to collaboratively discuss, reason about, and write about controversial issues. These skills, which are aligned with the 21st-century frameworks (Chalkiadaki, 2018), undergird the development of students' capacities for reasonable argumentation about controversial issues. Unfortunately, extensive research has indicated that collaborative argumentation poses a challenge for younger and older people alike (e.g., Andriessen & Baker, 2014).

Advances in educational technology have increased the effectiveness of computer-supported collaborative learning (Hmelo-Silver et al., 2013). Research has shown (e.g., Andriessen & Baker, 2014) that computer-supported collaborative learning systems can support students' engagement in argumentation, thereby fostering their understanding of controversial issues. Nevertheless, there is a noticeable gap in the research literature about the features of computer-supported systems that are designed to support the development of middle school students' collaborative argumentation. Education should emphasize not only content knowledge in specific domains but also the skills that enable students to evaluate different perspectives, articulate their ideas logically, and collaborate effectively. This requires a good understanding of the development of argumentation skills and means for targeting where middle school students most likely need support to overcome the challenges. As existing research studies have shown (e.g., Kuhn & Crowell, 2011; Song et al., 2020; Song et al., 2023), several argumentation skills are particularly challenging for students: (a) anticipating alternative perspectives and counterarguments, (b) rebutting counterarguments to strengthen one's own standpoint, and (c) evaluating arguments from different perspectives to reach a reasonable resolution. Additionally, students with limited prior knowledge about the

Corresponding author: Y. Song, E-mail: ysong@ets.org

topic or little experience in collaborative argumentative discourse can encounter difficulty in developing strong arguments (e.g., Deane & Song, 2015; Sparks & Deane, 2015).

This research project sought to determine the feasibility of a computer-supported collaborative *critical discussion* activity to support the development of middle school students' capacity for engaging in reasonable argumentation, evaluating arguments, and considering different perspectives in the ELA context. We used the ETS Platform for Collaborative Assessment and Learning (EPCAL), which was designed to support conducting research on collaboration. EPCAL has been used to support collaborative activities in multiple educational contexts, including science, mathematics, and collaborative problem solving (e.g., Andrews-Todd et al., 2019; Dowell et al., 2020; Hao et al., 2017; Liu et al., 2016; Zapata-Rivera et al., 2019). For this study, we adapted EPCAL to support collaborative argumentation in the ELA context and added new features to the platform. In this report, we focus on the collaborative task design, the initial exploration of the feasibility of the technology, and the development of a dialogue analysis framework as the Phase 1 research of a multiyear project. We start by discussing the conditions most likely to elicit students' reasoned considerations of different opinions and then review the affordances and limitations of existing technologies that have been designed to support collaborative argumentation. We then describe the design characteristics of our online platform that are essential for supporting collaborative argumentation. Finally, we present empirical evidence about EPCAL's capacity to both support and collect information about students' collaborative and argumentative discourse; we conclude with lessons learned from the feasibility study.

Theoretical Framework

Challenges in Developing Argumentation Skills

The argumentation literature has provided empirical evidence about the development of students' argumentation skills. Middle school students typically can construct oral arguments that anticipate and address potential criticisms about familiar topics (Ferretti & Lewis, 2019a). Moreover, writing research has shown that middle school students tend to incorporate more argument components when given specific goals for content and audience during the planning and revision phases (Midgette et al., 2008). By the fifth or sixth grade, many students can adeptly elaborate on their arguments, providing supporting details (Ferretti et al., 2009; Ferretti et al., 2000) and using relevant evidence to support their claims after receiving training (Kuhn & Crowell, 2011).

Nevertheless, certain aspects of argumentation remain challenging, even for older students, and may not fully mature until adulthood without explicit instruction and intentional practice. First, students often focus on their own ideas and ignore other people's opinions, whereas people with advanced argumentation skills consider different perspectives and anticipate potential counterarguments (Felton & Kuhn, 2001). Difficulty in identifying the assumptions underlying arguments or integrating perspectives from both sides of an issue has also been observed in high school and college students (Klaczynski, 2000). Thus refuting opposing viewpoints and anticipating counterarguments is a complex task for middle school students, particularly in a written context (Ferretti et al., 2000; Leitão, 2003; Nussbaum & Kardash, 2005). Song et al. (2020) showed that middle school students struggled to produce high-quality critiques because of challenges in recognizing or articulating the reasoning flaws in arguments. Typically, middle schoolers tend to accept the information presented in an argument as true, rather than asking questions that could uncover reasoning flaws (Ferretti et al., 2009; Nussbaum & Kardash, 2005; Song et al., 2020). These findings underscore that middle school students are at a critical, albeit early, stage in the development of their argumentation skills.

Furthermore, students' prior knowledge about a topic affects their reading and writing performance (Gil et al., 2010; O'Reilly et al., 2019). It is not surprising that students cannot make thoughtful arguments when they know little about a topic because they need information relevant to the topic to generate arguments and counterarguments (Hemberger et al., 2017). For example, Song et al. (2023) found that students performed better on a cursive writing task than on a foreign language task, even though the two tasks were designed from the same blueprint: Write a brief paragraph including a statement of a position, two or more reasons, and a consideration of the opposing position. One possible explanation for the difference is that students were relatively familiar with the cursive writing topic but had little knowledge about the best ages for learning a foreign language. Students need adequate background information to produce informed oral and written arguments. Thus we designed a collaborative activity that guided students through a series of argument tasks to overcome these challenges and promote their understanding of arguments from different perspectives.

Dialogic Approach to Promoting the Development of Students' Argumentation Skills

When students work collaboratively in a group, they bring their values, unique background experiences, prior knowledge, and assumptions to the discussion and thus produce something that extends beyond the individuals' abilities and dispositions (Johnson, 2015). The dialogic approach has been recognized as a primary means of promoting individual reasoning because argumentation is an inherently social activity between people who may hold different opinions about a controversial issue (van Eemeren & Grootendorst, 2004). Studies have shown that embedding argumentation in a dialogic context can facilitate the development of audience awareness and argument strategies, increase students' sensitivity to alternative perspectives, and influence a variety of other skills that support the ability to write extended arguments (Anderson et al., 2001; Ferretti & Lewis, 2019b; Goldstein et al., 2009; Kuhn & Crowell, 2011; Kuhn & Udell, 2007; Lin et al., 2012; Moore & MacArthur, 2012; Nussbaum, 2008; Reznitskaya et al., 2007). A recent study conducted by Iordanou and Kuhn (2020) revealed that students produced more and better functional evidence-based argumentative ideas in their essays after engaging in discourse with peers who held an opposing view rather than with peers who held the same position as them.

Middle school students may be able to generate oral arguments that address potential counterarguments in familiar contexts, but they do not typically engage in reasonable arguments or collaborative reasoning without guidance (e.g., Ferretti & Lewis, 2019b). Students may ignore others' points, attack the person rather than challenging the claim, or reach a quick consensus to avoid conflict (Andriessen & Baker, 2014; Baker et al., 2019; Rourke & Kanuka, 2007). According to Johnson and Johnson (2007), several factors influence whether people are able to resolve their differences during a discussion about a controversial issue, including the interlocutors' goals and their understanding of the standards for reasonable argumentation. Here we highlight two issues that we took into account in designing our activity. First, disagreements are most likely to be resolved when interlocutors receive cooperative rather than competitive goal structures. Though some competitive goals (e.g., debates) can be effective, they undermine cooperativity by focusing attention on winning, that is, refuting an opponent's views and proving the superiority of one's own arguments (Asterhan & Schwarz, 2009). Therefore a cooperative goal of resolving differences of opinion may create a noncompetitive context in which students can comfortably share their opinions and evaluate the arguments in an objective way. Second, participants must commit to reasonable arguments, applying evaluative standards, rubrics, or critical questions to assess whether their discourse possesses qualities that meet normative standards of argumentation (Andrade & Bouley, 2003; MacArthur, 2016; Song & Ferretti, 2013; van Eemeren et al., 2014).

Computer-Supported Collaborative Argumentation

Having explored the principles and benefits of dialogic argumentation, we now turn our attention to how these interactions can be conducted in a computer-supported collaborative environment to promote reasonable argumentation. Computer-supported collaborative argumentation has emerged as a dynamic and promising avenue for enhancing students' critical thinking and communication skills. In the "Argue With Me" series of studies, researchers began to use computers to mediate students' discussions; specifically, students used Google Chat or instant messages to participate in argumentative discourse (Iordanou & Rapanta, 2021). For example, in Kuhn et al.'s (2008) study, 28 sixth graders conducted dialogues via instant messaging software in small groups, then used the transcript of the dialogues for reflective activities. The technology was used primarily to keep a record of dialogues for subsequent activities and for discourse analyses. They focused on scaffolding student dialogues rather than developing an integrated computer system for collaborative argumentation.

Wecker and Fischer (2014) conducted a meta-analysis on the impact of argumentation interventions in the context of computer-supported collaborative learning, reporting a moderate effect size of 0.39 for argumentation skills. Specifically, the collaboration scripts (i.e., instructions that guide and support group interactions, clarifying what, when, and by whom certain activities need to be carried out) resulted in a statistically significant effect, ES = 0.91 (with a 90% confidence interval including 0), for argumentation, whereas the visualization tools led to a nonsignificant and nonsubstantive effect, ES = 0.17, for argumentation. Likewise, Vogel et al. (2017) investigated the impacts of incorporating collaboration scripts as a strategy to support group interaction and revealed a significant effect size of 0.95 for argumentation skill in comparison to collaboration without scripts.

