Chapter 13

An Examination of Peer-to-Peer Scaffolding as Metacognitive Support for Learning

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Abstract

This descriptive study examines peer-to-peer scaffolding implemented in an undergraduate, online digital literacies course for future educators. It identifies the different features of students collaboration processes and how these processes function as peer scaffolding to support their learning. Analyses of students' collaborative dialog and reflections on their collaboration processes. By analyzing dialog, this study examines how collaborative discussion that is high quality can act as a form of peer-to-peer scaffolding that encourages metacognition. Peer-to-peer scaffolding not only provides just-in-time support, but also triggers students' regulation thus helping them to refine their understanding and enhance self-awareness of their learning processes. Findings suggest that productive collaboration can serve as a useful means of peer-to-peer scaffolding marked by five specific features: 1) complementing each other's expertise, 2) co-constructing knowledge, 3) collaborating to problem-solve, 4) encouraging reciprocal support, and 5) triggering regulation. Findings further explore students' perspectives on collaboration. Students felt they benefited from peer-to-peer collaboration when the collaboration yielded the development of new ideas and understanding, offered support for problem solving, and provided opportunities for self-reflection. These markers of quality collaboration assisted students in achieving their learning goals. Recommendations outlined in this chapter offer guidance for educators by describing ways to promote productive collaboration when designing and implementing instruction.

Keywords: online learning, digital literacies, reflective thinking, collaboration, peer support

1. Introduction

We live in a world where digital collaboration is ubiquitous, however educators may not think about how collaboration elicits peer-to-peer dialog that could serve as scaffolding. This study aims to understand how peer-to-peer online collaboration can support metacognition and encourage the learning process.

The purpose of this chapter is to illustrate dialogic examples of peer-to-peer collaboration that serve as scaffolding within an online course for future educators. The analysis yields rich descriptions of the characteristics of quality collaboration that

scaffold learning [1, 2] and encourage both cognitive and metacognitive development [3–5]. The analysis looks closely at dialogic interactions to understand the nuanced exchanges that occur between learners. By examining the nature of dialog, distinct markers of peer-supported scaffolding can be identified.

The analysis described in this piece identifies markers of high-quality collaboration that can yield metacognitive support. Given the interconnectedness of peer scaffolding, metacognition, and learning, this study looks specifically at vignettes where productive collaboration occurs and demonstrates how collaborative dialog offers peer-to-peer support to complete digital projects.

Through the examination of dialog from different instances of collaboration among students, the study shows how educators can better take advantage of the strengths that different learners bring to collaboration and ways these strengths and collaboration can ultimately support metacognition.

This chapter examines the literature on metacognition to explore possibilities for ways that peer dialog can serve as metacognitive support for learning. In our highly collaborative digital world [6, 7] collaboration takes many forms, one of which is peer scaffolding. During peer scaffolding, individuals assist each other's learning by offering guidance, suggestions, and resources. As a result, learners' metacognitive knowledge is activated and enhances the learning experiences for both learners. The connection between peer-to-peer scaffolding and metacognition is demonstrated in the following two sections.

1.1 Peer-to-peer scaffolding

In educational settings, the concept of scaffolding derives from the socio-cultural theory of Vygotsky [8] and his philosophy about learning and development, which contends that learning occurs when individuals interact and cooperate with adults and/or peers. Learners ultimately develop their internal mental abilities to become more independent problem solvers. The essence of scaffolding lies in the guidance one person offers another which enables the other to achieve goals that would be otherwise unattainable if unassisted [8, 9].

Scaffolding can occur between experienced learners and novices [8–10], and between peers who are at similar stages of developing their understanding [3, 11]. Peer scaffolding emphasizes the mutual benefits that both participants gain from a shared learning experience [1]. Thus, peer collaboration may be the prerequisite for peer scaffolding, but not all peer collaboration represents scaffolding.

1.2 Peer- to-peer scaffolding and metacognition

Metacognitive knowledge constitutes cognitive knowledge and cognitive regulation [12–16]. It includes "knowledge about oneself as a learner and the factors that might impact performance, knowledge about strategies, and knowledge about when and why to use strategies" [17, p.2].

Peer-to-peer scaffolding may not be regarded as a form of metacognition itself, however, it can facilitate metacognitive processes for several reasons. First, when peers engage in collaborative dialog, they engage in explicit articulation. Speaking one's thoughts and ideas in a collaboration context prompts learners to be aware of their own comprehension and learning while sharing ideas with others. Second, peer-to-peer scaffolding brings together people with diverse expertise and perspectives. In the process of sharing perspectives, different ways of thinking are surfaced.

This additional input that comes from gaining new perspectives encourages learners to consider other ideas and reflect on their own learning. Third, through the act of peers working together to exchange ideas, clarification regularly occurs. Exchanging ideas and clarifying serves to help learners regulate and monitor their understanding. Finally, through the dialog that occurs during collaboration, learners are encouraged to share their thinking, expertise, resources, and problem-solving methods, which surfaces metacognitive awareness by both speaking one's own thinking and listening to peer's thinking.

