

**M12 Bachelor Thesis**

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## Abstract

Climate change poses a threat to our modern lives as we know them, especially for the younger generations, who inevitable have to deal with the long term consequences. For providing young people with the necessary skills and knowledge to combat climate change, the concept of climate change education ha been created. Furthermore, the second focus point next to climate change lays on collaborative work in school settings. For this, the AI chatbot Clair has been developed, who acts as a mediator for group discussions and thereby improves the discussion along with the quality of the product. This group work was designed with the approach of inquiry based learning, which was applied on the Twente Go-Lab online learning environment. Combined, this study aimed for exploring the effectiveness of the AI chatbot Clair on collaborative work in the setting of an learning environment, designed based on the inquiry leaning approach, on the topic of climate change. Furthermore, next to an intervention lesson conducted at a German high school, a pre- and a post-test have been conducted. After the data analysis, it showed that the overall scores for the used scales did not yield significant results, however, there were single items, where a significant effect of Clair in mediating can be observed. It can be said about the study, that it was not successful in retaining its hypotheses, however valuable information could be gathered from the questions demonstrating a significant effect. Furthermore, implications on how to continue research on this topic were given.

**Keywords:** Climate Change, inquiry-based learning, collaborative learning, AI, Chatbot, Go-Lab, environment education

## **Exploring Environmental Education: Evaluating the Impact of Collaborative Learning Agents in Go-Lab Simulations.**

### **Introduction**

The topic of climate change has become ever more important over the last decades. It has become such an important topic due to the threat it poses and the destruction it has already brought. The European Union has collected data on the damage's climate change has done and what threat it poses for different aspects of life. The most noted phenomenon when it comes to climate change is the higher occurrence of natural disasters such as droughts, floods or storms, who all come with high damages to property and human life. Another effect of rapid climate change is that the ice caps on the poles are melting, and the sea levels are rising, posing threat especially to people living close to the sea. The facts stated portray a clear picture of climate change and what danger and threat it poses for humanity, however, there still are a lot of people who do not want to act. Gifford, 2011 has conducted a study on this topic and concluded that there are several mental barriers when it comes to people ignoring or even denying climate change. The mental barriers described by Gifford include e.g. limited cognition or ideology. Another factor that endangers especially school children is the spread of false information concerning climate change on social media. Treen et al., 2020 found out that there are networks on different social media platforms that spread misinformation about climate change, mostly with the intention of strengthening their political agenda. It is especially children who are vulnerable to such false information as they are the largest age group using social media on a daily basis (Bazzola et al., 2022).

Another Problem when it comes to climate change is the education about it, Chang & Pascua, 2015 found out, that school children often have incomplete knowledge or misconceptions about climate change. A reason for this can be found in the study conducted

by Rousell & Cutter-Mackenzie-Knowles, 2019, who found out, that the education provided in schools on this topic does not build up the skills and knowledge necessary to seriously take on the challenge that climate change poses, same results were found in a study conducted by Hisu et al., 2022. Furthermore, an analysis by Dawson et al., 2022, who analyzed the curricular of different countries and how climate change is treated as a topic in school, found that as far as the school system is concerned, the curricular are not sufficient in educating on the problem of climate change. This lack of education has led UNESCO to issue a goal towards better climate change education in schools across the world. A study by Rousell & Cutter-Mackenzie-Knowles, 2019, who analyzed literature concerning climate change education identified key areas for further research, what climate change education is completely or in parts lacking. The key areas they identified include interdisciplinary-, creative or participatory approaches, approaches like these are in the current state missing from the literature available to teachers who must educate students on the topic of climate change. Furthermore, a study by Morote & Hernandez, 2022 conducted with school children from Spain found out that most children retrieve their information on climate change through the internet, often also social media. As mentioned earlier in the text, these sources put the children at risk as they are prone to containing false or misleading information, in the end forming misconceptions concerning the children's understanding and attitude towards climate change.

However, the problem goes deeper, in a study by De Jong, 2019 it became clear that it is not only students who have missing knowledge and misconceptions about climate change but that the same occurs in teachers. He concluded that teachers often themselves are not educated enough on the topic of climate change to teach the topic effectively to their students, similar findings have been concluded by Morote & Hernandez, 2022. With the advance of technology available for schools to enhance their education, online learning environments were introduced. An online learning environment is a website, where the students are provided with all material

necessary for the course and can then, alone or in a collaborative setting, navigate through the tasks themselves. Online learning environments are said to have benefits over regular learning approaches, in their study, Erdemir & Eksi, 2019 reported that participants in their study valued the increase of digital literacy, working collaborative and control over the individual learning process as the key benefits of this method. Since this method works completely remotely, teachers misconceptions about climate change do not hinder the learning of the students as well as enhancing the students skillset even further as a side effect next to conveying knowledge.

In this study, however, there is a second topic that is explored, namely the topic of group collaborative learning. Work in smaller groups is essential in most educational systems, facilitating not only knowledge but also social skills. However, it often occurs, that not all members of such a group contribute equally to the final product, e.g. there are students who are dominant in such a group, but also the other way around, where students feel intimidated and therefore are quieter in a group project. Furthermore, students benefit from collaborative learning approaches, in a paper by Laal & Ghodsi, 2012, they analyzed existing literature on this topic and came up with several ways, how collaborative learning enhances students' skillsets. The first benefit concerns the social ties and social skills of the students, during collaborative learning, problematic situations can arise that the students as a group have to deal with, enhancing their social ties through collective effort while also improving social skills, e.g. conflict solving through arguments that may arise during group work. Also, it was stated that communication and ties with former group members from collaborative learning settings often also continued after the project or task was finished. Moreover, it was stated that collaborative learning improves higher level thinking skills in students. Also, collaborative learning approaches foster acceptance of differences in others, whether these differences concern ones religion, culture of origin. Through working together with others from these religions or cultures, misconceptions or prejudice held against these groups are falsified and

acceptance grows. Additionally, when used in an online setting, through online learning environments or other methods, this effect can be further fostered by deliberately using this method with a diverse group, actively enabling a contact between the different cultures or religions. Lastly, Gillies & Ashman, 2000 discovered in their study, that collaborative learning especially improves the performance of children who are diagnosed with a learning disability, especially if the groups are further aided by learning assistance.