Noroozi and colleagues (2012) provided a synthesis of 15 years of research on argumentation-based computer-supported collaborative learning, which included 108 publications from 1995 to 2011. They concluded that such a learning

environment needs to attend to diverse student backgrounds, educational contexts, processes, and outcomes. Among the studies they reviewed, 29 studies were conducted at secondary schools, with only six targeting middle school students. Of these six middle school studies, four investigated domain-specific argumentation, such as scientific or historical argumentation, while only two studies (i.e., Nussbaum & Edwards, 2011; Schwarz & Glassner, 2007) focused on argumentation about controversial issues in a general or daily-life context. Notably, it is unclear how technology was involved in Nusbaum and Edwards's (2011) work, as the researchers used a paper-based graphic representation of argumentation.

Schwarz and Glassner (2007) investigated the impact of ontology (argument representations) and synchronicity on argumentative activities in e-discussions among seventh-grade students. One key aspect was using synchronous discussions through the Digalo web tool, emphasizing real-time interaction. Moreover, their study highlighted the technological framework that guides how arguments are represented. Incorporating an informal argumentative ontology played a pivotal role in shaping the discourse, influencing the quality and relevance of claims and arguments produced during the e-discussions. Schwarz and Glassner showed that combining an informal argumentative ontology with control over turn taking resulted in the highest number of relevant claims, arguments, and productive references and the lowest number of chat-style expressions. The researchers suspected that turn taking gave participants time to reflect on and react to the representations of argumentation.

A few technologies are designed to support collaborative argumentation or debates at the high school level, including the Dialogical Reasoning Educational Webtool (DREW; Baker et al., 2007; Van Amelsvoort et al., 2007), JigaDREW (Lund et al., 2007), and TC3 (Erkens et al., 2005; Van Amelsvoort et al., 2008). Their common features include synchronous collaborative chats and argument representation tools, which enable summarizing the key points in discussions, coconstructing knowledge, and coevaluating arguments (Schwarz, 2018). These studies have highlighted the efficacy of utilizing digital platforms to facilitate collaborative argumentation, enabling students to engage in more nuanced and structured discussions. These platforms often provide tools for organizing and presenting arguments, fostering a more interactive and dynamic learning environment. Additionally, computer-supported collaborative argumentation helps students navigate the complexities of expressing and defending their viewpoints, encouraging them to consider counterarguments and to refine their positions. However, most of the research on computer-supported collaborative argumentation took place in science education and focused on older students (Major et al., 2018; Noroozi et al., 2012). Relatively few studies have explored computer-supported collaborative argumentation within the context of middle school ELA.

ETS Platform for Collaborative Assessment and Learning Critical Discussion Activity

In this project, we adopt the critical discussion as a specific model of dialogic argumentation to promote middle school students' collaborative argumentation skills (Michaels et al., 2013; van Eemeren & Grootendorst, 2004). A critical discussion model typically involves four discussion stages: confrontation (identifying different opinions or contradictions), opening (establishing common ground, including prior knowledge, values, a discussion procedure, and rules), argumentation (developing and critically evaluating arguments), and concluding (drawing a conclusion). We perceive the value of the critical discussion model in structuring students' dialogic argumentation because it allows students to interact with same-side peers to build strong arguments for their own side and with opposing-side peers to address counterarguments for the purpose of resolving differences of opinion (i.e., a cooperative goal). It also affords the opportunity to apply critical standards for judging the relevance of argumentative strategies (Nussbaum & Edwards, 2011; Song & Ferretti, 2013; Wissinger & De La Paz, 2016). Critical standards may include information that guides the evaluation of the relevance of discourse that plays an argumentative function (e.g., standpoints, reasons, counterarguments, and rebuttals) as well as argumentative strategies used for accomplishing the speakers' discursive purposes (Macagno et al., 2015). People can best defend their arguments by answering critical questions about the relevance of their argumentative strategies (Walton et al., 2008). These key features of critical discussions are also well aligned with the cooperative goal structure and reasonable argument proposed by Johnson and Johnson (2007).

The successful resolution of a difference of opinion presupposes communication and reasoning skills, including social, conceptual, and discourse skills related to the development of argumentation. These include skills needed to support collaborative reasoning and engagement in learning tasks, knowledge of genre-specific discourse conventions, evaluative standards, and the acquisition of the self-regulatory skills needed to coordinate these complex skills. Some students may not reach an agreement at the end on the controversial issue; however, they are expected to provide stronger arguments that consider the perspectives of those with whom they disagree.

In this project, we adapted EPCAL (Hao et al., 2017) to deliver and facilitate small-group, online, collaborative argumentation. The EPCAL platform was designed to provide the research team control over authoring, designing, and manipulating activities and the learning environment. It affords the possibilities of (a) authoring, administering, and manipulating the instructional content; (b) controlling the grouping, event sequences, and timing of collaborative interactions among students; (c) capturing oral, written text chats and task responses in a secure student data record store, ready for analysis; and (d) providing real-time monitoring and feedback to teachers as students participate in activities.

The EPCAL interface includes (a) a shared stimulus screen (for accessing a shared text or question), (b) a chat dialogue section, and (c) a video interface so that participants can speak and interact orally. Teachers can upload content, assign tasks, and manage users and teams via the teacher dashboard. EPCAL can record and synchronize all communication data for the purpose of scoring or analysis, including written chat dialogues, audio of spoken interactions, and responses to items or tasks. For example, if the student communicates using text chat, then the prompt defining the issue, the student's responses to the task, and all text chat messages are entered into log files in an XML format. Meanwhile, audio recordings are automatically saved to a server.

The EPCAL platform has been used to support collaborative activities in multiple contexts (Andrews-Todd et al., 2019; Dowell et al., 2020; Hao et al., 2017; Liu et al., 2016; Zapata-Rivera et al., 2019), and updates have been made through these research studies. It is our contention that EPCAL affords opportunities for collaborative discussion and consensus building within teams of students arguing for the same or different standpoints during critical discussions. It also presents a sequence of controlled activities that help students build knowledge about the given controversial issue, and it captures a complete evidence trail, including participant responses to structured tasks, the sequence and timing of text chat, and the content and timing of video interactions.

We made multiple key modifications to EPCAL to support the online critical discussion activity. First, the updated system is now capable of dividing students into subgroups to perform certain tasks and then returning them to their original groups to perform other tasks. This is an important function because students need to be exposed to both sides of a controversial issue and have discussions with same-side and opposite-side peers. Second, as students progress through the activities, the system retains their products (e.g., argument tables they filled out, exchanges of tables from different subgroups, chat messages between partners) so that students can refer to that information in their discussions and collaboratively evaluate their arguments. Third, evaluative guidelines for critical discussion and argument evaluation are provided during the activity to reinforce the cooperative learning behaviors, evidence-based reasoning, consideration of different perspectives, and criteria for distinguishing strong arguments from weak ones (see Appendix A). Finally, in collaborative tasks, we built in the "take control" function, allowing students to take turns contributing to the shared workspace (e.g., filling out an argument table), then releasing control to let the next student take a turn. This is a common function in other computer-supported collaborative activities (e.g., Schwarz & Glassner, 2007). In addition, the EPCAL critical discussion activity allows students to talk directly and send text-based messages to their team members, as individual students may have their own communication preferences. Figure 1 is a screenshot of the critical discussion activity on EPCAL.

The Feasibility Study

This project was carried out during the COVID-19 pandemic, when many schools in the United States were compelled to use video conferencing technologies in support of hybrid or virtual models of education. During that time, there was an urgent need to support students' online collaborative argumentation. We conducted a feasibility study to examine students' use of the real-time dialogue and text-based chat features of EPCAL and their argumentation and collaboration skills demonstrated in the critical discussion activity. In addition, we hoped to identify potential technology challenges that students encountered during the online activity and to resolve these issues. Here we present the results of the feasibility study that address the following research questions (RQs):

1. What are students' interaction patterns during the online critical discussion activity?
2. To what extent do students' dialogues focus on arguments about the controversial issue?
3. Do the team solutions reflect students' consideration of both sides of the issue?
4. How do students perceive their collaborative experience on EPCAL?

Exploring these questions allowed us to determine the feasibility of the system and what design modifications and feature enhancements are needed for its successful implementation in classrooms.

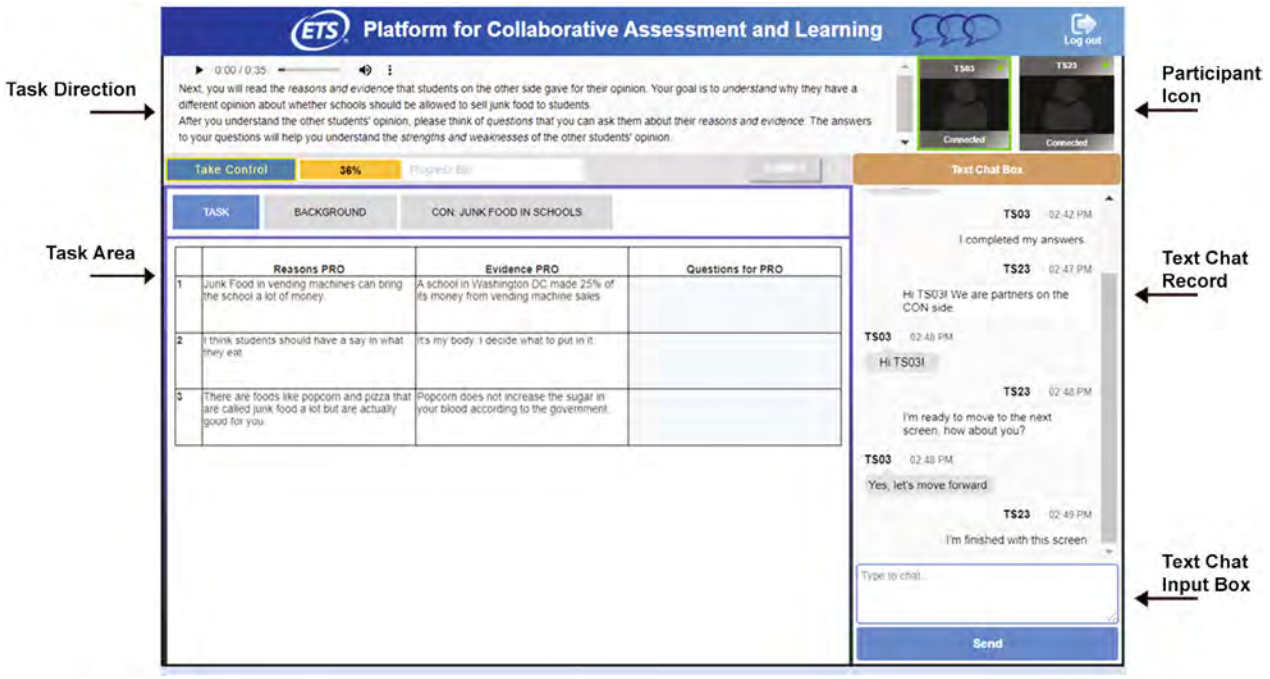

Figure 1 Example of the critical discussion activity on the ETS Platform for Collaborative Assessment and Learning.