The Literature Review section that follows provides an overview of empirical studies that connect: 1) human interaction and language exchange as a means of scaffolding, and 2) peer collaborative discussion as an approach to examine metacognition [18].

2. Literature review

This study draws on two interconnected areas of literature. The first area illustrates the importance of verbal exchange in scaffolded learning. The second focuses on peer collaborative discussion, which examines how dialog among peers can assist learners in achieving learning goals. In each of the studies reviewed, scaffolding is not limited to interactions between novice and experts, but also among peers [1, 3]. Together, these two bodies of research form the foundation to connect how peer collaboration can function as a scaffold that facilitates cognitive processes and metacognition.

2.1 Language as scaffolding

This study draws upon research that examines how language can be a powerful tool to assist learners in achieving learning goals [9, 10, 19, 20]. In early studies, Wood et al., [9] directly employed the scaffolding metaphor to explicitly describe the interactive tutorial process in a dynamic, face-to-face situation in which adults engaged in verbal intervention, direction, and correction to assist children to carry out a task, solve a problem, and achieve a goal. Cazden [21] demonstrated how language was used in classrooms and homes to assist children in speech development. Bruner [10] argued that the dialogs that happened between adults and children were vital to foster children's mental development.

In more recent studies, language interactions that were used as a form of educational scaffolding were also explored. For instance, Fennema-Bloom [20] illustrated that code-switching could serve as a scaffolding technique in facilitating science content learning involving bilingual teachers and students. Similarly, de Oliveira [19] proposed a language-based strategy to enhance content instruction, emphasizing that collaborative interactions and oral discourse were crucial for developing academic literacy. Choi et al., [3] proposed peer-questioning strategies used as meaningful discussion tools which served as scaffolding to facilitate reflective thinking among peers.

Language scaffolding also occurred among peers. Castek [22] documented ways that students pooled information and ideas informally as they worked collaboratively. Students supported each other in meeting their goals and frequently discussed strategies on how to achieve them. Strategies were shared during spontaneous conversations as they worked in collaboration.

Each of the studies reviewed demonstrates how interactions and language exchanges are an important means for educational support. Collectively, this literature base highlights that dialog between teachers and students, and among students themselves, serves as scaffolding and can have an impact on enhancing educational experiences [23].

2.2 Collaborative discussion

This study is informed by research that analyzed collaborative discussion among learners [24–27]. The findings of these selected studies demonstrated that peer collaborative discussion promoted learners' high-level thinking skills [26–28]. Peer-to-peer collaboration acted as scaffolding and created new opportunities to co-construct meaning. Shared discussions encouraged joint problem solving and idea exchange that fostered efficient and productive comprehension of online informational texts [29].

Sekeres and Castek [26] examined elementary grade students who collaboratively engaged in a teacher designed inquiry task. Findings suggested that talking while productively collaborating acted as a marker for high-level thinking, which indicated students were more expressive with reasoning when they shared their ideas orally. Evidence of student learning included making inferences beyond the text, integrating information, and evaluating the quality of the information they found online. Combining verbal discussion with written responses during the completion of an online inquiry project provided concrete ways for students to strengthen their argumentative skills. Sekeres et al., [27] contended that students who paired up and engaged in academic discussion (e.g., elaborating, interpreting, and extending ideas) demonstrated substantial use of evidence-based reasoning to support their learning.

Another comparable study by Coiro et al., [24] focused on upper elementary students engaging in structured online inquiry. The study found that high quality dialog promoted the use of cognitive strategies such as making inferences, synthesizing, and evaluating information. When partners employed these cognitive strategies in their collaborative discussions, it enhanced their understanding of the content they studied.

Peer collaborative discussion also facilitates students' metacognitive development, which is related to understanding, regulating, and monitoring their own thinking and learning processes [24, 25, 28]. For example, Coiro et al., [25] observed metacognitive activities when students partnered to complete an online learning task. These metacognitive processes included collaborative task monitoring, shared understanding of the content, awareness of group behavior, and strategy adjustment and modification (e.g., switching to an alternative approach to solve a problem).

Coiro et al., [28] investigated two adolescents reading independently and collaboratively on the Internet. Findings suggested when reading collaboratively, learners engaged in increased instances of metacognition such as inferring, integrating, monitoring, and reflective processing than when they read independently. Opportunities for peer discussion and shared decision-making may serve to encourage knowledge construction and deeper levels of understanding [30].

Though these studies suggest positive benefits associated with collaborative meaning making, not all peer collaboration is productive and sparks metacognitive awareness. Wen [31] conducted a study that captured both more and less productive peer collaboration. Peer scaffolding occurred when two learners actively participated in collaboration and mutually supported one another across multiple learning tasks.

Findings showed that when students worked together to share information, some offered minimal assistance, often without providing explicit support and guidance to their peers. In other situations, one participant received more support from their partner than they gave in return. It was found that during collaboration, support may not be evenly distributed between the two participants. Instances of productive collaboration were also documented in Wen [31]. Evidence and outcomes of productive collaboration is described in this article.

