Conversational Agent for Online Collaborative Learning: Facilitating Productive Discussions

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Abstract

Collaborative learning is an effective way for students to actively learn and thereby gain a deeper understanding of a specific topic, but it can be difficult for educators to monitor these discussions. This study investigates the effectiveness of Clair, an AI-powered conversational agent, in facilitating productive discussions during collaborative learning tasks. Clair uses the Academically Productive Talk (APT) framework, which includes specific "talk moves" designed to encourage students to share their thoughts, listen to each other, deepen their reasoning, and engage with others' ideas on the basis of Michaels and O'Connor's (2015) Four Goals for Productive Discussions (FGPD). In this study, 34 participants completed two discussion tasks: one without Clair and one with Clair's guidance. The results showed that Clair significantly increased deeper reasoning (G3) during discussions and helped improve productivity overall. Certain talk moves, like "Expand Reasoning" and "Recapping", were especially effective at encouraging deeper engagement and balancing contributions between participants. This research identified that Clair has the potential to support educators by improving the quality of collaborative discussions by guiding students. Future research should investigate how Clair can be implemented in real classrooms over time and assess its impact on students' learning outcomes.

Keywords: conversational agents, artificial intelligence, computer-supported collaborative learning, productive discussion

Introduction

Collaborative learning is an academic approach in which students achieve a shared goal by collaborating (Dillenbourg, 1999). Through sharing their knowledge and listening to others' opinions, students are able to deepen their knowledge (Teasley et al., 2008). Collaboration has shown to be more effective for the individual in gaining knowledge and understanding it than solely listening to an expert's opinion or provided materials (Laal & Laal, 2012; Gillies, 2019). If the collaboration is effective, students can learn to make sense of the knowledge (Michaels & O'Connor, 2015; Gillies, 2019; Araujo et al., 2024). But for collaboration to be effective, guidance is needed to ensure the students stay on task, equally contribute and discuss productively with one another (Weinberger, 2003; Papadopoulos et al., 2009).

To guide teachers in supporting students' dialogues to become more productive, Michaels and O'Connor (2015) developed the Four Goals for Productive Discussion (FGPD), which include "Helping individual students share their own thoughts", "Helping students orient to and listen carefully to one another", "Helping students deepen their reasoning" and "Helping students engage with others' reasoning". These FGPD can be used to understand the degree of productivity of a discussion. However, this depends on the educator's possibilities to monitor the student's discussions. To help educators monitor these discussions, the Academically Productive Talk (APT) framework was developed (Michaels & O'Connor, 2015). The APT framework provides educators with possible talk moves they can use to guide the discussions of students (Michaels & O'Connor, 2015). However, large class sizes make it challenging for educators to monitor every student.

Computer-Supported Collaborative Learning (CSCL) is a technology that can minimize the challenge of the teacher to monitor the whole class (Dillenbourg & Fischer, 2007). CSCL offers environments and tools that can support and monitor collaborative learning (Fischer et al., 2013). Furthermore, with recent developments in artificial intelligence (AI), conversational agents (CA) show a possible solution to increase the help CSCL can offer in the educational domain (Murad et al., 2019). As CA can interact with the students in a human-like way, they can take over the guidance of the discussion by prompting students with talk moves to keep the students on task and the discussion productive (de Araujo et al., 2023).

An example of such an AI-powered conversational agent is Clair (de Araujo et al., 2023). To prompt students during collaboration, Clair uses the APT framework, which is also the basis for the FGPD by Micheals and O'Connor (2015). Clair hereby takes on the role of

the teacher to guide students' discussion. The purpose of this study is to investigate Clair's effectiveness in enhancing productive discussions, with a focus on Michaels and O'Connor's (2015) FGPD. The FGPD are critical in guiding student interactions, and understanding how Clair influences these goals provides insights into the effectiveness and potential areas for improvement.

Theoretical Background

Collaborative Learning

Collaborative learning is a well-known academic approach where students work in groups to achieve common learning goals (Dillenbourg, 1999). Through dialogue, problem-solving, and the exchange of ideas, students deepen their understanding and build critical thinking skills (Dillenbourg, 1999; Teasley et al., 2008). However, effective collaboration is not achieved by solely placing students in groups (Liu & Tsai, 2008). It is highly dependent on the quality of communication and interaction within the group (Griffiths et al., 2021). This is also supported by early research conducted by Dillenbourg and Schneider (1995), who emphasised that effective collaboration requires more than just group interaction and hence needs controlled environments that facilitate goal-directed tasks and clear communication (Yildiz Durak & Atman Uslu, 2023). In a collaborative setting, students are socially and emotionally challenged as they are confronted with varied viewpoints and must express and defend their beliefs (Laal & Laal, 2012). The students are required to actively collaborate in a group to attain a common learning goal, rather than working alone on a task and then discussing their results with others (Qureshi et al., 2023). With this, the collaboration approach aims to avoid having passive students by encouraging each student to work equally on the task and share meaningful insights (Gillies, 2019). Productive collaboration hereby relies on the ability of students to share their thoughts, listen to their partners, and build upon each other's knowledge and reasoning (Michaels & O'Connor, 2015; Gillies, 2019; Araujo et al., 2024). This process encourages students to create their own frameworks, rather than relying solely on experts' opinions or preset materials, which can help students engage in deeper learning (Laal & Laal, 2012). However, in order for these elements to be incorporated and to ensure a productive discussion, students need to be guided in their interactions (Weinberger, 2003; Papadopoulos et al., 2009).

Productive Discussion

Because of the increasing need to think and work collaboratively on critical issues, developing effective communication and collaboration skills is regarded as an essential 21st-century competency due to its ability to improve students' cognitive, social, and emotional

development (Araujo et al., 2024; Hu & Chen, 2023; Noroozi et al., 2013). One of the key components of collaborative learning is goal-oriented discussion (Laal, 2013). In order to have a meaningful discussion there has to be a productive and equally contributed dialogue between the parties (Michaels et al., 2010). To understand whether a discussion is productive Michaels and O'Connor (2015) developed the Four Goals for Productive Discussions (FGPD) for educators, to assess and guide productive dialogue in educational settings. By defining these goals, it is possible to determine whether they are met and thus understand the dialogue, as well as how students who do not meet some of them can be helped (Michaels & O'Connor, 2015). These goals include:

Goal 1: Helping individual students share their own thoughts.

Goal 2: Helping students orient to and listen carefully to one another.

Goal 3: Helping students deepen their reasoning.

Goal 4: Helping students engage with others' reasoning.

Furthermore, to ensure productive discussion and active learning, there has to be a balanced contribution of the students (Johnson & Johnson, 2018). In order for discussions to be productive students have to actively engage with each other, and it has to be assured that they contribute an equal amount to the discussion (Strauß & Rummel, 2021). Unequal contribution can result in a limited learning process for the less contributing student (Gillies, 2019). Therefore, it is important for teachers to also ensure that the discussions are balanced (Qureshi et al., 2023). Despite the significant benefits of collaborative learning, its successful implementation depends largely on the ability of educators to effectively monitor and guide students' interactions (Michaels et al., 2010; Roll & Wylie, 2016). This is a big challenge for educators as they have to monitor large class sizes, which makes it impossible for them to follow the discussions of different groups simultaneously (Mertens, 2019). Because teachers struggle to ensure that all students are equally participating, staying on task, and actively engaging in productive dialogue (Saleem et al., 2021), this can result in problems or delays in students' learning progress (Michaels et al., 2010; Michaels & O'Connor, 2012). As not all students can be monitored at the same time, some students can fall behind (Michaels & O'Connor, 2012). Moreover, since online education is widely used, this challenge for teachers to monitor everyone has become more relevant (Silalahi & Hutauruk, 2020). Within the online environment, the teacher is more limited in monitoring the class because they can only visit one group's breakout room at a time and cannot see at all what the other students are doing. However, technology can be a help in minimizing this challenge, especially if it is computer-supported.

Computer-Supported Collaborative Learning

Computer-Supported Collaborative Learning (CSCL), is a learning paradigm, which uses new environments and tools that can support and monitor collaborative learning, including online settings (Dillenbourg & Fischer, 2007; Fischer et al., 2013). To promote productive collaboration, these CSCL environments make use of a variety of digital tools, such as shared workspaces and communication platforms (O'Malley, 2012). Additionally, CSCL systems can record the students' learning process, which can assist the teacher in keeping an overview of each student's performance for every task (Dillenbourg & Hong, 2008). Including an artificial intelligence (AI) system like conversational agents (CA) in the CSCL environment can enhance its effectiveness in facilitating productive discussions, as the CA can be tailored to meet the specific learning needs of the students (Cress & Kimmerle, 2023). The CA are able to monitor discussions, prompt students, and encourage deeper engagement with real-time feedback and support (Murad et al., 2019; Wollny et al., 2021; Cress & Kimmerle, 2023), which is necessary for productive discussion and the learning process of the students. These tools provide students with more personalised and immediate feedback, allowing them to stay engaged and facilitate collaborative learning even when the teacher is not present in every discussion (Tegos et al., 2020). With this, the CA show a possibility of taking over some of the teacher's tasks in guiding students during collaborative learning (de Araujo et al., 2023). Furthermore, CA offer the opportunity for continuous monitoring of discussions across the whole classroom, as they can be present in multiple groups simultaneously (Dimitriadou & Lanitis, 2023).

Conversational Agents in Education

CA use artificial intelligence, including natural language processing (NLP), enabling them to understand and respond to human language in a way that feels natural (Dimitriadou & Lanitis, 2023). Because of this capability, CA have emerged as powerful tools used in the educational field, as they can engage with students by simulating human-like interactions (Demetriadis et al., 2018). In a variety of subjects, research teams have developed agents, and multiple studies have shown that CA can be efficient in educating the user (Tegos et al., 2020; Wollny et al., 2021). Concerning this, combining these systems and integrating them in CSCL can give the students a more personalised and natural learning experience, which can enhance their learning outcomes in collaborative tasks, as it can interact with the students through natural language (Murad et al., 2019). This makes it more in line with how a teacher would interact with a student, facilitates productive dialogue, and interacts with students when a teacher's capacity is limited (Dimitriadou & Lanitis, 2023).

ConSent

In recent years, technological advancements have allowed for more effective monitoring and analysis of student interactions during collaborative learning. ConSent, a machine learning program designed to automate the content analysis of chat-based talks among students, is one such developed model (de Araujo et al., 2023). The ConSent algorithm is based on the pre-trained multilingual Universal Sentence Encoder, which enables accurate, automated content analysis across several languages and settings (Yang et al. 2019). To identify key moments in a conversation when intervention or support may be needed, the algorithm uses Contextual information and Sentence encoding as a core mechanism to identify moments where a conversational agent should interact in the discussion (de Araujo et al., 2023). This technology helps to facilitate effective talks by establishing the framework for intelligent conversational agents to intervene at the appropriate times, enabling students to stay on track and interact on a deeper level with their peers.

Clair

On the basis of the ConSent model, the Collaborative Learning Agent for Interactive Reasoning (Clair) was developed. Clair is an interactive CA that focuses on providing guiding questions to students during a collaborative exercise with the use of the APT framework (de Araujo et al., 2023). The APT framework is based on research on classroom discussion patterns and includes a set of "talk moves" that can encourage learning during classroom discussions (Michaels & O'Connor, 2015). Grounded on the APT principles (Michaels et al., 2015), eight talk moves were created for Clair (de Araujo et al., 2024). The eight talk moves are “Recapping”, “Add-on”, “Rephrasing”, “Agree/Disagree”, “Linking contributions”, “Build on prior knowledge”, “Example”, and “Expand reasoning” and are centred around Clair’s aim to assist students in achieving the FGPD depending on what happens in the dialogue (de Araujo et al., 2024). The talk moves are created in line, with how a teacher would use them. For example, to prompt a student to recap what was discussed so far, a teacher would ask “Can someone summarise what we have discussed so far?” (Michaels et al., 2015; de Araujo et al., 2024). Additionally, to make it sound more natural Clair can use three different prompts for each talk move (de Araujo et al., 2024). Example prompts for the different talk moves Clair uses are displayed in the materials section in Table 1.