Method

Participants

We recruited a convenience sample of 34 middle school students (11 sixth, 10 seventh, and 13 eighth graders), 19 females and 15 males, in the northeastern United States. Although everyone was a native English speaker, the participants came from different ethnic groups (Caucasian, $n = 9$; African American, $n = 4$; Asian, $n = 7$; Hispanic, $n = 2$; mixed, $n = 9$; unreported, $n = 3$). Twenty-six students reported that they achieved an A or A+ in their ELA course in the previous semester, and the rest achieved a B or B+. Students received a small honorarium after completing the study.

Online Critical Discussion Activity

The critical discussion activity was programmed and delivered through EPCAL. The discussion topic was "Should schools be allowed to sell junk food to students?" The critical discussion activity included the following tasks in a sequence: (a) four students in a group reading a background article about the given controversial issue and answering a few comprehension questions (confrontation and opening stage); (b) with random assignments, two students reading the pro-side article and two students reading the con-side article; (c) developing two to three reasons and evidence for the assigned position; (d) asking questions about the other side's reasons and evidence; (e) answering questions raised by the other side; (f) switching sides and repeating Steps b – e; (g) four students rejoining and evaluating arguments and information generated in the preceding steps for both pro and con sides [Steps b – g, argumentation stage]; and (h) the group discussing the arguments to reach an agreement on which side they should take (concluding stage).

Measures

Team Solution Task

The team solution task is the final collaborative task in the critical discussion activity. After developing and evaluating arguments from both sides, each team was asked to develop a solution to the junk food issue. The team's solution could be pro, con, or a different opinion, after all four members negotiated with each other to reach an agreement. They also were asked to justify their solution. Two annotators independently evaluated the team solutions and categorized them into either "one side" or "both sides." The interrater agreement was 100%.

Online Survey

The postactivity survey (see Appendix B) was designed to collect students' feedback on their experience with the critical discussion activity, asking them how much they agree with each statement on a 4-point scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*). Some statements were about the task itself, the EPCAL functions, and their engagement, while other statements were about their collaboration with their teammates.

Interviews

Interviews focused on collecting students' elaborated responses on their experience to help us understand what they liked or disliked about this activity and what challenges they encountered, including technology-related problems, as well as to collect their suggestions on how to improve the activity design. For example, we asked students what their favorite part of the activity was and what parts they felt were hard or confusing.

Dialogue Annotation

We reviewed frameworks in various dialogue analysis and collaborative problem solving research (Andrews-Todd & Forsyth, 2020; Coiro et al., 2019; Hennessy et al., 2016; Lin et al., 2015; Liu et al., 2016; Soter et al., 2008; Vrikki et al., 2019). Hennessy and colleagues (2016) developed a scheme for dialogue analysis that enabled them to investigate the teacher–student and peer dialogue interactions in classroom settings. To capture the function of agents' discursive moves, they created clusters of codes (e.g., invite elaboration and reasoning, make reasoning explicit, positioning and coordination), each of which had several subcategories. Lin et al. (2015) examined the influence of teachers' instructional moves on fourth graders' collaborative discussions. They created four major categories of scaffolding moves, including prompting, modeling, positive feedback, and management.

Informed by the existing dialogic frameworks, we developed a dialogue analysis framework that identified students' argumentative and collaborative discourse. The argumentative dimension covered discourse moves on providing reasons and evidence that support the position, discussing the different perspectives, determining how to address counterarguments, and resolving differences of opinion to develop a group solution to the given controversial issue. The collaborative dimension covered discourse moves to coordinate with teammates, clarify tasks, build communication, share task responses, express confusion, share understanding, and read aloud the text. Collaborative discourse was conducive to resolving different perspectives, which was the goal of students' critical discussions. In addition, there were codes for discussions related to technology issues (problems) and for off-topic chats. Table 1 presents an overview of our dialogue analysis framework. We developed a coding rubric based on the dialogue analysis framework, with each skill code corresponding to one of the skills (e.g., EVI for evidence) and a dimension code (e.g., ARGU for argumentation).

Text-based chats and written task responses were recorded and saved in group log files. Audio files were transcribed by humans, then merged with the text-based chats for each group by time stamp. The first author provided annotation training to two raters with prior experience in scoring students' constructed responses to ELA assessments. After the raters learned how to apply the codes, each independently annotated the dialogues of the nine groups (more than 3,000 dialogic turns; each dialogic turn represents a moment when a participant contributes to the conversation, adding new information, posing a question, providing a response, or making an argument). In this report, our analyses focus on the two overarching dimensions of argumentation and collaboration, rather than on specific skills under each dimension, because we used the dialogues to develop categorizations of specific skills and adjusted along the way; additionally, a few skills were relatively rare in the data set. Table 2 provides an example excerpt consisting of nine dialogic turns from Group 3 (G3), with dimension and skill annotations.

The raters were able to achieve 86.6% exact agreement on the dimensions: argumentation, collaboration, and other; the weighted quadratic kappa was .82. The raters discussed all the cases for which they initially had different codes and resolved the differences.

Procedure

Students participated in the study through their home computers during after-school hours. Each student was assigned to one of nine groups based on the student's availability, with four people per group (with a researcher participating in G4

Table 1 Overview of the Dialogue Analysis Framework

Skill	Description	Sample dialogue
Argumentation skill		
Invite reasoning or elaboration	Invite others to respond critically to ideas, perspectives, or problems.	Can you give more evidence?
Provide/elaborate/discuss reasons	Provide/elaborate/discuss reasons for the position or make reasoning explicit through elaboration.	Eating too much junk food can lead to childhood obesity.
Provide/discuss evidence	Provide/discuss evidence to support one's or others' arguments.	In the article, it says junk food doesn't satisfy most people's hunger, which leads to overeating and, eventually, obesity.
Raise counterarguments/challenges	Raise counterarguments or challenges. This can be done by asking a critical question.	Couldn't you just limit the junk food they eat?
Respond to a counterargument	Respond to a counterargument or challenge; answer a critical question.	Although a little junk food isn't that bad at that moment, it starts to add up if students eat it regularly at school.
Simple agreement	Express agreement with an argument or an opinion.	I agree.
Simple disagreement	Express disagreement with an argument or an opinion.	I don't think so.
Express uncertainty	Express uncertainty with an argument or an opinion.	I am not sure about this argument.
Express one's opinion	Express one's opinion on the issue; one may or may not have a reason.	Oh, well, I'm still going to eat chips.
Evaluate arguments	Evaluate whether an argument is strong or weak.	It's possibly weak because most junk foods aren't good for you. So if there's the minority that is good for you, it wouldn't really be.
Offer a solution	Offer a solution to resolve a conflict.	We can sell junk food, but we have to find healthier options and limit the amount of junk food a student can have per day.
Refer to the article	Point out information from a source article (textual citation).	In the CON article, it states that too much junk food can lead to gum disease and cavities.
Collaboration skill		
Coordinate with teammate	Coordinate with a teammate about responsibilities in the collaborative task, task progress, and satisfaction.	Do you want to type the next reason?
Clarify task	Clarify the task (what they are supposed to do).	I believe that we need to fill the argument table out.
Build communication	Communicate with teammates in a way that builds a sense of harmony, closeness, and trust.	Thank you. / Nice job! / No worries.
Share task response	Share task responses on the comprehension questions with teammates.	For the first question, my answer is, according to the article, one example of a healthy drink is orange juice.
Express confusion	Express confusion/frustration or a lack of understanding.	It's confusing.
Read aloud the text	Read aloud the articles, questions, or information.	"According to the article, what are some of the health risks besides obesity that junk food contributes to?" [Reading aloud the question to teammates]

Note. Additionally, there were two codes for discussions related to technology issues (problems) and off-topic chats.

Table 2 A Dialogue Annotation Example

Student	Dialogue	Dimension	Skill
S10	All right. Here we go. And now we should read the instructions.	Collaboration	Clarification
S12	Hello, we are reunited, back to our group! Hello.	Collaboration	Communication
S11	Hello, hi you guys! Welcome back.	Collaboration	Communication
S12	I will read this. [Read aloud the introduction of the group activity to the group]	Collaboration	Read aloud
S9	Who would like to start?	Collaboration	Coordination
…	…	…	…
S12	Yeah, so, maybe it gives more money, you get a food that people like, and it doesn't affect the kids. So school gets money, and kids' oral health is OK.	Argumentation	Reason
S10	I agree with that.	Argumentation	Agreement
S12	They should probably get like, you know, how apple juice instead of soda or something. Apple juice is good, and we like sugar, and it's probably natural sugar. Soda has 15 grams.	Argumentation	Reason
S10	Yeah, or like orange juice.	Argumentation	Reason

Note. S = student.

and G5 due to unexpected absences of students). First, students watched a brief video tutorial to learn how to use EPCAL during the critical discussion. The tutorial explained the key functions in EPCAL, including sending text messages, setting up microphones to talk to each other, and using the "take control/release control" button to complete collaborative tasks. Then they logged on to the platform and participated in the online critical discussion activity.