2.3 Research questions

With the advancement of technological tools and virtual communication platforms, learners who are in different physical spaces can interact in real time and collaboratively share their thinking [32]. Drawing upon the findings from studies on peer-to-peer collaboration and scaffolding in K-12 settings, this study examines how undergraduate university students worked in collaboration to complete assigned learning tasks online. It aims to understand the role that collaborative discussion plays in learning and to document collaborative features that emerged from online interactions among students.

Two research questions guided this investigation:

- How can peer-to-peer scaffolding support metacognition?
- What are students' perspectives about peer-to-peer scaffolding and metacognition?

3. Methods

This study was nested within a larger investigation that examined multiple forms of scaffolding used in a fully online digital literacies course. Data was collected over the course of two implementation cycles with students who were completing a BA degree and wanted to go on to become an educator. The broader study explored online learning, various forms of scaffolding, and the processes and perspectives of students who completed two specific digital projects where collaboration and the creation of digital projects were key features of analysis [31].

3.1 Context

This study was conducted in a research-intensive university located in the Southwestern U.S. The data collection occurred within an asynchronous online course called *Teaching and Learning with New Technologies*. This course explored multiple ways that learners make and exchange meaning in the digital world. Educational implications for digital instruction and student involvement were emphasized. Through the lens of exploration and discovery learning, the course encouraged the use of a wide array of technologies and examined the ways these technologies shape the way people think, read, write, communicate, and collaborate in formal and non-formal learning.

The analysis undertaken for this study focused on one module of instruction that was implemented in this fully online course. This module was *Designing Immersive Virtual Field Trips,* which involved students: 1) exploring a variety of

immersive virtual field trips to explore their design, content, and resources, 2) learning how virtual field trips prompt interest and engagement for learners of all ages, and 3) designing their own immersive virtual field trip using a free, online, browser-based technological tool to engage learners. Together, these objectives offered multiple opportunities for inquiry and exploration across the curriculum.

3.2 Participants

Twenty-two students voluntarily agreed to participate in the research [33]. These participating students came from different disciplines within and outside of the College of Education. In addition to being undergraduate students, some of the participants were non-traditional students with various teaching and tutoring experience in K-9 school settings such as substitute or guest teachers. Others held leadership roles in pre-school, after school, or intermural sports.

3.3 Learning task

Students were asked to work in pairs and record their online collaborative discussions to design their own immersive digital field trip. They formed pairs by mutual consent and scheduled online work sessions at times that were convenient for both partners. One option for collaboration partnership was to act as a "thought partner" for each other, stimulating deeper thinking about the project's design and creation. The other option was that students could jointly design and construct the project together, making collaborative decisions that incorporated both of their ideas. The use of Zoom video conferencing allowed students to record their collaborative processes.

Students were required to use a multimodal technological platform that allowed the building of a visual tour which could include video, audio, and other resources. The content of the virtual field trip was open-ended and flexible. The design encouraged the inclusion of web-based, immersive, and interactive audio, video, and visual resources into the design of the learning experience [34]. To complete the project, students needed to go through the following steps: 1) chose a content area, location, or topic, 2) collect or create relevant media and resources to augment the project, and 3) compile and connect the resources together to tell a story about a place or experience.

Of the 22 students who voluntarily participated in the study, six students did not choose to work with a partner and two pairs were unable to record their collaboration processes. As a result, six online collaboration videos were analyzed in the final analysis.

3.4 Data sources

To corroborate findings through triangulation, data was collected from multiple sources which included students' online collaboration videos, students' reflections, and semi-structured interviews. Triangulation refers to the use of multiple data sources to develop a comprehensive understanding of phenomena [35]. The collection and analysis of triangulated data sources was part of the research design and led to a more complete understanding of collaboration coupled with reflection.

Zoom video conferencing software was used to collect video and audio data to examine how the two students collaborated as they worked together online. They engaged in discussions by exchanging ideas and providing feedback to each other as they worked through the construction of their immersive virtual field trip. Students'

online collaboration processes were self-recorded and shared with the researchers for analysis. The online collaboration videos captured students' authentic dialog which was used to identify markers of productive collaboration. An analysis of the dialog captured in the video was used to respond to Research Question 1.

Following the completion of the collaboration, students were asked to record a short oral reflection. In their reflections, students were asked to consider various aspects of their learning experiences, particularly to share how they collaborated online to complete their projects and to explain what they gained from the experience. Semi-structured interviews were collected to gain a deep understanding of students' perspectives about peer support. Students' reflections and interviews were examined to gain insights about their perspectives and inform the researchers about students' collaborative discussion. Students reflections and interview data were used to respond to Research Question 2.

3.5 Data analysis

Data consisted of students' collaborative dialog captured in video and written transcripts, oral reflections, and interview responses. This data elicited their perspectives on their learning and collaboration processes. To conduct the analysis, recordings were auto transcribed, corrected, and member checked. The transcripts then underwent further in-depth analysis. In addition, students' oral reflections were transcribed, and member checked. After cleaning the data, all data sources were organized and archived to address two research questions: 1) peer support and collaboration as a form of scaffolding, 2) students' perspectives on online collaboration.