Current study

With an emphasis on Michaels and O'Connor's (2015) Four Goals for Productive Discussions (FGPD), this study will examine to what extent Clair can improve the

productivity of students' discussions. Understanding how Clair affects these goals offers insights into the effectiveness and possible areas for improvement of Clair to enhance student collaborative discussions. To test this, it will be focused on investigating how frequently and in which sequence the FGPD occur in an unguided collaborative learning task to understand the nature of the goal occurrences and sequences in a dialogue. This will be then compared to a discussion, that is guided by Clair. Next, this study will investigate the types of talk moves that are most effective at triggering various goals, as well as how these moves alter the dynamics of the discussion because discourse in collaborative learning is dynamic and evolves over time. Consequently, understanding how certain talk moves affect the achievement of specific goals is essential. This will be beneficial in determining which components of Clair's intervention are most helpful in facilitating productive discussions and triggering specific goals of the FGPD. Lastly, it will be focused on how the balance of achieved goals differs between the discussion without Clair and with Clair. This will be done to see if Clair is able to improve the user's goal achievements and balance the discussion contribution of both participants.

Therefore, this research will focus on answering the following research questions:

Research Question 1: How frequently and in what sequence do different FGPD occur during dialogues (without Clair)?

Research Question 2: How do Clair's talk moves affect the frequency and occurrence of specific goals in dialogues?

Research Question 3: What types of Clair's talk-moves trigger which FGPD?

Research Question 4: To what extent did Clair improve the discussion balance?

Method

Participants

The data collection of this study had a total of 34 participants of which 12 were male, and 22 were female. The participants were recruited by convenience sampling, by advertising the study through flyers, and by an online subject pool system from a university. The participants' age ranged from 19 - 28 years old (M_{age} = 22.7, SD_{age} = 2.11). The majority of participants were German (n = 31), two were Dutch and one was Greek. The educational backgrounds varied from participants holding a high school diploma (n = 7), an Undergraduate/Bachelor's degree (n = 26), to a Master's degree (n = 1). The experiment was carried out online in October 2024, using Microsoft Teams Meetings and the Twente Go-Lab system (de Jong et al., 2021). The study's tasks were completed by participants in dyads (n = 17), each of whom was randomly assigned an anonymous username and randomly paired.

The criteria for participants to take part in the study were that they had to be fluent in English and have access to a computer. Participants were motivated to join the study by the possibility to earn participation credits, required for their graduation.

Materials

Go-Lab

The research was conducted in Go-Lab (de Jong et al., 2021), an online learning system, where teachers are able to create their own environment. The participants needed a laptop or computer to join the online Teams Meeting and open the Go-Lab environment. The created environment in Go-Lab included a collaboration tool, a chat box, a consent form, and a questionnaire about the participant's demographics and their opinion about the discussion with Clair.

Preparation Materials. Based on this, two different preparation materials, one for each discussant of a dyad, were created for the study. Within the Go-Lab environment, both preparations are linked to their impact on climate change; the first focuses on food production and eating habits, while the second focuses on renewable energy. The preparation material included a short paragraph and a video (approximately 4 minutes) to give the participants background knowledge about their topic.

Discussion Topics. Furthermore, the Go-Lab environment included Phase 1 (discussion topic 1, see Figure 1) and Phase 2 (discussion topic 2, see Figure 2) with the interaction of Clair. The two discussion topics were created on the basis of the ARCS model of motivation to create an engaging activity for the participants (Keller & Keller, 2010). The ARCS model focuses on the components "attention", "relevance", "confidence", and "satisfaction" (Keller & Keller, 2010). To include all of the mentioned components of the ARCS model, the cases for the discussion topics included engaging questions, real-world scenarios, and clearly defined and achievable goals. The cases for discussion topic 1 and discussion topic 2 are displayed in Figure 1.

Figure 1
Case Tasks for Discussion Topic 1.

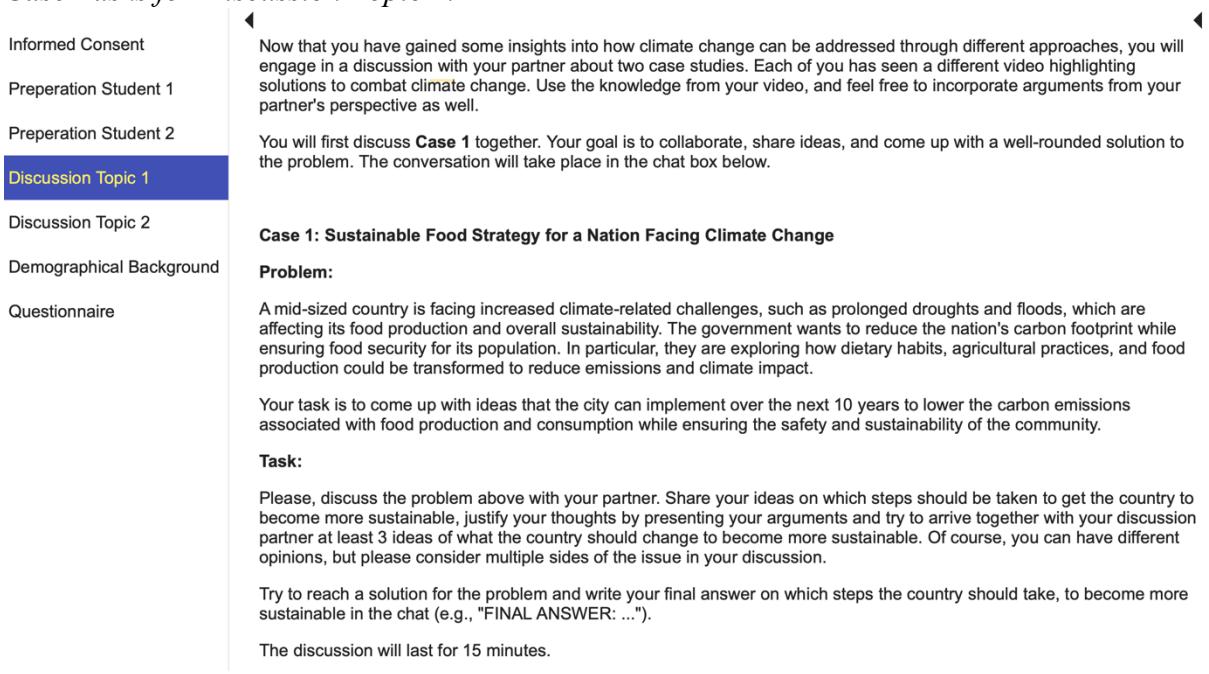
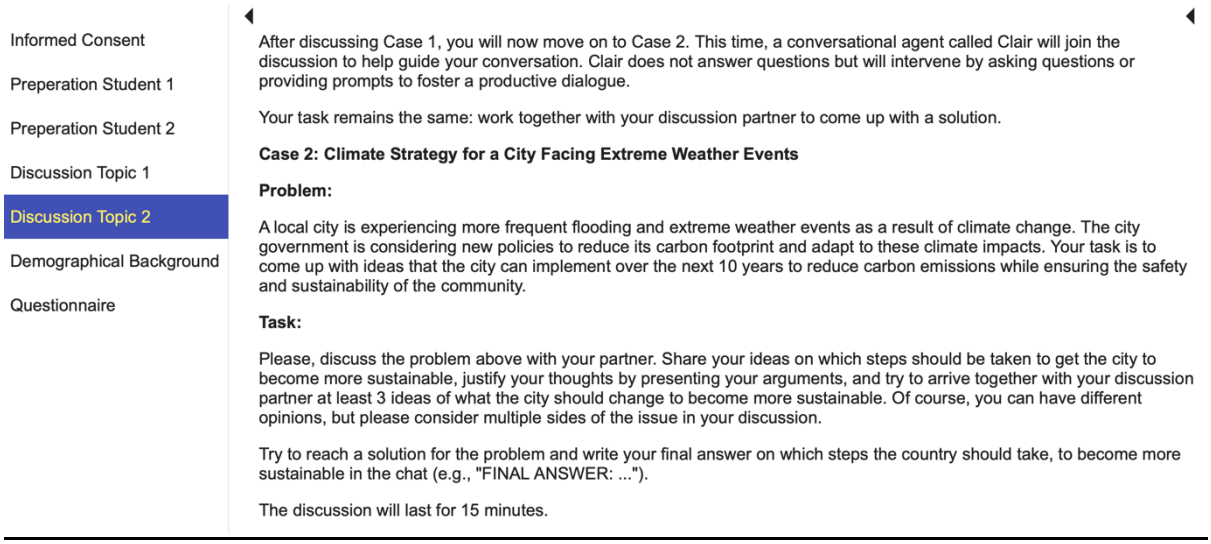


Figure 2
Case Tasks for Discussion Topic 2.



Clair. For this research, a conversational agent, Clair was used (de Araujo et al., 2023, 2024). Hereby, Clair was included in Phase 2 of the study. Clair interacts with the participants depending on, for example, the discussion balance, the time that has passed and the relevant keywords already mentioned. While interacting with the participants, Clair can prompt the discussants with eight talk moves which are in line with the APT Framework (Table 1).

Table 1
APT Base Talk Moves of Clair.

Talk Moves	Description Example
Expand Reasoning	["<speaker>, could you please elaborate more on this?"]
Agree/Disagree	["<discussant>, do you agree or disagree with your partner?"]
Linking Contributions	["<discussant>, how does your ideas align with what <speaker> just said?"]
Recapping	["This is a fascinating conversation. Would any of you be able to give a brief summary of what you've covered so far?"]
Example	["<speaker>, could you give an example?"]
Rephrasing	["<discussant>, could you put in other words what your partner just said?"]
Add-on	["<discussant>, would you like to add something to what your partner just said?"]
Build on prior knowledge	["<speaker>, how does this add to what <discussant> already said?"]

Procedure

At the start of the experiment, each participant logged into the system using their assigned username. After logging in, the participants were asked to read and fill out the informed consent (Appendix A). Next, participants had a preparation phase, in which background information with a short video (approximately 4 minutes), was given. Participants with an odd username (e.g. user001, user003) did “Preparation Student 1”, which focused on how food consumption habits can influence climate change (Appendix B). Simultaneously, participants with an even username (e.g. user002, user004) did “Preparation Student 2”, which provided them with information about how renewable energy can influence climate change (Appendix C). For this preparation, participants had 10 minutes. Afterwards, Phase 1 with discussion topic 1 began. The participants were presented with a case that they had to discuss and arrive at a joint answer in the chat tool (Appendix D). The participants were given 15 minutes, and after, they were asked to wrap up the discussion and were granted access to Phase 2, with discussion topic 2. In Phase 2 the participants had to discuss again and arrive at a joint answer to a different case. Clair was present in the chat tool and prompted them with the talk-moves, to help them reach the FGPD (Appendix E). This lasted again 15 minutes. Lastly, the participants were asked to fill out questions about their demographical background and their opinions about Clair’s interventions during Discussion Topic 2 (Appendix F, Appendix G).

Data Analysis

After the data-collecting procedure was completed, the acquired data was exported from Go-Lab and prepared for analysis. The chats were imported into the Atlas.ti software and the occurrences of the FGPD were coded. To code and analyse the FGPD in the discussions, a codebook, which is based on the APT principles, was used (Table 2). Thus, the participants speaking turns were deductively coded. To ensure inter-rater reliability, the chats were coded by two independent raters and Cohen's kappa was calculated across all chats ($\kappa = .85$). After that, the dataset was prepared for statistical analysis and imported into RStudio (Version 1.4.1717). The demographical data of the participants was examined, and a paired-samples t-tests was performed, to analyse the difference in FGPD occurrence in both phases (without and with Clair). For this, all test assumptions were checked, and a significance level of $\alpha = .05$ was used. A frequency analysis of the goals that were reached in Phase 1 and Phase 2 was made. Next, to analyze sequences of the goal occurrences, a Markov transition matrix was conducted and a Markov chain diagram was developed. Afterwards, a qualitative analysis of the goal sequences after specific interventions of Clair was executed. Lastly, to analyse the change in discussion balance between Phase 1 and Phase 2, the difference in goal contributions of the participants was calculated.