Session duration was set at a maximum of 2 hours. The researchers directed some groups to stop when time ran out. G1 and G7 participated in second sessions to complete all the tasks because these students had more common available time during the study time frame and agreed to complete all the remaining tasks. After the EPCAL activity, students completed an online survey, then participated in a brief interview via Zoom. Researchers observed students' actions on Zoom during the activity and provided supports when necessary.

Data Analysis

To answer RQ1, we counted the number of dialogic turns (including both text-based chats and the transcribed oral communications) for each group and each participant per session. For RQ2, we computed the percentages of argumentation codes, collaboration codes, and other codes for each group. Sample discussions were selected to illustrate the two contrasting patterns of group interactions. For RQ3, we identified which groups considered both sides of the junk food issue in their team solution. For RQ4, we computed the percentage of students who agreed or disagreed with each survey item.

Results

Research Question 1

The groups had different interaction patterns in the critical discussion activity, as Figure 2 shows. The total number of dialogic turns ranged from 41 to 688 per session. Five groups communicated with each other exclusively or mostly through text-based messages, and four groups talked to each other exclusively or mostly through the audio. G3, with the most dialogic turns, used a combination of both methods because one student's microphone did not work. The groups that used the audio function interacted more frequently than the groups relying on text-based chats.

Furthermore, individual students' participation varied greatly, with the number of dialogic turns ranging from 3 to 228 (see Figure 3). Thirteen students talked directly to their teammates, whereas the rest relied solely or mostly on text-based messages. Students who talked through the audio interacted more frequently than those who sent text messages, except for Student 3 (S3). Most groups had one or two students with less participation in the conversation. In contrast, G4 and G6 had relatively balanced participation, with everyone contributing to at least 20% of the group dialogue. These results show that students had different patterns of engagement in the critical discussion activity.

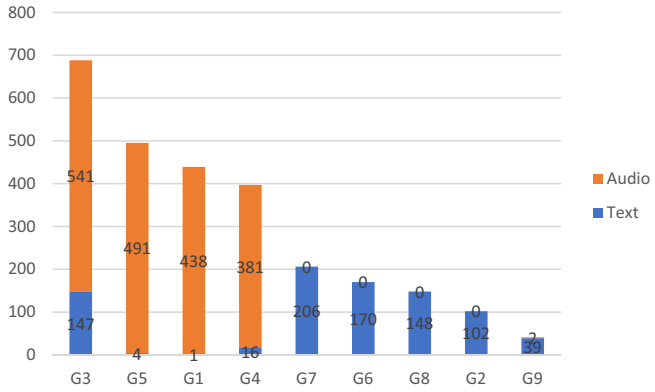

Figure 2 Group interaction patterns per session by dialogic turns per session. G = group.

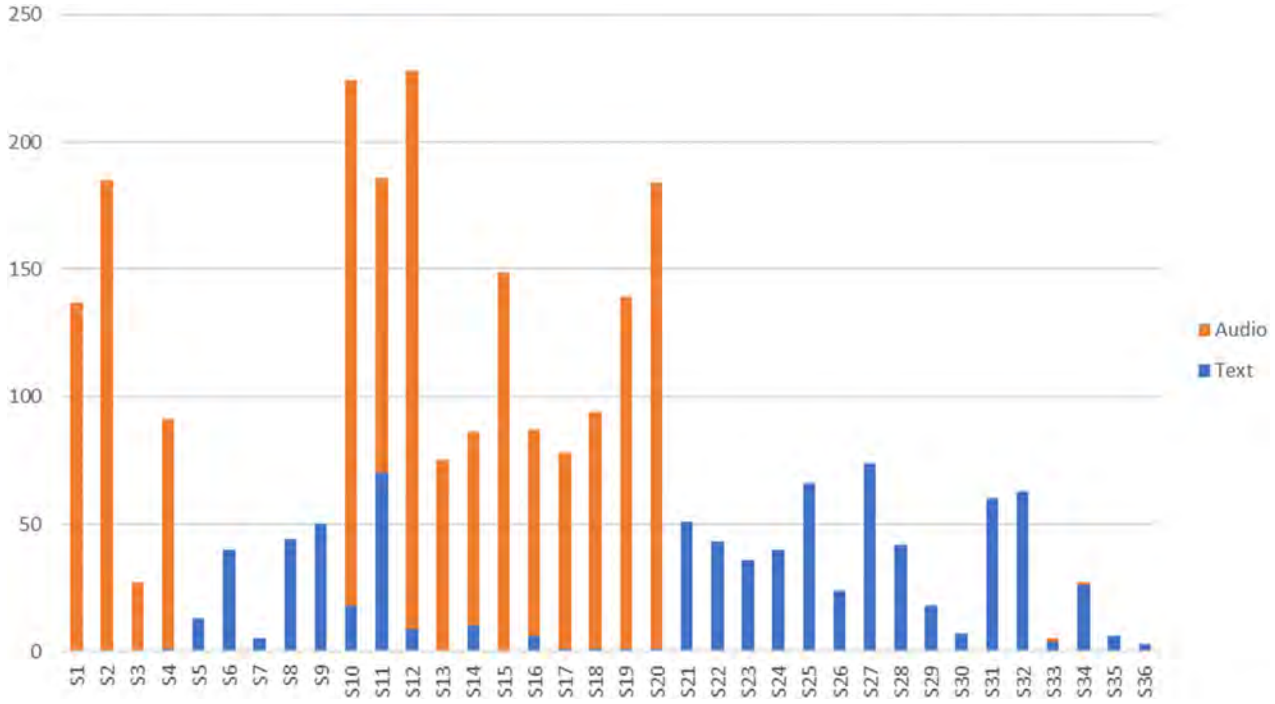

Figure 3 Individual participation in the critical discussion activity. Note that S16 and S18 were the researcher. S = student.

Research Question 2

Our dialogue analysis revealed that the groups had different engagement levels with argumentation (see Table 3). About half of the dialogues (more than 200 dialogic turns) in G4 and G5 were focused on discussing the arguments about allowing or banning junk food (note that these two groups had a researcher serving as the fourth participant). In contrast, G2 and G9 produced less than 10% responses coded as argumentative discourse. Most of their conversations were to coordinate with their teammates about task responsibilities and processes, and these groups also had the fewest dialogic turns. Between 25% and 37% of the dialogue responses of the remaining groups were coded as argumentative. G2 and G6 had some technology issues, so 19% and 24% of their conversations fell into the "other" category, respectively, whereas G1 had a considerable number of off-topic discussions because two students who were good friends happened to be partners. Individual students' engagement in argumentation also varied greatly within and across groups (see Figure 4). Whereas three students (from G2 and G9) did not have any argument-related conversations, eight students (from G1, G3, G4, and G5) made 50 or more argumentative statements.

Table 3 Dialogues Focused on Argumentation and Collaboration

Group	No. of codes	Argumentation (%)	Collaboration (%)	Other (%)
G1	445	28	53	19
G2	100	9	72	19
G3	695	25	65	10
G4	390	53	39	8
G5	512	47	50	3
G6	173	28	48	24
G7	211	36	49	15
G8	148	37	61	2
G9	41	7	85	8

Note. The number of codes can be slightly higher than the number of dialogic turns because a small proportion of dialogues were assigned more than one code. Groups 1 and 7 used the average number of codes of two sessions. G = group.

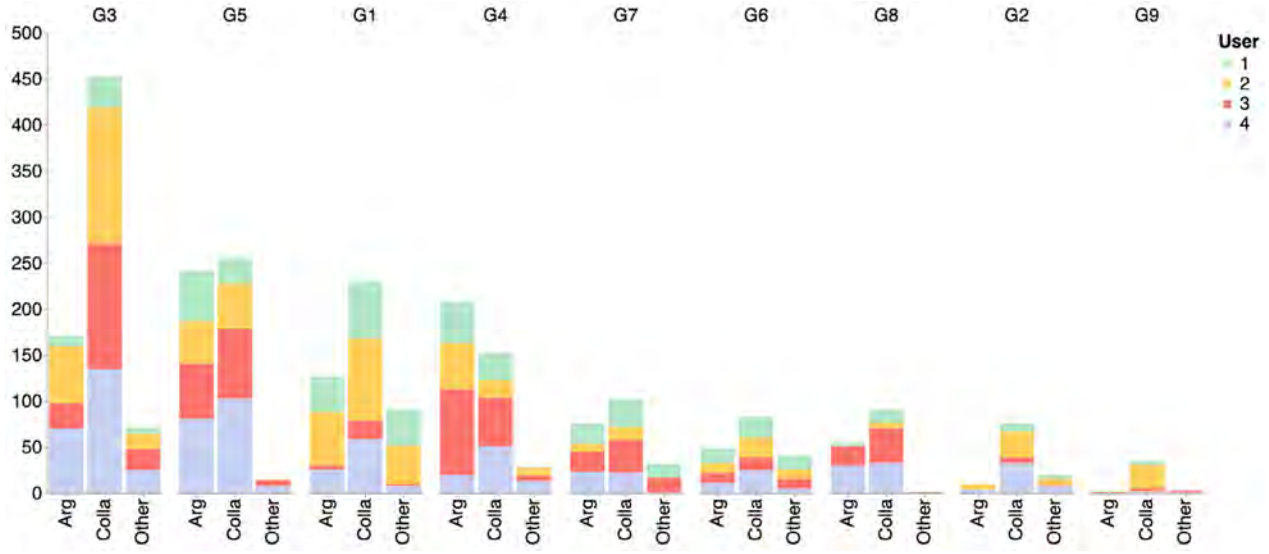

Figure 4 Individual students' dialogue contributions to argumentative and collaborative discourse. G = group.