Analysis of dialog is an important way to examine human interaction and scaffolding [9]. To address Research Question 1, the transcripts of each pair's dialog were carefully analyzed line by line independently by the researchers to better understand the quality of students' collaborative processes. Informed by the framework of collaborative online inquiry [25, 36], both researchers documented their initial insights and selected excerpts as instances that demonstrated pairs' productive collaborative processes. These instances included: 1) dialog about sharing sources, ideas, and knowledge, 2) dialog about negotiating responsibilities, rules, and ideas, 3) dialog about planning, executing, and making decisions, and 4) dialog about providing feedback, monitoring processes, and overall understanding.

Following independent analysis, the two researchers met together to discuss selected instances and further identified five markers that indicated high quality collaboration. These five markers addressed two important indicators of productive collaboration including: 1) how active collaboration occurred and 2) how the collaboration produced both process and product outcomes. The process outcome was instances of metacognition and the product outcome was the quality of the immersive virtual field trip project.

To answer Research Question 2, an inductive coding technique [37, 38] was employed during the data analysis process. First, two researchers worked independently to develop codes by reading and reviewing the transcripts of oral reflection and interviews multiple times. Then, two researchers met weekly to discuss the application of the codes, coding discrepancies, and emerging insights. During this process, the two researchers collapsed, expanded, and revised the codes, forming and fine-tuning the code categories [39]. Coding categories focused on reflections, affordances, and challenges of peer collaboration.

The analysis was made up of outcomes from coding, shared interpretations, categories, and the analytical reflections of two researchers [38]. Finally, two researchers aligned pairs' collaborative processes with their oral reflections and interviews to understand how students worked with partners and supported each other to achieve learning goals. Ultimately, the researchers arrived at emergent themes and identified illustrative quotes that anchored those themes. The themes revealed intricate relationships among the coding categories.

4. Findings

Three patterns of online collaboration were identified based on the analysis of students' Zoom recordings of their online collaboration. These patterns included: 1) collaborative situations with low or without scaffolding, 2) collaborative situations with unbalanced scaffolding, and 3) collaborative situations with peer-to-peer scaffolding [31]. This study reports solely on the third category, collaborative situations with peer-to-peer scaffolding. This choice was made because the analysis identified markers of productive online collaborative discussion and highlighted how students' metacognitive knowledge could be nurtured. Results of the study are organized around the two research questions in Sections 5.1 and 5.2.

4.1 How can peer-to-peer scaffolding support metacognition?

Scaffolding can occur among learners who are at similar levels of knowledge and abilities. Scaffolding t can also occur when students working in collaboration have different strengths and weaknesses. Five predominant markers were identified. The data suggested that no single pair's collaborative discussion possessed all these markers in one instance; the five markers were found across different pairs in various instances.

The six scenarios illustrated below demonstrate mutual scaffolding among students in a collaborative situation where they had different levels of knowledge, strengths, and weaknesses. Collaborative peer- to- peer scaffolding refers to interactions where two collaborators actively work together in a mutually supportive way to scaffold each other's learning and development. Both actively contribute to each other's progress.

Two pairs, Emily and Bella (pseudonyms), Kate and Amber (pseudonyms) are examples that represent collaborative mutual scaffolding. The following excerpts illustrate the characteristics of their mutual scaffolding and how the dialog indicates metacognition.

4.1.1 Complementing each other's expertise

When two students worked together, each offered up to the collaboration their knowledge, skills, and perspectives, and were open to listen and learn from their partner's expertise. **Table 1** illustrates how two students negotiated their tasks based on different expertise. Emily and Bella decided to co-design and construct an Immersive Virtual Field Trip project named *The Exploration of South Korea*.

During this instance of collaboration, Emily and Bella shared and negotiated the background knowledge they had about South Korea and what they could contribute to the mutual project (Lines 24, 27, 29, 30, 31, 32, 34). They had different experiences

Line	Participant	Dialogue
22	Emily	It's nice to know what you want to do. Like what's your preference?
23	Bella	I mean the only thing that I really know is the education part. I only really know it from what I did, but I feel that's different because I'm a foreigner.
24	Emily	So, I think that's perfect because you were in a study abroad program. Right?
25	Bella	Right! Okay!
26	Emily	I'm not trying to force you to do anything. Right?
27	Bella	No, no. That's okay, I think food would be easy for somebody who has not been there, and if you like Korean food, then that's good!
28	Emily	Yeah!
29	Bella	Do you know any history? I do not know that much but I know a little bit like…
30	Emily	I think I know a pretty good amount.
31	Bella	Okay! I only know about the King that invented the Korean language and stuff. I know that…
32	Emily	But I know a lot about the war between North and South Korea.
33	Bella	That's a good thing too!
34	Emily	I can do the history and then food okay? and then you do language and education.
35	Bella	I can do it!
36	Emily	Do you want to do customs? I mean I can try the customs.