Next to the benefits however, there are also risks involved with collaborative learning. In the *Journal of English Teaching*, a report containing a list of these risks was published. The first risk concerns major conflicts that can arise when working together with others on a project or a task. Conflicts during group work can, if not resolved hinder the learning process, demotivate students for the group work as well as decrease the quality of the product as a result of the named effects such an argument among group members can have. Furthermore, it was stated that when it comes to the grading of work completed in a collaborative setting, the amount of work the individual put into the project is not observable. As a result, the grade given to each group may not be fair for each member, considering their real contribution to the project. Lastly, in school settings, when it comes to group work, students are often eager to work together with their friends or people they like. This phenomenon can lead to group members feeling or in the worst case being excluded due to not being part of the social group, most of the other members are part of (JET, n.d.)

The last theory relevant to this study is the theory of inquiry-based learning. Inquiry based learning is an approach that emphasizes a learning process comparable to a scientific research process (Pedaste et al., 2015). The theory is divided into five phases, each having several more subphases. The main phases of this theory are Orientation, Conceptualization, Investigation, Discussion and Conclusion. This approach allows flexibility in which phase is seen as the focus point of the project, if this is done, the cycle needs to be slightly adjusted

accordingly. Lastly, it is stated that this approach can further be enhanced by inquiry based online learning environments. Inquiry based learning as an approach is effective, which can be seen when taking a closer look at the benefits of this approach. In their study, Bayram et al., 2013 found two benefits linked to inquiry-based learning. The first benefit concerns the motivation of students to engage in the learning process. From their results, it was concluded that students are more motivated to learn when engaged in inquiry-based learning process. This phenomenon can be explained by the students receiving more freedom in their choices concerning the learning process, making the student co-responsible for their learning. Furthermore, it was discovered that inquiry-based learning, through its similarity with scientific working processes, fosters openness and interest towards scientific processes and higher sciences in general. Additionally, Friesen & Scott, 2013 discovered in their literature review, that inquiry-based learning also has a positive impact on students' problem-solving skills and independent thinking. This is explained by the students needing to come up with a plan on solving the problem given themselves as well as thinking about possible solutions and testing them. Lastly, it was found that inquiry-based learning approaches are successful in connecting educational topics across academic subjects and by this further deepening the learned material.

To further enhance the effects of inquiry-based learning as well as of the online learning environment, there is another important factor present in this study. This factor is an ai chatbot called Clair, it is an ai chatbot that is based on the ConSent learning algorithm introduced by De Araujo et al., 2023. The algorithm uses contextual information as well as sentence encoding to code conversations. In their first study, they found that the algorithm was successful in coding input from two different languages across different topics. Based on their findings, De Araujo et al., 2024 developed Clair as an ai chatbot that uses the input from the introduced coding algorithm to select collaborative conversational agents to enhance a discussion among

students to be more productive. This means that in the Chatroom, Clair analyses the chats and then uses prompts or agents in the chat to guide the discussion when triggered. These collaborative conversational agents are based on the academically productive talk framework, which is a framework for teachers to give qualitative input on student discussions, only this time this input is given by an ai chatbot. In their study on Clair, it was discovered that Clair is successful in improving the communication among students, especially on the topic of the lesson, however there was no evidence found suggesting that also the collaborative part of the group work was enhanced. Clair will be the focus point of the study and how such an ai can help improve education on climate change.

### **Research Questions**

- Can collaborative inquiry learning in the Go-Lab simulation environment enhance students' understanding and attitudes towards climate change?
- What are the differences in the impact on students' knowledge between the two forms of collaborative learning (with and without Clair intervention)?
- What are the differences in the impact on student's attitude between the two forms of collaborative learning (with and without Clair intervention)?

### **Hypotheses**

- Collaborative inquiry learning in the Go-Lab simulation environment enhances students understanding and attitude towards climate change.
- There are observable differences in the impact on students' knowledge about climate change between the two forms of collaborative learning (with and without Clair intervention)
- There are observable differences in the impact on students' attitude towards climate change between the two forms of collaborative learning (with and without Clair intervention)



## Methods

### Research Design

The design of the study is a quantitative research utilizing a survey instrument as pre- and post-test as well as the Go-Lab platform at a German school to gather data from a sample of participants at a specific point in time.

### Participants

To recruit participants for this study, several German schools were contacted to inquire about the possibility of conducting the research at their locations. One school agreed to participate and facilitated the conduct of this study. The participants were 49, 11th-grade students from two classes at the participating school. Due to data security regulations imposed upon the researcher by the participating educational institution, not more details regarding the students characteristics could be collected in the current study.

### Instruments

#### *Domain Knowledge Questionnaire*

The variable Knowledge of climate change refers to the pure knowledge, the students have about the climate change, for measuring this variable, along with the effect of Clair on the development of the knowledge of the students, a pre- and a post-test will be admitted. Knowledge of Climate Change refers to students' factual understanding of climate change. To measure this variable and assess the effect of the chat based agent Clair on students' knowledge development, a pre- and post-tests assessing knowledge of Climate Change was administered. Both the pre- and post test consist of 19 multiple-choice questions with one correct answer each. The scores are represented as the amount of correct answers, an example of items can be seen in Figure 2. Furthermore, after the pre-test was administered, it was observed that many

students already scored high on this test, suggesting a ceiling effect to be present. The score for this test was calculated by counting the right answers given on the test, therefore, the participants could receive max. 19 as the score for their test.

*Figure 2: example items measuring Knowledge about climate change*

**Question 2:** Which human activity could lead to a rise in global temperatures?

**Question 14:** If the global use of fossil fuels increases, what effect would this have on the carbon emissions in the atmosphere?