Table 4 provides an example discussion from G9. This group had limited conversation, and it was mostly about clarifying the task (e.g., "what are we writing for the boxes," "are we doing all of these") and coordinating with teammates to take turns fulfilling individual responsibilities (e.g., "who's typing," "who wants to answer the next one"). There was not much argument-related dialogue in this group; this group was not engaged in resolving the differences of opinion. In other words, they did not take the opportunity to collaboratively explore and understand the controversial issue.

In contrast, the excerpt in Table 5 illustrates argumentative engagement in the critical discussion. Three students in G4 were evaluating a reason to determine whether it was a weak reason or a strong reason. S13 and S15 thought that the argument "they usually end up eating junk food outside of school" was strong, whereas S14 perceived it as weak. They not only offered their opinion but also provided justifications for their evaluation; when challenged, they fulfilled their obligation to justify their reasoning in the critical discussion. We saw a more constructive and respectful exchange of arguments in this group.

Research Question 3

In total, five groups (G1, G3, G4, G5, G7) completed the team solution task, and these groups offered a solution that clearly showed their consideration of both the pro and con sides of the junk food issue. For example, G4 offered a dual-perspective solution, demonstrating their understanding of both the benefits and the drawbacks of selling junk food in schools:

Table 4 Group 9 Team Coordination

Student	Dialogue (text)
S32	what are we writing for the boxes
S31	strengths and weaknesses
S31	whos typing
S32	idk
S30	not me
S32	who wants to answer the next one
S31	wait are we doing all of these
S29	TAKE. CONTROL.
S31	who
S32	i can lol

Note. S = student.

Table 5 Group 4 Evaluate Arguments

Student	Dialogue (audio)
S15	"They usually end up eating junk food outside of school." I personally think that's sort of a weak reason because instead of encouraging students to eat junk food even more, if schools sell healthy food, then that will ensure that kids eat healthy food, at least in one part of the day instead of always eating junk food.
S14	I think it's a strong argument, because when you think about it, most kids would rather eat junk food than healthy food. So if schools sell healthy food, they would most likely just not eat.
S15	No, but I still think if they didn't have a choice, they would rather eat healthy food than not eat any food at all.
S14	Most kids probably just wait until they get home.
S15	S13. What do you think?
S13	I think that they should be able to find healthy foods that they like. So, I think it's a weak reason too, because like I personally like there are some healthy foods I like, but there's some that I don't. So like people should be able to choose from whichever one like they like better, and they should like they should know that they should probably pick the healthy food, instead of the junk food.

Note. S = student.

> We believe that junk food should be able to be sold, but it has to be limited, and schools need many more healthy options that are appealing. Junk food provides a steady income for schools because it is an effective way for making money, but if we have too much junk food, then students will pick that over healthy food, which is very bad for their health. Without limitations, junk food can cause serious health problems, so if schools limit what kids [can have] at school, that will help with their overall health.

Similarly, G7 integrated both sides in their solution by raising the idea of schools educating students on the importance of eating healthily while allowing them to have a limited amount of junk food:

> Schools should sell a limited amount of junk food. They should also provide healthy options, and educate the kids on the importance of eating healthy and the health risks of eating too much junk food. There should be a well-balanced meal and there should be limits to how much junk food a kid can buy. The reason why our solution has more strengths than weaknesses is because having a strict diet as a child isn't fun and can lead to binge eating. At the same time allowing kids to eat whatever they want is not the answer. So having well-balanced meals can allow children to have sweets while also having some nutritious food.

Research Question 4

All 34 students completed a brief online survey. The survey results suggest an overall positive experience with the activity, with the mean scores for all survey items falling between 3 (*agree*) and 4 (*strongly agree*). Roughly 88% of the students agreed or strongly agreed that the EPCAL platform was easy to use; 97% agreed or strongly agreed that junk food was an interesting discussion topic and that the source texts were easy to understand. All the students agreed or strongly agreed that the source texts helped them develop arguments on the junk food issue and that they tried to understand both sides of

the issue, listened to each other, and took turns in the critical discussion. They all said that they tried their best to complete the task. More than 90% of the students agreed or strongly agreed that they would like to do this type of activity again.

In the follow-up interviews, 62% of the students said that their favorite part of the EPCAL activity was working with others; 47% appreciated the opportunity to question the opposing side and to respond to counterarguments. Although 65% of the students stated that nothing was difficult, three students reported that the "take control" button was confusing at the beginning (the button was designed for students to take turns entering their responses in the collaborative tasks), and another three students commented that they were not sure how to navigate the tables when working together, but all of them later figured out how these functions worked. Suggestions from students included enabling multiple people to have control simultaneously, allowing them to mute themselves in EPCAL, and increasing the font size of the texts.

Among the 24 students who responded, nine said that they had not done a similar activity in school, and 15 students mentioned that they had done similar collaborative activities in their school in various formats, including large-group discussions; classroom debates; and online, small-group discussions using breakout rooms. However, these students also pointed out that the EPCAL activity is a somewhat different experience than their school activities. For example, one student said, "We've done activities where we read articles and then found reasons and evidence and sort of debated with each other on it, but we haven't really done any of these online or in this specific format." Another student commented,

> I also enjoyed this, because I've done similar things in school, but it's different when it's just like a small group than in school when it's like 20 people who basically all have their own different rendition of the same exact thing. We'd have like half the class together in a breakout room. This is like all arguing with each other because some people just wouldn't be calm.

Discussion

The extant literature supports the efficacy of the dialogic approach to argumentation (Iordanou & Kuhn, 2020; Johnson, 2015). As Ehrenworth (2017) pointed out, "there has never been a more important time to teach young people to suspend judgment, weigh evidence, consider multiple perspectives, and speak up with wisdom and grace on behalf of themselves and others" (p. 35). Additionally, there is a growing body of literature about the potential affordances of technology-supported collaborative learning environments for argumentation (e.g., Noroozi et al., 2018; Noroozi et al., 2012; Scheuer et al., 2010; Schwarz & Glassner, 2007). The work reported here specifically focused on a computer-supported collaborative argumentation activity that was designed to support the development of middle school students' argumentation skills.

In the critical discussion context, students share a common goal of resolving differences of opinion rather than winning the debate in the competitive type of context found in other studies of dialogic argumentation (see Iordanou & Rapanta, 2021; van Eemeren & Grootendorst, 2004). In our study, students were encouraged to cooperate to develop evidence-based arguments and follow the critical standards to evaluate arguments from both perspectives. The critical discussion activity was supported by the EPCAL platform, which has substantive and methodological advantages. The platform enabled students to communicate in oral and chat modes about the collaborative tasks in pairs and in small groups; it also automatically collected their dialogues, text messages, and written responses.

We conducted this feasibility study with 34 middle school students to explore their argumentative discourse and collaborative behaviors in the critical discussion activity and to collect their feedback on the platform and activity design for future improvements. Analyses of discourse data showed an overall positive experience and revealed a range of participation in the critical discussion activity by group and by individual students. More students used text-based communications than audio, but the students who used the audio function interacted with each other more frequently. Prior research investigating modes of communication revealed that people interact more often when they talk directly compared to sending text-based messages in a collaborative environment (e.g., Kerr & Murthy, 2009). It may also have been easier for students to talk directly with each other, instead than typing, because keyboarding places an additional burden on the cognitive resources needed to communicate, that is, retrieving the appropriate letters and holding them in memory as well as learning the locations of the keys and utilizing movement patterns and keystrokes (Feng et al., 2019). However, making both communication modes available may be beneficial to students who prefer using the text-based chat.

We analyzed task responses and annotated students' dialogues to gain insight into their argumentation skills and engagement in the activity. We found that the groups and students varied not only in terms of number of dialogic turns

Table 6 Group 4 Dialogue Between the Researcher and Student 14

Speaker	Dialogue (audio)
Researcher	We need evidence.
S14	Yeah.
Researcher	Can you point me to any evidence that article mentions?
S14	Um, it says in the article, in the first paragraph that recent research shows that harmful bacteria produce acid in your mouths whenever they digest sugar, and then those acids remove minerals from tooth enamel, which is the shiny protective outer layer of your tooth, and it causes tooth decay.
Researcher	That's right. Thank you very much. This is very helpful.

Note. S = student.

but also in the dialogue content. Whereas some groups engaged in arguments about the junk food issue, other groups had barely any arguments about this topic; rather, they communicated mainly for the purpose of coordinating task-completion responsibilities among the teammates, for example, taking turns filling in individual responses. Such an interaction pattern indicated a surface level of collaboration and limited engagement in critical discussion. Multiple factors could have contributed to the lack of engagement, such as low motivation, poor collaboration skills, no prior experience in critical discussion, and unexpected technical problems (e.g., microphone disfunctions and loading issues). In addition, social loafing (also called *diffusion of responsibility*; Karau & Williams, 1993) may occur when students believe that someone else in the group will complete the task.

The two groups with the most argumentative discourse included a researcher as one of the participants due to unexpected absences of students. The researcher not only knew EPCAL's design features but also possessed expertise about argumentative discourse. The researcher helped solve technical problems and directed students' attention to completing tasks and cooperating during the critical discussion. For example, in the dialogue shown in Table 6, the researcher prompted the student (in G4) to find relevant evidence from the article and provided positive feedback to engage the student in the activity. When waiting for the other pair to finish a particular task, the researcher initiated a task-focused conversation with the student with whom she worked in G5, which provided an opportunity for the student to further elaborate his reasoning on the junk food issue (see Table 7 for the sample dialogue). These findings highlight the value of expert guidance when novices engage problem-solving activities (e.g., Collins et al., 1991).