Table 1.
Example of complememtary expertise.

and expertise and they offered complementary expertise to include within the shared digital project they created together. This collaborative project could not have been achieved without their shared expertise. When these two learners shared and exchanged their knowledge and skills, they were prompted to reflect on one's own expertise and skills, which led to reconsideration and reorganization of their mutual project. This learning instance encouraged students to reflect on what they knew and what they did not, as well as understanding what knowledge was needed to complete the project.

4.1.2 Co-construction of knowledge

When two learners were sharing ideas during the collaboration, they constructed meaning by stretching each other's thinking, ideas, and perspectives. **Table 2** demonstrates Emily and Bella's co-construction of ideas.

The interactions captured in **Table 2** showed how Emily and Bella were co-constructing an idea planning would design for their virtual field trip project. At the beginning, they brainstormed what resources and media they had to build the project (Lines 8, 9). However, they did not have a clear idea of what to do and how to do it. Then, Emily suggested they could find an example to refer to (Line 10). This suggestion was echoed by Bella (Line 11). Together, both figured out what they could do based on their mutual understanding of the example they found (Lines 16, 17). In this situation, students built on each other's ideas and filled in each other's thoughts. This iterative process is also an essential part of metacognition.

Line	Participant	Dialogue
8	Emily	…If you have your own media. Do you have a lot of pictures from when you went?
9	Bella	Um… I was thinking about that. This morning, I found some… Uh…it was not really like an outdoor thing, though. So, I guess, I mean it still counts. I guess, I just do not know how much stuff we have to have.
10	Emily	Right! Do we have an example of a Virtual Field Trip?
11	Bella	Yeah! like the Tornado one?
12	Emily	The Tornado one!!
13	Bella	Yeah, she has like…. I do not know!
14	Emily	She has like five scenes.
15	Bella	I was just trying to see how many scenes she has.
16	Emily	She has like five pictures. So, we'll choose five topics. Oh, like history…
17	Bella	Customs and education. We could just pick Korean looking pictures. How about those topics? Then [we] do the same thing that she did.

Table 2.
Example of co-construction.

4.1.3 Collaborative problem-solving

Collaborative problem-solving occurred when two learners tried to solve problems and tackle the difficulties during the collaboration. Amber and Kate worked on the virtual field trip project individually, however they scheduled an online meeting to work together as thought partners. **Table 3** shows how Amber and Kate solved a problem they both faced.

Line	Participant	Dialogue
218	Amber	You know if you are doing a lot of videos and additional graphics. I do not know if the voiceover would add anything.
219	Kate	[Do] you know some of the ones that had music or something I can do like [adding] underwater sounds?
220	Amber	I am not that tech savvy though. I do not know how they were adding noise to my first image. Let us go back. We will see. Do you know how to do that?
221	Kate	No. How about…? I think you can record.
222	Amber	Oh well, there is an upload audio button.
223	Kate	Then probably just downloaded one and then uploaded it.
224	Amber	Maybe I'll go back and add some audio, like some cannonball noises.
235	Kate	Yeah, I guess you just do it on a tag, but that's not a big deal.
236	Amber	Hmm. Maybe I'll go to check them. Yeah! I've completely forgotten about that until you said something.

Table 3.
Example of collaborative problem-solving.

The documented interactions illustrated in the discussion between these two learners focused on ways to make a virtual field trip more multisensory by adding sounds. Amber posed her question about how to add noise to the image (Line 220). Kate was also unsure about the answer, but proposed a suggestion (Line 221), which triggered Amber to explore more features within the technological design tool. Together, they both figured out how they could add sounds to the images. Tackling problems together required learners to prompt each other's thinking, seek for alternatives, and reflect on the effectiveness of multiple solutions, which was also central to metacognitive skills.

4.1.4 Reciprocal support

When these two students collaboratively scaffolded each other's ideas, they actively participated in discussion and provided support, feedback, guidance, affirmation to each other, which mutually benefited each of them. **Table 4** illustrates how Kate sought support from her collaborator Amber. With the guidance of Amber, Kate figured out some of the features of the technological tool to "create a tour".

Table 4 demonstrates how Kate sought support from Amber and Amber affirmed and extended Kate's approaches to connecting images together into a tour. In a reciprocal manner, **Table 5** illustrates how Amber sought and received support from Kate when she requested help. **Table 5** describes the suggestions and feedback that Kate offered to Amber to determine which option (360 image or aerial view) would work best for her project.

Line	Participant	Dialogue
17	Kate	So, the idea is like they can click around to know what lives here. And then, they could go deeper. And then, it takes them to the next page. I do not know if that's the right way to do it.
18	Amber	That's how I did mine for the ones that are supposed to go to another page. They just go to another image that has more hotspots.
19	Kate	Yeah! I just could not figure out how to get all the images together, so I was like… Oh, I guess…they have to be separate, and you just point them out, yeah that's what I did…
20	Amber	When you are clicking on those to go to the next image. Did you use the "create a tour" button?
21	Kate	Yeah!
22	Amber	Okay! That's what I did too. So, I mean if that's not the right way to do it, it's still doing the function to me.
23	Kate	Yeah! like I did this for mine.
24	Amber	You know what the next level to learn about. So, I think what you did is fine.
25	Kate	I do not have any part of it because I did not know. I was like the only way I found that I could link the images. Yes, "create a tour" and just upload things.
26	Amber	Yep, and for me, as I said, "create an image" or "create a tour". That did not do anything different from those others, like templates. You still have the same options as if it was just a flat image. So, Yay!
27	Kate	Right!
28	Amber	I did the exact same way as you did!