Table 2
Codebook of FGPD

FGPD	Goal Definition	Code	Description	Coding Indicators	Example Quotation
Goal 1	Individual students share their own thoughts	G1	examining task-related informative and argumentative statements	- Information - Opinions	"One idea could be building more solar systems on the buildings roofs' within that city"
Goal 2	Students orient to and listen carefully to one another	G2	orienting and listening carefully to one another (message related to statement of other student before)	- Reacting to statement of the other - Agreeing/disagreeing - Orienting towards discussion partner	"I agree with your ideas."

Goal 3	Students deepen their reasoning	G3	extending their own task-related contributions	-	Deepening own thoughts/opinions that were mentioned by them before	"In terms of food security, a carnivore diet might still be necessary. By improving the feeds and feeding techniques, the animals could produce less carbon emission by still ensuring food security, especially in rural areas."
Goal 4	Students engage with others' reasoning	G4	Students engage with each other's arguments	-	Engaging with statement from the other	Student 1:" or as you said the biggest problem is beef, so for beef alternatives"; Student 2: "For the meat alternatives, we could also make them cheaper by goverment fund, so the goverment/ taxes pay for it. Becuase it will be a good change for the enviroment in the long run"

Note. Example Quotations are taken from the collected data.

Results

Table 3 gives an overview of the frequencies of the reached goals by the participants across all discussions of Phase 1 (without Clair). In these discussions, G1 (sharing understanding) is the most frequently occurring goal ($M = 4.65$), followed by G2 (orient to one another) ($M = 3.59$). In total, the participants reached 238 goals in the first discussion. The frequencies of the reached goals by the participants and Clair's interventions across all discussions in Phase 2 are summarized in Table 4. Clair contributed 70 times throughout the discussions of Phase 2 ($M = 4.12$, $SD = 2.49$), while the overall mean frequency of the FGPD across groups was 16.35 ($SD = 7.41$). G4 (engage with others reasoning) is the least common goal in Phase 2 ($M = 3.53$, $SD = 1.97$), whereas G3 (deepening reasoning) is the most common ($M = 4.71$, $SD = 2.24$). In comparison to Phase 1 (Table 3), the total amount of goal occurrences increased by 40 (N = 278) in Phase 2 (Table 4).

Table 3
Frequency of FGPD in Phase 1.

	Without Clair				
	G1	G2	G3	G4	Total
M	4.65	3.59	2.71	3.06	14.00
SD	*2.61*	*2.47*	*1.93*	*2.10*	*6.53*
N	79	61	46	52	238

Table 4
Frequency of FGPD and Clair's Interventions in Phase 2.

	With Clair					
	G1	G2	G3	G4	Total	Clair
M	4.18	3.94	4.71	3.53	16.35	4.12
SD	*1.76*	*3.44*	*2.24*	*1.97*	*7.41*	*2.49*
N	71	67	80	60	278	70

Table 5 shows the frequency of sequence occurrences of the FGPD during the discussions in Phase 1 (without Clair). The statistics show that G2 has a high occurrence in proceeding to G1 (53.70%). Moreover, G1 transitions most often to G3 (40%). In Table 6, the frequency of sequence occurrences of the FGPD in Phase 2 and the frequency of the goals occurring after Clair's intervention are shown. After Clair's intervention, G3 was found to have the highest occurrence (55.71%), followed by G4 (22.86%). G1 (8.57%) and G2 (12.86%) appeared less frequently following Clair's intervention (e.g., Clair → G1, Clair → G2). Across all FGPD, G2 has the highest frequency of transferring to G1 (32.26%), whereas G3 most commonly progressed to G4 (23.08%). In comparison, G4 had fewer transitions to other goals. For a comprehensive overview, of the sequence occurences in Phase 1 and Phase 2, see Figure 3.

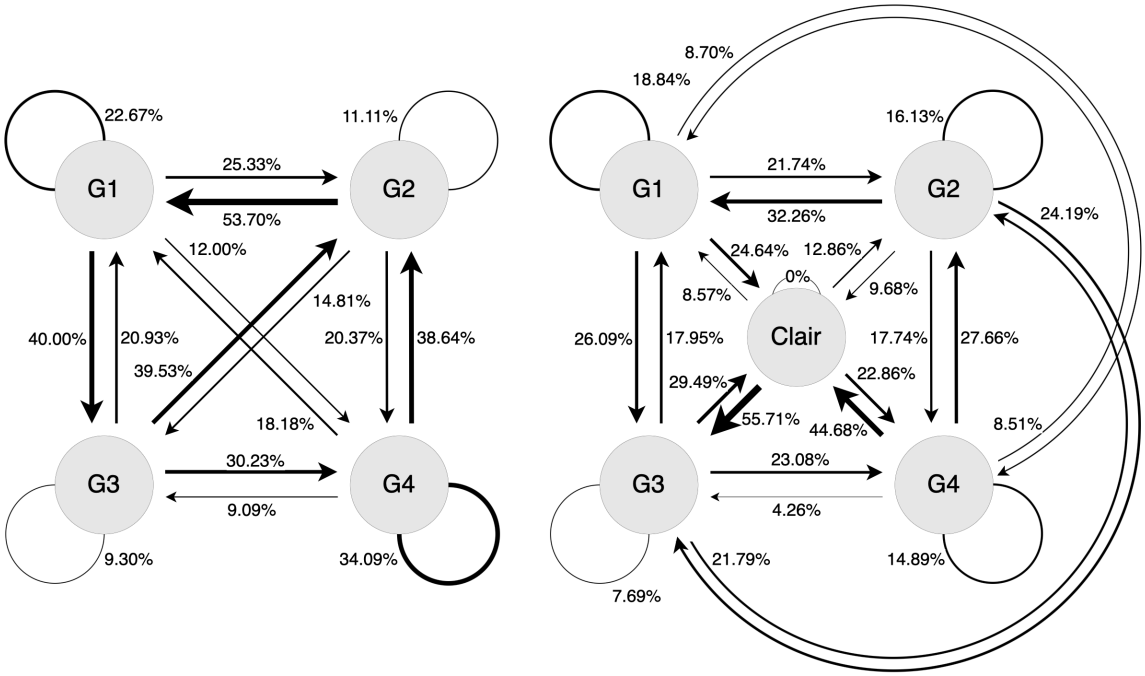
Table 5
Markov Transition Matrix of the FGPD Sequence Occurrences in Phase 1.

	Without Clair			
	→ G1	→ G2	→ G3	→ G4
G1	22.67	25.33	40.00	12.00
G2	53.70	11.11	14.81	20.37
G3	20.93	39.53	9.30	30.23
G4	18.18	38.64	9.09	34.09

Table 6
Markov Transition Matrix of the FGPD Sequence Occurrences in Phase 2.

	With Clair				
	→ G1	→ G2	→ G3	→ G4	→ Clair
G1	18.84	21.74	26.09	8.70	24.64
G2	32.26	16.13	24.19	17.74	9.68
G3	17.95	21.79	7.69	23.08	29.49
G4	8.51	27.66	4.26	14.89	44.68
Clair	8.57	12.86	55.71	22.86	0.00

Figure 3
Markov Chain Diagrams for the First (without/left) and Second (with/right) Discussion Tasks.



To determine whether there were significant differences between the "Without Clair" and "With Clair" conditions across different goals, paired-samples t-tests were performed for each goal (Table 7). Only G3 showed a significant difference (t[16] = -2.768, p = .014, d = 1.08), indicating that the frequency of G3 increased significantly in the discussion in which Clair was present.

Table 7
Results of Paired-samples t-tests Comparing "Without Clair" and "With Clair" Conditions Across Goals.

	Paired-samples *t*-test			
	t	*df*	p	95% CI
G1	0.714	16	.486	[-0.927, 1.868]
G2	0.560	16	.583	[-1.688, 0.982]
G3	2.768	16	.014*	[-3.532, -0.468]
G4	0.733	16	.474	[-1.832, 0.891]

* $p < .05$

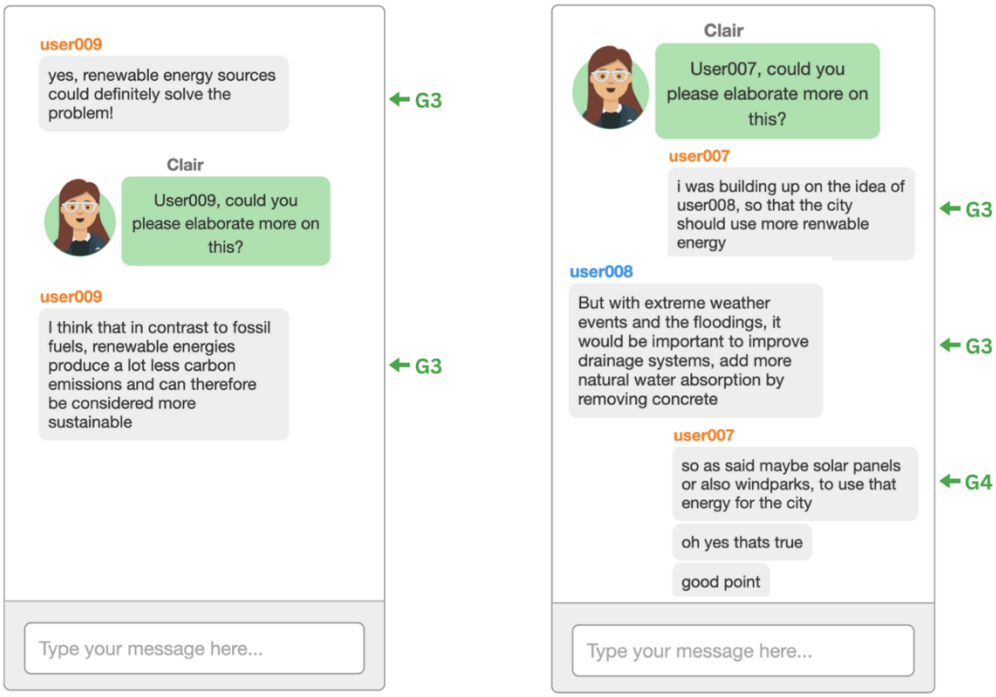
To gain more insights into the FGPD sequence occurrences following Clair's intervention, the chats were analysed qualitatively. As previously stated, Clair intervened in total 70 times, in Table 8 the frequency of the specific talk moves are displayed.

Table 8
Clair's Interventions.

Talk Moves	Frequency	Percentage
Expand Reasoning	21	30.0 %
Agree/Disagree	11	16.0 %
Linking Contributions	3	4.5 %
Recapping	15	21.0 %
Example	12	17.0 %
Rephrasing	3	4.5 %
Add-on	5	7.0 %
Build on prior knowledge	0	0.0 %

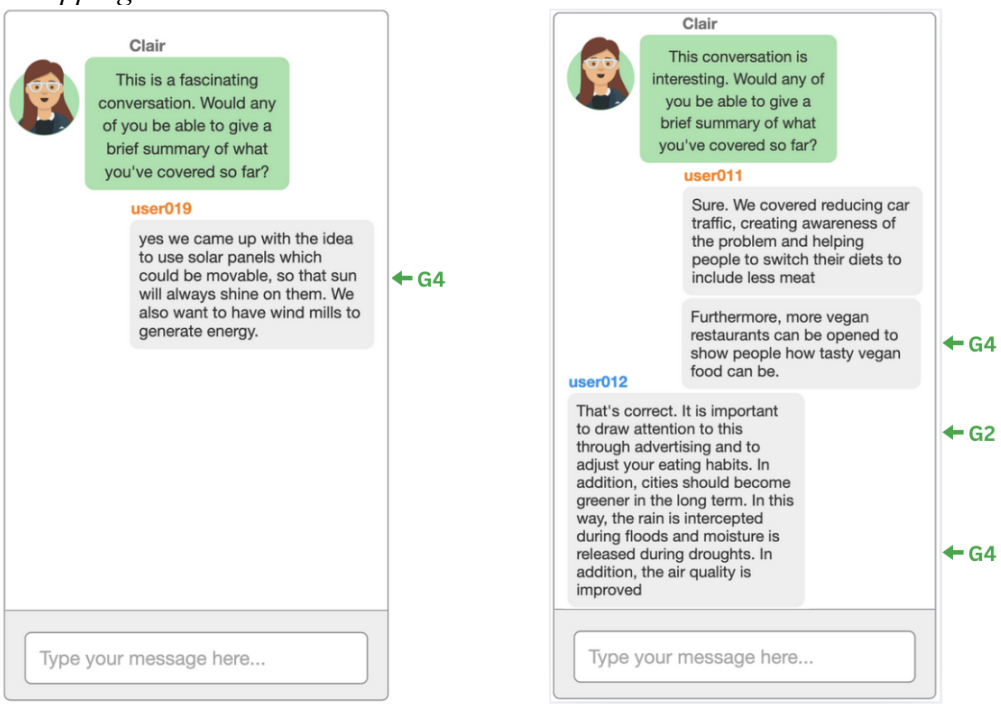
Firstly, the talk move with the highest occurrence across the chats is "Expand reasoning" (30%), which resulted in most of the cases in a G3 response, (Figure 4, left). The "Expand reasoning" intervention of Clair did not only influence the response directly after the intervention but also a longer sequence of goals (Figure 4, right).