Although the results from this feasibility study are tentative, it is promising that some students proposed a team solution that integrated both sides of the junk food issue and resolved the difference of opinions at the end of their critical discussion. This shows that such an environment encourages students to consider arguments from different perspectives, refine their understanding of an issue, and thus reduce my-side bias in approaching a controversial issue. As Ehrenworth (2017) pointed out, students need to learn to suspend judgment, weigh evidence, and consider multiple perspectives, because thoughtful arguments rely on evidence-based reasoning and require an understanding of different perspectives. As a result of thoughtful arguments, the multifaceted nature of issues emerges as people propose solutions, defend their ideas, and explore alternative viewpoints (Malloy et al., 2020).

Overall, the survey and interview results indicate that most students were motivated to complete the task, appreciated the opportunity to explore both sides of the junk food issue, and enjoyed discussing the arguments with their teammates. Although some students had experience with collaborative discussion activities in their schools, they acknowledged the merits of technology (e.g., easy to use, supporting small-group discussion) that was developed to support collaborative argumentation. These findings suggest that technology-supported collaborative argumentation activities can be implemented in the classroom to provide opportunities for students to develop their argumentation skills. However, additional functions and features may be needed for successful implementation of this activity in a classroom, including functionality that enables the teacher to monitor several groups' participation.

Limitations and Potential Improvements

As the first step of a large project, we conducted this small-scale study to evaluate the usability and appeal of an online, collaborative critical discussion activity with small groups of middle school students. One limitation of the convenience sample of students who participated was that all had relatively good reading and writing skills, whereas a sample that was representative of the general population would be much more heterogeneous in skill. These participants did not perceive

Table 7 Group 5 Dialogue Between the Researcher and Student 17

Speaker	Dialogue (audio)
Researcher	What's your belief? Do you think it should be banned or allow junk food?
S17	I think it depends, which is such a ridiculous answer, but I think it depends on what it is like. I don't think you should sell ice cream in school, but I think having like a pizza is fine. Having maybe like a bag of chips in there is fine, I think. But like having super unhealthy things that really can't have any kind of benefit is not the greatest idea.
Researcher	Uh-huh.
S17	Put down your popcorn or pizza as a lunch is fine, but I think you should also have a side salad with it. That's free if you buy the lunch that you get a pizza You get a salad with it. I think that's a good idea. But I think it depends on what you're selling.
Researcher	Yeah, interesting. I think it's hard to decide which ones are junk food and which ones are not for some food. There are gray areas. They have nutrients or some values.
S17	Yeah, yeah.
Researcher	And if you don't eat too much, it's probably fine.
S17	Yeah, I think you could have, like most schools do, like pizza on Fridays and that's a good idea. And the rest of the week you have more healthy options. And then, usually after some schools, sell a snack option and you can go up and buy extra things if you have money. And I think that's really what they're like talking about. And then like some schools, you can buy ice cream. Some schools you can buy like a pretzel. And I think selling ice cream is too much, but a pretzel, I think that could be fine. You know, even some people might consider that junk food, but you never know. I think that's better than selling ice cream.
Researcher	Right. OK. Yeah, I heard of that. Some schools offer ice cream and chips. If you pay extra money, you can get those. I think one possible impact if kids only eat those items, and they don't eat the lunches the school provides.
S17	I could see that.

Note. S = student.

difficulties in reading and writing, but students with poor reading and writing skills may experience challenges. Future studies will include a more heterogeneous group of middle school students with varying levels of academic achievement.

A second limitation concerned running the study in a single, 2-hour session. Most groups were not able to complete all the tasks in the critical discussion during this restricted period because they needed time to read the articles, exchange ideas with their teammates, and write and refine their task responses. Two groups participated in a second session to complete all the tasks because these students had additional common available time during the study time frame. The availability and willingness of these students to participate in additional sessions could have been influenced by factors such as higher motivation levels, greater interest in the subject matter, or more flexible schedules, which may have impacted their performance and engagement in the study. Thus a full cycle of critical discussion may require multiple class periods in an actual classroom, which would provide students sufficient time to learn the rules of discourse and the platform functionality and then to discuss the issues with each other and generate their task responses without rushing.

Additionally, owing to unexpected absences of two students, two groups had a researcher as the fourth participant in the critical discussion activity. Although this change might have impacted group interactions, the students' behavior in the groups that involved the researcher's participation suggests that collaborative activities should be monitored by the teacher or a more knowledgeable adult to be successful (Webb et al., 2002). The most effective moves made by a teacher in collaborative reasoning are prompting for relational thinking and reasoning, including logical reasoning, counterargument, alternative hypothesis, elaboration, and clarification (Lin et al., 2015). The teacher can ask questions that prompt students to justify their arguments and complete specific steps in the protocol. Illustrative questions include the following:

- Can you add more reasons?
- Why are some reasons better than other reasons?
- Is there any evidence for this?
- Why is this evidence relevant?
- Did your opponent use any evidence for their argument?
- Can you come up with a strong counterargument?

Further, instructional activities that help students develop knowledge about high-quality arguments and collaborative reasoning may improve engagement in the critical discussion activities.

Last, there were challenges related to remote implementation of the study during the COVID-19 pandemic. It was difficult to provide technical support remotely, and students used their own devices and might not have set up the devices according to our requirements. Four students' microphones did not work during the study, so they were not able to participate through audio. Furthermore, compared to a face-to-face situation, it was more difficult to monitor students and observe their participation online. We used Zoom to communicate with students after the fact; however, using Zoom during the activity could be interruptive. Therefore we have designed a teacher dashboard for future work that will include two critical functions that allow teachers to (a) assign students to groups easily and (b) monitor critical discussion of student groups in a well-organized structure. With the insights gained from this feasibility study, we are now better prepared to refine and implement the EPCAL critical discussion activity in classroom environments.

Conclusion

Dialogic interactions encourage students to consider multiple perspectives about controversial issues and thus facilitate the development of argumentation and perspective taking. However, students need supports to truly engage in the argumentative discourse. This feasibility study helped us understand the interaction patterns of middle school students as well as the challenges they experienced during the online critical discussion activity. We formed initial ideas of supports that can be used to engage students in online collaborative argumentation. Using the information gathered, we resolved minor technology issues and refined the activity to create a better collaborative learning environment for students to engage in critical discussion. The critical discussion activity will be implemented in schools to allow us to understand how teachers support students with varying abilities in collaborative argumentation. Synthesizing the literature along with our data, we developed a conceptual framework for dialogue analysis that focused on argumentation and collaboration skills. In the next steps, we will collect further empirical data to evaluate and refine this framework.

Acknowledgments

This research was supported by a U.S. Department of Education Institute of Education Sciences award (award R305A190242) to Educational Testing Service and subawards to the University of Delaware and the University of Memphis. The opinions expressed are those of the authors and do not represent views of the U.S. Department of Education, Educational Testing Service, the University of Delaware, or the University of Memphis.

References

Anderson, R. C., Nguyen-Jahiel, K., McNurlen, B., Archodidou, A., Kim, S.-Y., & Reznitskaya, A. (2001). The snowball phenomenon: Spread of ways of talking and ways of thinking across groups of children. *Cognition and Instruction*, *19*(1), 1–46. https://doi.org/10.1207/S1532690XCI1901_1

Andrade, H. L., & Bouley, B. (2003). Role of rubric-referenced self-assessment in learning to write. *Journal of Educational Research*, *97*(1), 21–34. https://doi.org/10.1080/00220670309596625

Andrews-Todd, J., & Forsyth, C. M. (2020). Exploring social and cognitive dimensions of collaborative problem solving in an open online simulation-based task. *Computers in Human Behavior*, *104*, Article 105759. https://doi.org/10.1016/j.chb.2018.10.025

Andrews-Todd, J., Jackson, J. T., & Kurzum, C. (2019). *Collaborative problem solving assessment in an online mathematics task* (Research Report No. RR-19-24). ETS. https://doi.org/10.1002/ets2.12260

Andriessen, J., & Baker, M. (2014). Arguing to learn. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 439–460). Cambridge University Press. https://doi.org/10.1017/CBO9781139519526.027

Asterhan, C. S. C., & Schwarz, B. B. (2009). Transformation of robust misconceptions through peer argumentation. In B. B. Schwarz, T. Dreyfus, & R. Hershkowitz (Eds.), *Guided transformation of knowledge in classrooms* (pp. 159–172). Routledge.

Baker, M., Andriessen, J., Lund, K., Van Amelsvoort, M., & Quignard, M. (2007). Rainbow: A framework for analyzing computer-mediated pedagogical debates. *International Journal of Computer-Supported Collaborative Learning*, *2*(3), 315–357. https://doi.org/10.1007/s11412-007-9022-4

Baker, M. N., Wegerif, R., & Major, L. (2019). Collaborative argumentation-based learning. In N. Mercer, R. Wegerif, & L. Major (Eds.), *The Routledge international handbook on dialogic education* (pp. 76–88). Routledge. https://doi.org/10.4324/9780429441677-8

Brinkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). Defining twenty-first century skills. In *Assessment and teaching of 21st century skills* (pp. 17–66). Springer. https://doi.org/10.1007/978-994-007-2324-5_2

Chalkiadaki, A. (2018). A systematic literature review of 21st century skills and competencies in primary education. *International Journal of Instruction*, *11*(3), 1–16. https://doi.org/10.12973/iji.2018.1131a

Coiro, J., Sparks, J. R., Kiili, C., Castek, J., Lee, C., & Holland, B. R. (2019). Students engaging in multiple-source inquiry tasks: Capturing dimensions of collaborative online inquiry and social deliberation. *Literacy Research: Theory, Method, and Practice*, *68*(1), 271–292. https://doi.org/10.1177/2381336919870285

Collins, A., Brown, J. S., & Holum, A. (1991). Cognitive apprenticeship: Making thinking visible. *American Educator*, *15*(3), 6–11, 38–46.

Council of Chief State School Officers & National Governors Association. (2010). *Common Core State Standards for English language arts and literacy in history/social studies, science, and technical subjects*.