Table 4.
Example of reciprocal support (Kate seeking support from Amber).

Line	Participant	Dialogue
86	Amber	I wasn't sure what else I was supposed to do.
87	Kate	I think yours is way more advanced than it is supposed to be, but I was thinking, there are certain sites that allow you to download YouTube videos. I wonder if you could do that with 360 and then upload it to the technological platform. Because I know National Geographic has a bunch of underwater ones. Well, if you could figure out how to get that to work, that would be cool.
88	Amber	Yeah! That would be nice, especially for underwater. Um… for ones like this, I did not really see 360 being that big of an advantage, like this one, right here, I already have it. There was an aerial view that you can move around.
89	Kate	I think that's fine. The only thing I could think of is where that would be useful for you. It would be more like if you are inside of one building, like an old schoolhouse. …I feel like you already have plenty of things, even if they are just links.

Table 5.
Example of reciprocal support (Amber seeking suggestions from Kate).

Tables 4 and **5** illustrate how Kate and Amber mutually supported each other and pushed each other's progress in learning. In **Table 4**, the conversation was started by Kate who felt unsure if she did the right thing to link separate images together to become a virtual tour (Lines 17, 19). Amber confirmed that she did the same thing as Kate did. Then, Amber mentioned two features of that technological platform, "create an image" and "create a tour", which functioned the same when uploading flat images. Amber's feedback and support gave Kate confidence to continue the project. Meanwhile, **Table 5** shows how Amber sought suggestions from Kate. Kate gave Amber suggestions in a detailed way (Lines 87, 89), such as: what kind of media Amber could use; where Amber could get the resources she wanted; and what the most important thing to think about in creating a virtual field trip.

When examined together **Tables 4** and **5** demonstrate that the two students took turns sharing their concerns and questions, and they both actively participated in this conversation and learning process. They made sure each one was able to ask questions and received enough support. During the reciprocal support, peers can observe, monitor, and think about each other's work and provide feedback as well. The shared insights that are elicited from the conversations help individual learners reflect and adjust their project accordingly, which is a key representation of metacognitive skill.

4.1.5 Regulation

As seen in the analysis **Tables 3–5** Kate and Amber both regulated and monitored their working processes, and as a result, made sure that their work achieved the task goals. Regulation in this case refers to the knowledge of one's own ability to learn and monitoring refers to the awareness of one's own learning. **Table 6** shows an additional example of regulation from Emily and Bella who engaged in reflecting on what was needed to add into the project, and how their project could meet the instructor's expectation.

The interactions depicted in **Table 6** illustrate how Emily and Bella reflected on what images and media could be incorporated in their Immersive Virtual Field Trip project (Lines 55, 56). Emily suggested that they could use some media from the internet or YouTube. However, Bella reminded Emily about the instructor's

Line	Participant	Dialogue
54	Emily	Anything else we can use?
55	Bella	Um I have one of me at the beach, but it's not like that one…
56	Emily	That's right! You know, either we can find a 360 tour or something on YouTube. We can use whatever we want. It will always look well!
57	Bella	Yeah! but I mean, she [the instructor] said, "as long as it's something somewhat personal." I feel like she will give us some points.
58	Emily	Oh, as long as it's personal?
59	Bella	I think it's supposed to personalize your materials with your own creativity.
60	Emily	Oh yeah!
61	Bella	If we put them together using our own. I think it will be okay.

Table 6.
Example of regulation.

expectation regarding the choice of media. The instructor required that media choices be purposeful, personalized, or customized to advance the objectives the creator identified. Reflecting collaboratively illustrated metacognition and helped the two students monitor, revise, and regulate their work. They thought about their thinking in the process, connected the learning expectations and objectives to their content creation. This ability to regulate learning and reflect on oneself is also a crucial aspect of metacognition.

4.1.6 Summary

The six vignettes were offered to represent a close analysis of peer-to-peer dialog. Findings showed that high quality peer collaboration can act as a form of scaffolding and that peer-to-scaffolding plays an important role in exchanging ideas, providing support, and monitoring learning. Across various scenarios, pairs of students were captured engaging in online collaboration and prompted metacognitive awareness. The vignettes illustrated how peer-to-peer scaffolding can encourage metacognition.

4.2 What are students' perspectives on peer-to-peer scaffolding?

During oral reflections and semi-structured interviews, students expressed their opinions about the online peer-to-peer collaboration designed by the instructor in the module. It suggested that not every collaboration is supportive and leads to satisfactory outcomes. Some interactions connect individuals but were less supportive. Students felt they have benefited from peer- to-peer collaboration when the collaboration yielded: 1) development of new ideas and understanding, 2) problem solving, and 3) opportunities for self-reflection.