*Attitude towards climate change*

Participants' perceptions of climate change, including its importance in their personal lives and the seriousness with which they regard the issue was assessed using a scale that was based on (refer to instrument 1) and (refer to instrument 2). Scores on both scales were combined, to calculate the score for each participant. The items measuring the variable attitude towards climate change in the two tests stem from the New Ecological Paradigm Scale (NEP) for children (Manoli et al., 2007). The new ecological Paradigm scale for children is made up of three different subscales, the first one is Rights of Nature and consists of three items, the second subscale is Eco-Crisis and consists of four items, the third and last subscale is Human Exemptionalism and consists of four items. Furthermore, next to looking at the score of the entire test, the subscales of the NEP are also scored to have insights into whether they behave similar to each other. Lastly, next to the eleven questions from the NEP, there are five more items for scoring this variable. These items were developed by Lai & Hwang, 2014, from their test, the subscale measuring collaboration tendencies was taken to complement the NEP. All the items for measuring this variable were scored using a five-point Likert scale.

## **Learning Environment**

In the present study, students worked with an Inquiry Learning Space about Climate

Change, The Inquiry Learning Space was developed using the [Twente Go-Lab platform](#) and covered topics around the overall topic of climate change. Assignments in the inquiry learning space students were invited to discuss and collaborate. The inquiry learning space approximately lasts two regular class periods of 45 minutes. In both versions students collaborate using a dedicated chat tool. In the control condition students do not get additional support aimed at their collaborative process. However, students in the experimental condition will be supported by the chat bot Clair. Through the in the introduction mentioned methods, it is expected that Clair is able to positively impact learning through enhancing students communication and collaboration through prompts posted in the chats of the student groups when triggered.

#### *Clair Intervention*

The Claire intervention is an agent ai, that is used to enhance the quality of group work in student groups by giving cues into the chatroom to the students on how to improve their communication. As a variable, it has a mediating effect on the other two variables. There are two conditions, in the first condition, students have to complete the tasks in the Go-Lab environment with the support from Clair, in the second conditions, they have to complete the tasks without Clair's support. This variable can be measured in the difference of scoring between the two tests between the two conditions, if this difference can be labeled as significant one can conclude that this variable was successful in mediating the effect that the learning environment has on the students.

#### *Inquiry learning*

Inquiry learning is a learning approach that emphasizes the student's role in the learning process. Key features of this approach are active exploration, questioning and investigation, which allows the student to construct their own knowledge through direct experience. In this study, inquiry learning was applied using the Go-Lab online learning environment. This

variable acts as a moderator for the two dependent variables knowledge of climate change and attitude toward climate change. For the assessment, the scores on the pre- and post-test are compared. If there is a significant improvement that can be observed, one can conclude that inquiry learning was successful in enhancing the two dependent variables.

## **Procedure**

Before starting the data gathering process, an ethical approval had to be requested from the ethical board of the University of Twente, the ethical approval was given on the 30<sup>th</sup> May (Appendix A). Codes were created for the students participating in the study to ensure anonymity. Together with the school and the teachers about a time-slot for a 90 minute session, was organized to conduct the study. In order to allow students to work on the ILS for the full 90-minutes the pre- and post-test were administered in the lesson before and after the experimental session. Both the pre- and post-test and the questionnaire. were administered digitally. The main part of the study was conducted using the Go-Lab Twente platform where an environment was created on the topic of climate change with half of the student groups assigned to the condition where Claire is assisting in enhancing the group discussion in the chat and the other half were given the task without Claire in the same environment with the same conditions as the first group. After the lesson was conducted, all chats were anonymized before the analysis can take place. All survey data was stored securely on a password-protected computer only accessible by the research team.

## **Data Analysis**

The goal of the study was to find out whether Inquiry based learning in a Go-Lab simulation environment can enhance students understanding and attitude towards climate change. Another goal of the study was to whether Clair has an influence on the students knowledge and attitude of the students on climate change. Before these questions can be answered, firstly the dataset needs to be cleaned of any error data and the data has to be

accounted for any students that wished for their data to not be used in the study. The main data that is collected in this study is derived from the pre- and post-tests.

Before being able to answer the research questions the parametric assumptions have to be checked to make sure the dataset meets all necessary criteria for performing parametric tests. The first assumption, normality, is tested using the Shapiro-Wilk Test in R, the assumption tests whether the data are distributed normally. Furthermore, the second assumption, Homoscedasticity, means that different groups have similar variances and there are no clusters somewhere in the dataset. It is tested using the Bartlett's Test in R. The third assumption, linearity, is tested by creating a scatter plot and checking whether the residuals in the plot are linear or not. The fourth and last assumption, independence, is tested in R with the Durbin-Watson test. These steps are used for the two datasets of the pre- and post-test. If any assumptions are not met, non-parametric tests have to be used for the data analysis.

For answering the first research question, the scores of all participants on the two tests are reviewed and assessed if there are any significant differences that can be found between the two tests. The same goes for the subscales of the variable attitude towards climate change, Rights of Nature, Eco-Crisis, Human Exemptionalism from the NEP, as well as collaboration tendencies.

For answering the second research question, What are the differences in the impact on students' knowledge between the two forms of collaborative learning (with and without Clair intervention), first the dataset is divided between the control- and the experimental group. The relevant variables for this analysis are the dependent variable knowledge of climate change as well as the mediating variable Clair intervention.

In the next step the overall performance of the two groups is compared to see if there are any significant differences present between the groups. Furthermore, a paired t-test will be used to account for the individual improvement and to be able to see how much the individual

students improved in their condition and if the students in the experimental group showed higher improvement rates than the students in the control group as a result of being helped by Clair during the intervention.

The analysis of the data relevant for the third research question is pretty similar to the analysis conducted for answering the second research question. The variables important to this question are attitude towards climate change as well as Clair intervention as the mediator. The steps of the analysis are the same as for the second research question.

### Results

The participants in this study mainly originate from Germany as the study took part at a German Highschool. However, no particular demographic data has been gathered as the participants were underage and therefore extra care had to be taken while gathering data. In total there were 47 responses on the pre-test and 36 responses to the post-test, after clearing the data of missing pairs and accounting for participants who did not wish for their data to be collected, it came to 29 pairs of responses were left to be included in the analysis.