Figure 4
Expand Reasoning



The talk move with the second highest frequency is "Recapping" (21%), these interventions of Clair resulted most of the time in participants reaching G4 (Figure 5, left). The "Recapping" talk move also resulted in the participation of both discussants (Figure 5, right).

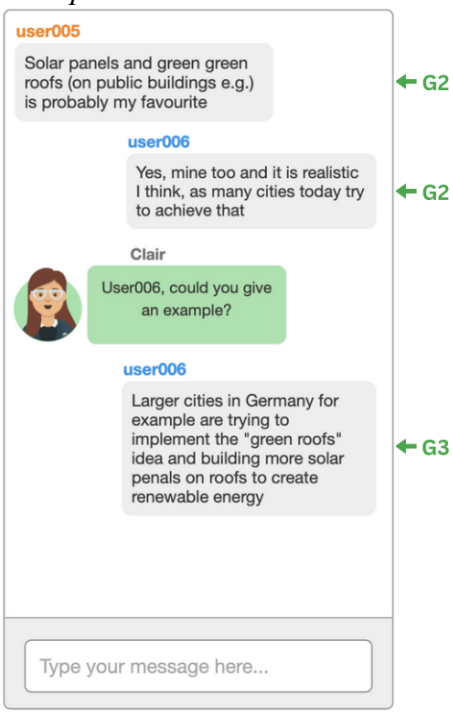
Figure 5
Recapping



Thirdly, Clair's talk move "Example" occurred most frequently (17%), which resulted in almost all of the chats in the discussant responding in reaching G3. For example, in the discussion between user005 and user006, Clair transferred user006s contribution from G2 to G3 (Figure 6).

Figure 6

Example



Following that, Clair's talk move "Agree/Disagree" was the fourth most common (16%). The response to this talk move resulted in every discussion G2. An example of a participant's reaction towards Clair's intervention "Agree/Disagree" is shown in Figure 7.

Figure 7
Agree/Disagree

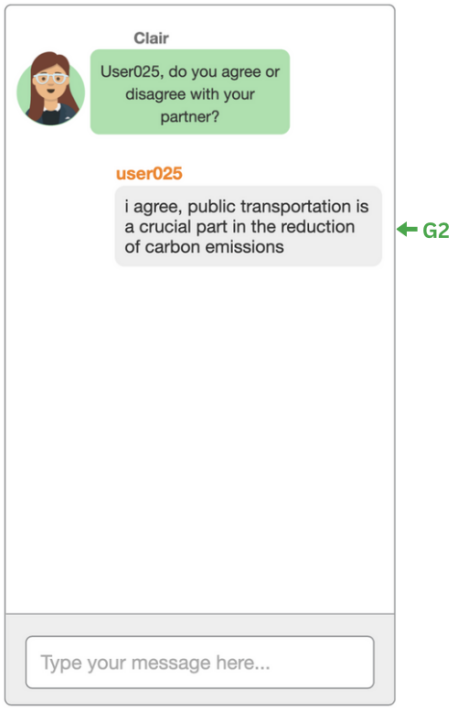


Table 9 shows the summary of the overall contribution balance among all participants between Phase 1 and Phase 2. The mean was lower in Phase 2 with Clair (M = 40.28). Overall, the contribution balance increased for G2 (Diff = 44.85) and G4 (Diff = 35.84) with the presence of Clair.

Table 9
Summary of Individual Contribution Balance between Phase 1 and Phase 2.

	G1 Diff (%)	G2 Diff (%)	G3 Diff (%)	G4 Diff (%)	M	*SD*
Without Clair	30.24	52.30	36.67	46.76	41.49	*9.91*
With Clair	36.92	44.85	43.50	35.84	40.28	*4.56*

Note. G1 Diff = Goal 1 Difference; G2 Diff = Goal 2 Difference; G3 Diff = Goal 3 Difference; G4 Diff = Goal 4 Difference.

To gain better insights into how Clair was able to balance the individual contributions in the discussions, specific examples of different chats will be displayed in the following. Table 10 and Table 11 display Chat 1, the first example chat, whereby Clair's interventions raised the individuals' total contribution (12 - 15) and slightly improved the balance (11.11% → 10.00%).

Table 10
Chat 1 without Clair.

	Without Clair				
	G1	G2	G3	G4	Total
Frequency	7	10	2	8	27
Individual Contribution	2 - 5	4 - 6	1 - 1	5 - 3	12 - 15
Diff%	42.86%	20.00%	0.00%	25.00%	11.11%
M	3.5	5.0	1.0	4.0	3.4
SD	*2.12*	*1.41*	*0.00*	*1.41*	*1.92*

Table 11
Chat 1 with Clair.

	With Clair					
	G1	G2	G3	G4	Total	Clair
Frequency	8	16	8	8	40	5
Individual Contribution	4 - 4	7 - 9	4 - 4	3 - 5	18 - 22	2 - 3
Diff%	0.00%	12.50%	0.00%	25.00%	10.00%	20.00%
M	4.0	8.0	4.0	4.0	5.0	2.5
SD	0.00	1.41	0.00	1.41	2.00	0.71

The next example chat, Chat 12, is displayed in Table 12 and Table 13 and shows an overall decrease in contribution balance from the chat without Clair (14.29%) to with Clair (20.00%), while Clair improved the overall contribution (10 - 8).

Table 12
Chat 12 without Clair.

	Without Clair				
	G1	G2	G3	G4	Total
Frequency	2	2	1	4	9
Individual Contribution	1 - 1	1 - 1	0 - 1	2 - 2	4 - 5
Diff%	0.00%	100.00%	100.00%	33.33%	14.29%
M	1.0	1.0	0.5	2.0	1.1
SD	0.00	0.00	0.71	0.00	0.64

Table 13
Chat 12 with Clair.

	With Clair					
	G1	G2	G3	G4	Total	Clair
Frequency	4	2	7	5	18	6
Individual Contribution	1 - 3	2 - 0	3 - 4	4 - 1	10 - 8	4 - 2
Diff%	50.00%	100.00%	14.29%	60.00%	20.00%	33.33%
M	2.0	1.0	3.5	2.5	2.4	2.3
SD	1.41	1.41	0.71	0.00	2.12	1.49

The last example chat, Chat 3, had a completely balanced contribution from both participants (0.00%) for the discussion without Clair (Table 14). This contribution balance increased in the chat Clair interacted (12.50%), while both individual contributions raised (7 - 9) (Table 15).

Table 14
Chat 3 without Clair.

	Without Clair				
	G1	G2	G3	G4	Total
Frequency	4	0	0	2	6
Individual Contribution	2 - 2	0 - 0	0 - 0	1 - 1	3 - 3
Diff%	0.00%	0.00%	0.00%	0.00%	0.00%
M	2.0	0.0	0.0	1.0	0.75
SD	0.00	0.00	0.00	0.00	0.89

Table 15
Chat 3 with Clair.

	With Clair					
	G1	G2	G3	G4	Total	Clair
Frequency	5	5	3	3	16	3
Individual Contribution	3 - 2	2 - 3	0 - 3	2 - 1	7 - 9	1 - 2
Diff%	20.00%	20.00%	100.00%	33.33%	12.50%	33.33%
M	2.5	2.5	1.5	1.5	2.0	1.5
SD	0.71	0.71	2.12	0.71	1.07	0.71

Discussion

Main findings

The results of this study revealed distinct patterns in the frequency and sequence of the occurrence of the FGPD, in both conditions. Research Question 1: “How frequently and in what sequence do different FGPD occur during dialogues (without Clair)?” was answered by analysing the frequency and sequence of the goal occurrences. In the absence of Clair (Phase 1), G1 and G2 emerged as the most frequently achieved goals. In the discussion without Clair, G2→G1 and G1→G3 were the most frequently occurring transitions, indicating that the discussions remained on surface levels, making it difficult for the discussants to reach higher levels like G4. These findings suggest that discussions in Phase 1 were foundational and stayed on the surface level of productive discussion, reflecting challenges in achieving deeper engagement without guidance (Weinberger, 2003; Michaels & O'Connor, 2015).

In Phase 2, Clair’s interventions led to an increased overall frequency of the FGPD, with the total number of goals achieved rising by 40. The most notable change was the significant increase in the occurrence of G3, which became the dominant goal in discussions with Clair. This finding is particularly relevant, as G3 frequently occurred directly after Clair’s interventions, showing Clair’s influence towards directing dialogues to a deeper, more exploratory and elaborative level. These results are also in line with prior research by Michaels et al. (2010), who emphasized that reaching G3 in a discussion is an important part of having an academically productive discussion. To answer Research Question 2: “How do Clair's talk moves affect the frequency and occurrence of specific goals in dialogues?” it can be said that the G3 occurrence in the phase with Clair increased significantly compared to the phase without Clair. Even though the other goals did not increase significantly, the frequency of G2 and G4 increased in the phase with Clair. Only G1 decreased, which can be explained by students already sharing their basic understanding in the first discussion, hence did not repeat it in Phase 2. This shows that Clair is able to facilitate the discussion to reach a deeper level of academic productive discussion (e.g. G3 & G4). This also aligns with previous research that students need guidance in a discussion (Papadopoulos et al., 2009; Weinberger, 2003).

With the focus on Research Question 3, “What types of Clair’s talk-moves trigger which FGPD?”, the talk moves that mostly occurred in the discussions were „Expand reasoning“, „Recapping“, „Expand“, and „Agree/Disagree“. Each of these talk moves triggered different goals and goal sequences in the responses of the participants. The talk

move with the highest frequency, „Expand reasoning“ followed in almost all of the cases in G3. This is also in line with the previous findings of research question 2, as G3 was also the goal found most frequently in the discussion with Clair. Furthermore, the sequence of reached goals after this talk move (e.g., Clair → G3 → G3 → G4), showed that also following a longer sequence after Clair's intervention, the participants' discussion reached a deeper level. These findings are also in line with previous research on CA possibilities to guide discussions to a deeper and more productive level (Tegos et al., 2020). The following talk move „Recapping“ resulted in most of the cases in G4 or a longer sequence of G4, whereby both participants discussed an argument together. With this talk move, Clair prompted one discussant to argue on a deeper level about what was discussed before, which also in most cases led the other discussant to join in. By that Clair took over the guidance role, which in return shows the possibility to use Clair instead of needing an educator to facilitate the discussion (Dimitriadou & Lanitis, 2023). The talk move „Example“, similar to „Expand Reasoning“, prompted participants to deepen their reasoning and thereby reaching G3. Lastly, Clairs talk move „Agree/Disagree“ resulted in G2 across all chats, which can be supported by previous research indicating that Clair can aid in guiding students to listen to each other's arguments (de Araujo et al., 2024).

In regards to Research Question 4, "To what extent did Clair improve the discussion balance?" an overall improvement across all chats and for all goals could not be found. In the summary, it was only found that Clair increased the contribution balance for G2 and G4, while G1 and G3 decreased. As these differences only focus on the general contribution balance per goal across all discussions, the individual contributions per chat were included. By looking into specific chats, it became clear that the difference in the contribution balance did not become lower in the discussions in which Clair intervened, as the talk moves of Clair made some discussants interact more than they did in the prior discussion. For the first example chat, it was found that even though the contribution balance slightly increased, the individual contribution of each participant was raised through Clair. Similar results were also observed for the second chat example, whereby the total contribution balance decreased, but Clair raised the first participant's contribution by over 50%, while also raising the second participant's contribution. The last chat example shows why it was necessary to look into specific examples, as the summary difference in contribution balance was not able to display these findings. Even though the first discussion without Clair was balanced for this chat, the overall individual contribution of the participants was lower. With Clair's interaction, the discussion got more productive as the talk moves of Clair raised the individual contribution.