When two students collaboratively worked together, they actively participated in two-way dialog, expressing thoughts, exchanged ideas, and offered suggestions and constructive critiques in a reciprocal way. During this process, both students gathered different perspectives from their peers, learned from each other's insights, and collectively produced new understandings to improve their projects. The quotes below illustrate students' opinions on collaboration, captured in semi-structured interviews.

> *Before Kate I had never heard of Canva and ever since then that's all I use for my presentations and before collaborating with Kate, I probably would have finished my virtual field trip project, I turned it in, moved on with my life, but collaborating with her forced me to really look into the features of the technological platform, because we were troubleshooting together, searching back through our resources on how to add certain things.*

> *It was nice to have someone there to bounce ideas off and show them the project or get their feedback in real time. We also talked about how to build a field trip around a selected age range. So that you could make sure the complexity is not too far or below their comprehension levels.*

> *You get the benefit of having another person's perspective and their own creative ideas. It was a great way to discover things that we had not really thought of before. For work it was a nice way to get inspiration and come up with new ideas.*

By engaging in collaboration, students gained positive learning experiences because they were able to get assistance from peers and solve problems they encountered during project completion. In their oral reflections, students shared how with the support of their peers, untangle problems that they otherwise would not have been able to overcome. Amber said,

> *We spent a lot of time tinkering with the technological platform and Google Earth and different YouTube expeditions trying to figure out how to make certain features work to make a more seamless project. My partner helped me come up with some of the final touches that I needed to make my project seem more immersive, like the additional sound effects that I added to the icons.*

Collaborative discussion also prompted self-reflection because students could articulate their thinking while they exchanged ideas and feedback. Two students shared their perceptions about the affordances of collaborative discussion.

> *[During online collaboration], you need to explain your thoughts and work through any problems you are having. When you are talking through it, I think it can help your mind work through that process, and you can probably come up with new ideas that way.*

> *When I shared my project with my partner, I had to demonstrate it well, so that my partner could understand my project and provide me with the feedback I needed. From the feedback, I could make my project better.*

4.2.1 Summary

Collaborating with peers provided each learner with an opportunity to explain and talk through their own ideas while also having the chance to build on other's ideas by listening and incorporating a collaborator's suggestions. Not only did collaborative dialog appear to enhance individuals' understanding and thinking through an articulation of their own ideas, but also it strengthened metacognitive skills by prompting reflection on the learning process and product.

Students' quotes indicate supportive online collaboration, which is an example of peer-to-peer scaffolding peer-to-peer scaffolding. Students reflected on their learning

experiences and improved their learning performance by considering peers' ideas and suggestions. By working collaboratively in pairs, students recognized different perspectives and creativity that their peers contributed and contributions coming from a peer's perspective were appreciated and built on collectively. Peers' constructive feedback helped refine and improve each other's understanding and learning products, which furthered both students' intellectual development. Peer-to-peer scaffolding held strong potential to promote metacognition.

5. Discussion

The concept of scaffolding originally emphasized the interactive process between learners and the more capable and experienced other [40, 41]. However, when learners with similar levels of knowledge and abilities, provide each other with support when they were engaged in collaborative work. The work involves collaborative discussion and mutual support among peers, where individuals contribute to the learning process. In an online learning environment, peer-to-peer scaffolding plays a crucial role for students' success in the course, since it is challenging for instructors to provide immediate and appropriate support, which naturally occurs in a face-to-face classroom setting. Peer-to-peer support requires collaborators to participate actively in the process, in which learning starts from the social (intermental) level to the individual (intramental) level [42].

Analysis of students' online scaffolding suggests that learners' can actively exchange ideas, share expertise, and collaboratively address problems while regulating their learning. This is further corroborated by students' self-reports on their perspectives on online collaboration. Moreover, online peer-to-peer scaffolding not only enhances students' learning experiences in terms of collaboration, communication, cognitive processing, but also fosters their metacognitive skills, including thinking and understanding of their own thinking and knowing [14], and monitoring of their cognition [12, 15, 16]. Metacognition requires learners to think about their own thinking, but how are students able to think about their thinking? Whole class meetings where communication is shared might be one of the vital ways to achieve this goal. Through collaborative discussion, learners check on each other's understanding, build on each other's ideas, and evaluate each other's perspectives. Thus, when learners engage in discussion, they can unlock deeper introspection and reflection.

Learners can be encouraged to assess their own thinking, understanding, and perspectives. By continuously reflecting on their own thinking, learners can identify gaps in their understanding and then adjust improve their learning. In addition, metacognition involves monitoring and regulation. Peer-to-peer scaffolding provides learners with the opportunity to collectively regulate their shared learning process through reminders and by offering suggestions and supportive critique. These findings echo previous research which argues that metacognition should go beyond looking at reflection on an individual level, but also to extend reflection from a group dimension. Examining collaborative processes provides opportunities for collective and individual reflection [18].