Table 1

	Pre-Test (mean)	Post-Test (mean)	P
Attitude	3.42	3.49	.5842
Subscales:			
Collaboration	3.73	3.81	.7037
Rights of Nature	3.18	3.23	.7666
Eco-Crisis	4.30	4.21	.5972

Human	2.33	2.56	.2854
Exemptionalism			
Knowledge	16.20	16.17	.9719

In Table 1, one can observe that the means on both tests did not change much from the pre- to the post-test, for the knowledge variable, the score even went slightly down. The same phenomenon can be observed by the subscales of the NEP as well as the first test measuring the variable Attitude focusing on collaboration tendency. The next test that was conducted was an ANOVA for testing the differences between the control and the experimental group from the pre- to the post-test. The ANOVA indicated that Clair did not have a significant impact on the attitude towards climate change ( $F(1,27) = .084, p = .775$ ) and knowledge about climate change ( $F(1,27) = .744, p = .396$ ). A post hoc analysis was not conducted as the ANOVA did not yield significant results. Lastly a paired t-test was conducted to account for individual development and differences among the participants from the pre- to the post-test. On the overall scores on the two tests, there were no significant differences visible. Furthermore, the paired t-test was also conducted for the individual questions on the pre- and post-test to see differences between the intervention- and the control group. On here, there were some Items, where there was a trend of improvement visible of the intervention group as opposed to the control group. Meaning, that on the item itself, there was a significant improvement, however as these are just single items, no clear assumption can be made. These items were from the scale measuring attitude on the subscale of collaboration tendency A4 ( $F(1,27) = .102, p = .033$ ) and from the scale measuring knowledge K6 ( $F(1,27) = 64.353, p = .019$ ) and K13 ( $F(1,27) = 25.236, p = .034$ ). Lastly, it was counted how many times Clair interacted with the participants in the study to make implications on the activeness of Clair throughout the intervention. Here, it could be observed, that Clair was active one to nine times, during the intervention with a mean activity of 4.18 contributions per student group in the experimental group during the intervention.

## Discussion and Conclusion

The research questions for this paper were “Can collaborative inquiry learning in the Go-Lab simulation environment enhance students' understanding and attitudes towards climate change?”, “What are the differences in the impact on students' knowledge between the two forms of collaborative learning (with and without Clair intervention)?” and “What are the differences in the impact on students' knowledge between the two forms of collaborative learning (with and without Clair intervention)?”. In the introduction, the hypotheses were stated, the first one is, that inquiry based learning in the Go-Lab simulation environment had a significantly positive effect on the test scores of the participants for attitude and knowledge about climate change. The second hypotheses that was stated was that there is a significant difference between the control- and intervention group using Clair on the variable knowledge about climate change between the pre- and post-test. Lastly, the third hypotheses is that there is a significant difference between the control- and intervention group on the variable attitude towards climate change between the pre- and post- test.

The first hypothesis, “that inquiry based learning in the Go-Lab simulation environment had a significantly positive effect on the test scores of the participants for attitude and knowledge about climate change”, could not be accepted. The first research question can therefore be answered with no, in this situation, inquiry based learning could not significantly enhance students' knowledge and attitude towards climate change. This can be explained by the findings summarized in Table 1, there was no significant improvement visible when comparing the scores for the two variables, knowledge and attitude on the pre- and post-test with each other. The same effects could be observed when looking at the subscales of the variable attitude towards climate change, where also on no of the four subscales, significant improvement was visible. The second hypothesis, “that was stated was that there is a significant difference between the control- and intervention group using Clair on the variable knowledge



about climate change between the pre- and post-test”, can be partly accepted. While there was no significant difference visible between the overall scores of the intervention -and control group, there was a significant increase visible in two items of the scale measuring knowledge about climate change in the intervention group using Clair compared to the control group. A similar effect can be observed when comparing the scores relevant for the third hypothesis, “that there is a significant difference between the control- and intervention group on the variable attitude towards climate change between the pre- and post- test”. When comparing the scores of the control- and intervention group for one item on the scale measuring attitude towards climate change, there is a significant increase visible in the intervention group when compared to the control group. The second and third research questions can therefore be answered by, there is no significant difference between the overall scores on the pre- and post-test between the control- and intervention group, but there were some items in the tests, where Clair was successful in improving the intervention group significantly when compared to the control group.

When analyzing the total scores of the two tests, it was observed that none of the results yielded significant values to support the hypotheses presented in the introduction. Since the overall results were not supportive of the hypotheses, the question for possible reasons to explain this phenomenon has to be asked. Firstly, when comparing the overall scores of the pre-test with the scores from the post-test, a ceiling effect becomes visible. A ceiling effect describes such high results on a pre-test, that there is only a low ceiling, meaning that there is low space for improvement. On the pre-test, participants already scored 85% of the test correctly, for the post test, this value stays stable with only very minor changes concerning the denominator. Thus, there was no or only little room to observe significantly improved values from the pre- to the post test, suggesting the questions were too easy for the students to complete with their existing knowledge about climate change, limiting the space for

improvement. Another reason for the lack of significant results can be found in the layout of the study, more detailed in the planning of the intervention. While conducting the intervention, it became clear that the participants needed more time than was planned for the intervention. Since this study was conducted in a school setting, there was also no room to elongate the duration of the intervention. For the participants this meant that they had to quickly maneuver through the tasks, missing the time to go into specific details and explore the learning environment thoroughly into depth. This could result in students not being able to take in all the information provided as well as the participants experiencing stress and thereby decreasing their ability to take in information and process it accordingly (Lin & Yusoff, 2013). Continuing, another factor that could play a role in the observed circumstances is test-fatigue or test-anxiety. According to a by McDonald, 2001, test anxiety is widespread among secondary school students, resulting in their test scores being lower than what they could have achieved under normal circumstances as well as lowering the students' motivation, which can be impaired due to the anxiety from the beginning, already falsifying the results from the beginning. Lastly, Clair functions in a way that the prompts need to be triggered by the students in the discussion in order for Clair to go into action and have an effect on the learning of the participants. The fact, that on the overall scores, there was no significant difference visible could suggest that Clair did not have an effect on the learning in this scenario as it was simply not present enough to have a lasting impact, meaning that Clair was not triggered in the discussion. Doing a complete in depth analysis of the chat logs is out of the scope for this study, however the activity levels were calculated in the results. It could be therefore argued that Clair was not active enough to make a significant difference in the scores with a mean activity of 4.18 contributions per student group in the experimental condition.