Implications

Overall, the findings of this study bring significant contributions to implementing CA in the educational domain. In regards to practical implications, it was found, that Clair provides a structured way to improve collaborative learning, especially in online environments where teachers face more challenges in monitoring multiple groups at the same time. According to the findings of this study, Clair was able to assist students in achieving deeper discussions (e.g., G3) and improving the contribution balance of both discussants. For example, if one student is not actively participating in the discussion, Clair is able to increase the participation while also maintaining the participation level of the other among all goals. Moreover, the use of the APT framework and Clair talk moves can be implemented by instructional designers to develop adaptable systems for guiding productive discussions. Especially, the talk moves “Expand Reasoning” and “Recapping” demonstrated the ability to guide the discussions of students to a deeper and more productive level, providing valuable insights for designing future conversational agents for collaborative learning.

All of the aforementioned practical implications demonstrate Clair's ability to effectively guide discussions, implying the possibility of integrating Clair into real-world settings. Furthermore, the integration of Clair into platforms like Go-Lab demonstrates the potential to use Clair in classrooms with minimal adjustment. This makes it possible to implement Clair on a wider range, for example, in multiple classrooms. Which can help the teachers in monitoring their students and allow students to receive more guidance in order to stay on task and have productive discussions.

Concerning the theoretical implications, this study supports the APT framework and its connection with the FGPD (Michaels & O'Connor, 2015), as it demonstrates that specific talk moves (e.g. “Expand Reasoning”, “Recapping”) effectively lead to deeper discussions, particularly achieving G3 and G4. Furthermore, distinct patterns in the frequency (e.g. G3 being more frequent with Clair) and sequences (e.g., Clair → G3 → G4) of the FGPD were identified. These provide insights into how discussions can evolve with AI guidance. Adding on to this, it was found that Clair enables discussions to move from the surface levels of productive discussions (G1, G2) into deeper reasoning and engagement (G3, G4). These results build on earlier research by demonstrating that by using the APT framework, conversational agents such as Clair can facilitate academically productive discussions (de Araujo et al., 2024).

Limitations

One of the study's limitations is the small sample size of 34 participants, which limits the generalizability of this experiment. To recruit participants, the researcher employed convenience sampling, which can cause selection bias and a reduction of the representativeness of the sample. Lastly, the experiment did not include a control group, which would be important to incorporate to ensure the reliability of the findings. Having no control group included in the study, there is a chance that in Phase 1 students implicitly practised having a discussion and gained knowledge about the climate change topic, which could have led to a learning effect in Phase 2.

This study did, however, also have strengths. To begin with, participants received structured preparation materials that were tailored to the discussion topics, ensuring a basis of shared knowledge. Furthermore, the set-up of the experiment is connected to how the CA would be employed in a real-life setting, a classroom. Additionally, the discussion topics focused on climate change, adding social relevance to the study and a possibility to use it across different cultural and educational backgrounds. Lastly, the participants were paired up randomly, which decreases the possibility that the discussions were influenced by pre-existing relationships or dynamics between participants.

Conclusion and future research

In conclusion, Clair's impact showed a possibility to guide student discussions into reaching a deeper and more productive level, which gives the opportunity to implement Clair in the classroom to support educators and increase students learning outcomes through collaborative learning.

Before this can be done future research should focus on implementing Clair in a real classroom and test the outcomes of Clair's possibility to facilitate productive discussions after a longer period. For this research, it should also be considered to test the knowledge of the students prior to the implementation of Clair and after it has been deployed for longer. This should be done to test whether students' knowledge will be expanded through the combination of collaborative learning and the guidance of a CA.

References

Cress, U., & Kimmerle, J. (2023). Co-constructing knowledge with generative AI tools: Reflections from a CSCL perspective. *International Journal of Computer-Supported Collaborative Learning*, *18*(4), 607-614.

de Araujo, A., Papadopoulos, P. M., McKenney, S., & de Jong, T. (2023). Automated coding of student chats, a trans-topic and language approach. *Computers and Education: Artificial Intelligence*, *4*, 100123.

de Araujo, A., Papadopoulos, P. M., McKenney, S., & de Jong, T. (2023). Supporting Collaborative Online Science Education with a Transferable and Configurable Conversational Agent. In *15th International Conference on Computer-Supported Collaborative Learning (CSCL)*.

de Araujo, A., Papadopoulos, P. M., McKenney, S., & de Jong, T. (2024). A learning analytics-based collaborative conversational agent to foster productive dialogue in inquiry learning. *Journal of Computer Assisted Learning*.

de Araujo, A., Martens, J., & Papadopoulos, P. M. (2024, July). Enhancing student dialogue productivity with learning analytics and fuzzy rules. In *International Conference on Artificial Intelligence in Education* (pp. 397-404). Cham: Springer Nature Switzerland.

Demetriadis, S., Tegos, S., Psathas, G., Tsiatsos, T., Weinberger, A., Caballé, S., Dimitriadis, Y., Sanchez, E., Papadopoulos, P. M., & Karakostas, A. (2018). *Conversational Agents as Group-Teacher Interaction Mediators in MOOCs*. https://doi.org/10.1109/lwmoocs.2018.8534686

Dillenbourg, P. (1999). What do you mean by collaborative learning? In P. Dillenbourg (Ed.), Collaborative-learning: Cognitive and computational approaches (pp. 1-19). Oxford, UK: Elsevier.

Dillenbourg, P., & Fischer, F. (2007). Computer-supported collaborative learning: The basics. *Zeitschrift für Berufs-und Wirtschaftspädagogik*, *21*, 111-130.

Dillenbourg, P., & Hong, F. (2008). The mechanics of CSCL macro scripts. *International Journal of Computer-Supported Collaborative Learning*, *3*, 5-23.

Dimitriadou, E., & Lanitis, A. (2023). A critical evaluation, challenges, and future perspectives of using artificial intelligence and emerging technologies in smart classrooms. *Smart Learning Environments*, *10*(1), 12.

Eison, J. (2010). Using active learning instructional strategies to create excitement and enhance learning. *Jurnal Pendidikantentang Strategi Pembelajaran Aktif (Active Learning) Books*, *2*(1), 1-10.

Gillies, R. M. (2019). Promoting academically productive student dialogue during collaborative learning. *International Journal of Educational Research*, *97*, 200–209. https://doi.org/10.1016/J.IJER.2017.07.014

Griffiths, A. J., Alsip, J., Hart, S. R., Round, R. L., & Brady, J. (2021). Together we can do so much: A systematic review and conceptual framework of collaboration in schools. *Canadian Journal of School Psychology*, *36*(1), 59-85.

Johnson, D. W., & Johnson, R. T. (2018). Cooperative learning: The foundation for active learning. *Active learning—Beyond the future*, 59-71.

Kane, L. (2004). Educators, learners and active learning methodologies. *International journal of lifelong education*, *23*(3), 275-286.

Keller, J. M., & Keller, J. M. (2010). The Arcs model of motivational design. *Motivational design for learning and performance: The ARCS model approach*, 43-74.

Laal, M. (2013). Collaborative learning; elements. *Procedia-Social and Behavioral Sciences*, *83*, 814-818.

Mertens, D. M. (2019). *Research and evaluation in education and psychology: Integrating diversity with quantitative, qualitative, and mixed methods*. Sage publications.

Michaels, S., O'Connor, M. C., Hall, M. W., & Resnick, L. B. (2010). Accountable talk® sourcebook. *Pittsburg, PA: Institute for Learning University of Pittsburgh. Murphy, PK, Wilkinson, IAG, Soter, AO, Hennessey, MN, & Alexander, JF*.

Michaels, S., & O'Connor, C. (2012). Talk science primer. *Cambridge, MA: TERC*.

Michaels, S., & O'Connor, C. (2015). Conceptualizing talk moves as tools: Professional development approaches for academically productive discussion. *Socializing intelligence through talk and dialogue*, 347-362.

Murad, D. F., Iskandar, A. T. P., Fernando, E., Octavia, T. S., & Maured, D. E. (2019). *Towards Smart LMS to Improve Learning Outcomes Students Using LenoBot with Natural Language Processing*. https://doi.org/10.1109/icitacee.2019.8904311

O'Malley, C. (Ed.). (2012). *Computer supported collaborative learning* (Vol. 128). Springer Science & Business Media.

Oyinloye, G.O. (2010). Primary school teachers' perceptions of classroom management and its influence on pupils' activities. European Journal of Educational Studies, 2(3), 305-312.

Papadopoulos, P. M., Demetriadis, S. N., & Stamelos, I. G. (2009). Analyzing the role of student's self-organization in a case of scripted collaboration. In *8th International Conference on Computer Supported Collaborative Learning, CSCL 2009* (pp. 487-496).

Qureshi, M. A., Khaskheli, A., Qureshi, J. A., Raza, S. A., & Yousufi, S. Q. (2023). Factors affecting students' learning performance through collaborative learning and engagement. *Interactive Learning Environments*, *31*(4), 2371-2391.

Roll, I., & Wylie, R. (2016). Evolution and Revolution in Artificial Intelligence in Education. *International Journal of Artificial Intelligence in Education*, *26*(2), 582–599. https://doi.org/10.1007/s40593-016-0110-3

Teasley, S. D., Fischer, F., Weinberger, A., Stegmann, K., Dillenbourg, P., Kapur, M., & Chi, M. T. H. (2008). Cognitive convergence in collaborative learning. *International Conference of Learning Sciences*, 360-367. http://www.gerrystahl.net/proceedings/icls2008/papers/paper192.pdf

Tegos, S., Demetriadis, S., Papadopoulos, P. M., & Weinberger, A. (2016). Conversational agents for academically productive talk: a comparison of directed and undirected agent interventions. *International Journal of Computer-supported Collaborative Learning*, *11*(4), 417–440. https://doi.org/10.1007/s11412-016-9246-2

Tegos, S., Demetriadis, S., Psathas, G., & Tsiatsos, T. (2020). A Configurable Agent to Advance Peers' Productive Dialogue in MOOCs. In *Lecture Notes in Computer Science* (pp. 245–259). Springer Science+Business

Saleem, A., Muhammad, Y., & Masood, S. (2021). Managing elementary classrooms: Experiences of novice public-schools teachers regarding behavioral challenges of students. *Asian Social Studies and Applied Research*, *2*(3), 354-366.

Silalahi, T. F., & Hutauruk, A. F. (2020). The application of cooperative learning model during online learning in the pandemic period. *Budapest International Research and Critics Institute-Journal (BIRCI-Journal)*, *3*(3), 1683-1691.

Strauß, S., & Rummel, N. (2021). Promoting regulation of equal participation in online collaboration by combining a group awareness tool and adaptive prompts. But does it even matter?. *International Journal of Computer-Supported Collaborative Learning*, *16*(1), 67-104.