6. Conclusions

While it is recognized that the digital world is a collaborative world [6] and that collaboration may encourage metacognition, supporting quality collaboration

involves more than just an invitation to students to go out and collaborate. Teachers play a critically important role in guiding instruction around collaborative dialog and steering peer-to-peer scaffolded dialog in productive directions that encourage reflection, cooperation, and quality collaborative talk. Promoting quality collaboration takes effort and careful planning. The analysis illustrates that peer-to-peer collaborative discussion that is high quality can act as a form of scaffolding, supporting metacognition. Such interactions not only provide immediate support for learning, but also facilitate learners' metacognitive processes in multiple ways, enhancing their self-awareness and ability to regulate their learning.

Findings from this study capture and document how pairs engaged in collaborative discussion to complete tasks and scaffolded each other's learning by exchanging expertise, co-constructing knowledge, collaboratively solving problems, offering reciprocal support, and regulating, across shared learning processes. The learning experiences highlighted here appear to provide students with opportunities to reflect on their thoughts and perspectives, articulate and monitor thinking, and bolster self-awareness, which promotes learners' cognitive skills and metacognitive knowledge. Metacognition does not only refer to an individual's inner reflective thinking, but also to distributed knowledge that travels across group members. Social interaction is an important means to activate an individual's metacognition.

This study suggests that productive peer collaboration leads to peer scaffolding, ultimately eliciting metacognition among learners. Thus, the findings ask researchers and educators to consider our own teaching practices for additional opportunities to enact collaborative learning and peer-to-peer scaffolding. Supporting collaboration and dialog can be strengthened by providing more opportunities for engagement in paired collaborative discussion. Learning tasks with this emphasis, enacted repeatedly with time for reflection, serves to equip learners with the necessary strategies to effectively collaborate in and out of school settings.

Findings from this study have important implications for scaffolding design and classroom implementation. The sections that follow are designed to provide guidance to instructors in ways to foster peer-to-peer scaffolding in teaching practices whether teaching online, in face-to-face settings, or through blended learning.

6.1 Recommendations

In the vignettes and dialog collected for analysis, no single instance of collaboration included all five of the identified features of peer-to-peer scaffolding. Still, the analysis identifies important opportunities for instruction where educators can guide collaboration to maximize the potential for encouraging metacognition.

6.1.1 Create a learning community that supports collaboration

Not all learning environments and assignments are designed with collaboration in mind. If an instructor chooses to implement collaboration, attention needs to be paid to cultivate a collaborative learning environment in which students feel comfortable to work together, share ideas, ask questions, and make suggestions that encourage learning together. Learning activities also need to be designed to prompt collaboration, such as group discussion, collaborative writing, and peer review. Fostering collaboration involves taking time to structure group tasks well so that collaboration can occur and to discuss what productive collaboration involves.

6.1.2 Articulate objectives and expectations of the collaboration

Assigning a collaborative task involves explicitly articulating expectations and objectives focused on collaboration as well as content. Beginning a lesson by pointing out previous instances of positive collaboration can encourage regulation and reflective practices among students. Instructors can work together with learners to generate a collaboration checklist that defines the characteristics of high-quality collaboration, roles and responsibilities for each collaborator and norms for participating in discussion with your peers. While some guidelines can be offered to students, generating the checklist with students encourages reflection and metacognitive awareness of these qualities while collaboration occurs.

6.1.3 Become knowledgeable about learners' background, expertise, and skills

When planning for collaboration, instructors can purposefully form groups to encourage collaboration. Knowing different students' expertise, personalities, characteristics, and skills of learners, instructors can balance group work and collaboration by pairing up learners strategically and explaining why those pairings were selected. The instructor can create an exit ticket, a formative assessment tool that a student completes before leaving the instructional setting, offering an ideal way to reflect and provide feedback to the instructor. Prompts about how collaboration pairings worked not only prompts reflection but also provides feedback about areas of strength and opportunities for growth.

6.1.4 Model collaboration strategies

Quality collaboration does not just happen, students need to learn strategies to become productive collaborators. Modeling using role-playing demonstrates how to turn collaboration situations around to become more productive. Offering tools that help students work in collaboration such as learning how to disagree productively, how to communicate effectively while sharing responsibilities, how to manage conflict, and how to provide constructive suggestions. Creating scenarios, acting them out, and encouraging reflection can help enhance attention to quality collaboration. Modeling can encourage students to enact an equal and reciprocal balance of talking and listening during collaboration. Instructional practices that provide practice opportunities include Socratic seminars, fish-bowl discussions, and planned discussion protocols where students who collaborate well can lead by example. An open discussion following how these activities can lead to a more balanced and reciprocal exchange and transferable metacognitive awareness.

6.1.5 Encourage learners' reflection on their collaborative processes

People learn from their reflection; reflection offers a means for individuals to think deeply about their experiences and thoughts. By reflecting on their collaborative processes, students gain insights from making connections, identifying unexpected outcomes, which help them adjust future performance.

The five recommendations stemming from this research offer some guidance to educators, however there are many other ways to promote positive collaboration opportunities. Encouragement with specific praise goes a long way to increase the likelihood of a student's metacognitive awareness of their own collaborative strengths.

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