Contrary to these findings, in the second analysis, a paired t-test, it was discovered that Clair was able to significantly increase the scores of the intervention group of three items on

the post-test as compared to the pre-test, which can, as they are only single items, not be seen as significant improvement but as a trend and indication. The first item is the fourth item from the scale measuring the variable attitude towards climate change, "When collaborating with peers, I generally communicate well with them". The second and third item, where this phenomenon occurred were items from the scale measuring the variable knowledge about climate change. The second item is "What are the possible impacts of climate change on agriculture?", and the third one is "Which of the following activities is crucial for combatting climate change?". Before going into details, it is important to mention that there is emphasize on these questions as they indicate that Clair was able to positively effect the learning outcome of the experimental group, therefore also serving as focus points for a possible continuation or replication of the study. The first of these three questions concerns the communication of the students during collaborative work. Having this question yielding significant results can be seen as a positive sign for the effectiveness of the Clair intervention since the improvement of communication among students during collaborative work was the focus point of Clair, for which she was developed. It can therefore be inquired that Clair helps to improve the attitude towards communication during collaborative work based on the results on one item from the two tests. The second question of interest concerns agriculture and the consequences of climate change on it. This question being significantly influenced by Clair can be explained with the help of the video, which served as the main source of information on the Go-Lab learning environment. In this video, the emissions produced by agriculture as well as what consequences climate change has on it were explained. In the tasks following this video, students were asked to summarize the information of the video and name the most important point, since Clair's main role resolves around fostering communication, there are a lot of prompts connected to re-summarizing something, adding information to a point or to explain a topic differently. Through this, students could have repeatedly been asked to re-explain the topic surrounding

climate change and agriculture and thereby deepening the understanding of this particular topic. Lastly, the third question of interest is about what actions we as humans can take to combat climate change. As with the first two questions, this question also is of special interest, fostering knowledge and skills important for combatting climate change is one of the main goals of climate change education. Hence, one could argue that with Clair, knowledge concerning this topic was learned more effectively and more sustainably than when working without the assistance of Clair. The three discussed questions were mediated by Clair in the difference in scores on the post-test when compared to the pre-test, however, on the whole test, there were a lot more questions, where such a result was not observed. Hence, it is positive to see, that the questions, which were successfully mediated concern highly important concepts of Clair as well as those of climate change education, also indicating that these two work well together.

Overall, there were some items, where an improvement trend could be observed when comparing the experimental and the control group on the pre- and post test, however the overall scores did not yield significant results. Possible explanations for these findings can be found in the limitations of this study. The first weak point of the study was the high dropout rate of the participants. In total, there were 49 participants planned for the experiment, however out of these 49, only 29 were eligible for analysis. Participants dropped out due to e.g. not filling out the post test. The result of this phenomenon is that the reliability, as well as the generalizability of the results of the study decreasing. Furthermore, the second weak point concerns the time the participants were given to go through the Go-Lab environment and complete the tasks provided for them. During the lesson, where the study was conducted, some of the participants experienced trouble finishing the intervention in time and completing all the tasks in the different steps. Kelly & Lovings, 2004, concluded in their study that in a group work setting, time pressure can have effects like narrowed attention or restricted processing of information of the individuals. Continuing, the third limitation of the study concerns the previous

knowledge of the participants on the topic of climate change. This led to the pre-test already yielding really good results, leaving not much room for improvement to be observed on the post-test. This is problematic for the study as, especially for the knowledge part, significant improvement was next to impossible to observe. This phenomenon could be observed in both, the control, as well as the experimental group. Lastly, Clair's appearance in the chat of the participants can be seen as the fourth limitation to this study. Clair was not as active as hoped during the study, which decreases the mediating effect on the dependent variables tested in the study. However, next to limitations, there are also some strengths worth noting in this study. The most important strength is the replicability of the study, which makes it on the one hand easy to validate the findings from this study through replication but also on the other hand qualifies for international comparison as the approach of this study is not central to only one cultural environment but concerns and also should work within other cultural settings.

Regarding the strong and weak points of the study, inferences need to be made about the importance of the study and the continuation of research on this topic. There are recommendations to be made for future research on the same or similar topics. Firstly, the findings show that there are some items, on which Clair had a significant effect, this indicates that there is an impact that Clair is having on the students, making this phenomenon interesting for further investigation. The first weak points concern the design of the experiment conducted, for future research in form of a replication, these points can be improved by e.g. planning more time for the intervention or create incentives so that participants are more motivated to fill out the study until the end. Furthermore, for a possible everyday use of Clair in the future, it is important to explore how Clair fares with different other variables, e.g. which age groups benefit most from learning with Clair and for which age groups it may have little to no benefits, not only for optimization of the intervention itself but also for designing programs as profitable as possible. Another recommendation for an improvement in the design of the study in a

replication is to, if possible, conduct a longitudinal study with more use of Clair in the classroom than one lesson to be able to make inferences about Clair in a scenario close to implementation of the intervention in everyday teaching. Furthermore, as Clair was not as active as hoped for in this study, an interesting topic for research continuation could be to analyze the chat logs in depth to find possible reasons for Clair not being triggered in the discussion by the participants, which was out of the scope for this study but could gain valuable insights into how Clair matches the varying needs of the students in the collaborative dialogue. Lastly, there is one more implication for future research that can be made concerning the questionnaire used, it was found that the questionnaire was too easy for the participants, implying that students already have a good conception of climate change. In a replication, the questionnaire needs to be better tailored to the target audience and go more in-depth on the topic of climate change to decrease the ceiling effect.