Wadesango, N., Hove, J., & Kurebwa, M. (2016). Effects of a Large Class Size on Effective Curriculum Implementation. *International Journal of Educational Sciences*, *12*(2), 173–183. https://doi.org/10.1080/09751122.2016.11890424

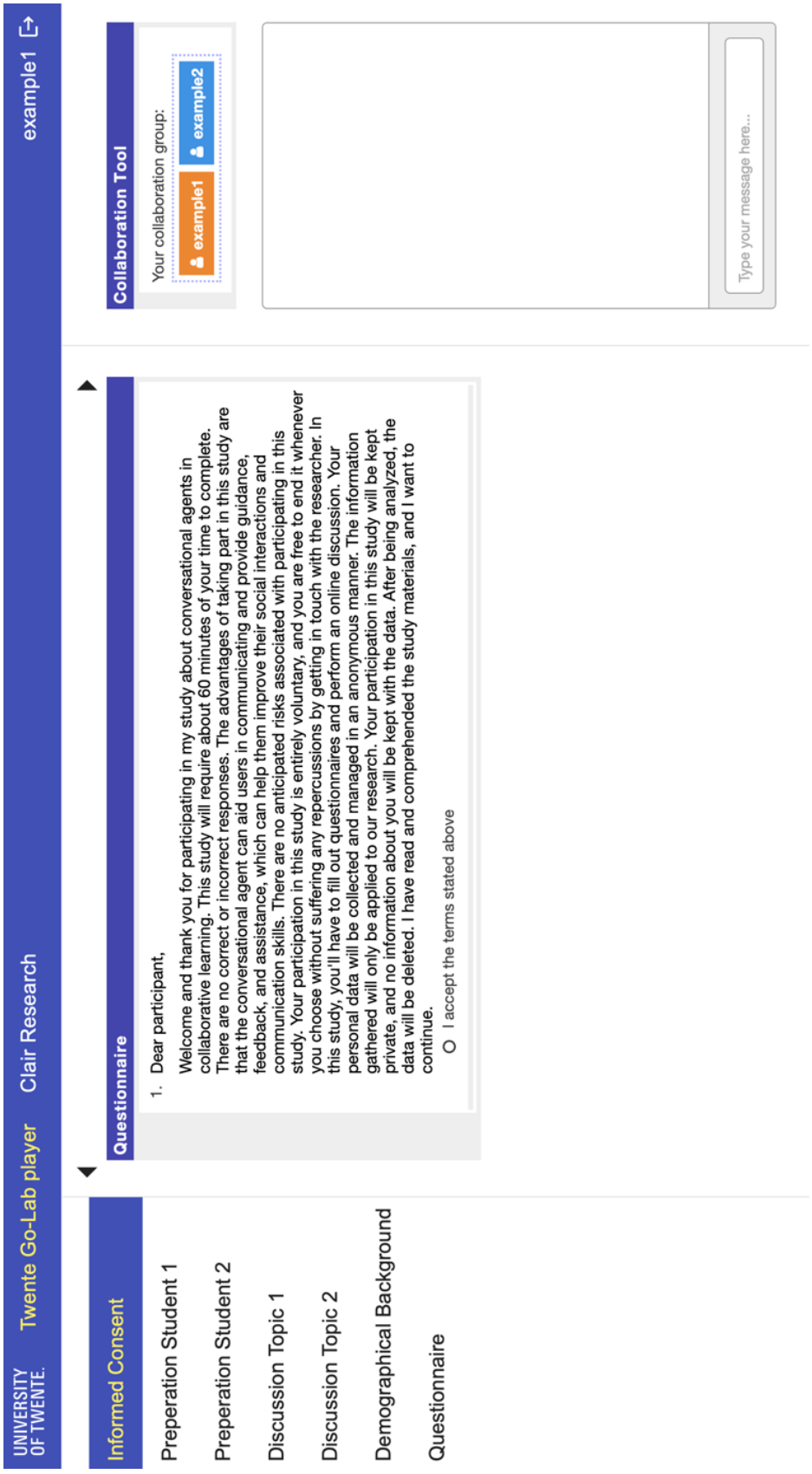
Wollny, S., Schneider, J., Di Mitri, D., Weidlich, J., Rittberger, M., & Drachsler, H. (2021). Are We There Yet? - A Systematic Literature Review on Chatbots in Education. *Frontiers in Artificial Intelligence*, *4*. https://doi.org/10.3389/frai.2021.654924

Yang, Y., Cer, D., Ahmad, A., Guo, M., Law, J., Constant, N., ... & Kurzweil, R. (2019). Multilingual universal sentence encoder for semantic retrieval. *arXiv preprint arXiv:1907.04307*. 87–94. https://doi.org/10.48550/arxiv.1907.04307

Yildiz Durak, H., & Atman Uslu, N. (2023). Group regulation guidance through agile learning strategies: empowering co-regulation, transactive memory, group cohesion, atmosphere, and participation. *Educational technology research and development*, *71*(4), 1653-1685.

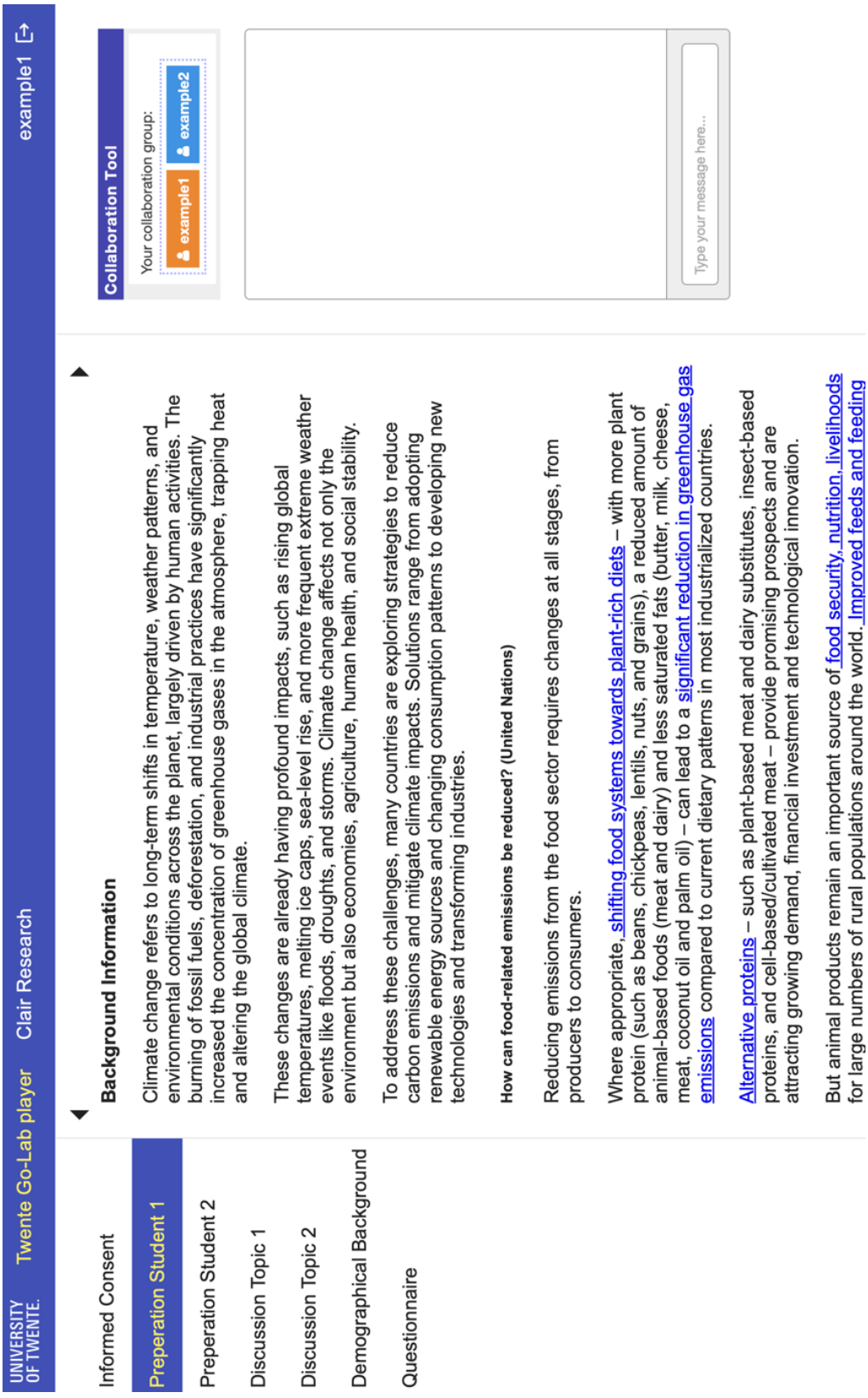
Appendix A

Go-Lab Environment – Informed Consent



Appendix B

Go-Lab Environment – Preparation Student 1



UNIVERSITY OF TWENTE. Twente Go-Lab player Clair Research example1

- Informed Consent
- Preperation Student 1
- Preperation Student 2
- Discussion Topic 1
- Discussion Topic 2
- Demographical Background
- Questionnaire

But animal products remain an important source of food security, nutrition, livelihoods for large numbers of rural populations around the world. Improved feeds and feeding techniques can reduce methane generated during cattle's digestion as well as the amount of gases released by decomposing manure. Smaller herd sizes, with fewer, more productive animals can also help. And better agricultural practices, such as improved manure and fertilizer management, rotational grazing to maintain healthy soil to store carbon, and the restoration of degraded lands can significantly reduce greenhouse gas emissions.

At the same time, reducing food waste is key. Almost 1 billion tons of food – 17 percent of all food available to consumers worldwide – goes into trash bins every year. Producing, transporting, and letting that food rot contribute more than 8 percent of global greenhouse gas emissions. If food waste were a country, it would be the third-largest emitting country in the world.

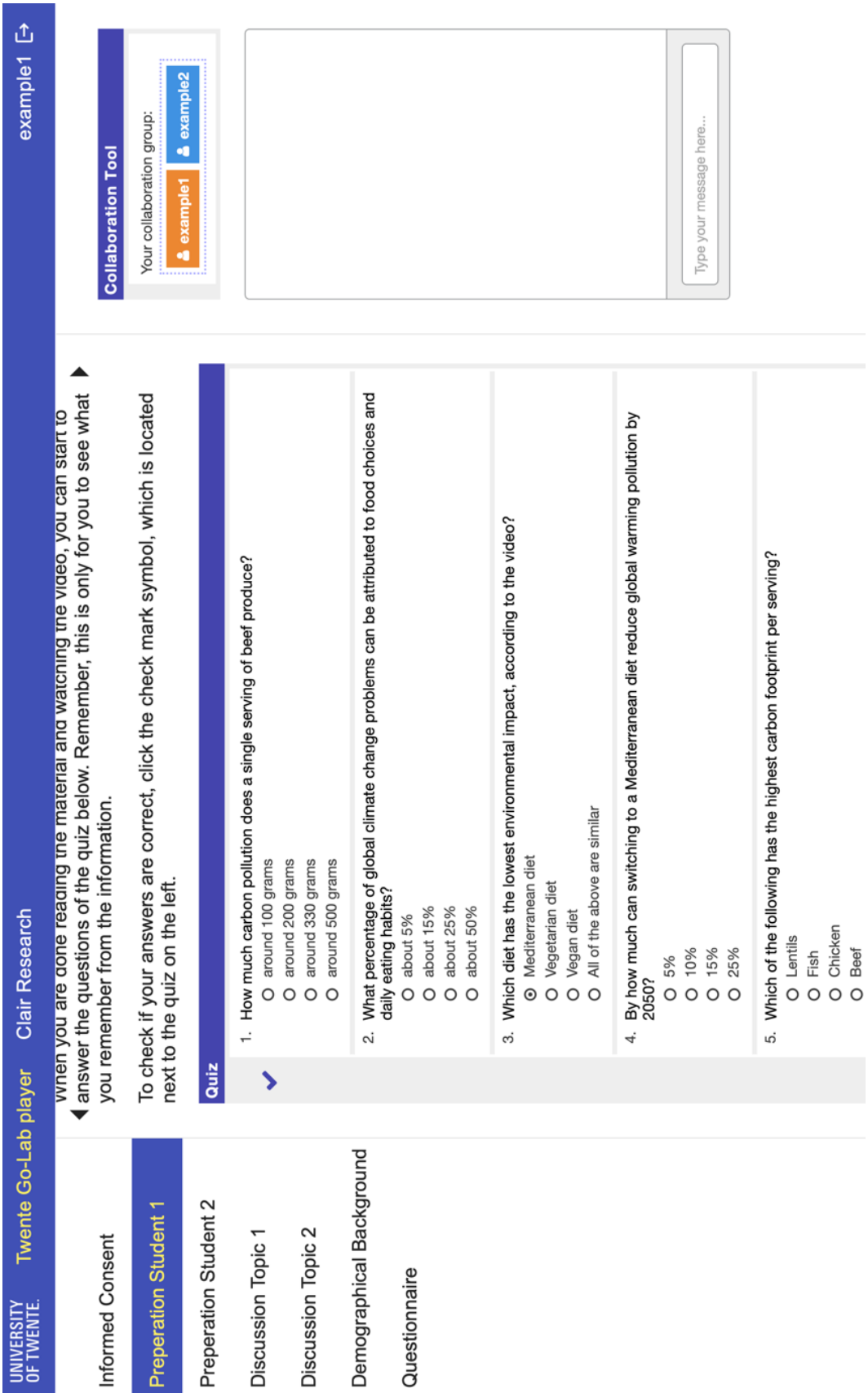
To get more insights into what actions can be taken, please watch the video below.