Deane, P., & Song, Y. (2015). *The key practice, "Discuss and debate ideas": Conceptual framework, literature review, and provisional learning progressions for argumentation* (Research Report No. RR-15-33). ETS. https://doi.org/10.1002/ets2.12079

Dowell, N. M. M., Lin, Y., Godfrey, A., & Brooks, C. (2020). Exploring the relationship between emergent sociocognitive roles, collaborative problem-solving skills, and outcomes: A group communication analysis. *Journal of Learning Analytics*, *7*(1), 38–57. https://doi.org/10.18608/jla.2020.71.4

Dubé, A. K., & Wen, R. (2022). Identification and evaluation of technology trends in K–12 education from 2011 to 2021. *Education and Information Technologies*, *27*, 1929–1958. https://doi.org/10.1007/s10639-021-10689-8

Ehrenworth, M. (2017). Why argue? *Educational Leadership*, *74*(5), 35–40. https://doi.org/10.1177/1086296X19896495

Erkens, G., Jaspers, J., Prangsma, M., & Kanselaar, G. (2005). Coordination processes in computer supported collaborative writing. *Computers in Human Behavior*, *21*(3), 463–486. https://doi.org/10.1016/j.chb.2004.10.038

Felton, M., & Kuhn, D. (2001). The development of argumentive discourse skills. *Discourse Process*, *32*(2–3), 135–153. https://doi.org/10.1080/0163853X.2001.9651595

Feng, L., Lindner, A., Ji, X. R., & Joshi, R. M. (2019). The roles of handwriting and keyboarding in writing: A meta-analytic review. *Reading and Writing*, *32*(1), 33–63. https://doi.org/10.1007/s11145-017-9749-x

Ferretti, R. P., & Lewis, W. E. (2019a). Knowledge of persuasion and writing goals predict the quality of children's persuasive writing. *Reading and Writing*, *32*, 1411–1430. https://doi.org/10.1007/s11145-018-9918-6

Ferretti, R. P., & Lewis, W. E. (2019b). Teaching argumentative writing. In S. Graham, C. A. MacArthur, & M. Hebert (Eds.), *Best practices in writing instruction* (2nd ed., pp. 135–161). Guilford Press.

Ferretti, R. P., Lewis, W. E., & Andrews-Weckerly, S. (2009). Do goals affect the structure of students' argumentative writing strategies? *Journal of Educational Psychology*, *101*(3), 577–589. https://doi.org/10.1037/a0014702

Ferretti, R. P., MacArthur, C. A., & Dowdy, N. S. (2000). The effects of an elaborated goal on the persuasive writing of students with learning disabilities and their normally achieving peers. *Journal of Educational Psychology*, *92*(4), 694–702. https://doi.org/10.1037/0022-0663.92.4.694

Gil, L., Braaten, I., Vidal-Abarca, E., & Strømsø, H. I. (2010). Summary versus argument tasks when working with multiple documents: Which is better for whom? *Contemporary Educational Psychology*, *35*(3), 157–173. https://doi.org/10.1016/j.cedpsych.2009.11.002

Goldstein, M., Crowell, A., & Kuhn, D. (2009). What constitutes skilled argumentation and how does it develop? *Informal Logic*, *29*(4), 379–395. https://doi.org/10.22329/il.v29i4.2905

Hao, J., Liu, L., von Davier, A. A., Lederer, N., Zapata-Rivera, D., Jkal, P., & Bakkenson, M. (2017). *EPCAL: ETS Platform for Collaborative Assessment and Learning* (Research Report No. RR-17-49). ETS. https://doi.org/10.1002/ets2.12181

Hemberger, L., Kuhn, D., Matos, F., & Shi, Y. (2017). A dialogic path to evidence-based argumentive writing. *Journal of the Learning Sciences*, *26*(4), 575–607. https://doi.org/10.1080/10508406.2017.1336714

Hennessy, S., Rojas-Drummond, S., Higham, R. A., Màrquez, M., Maine, F., Ríos, R. M., GarcíaCarrìòn, R., Torreblanca, O., & Barrera, M. J. (2016). Developing a coding scheme for analysing classroom dialogue across educational contexts. *Learning, Culture, and Social Interaction*, *9*, 16–44. https://doi.org/10.1016/j.lcsi.2015.12.001

Hmelo-Silver, C. E., Chinn, C. A., Chan, C. C., & O'Donnell, A. M. (2013). *The international handbook of collaborative learning*. Routledge. https://doi.org/10.4324/9780203837290

International Society for Technology in Education. (2007). *National educational technology standards for students: The next generation* (ED497527). ERIC. https://eric.ed.gov/?id=ED497527

Iordanou, K., & Kuhn, D. (2020). Contemplating the opposition: Does a personal touch matter? *Discourse Process*, *57*(4), 343–359. https://doi.org/10.1080/0163853X.2019.1701918

Iordanou, K., & Rapanta, C. (2021). "Argue with me": A method for developing argument skills. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.631203

Johnson, D. W. (2015). *Constructive controversy: Theory, research, practice*. Cambridge University Press. https://doi.org/10.1017/CBO9781316105818

Johnson, D. W., & Johnson, R. (2007). *Creative constructive controversy: Intellectual challenge in the classroom* (4th ed.). Interaction. https://doi.org/10.2139/ssrn.1298645

Karau, S. J., & Williams, K. D. (1993). Social loafing: A meta-analytic review and theoretical integration. *Journal of Personality and Social Psychology*, *65*(4), 681–706. https://doi.org/10.1037/0022-3514.65.4.681

Kerr, D. S., & Murthy, U. S. (2009). The effectiveness of synchronous computer-mediated communication for solving hidden-profile problems: Further empirical evidence. *Information and Management*, *46*(2), 83–89. https://doi.org/10.1016/j.im.2008.12.002

Klaczynski, P. (2000). Motivated scientific reasoning biases, epistemological beliefs, and theory polarization: A two-process approach to adolescent cognition. *Child Development*, *71*(5), 1347–1366. https://doi.org/10.1111/1467-8624.00232

Kuhn, D., & Crowell, A. (2011). Dialogic argumentation as a vehicle for developing young adolescents' thinking. *Psychological Science*, *22*(4), 545–552. https://doi.org/10.1177/0956797611402512

Kuhn, D., Goh, W., Iordanou, K., & Shaenfield, D. (2008). Arguing on the computer: A microgenetic study of developing argument skills in a computer-supported environment. *Child Development*, *79*(5), 1310–1328. https://doi.org/10.1111/j.1467-8624.2008.01190.x

Kuhn, D., & Udell, W. (2007). Coordinating own and other perspectives in argument. *Thinking and Reasoning*, *13*(2), 90–104. https://doi.org/10.1080/13546780600625447

Leitão, S. (2003). Evaluating and selecting counterarguments: Studies of children's rhetorical awareness. *Written Communication*, *20*(3), 269–306. https://doi.org/10.1177/0741088303257507

Lin, T.-J., Anderson, R. C., Hummel, J. E., Jadallah, M., Miller, B., Nguyen-Jahiel, K., Morris, J. A., Kuo, L.-J., Kim, I.-H., Wu, X., & Dong, T. (2012). Children's use of analogy during collaborative reasoning. *Child Development*, *83*(4), 1429–1443. https://doi.org/10.1111/j.1467-8624.2012.01784.x

Lin, T.-J., Jadallah, M., Anderson, R. C., Baker, A. R., Nguyen-Jahiel, K., Kim, I.-H., Kuo, L.-J., Miller, B. W., Logis, H. A., Dong, T., & Wu, X. (2015). Social influences on children's development of relational thinking during small-group discussions. *Contemporary Educational Psychology*, *41*, 83–97. https://doi.org/10.1016/j.cedpsych.2014.12.004

Liu, L., von Davier, A. A., Hao, J., Kyllonen, P., & Zapata-Rivera, J.-D. (2016). A tough nut to crack: Measuring collaborative problem solving. In Y. Rosen, S. Ferrara, & M. Mosharraf (Eds.), *Handbook of research on computational tools for real-world skill development* (pp. 344–359). IGI-Global. https://doi.org/10.4018/978-1-4666-9441-5.CH013

Lund, K., Molinari, J., Sejourne, A., & Baker, M. (2007). How do argumentation diagrams compare when student pairs use them as a means for debate or as a tool for representing debate? *International Journal of Computer-Supported Collaborative Learning*, *2*(2–3), 273–295. https://doi.org/10.1007/s11412-007-9019-z

Macagno, F., Mayweg-Paus, E., & Kuhn, D. (2015). Argumentation theory in education studies: Coding and improving students' argumentative strategies. *Topoi*, *34*, 523–537. https://doi.org/10.1007/S11245-014-9271-6

MacArthur, C. A. (2016). Instruction in evaluation and revision. In C. A. MacArthur, S. Graham, & J. Fitzgerald (Eds.), *Handbook of writing research* (2nd ed., pp. 272–287). Guilford Press.

Major, L., Warwick, P., Rasmussen, I., Ludvigsen, S., & Cook, V. (2018). Classroom dialogue and digital technologies: A scoping review. *Education and Information Technologies*, *23*, 1995–2028. https://doi.org/10.1007/s10639-018-9701-y

Malloy J. A., Tracy, K. N., Scales, R. Q., Menickelli, K., & Scales, W. D. (2020). It's not about being right: Developing argument through debate. *Journal of Literacy Research*, *52*(1), 79–100. https://doi.org/10.1177/1086296X19896495

Michaels, S., O'Connor, M. C., Hall, M. W., & Resnick, L. B. (2013). *Accountable Talk® sourcebook: For classroom conversation that works*. University of Pittsburgh Press.