All in all, it can be concluded that Clair was not successful in enhancing students knowledge and attitude towards climate change based on the overall scoring of the questionnaire and the test. However there were significant improvements to be found for single items, which cannot be validated as full results but can be seen as trends and indications for follow-up research. Therefore, the first research question can be answered by no, the collected data does not support the hypothesis that collaborative inquiry learning in the Go-Lab simulation environment enhances student's understanding and attitude towards climate change. The second and third research questions can be answered with that there are minor differences in the impact on students' knowledge and attitude towards climate change between the two forms of collaborative learning. Furthermore, recommendations were given for future research to improve the design of the study and thereby improving the quality of the results along with its chances for a possible intervention implemented in everyday life.

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**Appendix A: Ethical Approval****240665 REQUEST FOR ETHICAL REVIEW**FACULTY BMS

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Request nr: 240665  
Researcher: Böder, S.H.W.  
Supervisor: Gijlers, A.H.  
Reviewer: Farrokhnia, M.  
Status: Approved by commission  
Version: 2

**1. START****A. TITLE AND CONTEXT OF THE RESEARCH PROJECT****1. What is the title of the research project? (max. 100 characters)**

Exploring Environmental Education: Evaluating the Impact of Collaborative Learning in Go-Lab Climate

**2. In which context will you conduct this research?**

Bachelor's Thesis

**3. Date of the application**

17-04-2024

**5. Is this research project closely connected to a research project previously assessed by the BMS Ethics Committee?**

No/Unknown

**B. CONTACT INFORMATION****6. Contact information for the lead researcher 6a.**

Initials:

S.H.W.

6b. Surname:

Böder

6c. Education/Department (if applicable):

B-PSY

6d. Staff or Student number:

2735342

6e. Email address:

s.h.w.boder@student.utwente.nl

6f. Telephone number (during the research project):

+4915732548185

6g. If additional researchers (students and/or staff) will be involved in carrying out this research, please name them:

-

6h. Have you completed a PhD degree?

No

7. Contact information for the BMS Supervisor 7a.

Initials:

A. H.

7b. Surname:

Gijlers

7c. Department:

BMS-IST

7d. Email address:

a.h.gijlers@utwente.nl

7e. Telephone number (during the research project):

+31534894074

8. Is one of the ethics committee reviewers involved in your research? Note: not everyone is a reviewer.

No

## C. RESEARCH PROJECT DESCRIPTION

9a. Please provide a brief description (150 words max.) of the background and aim(s) of your research project in non-expert language.

Education plays a crucial role in inspiring young people to understand and respond to global climate change challenges. Current research indicates that existing educational systems are not adequately preparing students with the knowledge and skills needed to tackle climate change, highlighting the urgent need for educational reform in this area. This study aims to explore the impact of simulation-based collaborative inquiry learning strategies on climate change education. We will conduct evaluations in two different collaborative learning settings: one with the integration of the virtual chatbot Clair for learning, and the other without it. This setup will help us compare the differences in students' understanding and attitudes towards climate change concepts and knowledge.

9b. Approximate starting date/end date of data collection:

Starting date: 2024-05-22

End date: 2024-05-23

9c. If applicable: indicate which external organization(s) has/have commissioned and/or provided funding for your research.

Commissioning organization(s):

Not applicable

Funding organization(s):

Not applicable

## 2. TYPE OF STUDY

Please select the type of study you plan to conduct:

I will be collecting new data from individuals acting as respondents, interviewees, participants or informants.

## 4. RESEARCH INVOLVING THE COLLECTION OF NEW DATA

### A: RESEARCH POPULATION

20. Please provide a brief description of the intended research population(s):

The research population consist of students of two german highschool classes in the 11th grade.

21. How many individuals will be involved in your research?

If all children from the two classes participate, in total it will be 49 participants.

22. Which characteristics must participants/sources possess in order to be included in your research?

The only inclusion criteria of importance for this study is that participants need to be enrolled in a highschool or similar institution.

23. Does this research specifically target minors (<16 years), people with cognitive impairments, people under institutional care (e.g. hospitals, nursing homes, prisons), specific ethnic groups, people in another country or any other special group that may be more vulnerable than the general population?

Yes, minors

Educational research

24. Are you planning to recruit participants for your research through the BMS test subject pool, SONA

No

### B. METHODS OF DATA COLLECTION

25. What is the best description of your research?

- (Online) survey research
- Experimental/intervention research

26. Please provide a brief yet sufficiently detailed overview of activities, as you would in the Procedure section of your thesis or paper. Among other things, please provide information about the information given to your research population, the manipulations (if applicable), the measures you use (at construct level), etc. in a way that is understandable for a relative lay person.

There will be a lesson in the class that is participating (90 min.) where first, a pre-test is admitted. After this, the students go on the Go-Lab learning environment and go through the lesson on climate

change. half the student groups will be supported by Clair, a Chat-Ai, whose purpose is to enhance the teamwork between students. Lastly, in the lesson after the study, the post-test will be admitted.

How much time will each participant spend (mention the number of sessions/meetings in which they will participate and the time per session/meeting)?

session 1: 90 min: pre-test and Go-Lab; Session 2: 15min. post-test

### C: BURDEN AND RISKS OF PARTICIPATION

27. Please provide a brief description of these burdens and/or risks and how you plan to minimize them:

I cannot think of any burden or risk concerning this study.

28. Can the participants benefit from the research and/or their participation in any way?

Yes

Please Explain:

The students can benefit from the study as they get the opportunity to learn about the important topic of climate change using new technologies ant to an extent that is not covered in the german curriculum for the year. Furthermore, future student generations can benefit from this research, in case an intervention like this is implemented on a bigger scale.

29. Will the study expose the researcher to any risks (e.g. when collecting data in potentially dangerous environments or through dangerous activities, when dealing with sensitive or distressing topics, or when working in a setting that may pose 'lone worker' risks)?