Collaboration Tool

Your collaboration group:

example1 example2

Type your message here...

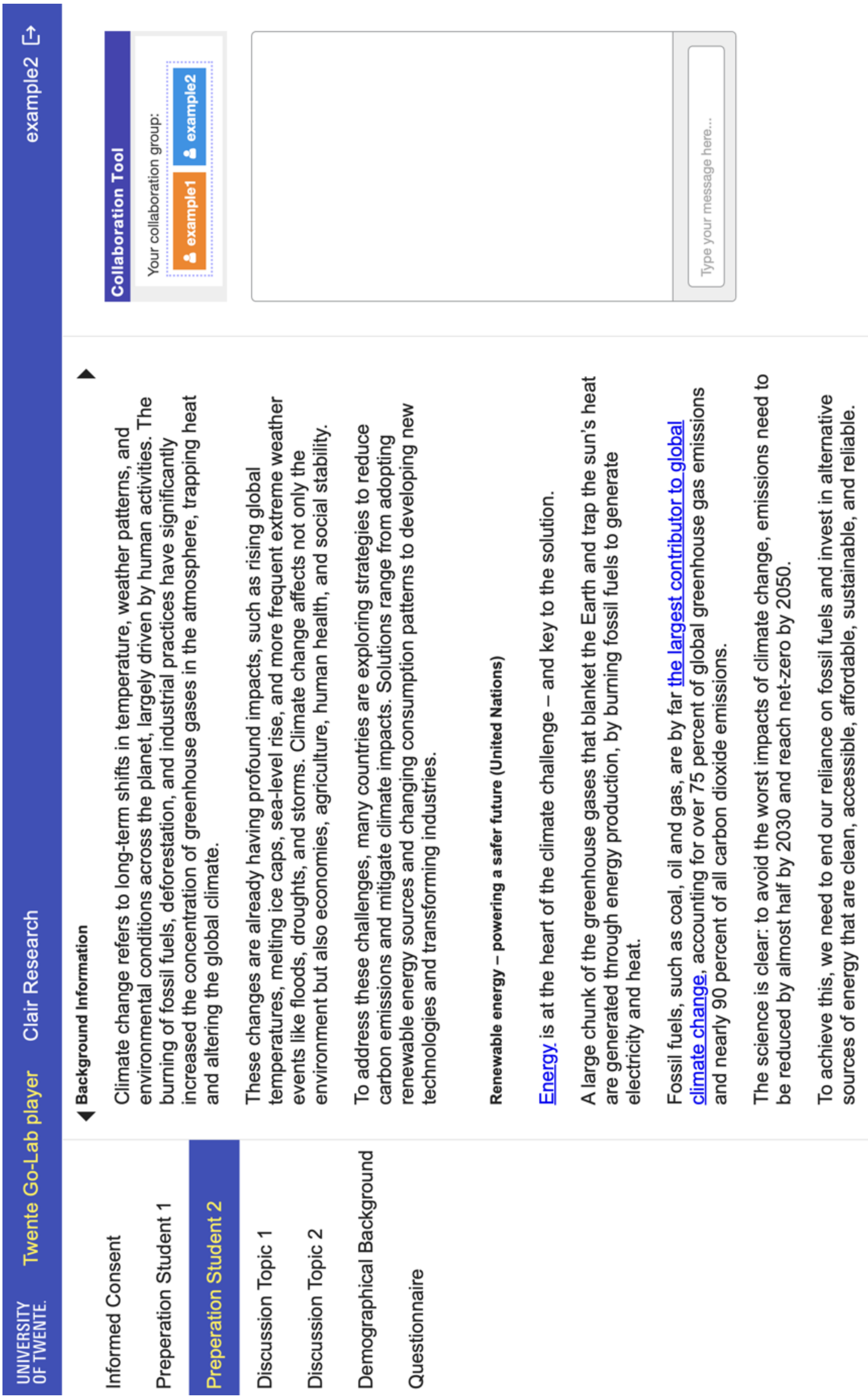


Video Link – Preparation Student 1

https://www.youtube.com/watch?v=nUnJQWO4YJY

Appendix C

Go-Lab Environment – Preparation Student 2



UNIVERSITY OF TWENTE. Twente Go-Lab player Clair Research example2

- Informed Consent
- Preperation Student 1
- Preperation Student 2
- Discussion Topic 1
- Discussion Topic 2
- Demographical Background
- Questionnaire

To achieve this, we need to end our reliance on fossil fuels and invest in alternative sources of energy that are clean, accessible, affordable, sustainable, and reliable.

Renewable energy sources – which are available in abundance all around us, provided by the sun, wind, water, waste, and heat from the Earth – are replenished by nature and emit little to no greenhouse gases or pollutants into the air.

Fossil fuels still account for more than 80 percent of global energy production, but cleaner sources of energy are gaining ground. About 29 percent of electricity currently comes from renewable sources.

About 80 percent of the global population lives in countries that are net-importers of fossil fuels -- that's about 6 billion people who are dependent on fossil fuels from other countries, which makes them vulnerable to geopolitical shocks and crises.

In contrast, renewable energy sources are available in all countries, and their potential is yet to be fully harnessed. The International Renewable Energy Agency (IRENA) estimates that 90 percent of the world's electricity can and should come from renewable energy by 2050.

Renewables offer a way out of import dependency, allowing countries to diversify their economies and protect them from the unpredictable price swings of fossil fuels, while driving inclusive economic growth, new jobs, and poverty alleviation.

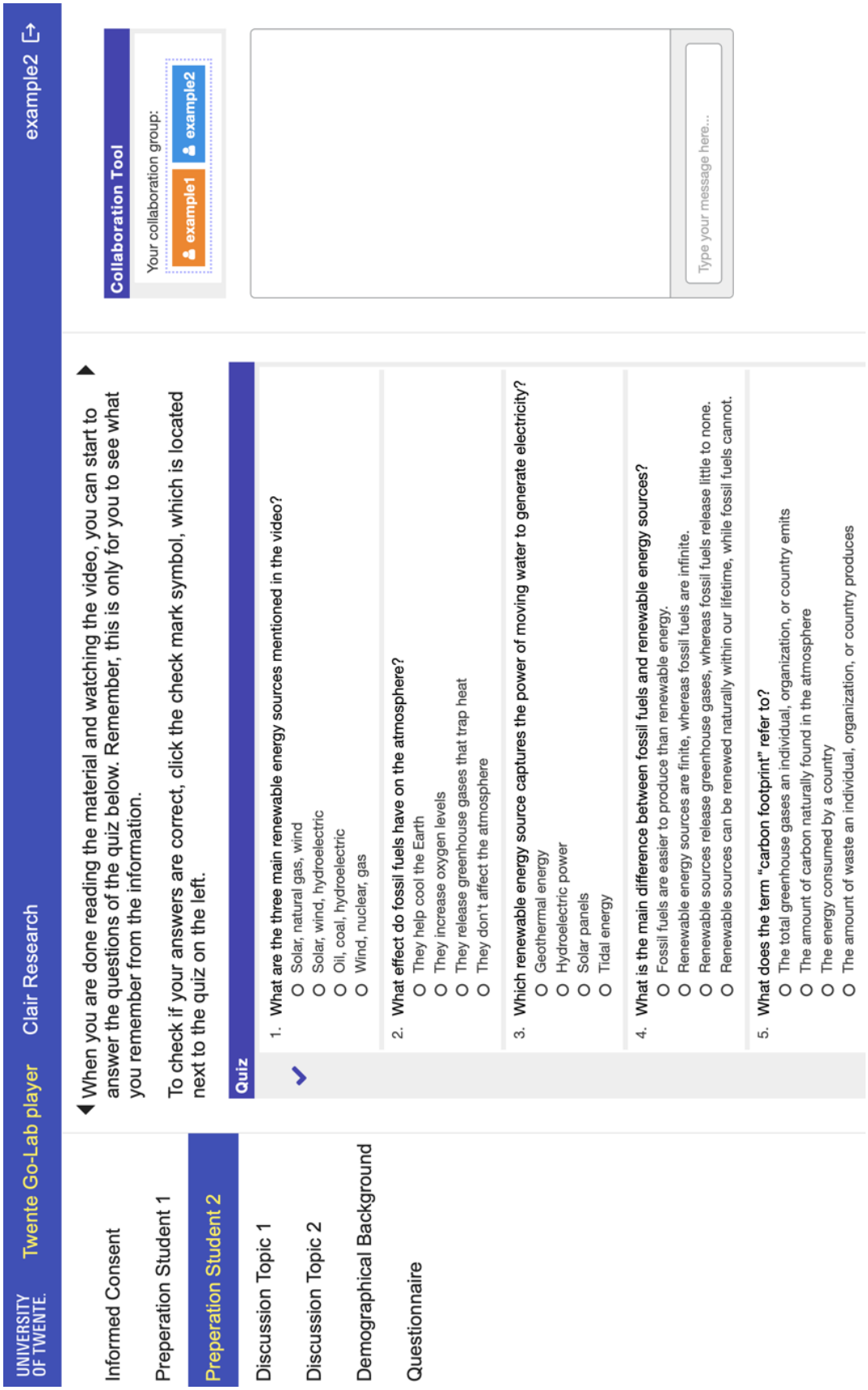
To get more insights into renewable energy, please watch the video below.

Collaboration Tool

Your collaboration group:

example1 example2

Type your message here...