Midgette, E., Haria, P., & MacArthur, C. (2008). The effects of content and audience awareness goals for revision on the persuasive essays of fifth- and eighth-grade students. *Reading and Writing*, *21*, 131–151. https://doi.org/10.1007/s11145-007-9067-9

Moore, N. S., & MacArthur, C. A. (2012). The effects of being a reader and of observing readers on fifth-grade students' argumentative writing and revising. *Reading and Writing*, *25*, 1449–1478. https://doi.org/10.1007/s11145-011-9327-6

Noroozi, O., Kirschner, P. A., Biemans, H. J. A., & Mulder, M. (2018). Promoting argumentation competence: Extending from first- to second-order scaffolding through adaptive fading. *Educational Psychology Review*, *30*(1), 153–176. https://doi.org/10.1007/s10648-017-9400-z

Noroozi, O., Weinberger, A., Biemans, H. J. A., Mulder, M., & Chizari, M. (2012). Argumentation-based computer supported collaborative learning (ABCSCL): A systematic review and synthesis of fifteen years of research. *Educational Research Review*, *7*(2), 79–106. https://doi.org/10.1016/J.EDUREV.2011.11.006

Nussbaum, E. M. (2008). Collaborative discourse, argumentation, and learning: Preface and literature review. *Contemporary Educational Psychology*, *33*(3), 345–359. https://doi.org/10.1016/j.cedpsych.2008.06.001

Nussbaum, E. M., & Edwards, O. V. (2011). Critical questions and argument stratagems: A framework for enhancing and analyzing students' reasoning practices. *Journal of the Learning Sciences*, *20*(3), 443–488. https://doi.org/10.1080/10508406.2011.564567

Nussbaum, M. E., & Kardash, C. M. (2005). The effects of goal instructions and text on the generation of counterarguments during writing. *Journal of Educational Psychology*, *97*(2), 157–169. https://doi.org/10.1037/0022-0663.97.2.157

O'Reilly, T., Sabatini, J., & Wang, Z. (2019). What you don't know won't hurt you, unless you don't know you're wrong. *Reading Psychology*, *40*(7), Article 7. https://doi.org/10.1080/02702711.2019.1658668

Reznitskaya, A., Anderson, R. C., & Kuo, L. J. (2007). Teaching and learning argumentation. *Elementary School Journal*, *107*(5), 449–472. https://doi.org/10.1086/518623

Rourke, L., & Kanuka, H. (2007). Barriers to online critical discourse. *International Journal of Computer-Supported Collaborative Learning*, *2*(1), 105–126. https://doi.org/10.1007/s11412-007-9007-3

Scheuer, O., Loll, F., Pinkwart, N., & McLaren, B. M. (2010). Computer-supported argumentation: A review of the state of the art. *International Journal of Computer-Supported Collaborative Learning*, *5*(1), 43–102. https://doi.org/10.1007/s11412-009-9080-x

Schwarz, B. B. (2018). Computer-supported argumentation and learning. In F. Fischer, C. E. Hmelo-Silver, S. R. Goldman, & P. Reimann (Eds.), *International handbook of the learning sciences* (pp. 318–329). Routledge. https://doi.org/10.4324/9781315617572

Schwarz, B. B., & Glassner, A. (2007). The role of floor control and of ontology in argumentative activities with discussion-based tools. *International Journal of Computer-Supported Collaborative Learning*, *2*(4), 449–478. https://doi.org/10.1007/s11412-007-9024-2

Song, Y., Chao, S.-F., & Attali, Y. (2020). Exploring the effect of a scaffolding design on students' argument critique skills. *Informal Logic*, *40*(4), 605–628. https://doi.org/10.22329/il.v40i4.6034

Song, Y., & Ferretti, R. P. (2013). Teaching critical questions about argumentation through the revising process: Effects of strategy instruction on college students' argumentative essays. *Reading and Writing*, *26*, 67–90. https://doi.org/10.1007/s11145-012-9381-8

Song, Y., van Rijn, P., Deane, P., & Chao, S-F. (2023). Assessing argumentation skills of middle school students: A learning progression approach. *Reading and Writing*, *37*, 103–127. https://doi.org/10.1007/s11145-022-10407-x

Soter, A. O., Wilkinson, I. A., Murphy, P. K., Rudge, L., Reninger, K., & Edwards, M. (2008). What the discourse tells us: Talk and indicators of high-level comprehension. *International Journal of Educational Research*, *47*(6), 372–391. https://doi.org/10.1016/j.ijer.2009.01.001

Sparks, J. R., & Deane, P. (2015). *Cognitively based assessment of research and inquiry skills: Defining a key practice in English language arts* (Research Report No. RR-15-35). ETS. https://doi.org/10.1002/ets2.12082

Van Amelsvoort, M., Andriessen, J., & Kanselaar, G. (2007). Representational tools in computer-supported collaborative argumentation-based learning: How dyads work with constructed and inspected argumentative diagrams. *Journal of the Learning Sciences*, *16*(4), 485–521. https://doi.org/10.1080/10508400701524785

Van Amelsvoort, M., Andriessen, J., & Kanselaar, G. (2008). How students structure and relate argumentative knowledge when learning together with diagrams. *Computers in Human Behavior*, *24*(3), 1293–1313. https://doi.org/10.1016/j.chb.2007.05.004

van Eemeren, F. H., Garssen, B., Krabbe, E. C. W., Snoeck Henkemans, A. F., Verheij, B., & Wagemans, J. H. M. (2014). *Handbook of argumentation theory*. Springer. https://doi.org/10.1007/978-90-481-9473-5

van Eemeren, F. H., & Grootendorst, R. (2004). *A systematic theory of the argumentation: The pragma-dialectical account*. Cambridge University Press. https://doi.org/10.1017/CBO9780511616389

Vogel, F., Wecker, C., Kollar, I., & Fischer, F. (2017). Socio-cognitive scaffolding with computer-supported collaboration scripts: A meta-analysis. *Educational Psychology Review*, *29*, 477–511. https://doi.org/10.1007/s10648-016-9361-7

Vrikki, M., Wheatley, L., Howe, C., Hennessy, S., & Mercer, N. (2019). Dialogic practices in primary school classrooms. *Language and Education*, *33*(1), 85–100. https://doi.org/10.1080/09500782.2018.1509988

Walton, D. N., Reed, C., & Macagno, F. (2008). *Argumentation schemes*. Cambridge University Press. https://doi.org/10.5860/choice.46-3777

Webb, N. M., Farivar, S. H., & Mastergeorge, A. M. (2002). Productive helping in cooperative groups. *Theory Into Practice*, *41*(1), 13–20. https://doi.org/10.1207/s15430421tip4101_3

Wecker, C., & Fischer, F. (2014). Where is the evidence? A meta-analysis on the role of argumentation for the acquisition of domain-specific knowledge in computer-supported collaborative learning. *Computers and Education*, *75*, 218–228. https://doi.org/10.1016/j.compedu.2014.02.016

Wissinger, D. R., & De La Paz, S. (2016). Effects of critical discussions on middle school students' written historical arguments. *Journal of Educational Psychology*, *108*(1), 43–59. https://doi.org/10.1037/edu0000043

Zapata-Rivera, D., Forsyth, C., & Molloy, H. (2019). Supporting computational thinking skills for adults. *CEUR Workshop Proceedings, 2395*, Paper 5. http://ceur-ws.org/Vol-2395/paper5.pdf

Appendix A

Critical Discussion Guidelines

The following criteria are provided to guide students' cooperative behavior during a critical discussion:

- Listen to each other even if you don't agree with the other person.
- Take turns, and don't interrupt each other.
- Try to understand both sides of the controversial issue.

- Give reasons and evidence for your opinions.
- Ask and answer questions about each other's reasons and evidence.
- Find a solution that you both can accept.

Additionally, the following questions prompt students to evaluate arguments before trying to reach a team solution on the junk food issue:

- Does the reason help *explain and justify* the position about the issue?
- Is the reason backed up with *strong evidence* (research, facts, and examples)?
- Does the *question* about the reason and evidence help you evaluate the strengths and weaknesses of the position?
- Does the *answer* to the question help solve the differences of opinion?

Appendix B

Student Survey

Please answer the following questions regarding the *Critical Discussion* Activity. Select the number that best represents your choice.

1. How much do you agree with each statement?	Strongly Disagree	Disagree	Agree	Strongly Agree
(a) "Junk Food" was an interesting topic to discuss.	1	2	3	4
(b) It was easy for me to know what to do next to move forward in the critical discussion activity.	1	2	3	4
(c) The source texts were easy to understand.	1	2	3	4
(d) The source texts helped me develop arguments on the "Junk Food" issue.	1	2	3	4
(e) The EPCAL platform was easy to use.	1	2	3	4
(f) I was engaged in the discussion.	1	2	3	4
(g) I was able to understand what my team members said.	1	2	3	4
(h) I tried my best to complete the tasks.	1	2	3	4
(i) I would like to do this type of activity again.	1	2	3	4

2. How much do you agree with each statement about the critical discussion in your group?	Strongly Disagree	Disagree	Agree	Strongly Agree
(a) Everyone in my group participated in the discussion actively.	1	2	3	4
(b) We listened to each other even if we didn't agree.	1	2	3	4
(c) We took turns and didn't interrupt each other.	1	2	3	4
(d) We tried to understand both sides of the issue.	1	2	3	4
(e) We gave reasons and evidence for our opinion.	1	2	3	4
(f) We asked and answered questions about each other's reasons and evidence.	1	2	3	4
(g) We found a solution that all of us could accept.	1	2	3	4

Suggested citation:

Song, Y., Ferretti, R. P., Sabatini, J. & Cui, W. (2024). *Insights into critical discussion: Designing a computer-supported collaborative space for middle schoolers* (Research Report No. RR-24-12). ETS. https://doi.org/10.1002/ets2.12387

Action Editor: Jamie Mikeska

Reviewers: Jessica Andrews Todd and Paul Deane