No

### D. INFORMED CONSENT

30. Will you inform potential research participants (and/or their legal representative(s), in case of non-competent participants) about the aims, activities, burdens and risks of the research before they decide whether to take part in the research?

Yes

Briefly clarify how:

Yes, research participants, and their guardians are informed aout the aims, activities, burdens and risks of the research beforehand through an informed consent form.

32. How will you obtain the voluntary, informed consent of the research participants (or their legal representatives in case of non-competent participants)?

Passive/tacit consent

Please provide a brief explanation of why you think passive consent is acceptable and how sufficient action will be taken to inform the participants or their legal representatives

-

33. Will you clearly inform research participants that they can withdraw from the research at any time without explanation/justification?

Yes

34. Are the research participants somehow dependent on or in a subordinate position to the researcher(s) (e.g. students or relatives)?

No

35. Will participants receive any rewards, incentives or payments for participating in the research?

- No

36. In the interest of transparency, it is a good practice to inform participants about what will happen after their participation is completed. How will you inform participants about what will happen after their participation is concluded?

- Participants will receive the researcher's contact details, so that they can contact the researcher if they have questions/would like to know more.
- Participants will receive oral/written information about what the researcher(s) will do with the collected data.

## E. CONFIDENTIALITY AND ANONYMITY

37. Does the data collected contain personal identifiable information that can be traced back to specific individuals/organizations?

No

39. Will you make use of audio or video recording?

No

## 5. DATA MANAGEMENT

- I have read the UT Data policy.
- I am aware of my responsibilities for the proper handling of data, regarding working with personal data, storage of data, sharing and presentation/publication of data.

## 6. OTHER POTENTIAL ETHICAL ISSUES/CONFLICTS OF INTEREST

40. Do you anticipate any other ethical issues/conflicts of interest in your research project that have not been previously noted in this application? Please state any issues and explain how you propose to deal with them. Additionally, if known indicate the purpose your results have (i.e. the results are used for e.g. policy, management, strategic or societal purposes).

No i do not expect any other ethical issues or conflicts of interest.

## 7. ATTACHMENTS

Informed Consent\_New.pdf

## 8. COMMENTS

Gijlers, A.H. ( 30-05-2024 06:38) :

-

Böder, S.H.W. ( 22-05-2024 15:59) :

Regarding the changes in the consent form, I have looked at the

template of the University and made sure all necessary points are included in the consent form, as well as additional information that could be useful for the participants and their guardians in deciding whether they want their data used in the study. The biggest change in the updated version is an added paragraph that refers the participants and their guardians to the ethical committee in case they wish to talk to someone about the study, who is not myself or one of my supervisors.

Gijlers, A.H. ( 17-05-2024 12:55):

Please make sure that it is very clear why you can use passive consent. Als describe in your reaction what you changed (from the previous submission of the form --> how questions where adressed).

Böder, S.H.W. ( 20-04-2024 17:46):

I did not find a field to put this information so i hope it is sufficient if i provide it here.

About the dependent variables and the data security while collecting data:

The dependent variables are Understanding of climate change and Attitude towards climate change The variables will be assessed in a pre- and post-test using the NEP scale as well as the 5C competences questionnaire. There will no personal data collected from the participants. Furthermore, before using data, it will be made sure that all data is anonymized so that no participant can be identified based on the data collected. As a last measure for securing data safety, all participants will be given codes that will be used as identification during the lesson as well as the pre- and post-test.

Farrokhnia, M. ( 20-04-2024 10:43):

Thank you for providing detailed information about your interesting study, which aims to improve high school students' knowledge of climate change. I can only identify three minor issues, which I hope you can clarify further:

First, what was the reason for choosing "passive consent" as the method for obtaining consent to participate? Passive consent implies that individuals' consent is assumed if they do not explicitly object to participation after they have been informed about the study. In principle, passive informed consent is considered undesirable: first, because there is no way of knowing whether the relevant information has been received, and second, because participants (or their legal representatives) may have been unable to perform the action required to indicate non-consent. This can lead to infringement of personal autonomy and privacy. (For more information, see:

<https://www.utwente.nl/en/bms/research/ethics-domainHSS/explanation->



[webapplication/types-of-informed-consent/](#)).

Second, I need more information about the dependent variables in your study, how you will measure them, and more importantly, how you will ensure that the collected data does not contain personally identifiable information.

Third, please make sure you use the suggested template for preparing the consent form (find the templates here: [Ethics \(BMS/domain HSS\) | Faculty of Behavioural, Management and Social sciences \(BMS\) \(utwente.nl\)](#))

## 9. CONCLUSION

Status:           Approved by commission

The BMS ethical committee / Domain Humanities & Social Sciences has assessed the ethical aspects of your research project. On the basis of the information you provided, the committee does not have any ethical concerns regarding this research project. It is your responsibility to ensure that the research is carried out in line with the information provided in the application you submitted for ethical review. If you make changes to the proposal that affect the approach to research on humans, you must resubmit the changed project or grant agreement to the ethical committee with these changes highlighted.

Moreover, novel ethical issues may emerge while carrying out your research. It is important that you reconsider and discuss the ethical aspects and implications of your research regularly, and that you proceed as a responsible scientist.

Finally, your research is subject to regulations such as the EU General Data Protection Regulation (GDPR), the Code of Conduct for the use of personal data in Scientific Research by VSNU (the Association of Universities in the Netherlands), further codes of conduct that are applicable in your field, and the obligation to report a security incident (data breach or otherwise) at the UT.

Attachment: Informed Consent\_New.pdf

Dear Parent,

I hope this message finds you well. Your child's class is scheduled to participate in an online educational research activity during their class. The research is designed by a psychology student named Böder, S.H.W. (Simon) from Twente University, under the guidance of Dr. Hannie Gijlers and Dr. Lily Chen. This letter serves to inform you of the purpose of the research and how data will be collected and used.