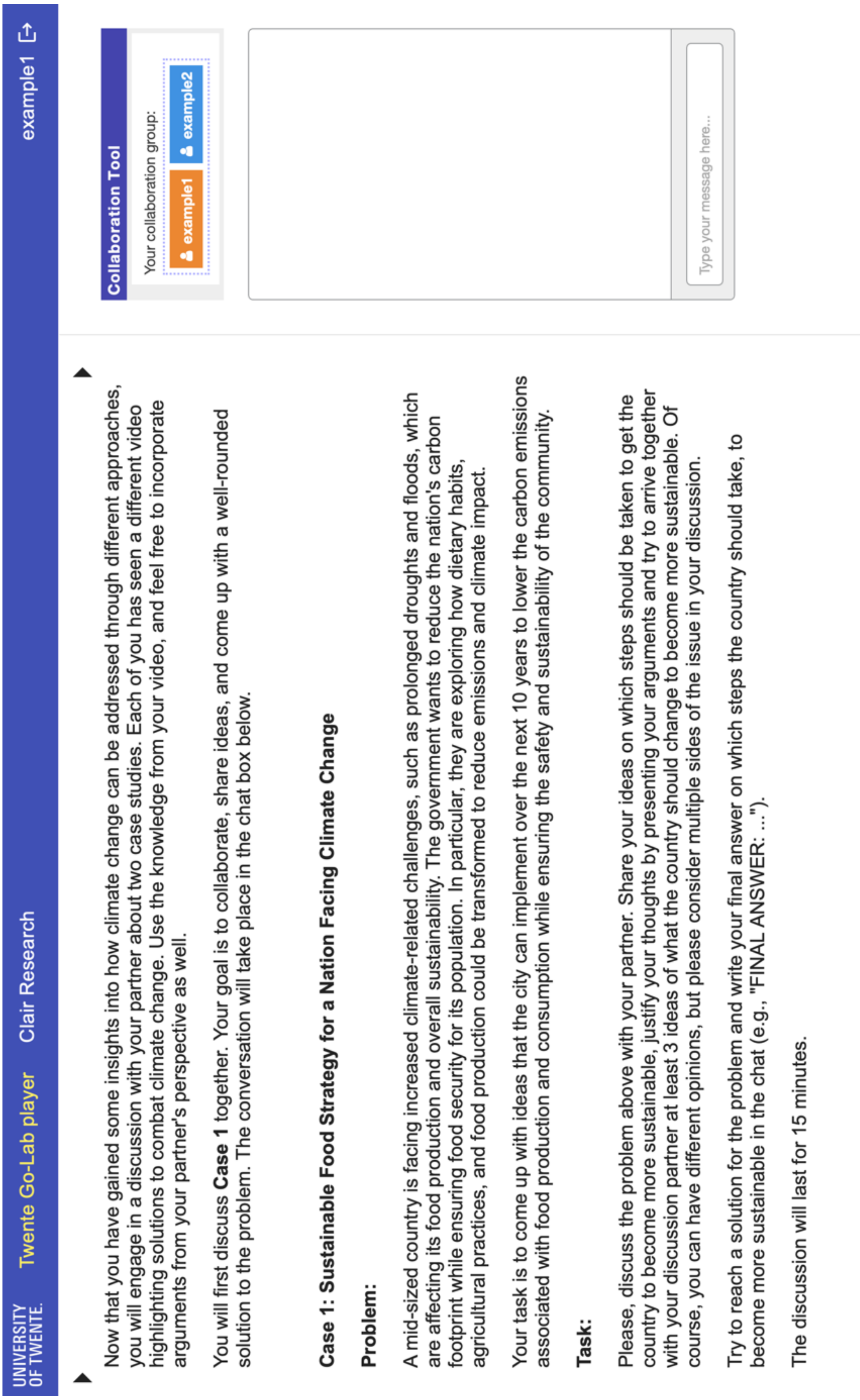


Video Link – Preparation Student 2

https://www.youtube.com/watch?v=H1jVz5uxQ8o

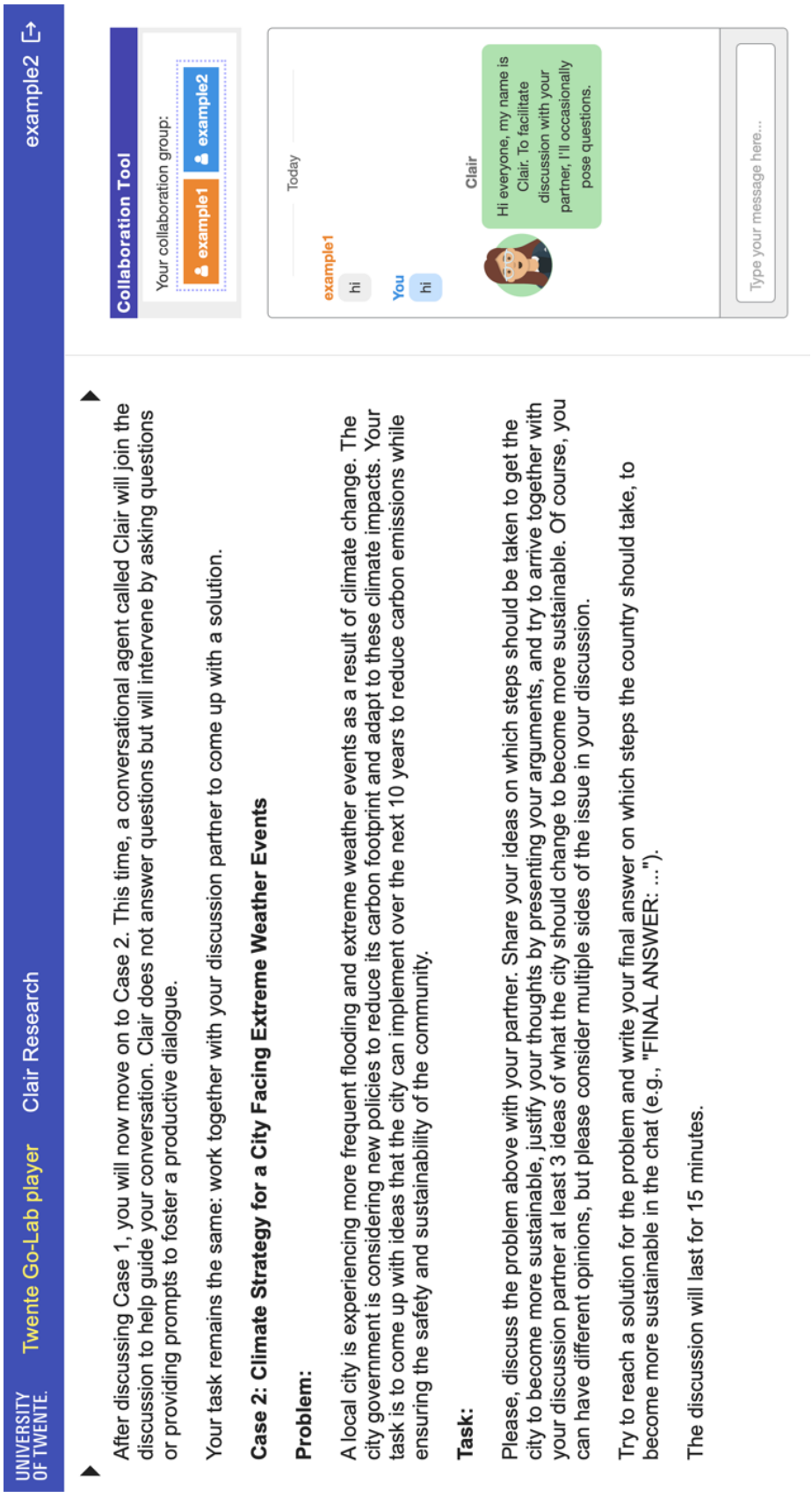
Appendix D

Go-Lab Environment – Discussion Topic 1 (without Clair)



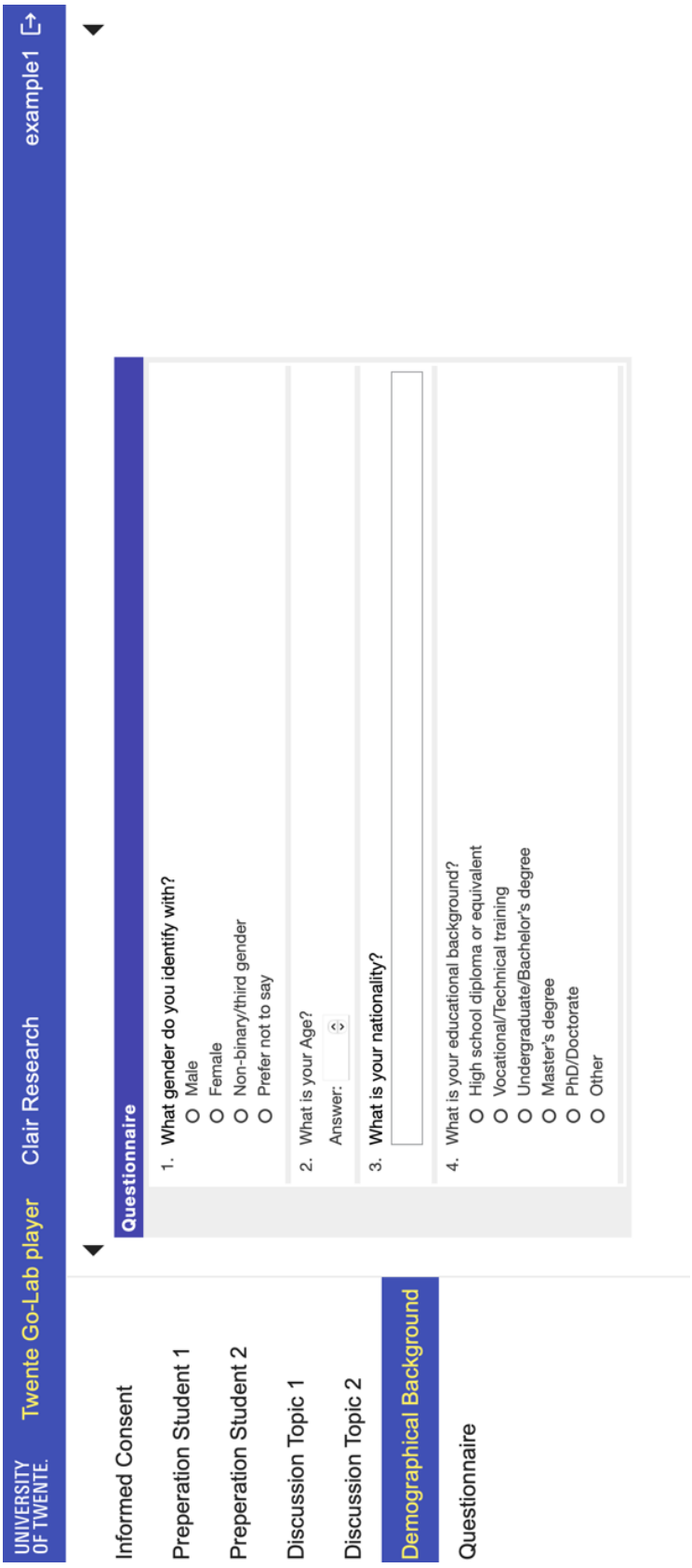
Appendix E

Go-Lab Environment – Discussion Topic 2 (with Clair)



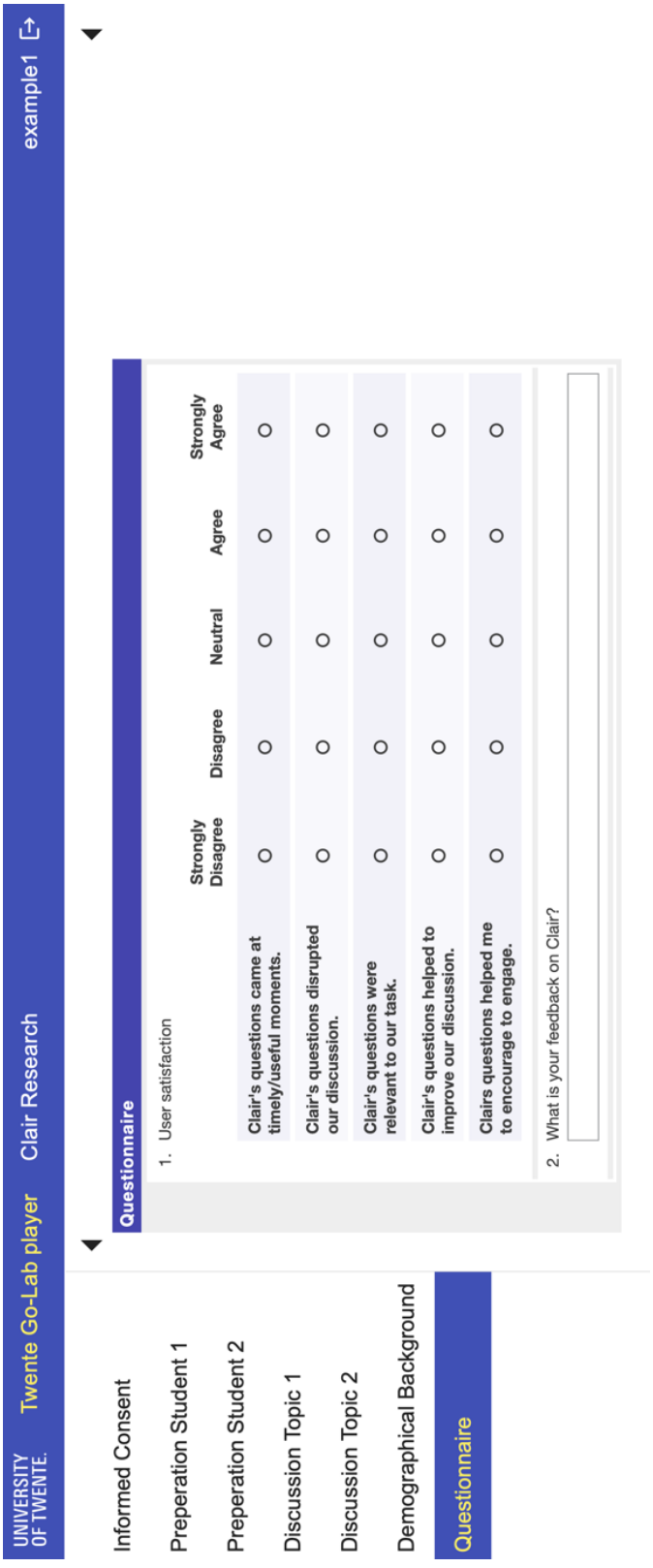
Appendix F

Go-Lab Environment – Demograhical Background



Appendix G

Go-Lab Environment – Questionnaire



Appendix H

AI Statement

During the preparation of this work, the author used Grammarly, Quillbot and ChatGPT-4o in order to structure information, get feedback, use the correct grammar and reformulate phrases to sound more fluent. After using this service, the author reviewed and edited the content as needed and takes full responsibility for the content of the work.