The study links citizenship with sustainable development literacy and awareness of climate change. The primary objective is to explore how different collaborative inquiry learning strategies affect secondary students' understanding and development of key concepts and attitudes related to climate change. We hope to identify effective methods that can enhance students' learning and subsequently increase their engagement with climate change issues.

In this study, your child will participate in an independent inquiry-based learning session within an online learning environment called Go-Lab. The topic for their self-directed inquiry is "The Impact of Human Activities on Climate Change." In this learning setting, your child will explore factors that cause climate change, understand how human activities affect our environment, investigate methods to reduce carbon emissions, and learn how to address environmental challenges. Before and after the learning session, students will take quizzes to assess their knowledge. The research will be conducted during regular class hours, lasting approximately 1.5 hours. All data collected during the activity will be used solely for research purposes and will be anonymized.

Research and experience show that students enjoy participating in these types of learning activities. Not only do they acquire knowledge about the subject through online learning, but they also experience the joy of learning through hands-on experiments.

For more detailed supplementary information about this study, please refer to Appendix 1 of this informed consent form.

If you agree to your child's participation in this study, please sign on the line below.

Student Name: \_\_\_\_\_

Parent Signature: \_\_\_\_\_

If you have any questions, please feel free to contact Böder, S.H.W. (Simon) at [s.h.w.boder@student.utwente.nl](mailto:s.h.w.boder@student.utwente.nl).

Appendix 1: Supplementary Information on the  
Online Climate Change Course

## 1. Research Steps and Student Activities:

This study aims to assess the impact of simulation-based collaborative learning on seventh-grade students' understanding of climate change. The study will proceed as follows:

- 1.1 Introduction and Grouping:** Initially, participants will be introduced to the study's goals and given fundamental knowledge about climate change. Students will be divided into two groups; one group will use a virtual chatbot named "Clair" for learning, while the other will not, to compare learning outcomes between the groups.
- 1.2 Pre-test:** Before the study begins, participants will take a pre-test lasting about 15-20 minutes to assess their initial understanding of climate change.
- 1.3 Climate Change Course:** During the official course, students will watch videos about climate change, engage in group discussions, and complete interactive tasks in a simulated environment. These activities are designed to deepen students' understanding of climate change issues.
- 1.4 Post-test:** After the course, students will take a post-test lasting about 15-20 minutes to evaluate their understanding of climate change following the learning activities.

## 2. Specific Steps of the Study and Student Participation Activities

### 2.1 Non-participation and Its Implications:

If parents or students choose not to participate in this study, we guarantee that this decision will not negatively affect the student's educational progress or rights and treatment at school. All students, whether they participate in the research or not, will receive the same educational resources and support and will have equal learning opportunities. Students who opt out will not be required to participate in any specific activities related to the study, such as watching certain educational videos, participating in group discussions, or completing pre- and post-tests. This means that students who choose not to participate will not be included in the data collection and analysis process, and their learning data or responses will not be used for research purposes. We respect each parent and student's choice and commit to maintaining all students' educational rights and personal privacy throughout the research process.

### 2.2 Photography and Recording Policies:

In this study, no audio recordings will be made. As for photography, while some photos may be taken during activities to document the progress of the learning activities and student participation, we will take the following measures to protect students' privacy:

- ♦ **Avoid Direct Shots:** When taking photos, we will avoid capturing students' faces directly. The camera will primarily focus on the activity scenes rather than specific students.

- ◆ **Privacy Measures:** If students' faces are inadvertently captured, we will obscure their faces with smiley symbols or other visual elements before using these photos to ensure

their identities are not recognized.

- ◆ **Use Solely for Research Purposes:** All photos taken will be used solely for research documentation and analysis purposes and will not be used for public display or other uses without permission.

We commit to respecting each participating student's privacy and taking all necessary measures to ensure their personal data is secure.

### 3. Data Anonymization and Confidentiality Measures

In this study, we place a high priority on the privacy and confidentiality of student data. To ensure that all collected data is handled anonymously and stored securely, we will take the following measures:

- ◆ **Data Anonymization:** All participating students will be assigned a unique identifier that replaces their name and other personally identifiable information. Throughout all stages of the research, including data collection, analysis, and report writing, these identifiers will be used to represent students.
- ◆ **Access Restrictions to Data:** Access to all collected data will be strictly limited. Only members of the research team will have access to this data, and it will only be used for research purposes. All electronic files involving student data will be encrypted and stored on password-protected computer systems.
- ◆ **Data Use and Sharing Restrictions:** The collected data will only be used for the purposes of this research and will not be shared with third parties or used for any other research without consent. When publishing research findings, all data will be presented in an anonymized form to ensure individuals cannot be identified.
- ◆ **Data Retention and Destruction:** After the conclusion of the study, all data will be securely retained for a specified period according to relevant regulations and standards. Once this period has expired, all data will be permanently deleted or destroyed.

Through these measures, we commit to protecting the privacy of participating students and ensuring the security and confidentiality of all research data.

### 4. Right to Withdraw and Impact on Participants:

We fully understand that parents and students have complete autonomy to participate in research and respect their right to withdraw from the study at any time. Should parents or students choose to withdraw at any point during the study, here are the related impacts and assurances:

- ◆ **Right to Withdraw at Any Time:** Parents or students can decide to no longer participate at any stage of the research without providing any reason. This includes before the start of the research, during its progress, or even just before its conclusion.
- ◆ **No Negative Impact:** Withdrawing from the study will not have any negative impact on the

student's educational evaluation, school life, or future learning opportunities. The student

will continue to receive the same education and support as their peers.

- ◆ **Data Handling:** If a student chooses to withdraw, all their data in the study will be removed from the research data and handled appropriately according to privacy protection measures. Any data collected will not be used in research analysis or reporting.
- ◆ **Support Available at Any Time:** If parents or students have any questions or concerns about withdrawing from the research, our team is ready to provide relevant information and support at any time.

We commit to maintaining the autonomy of each participant and respecting their decisions, ensuring that the conduct of the research does not adversely affect any student.

If you have any questions about this study or the supplementary information, please feel free to contact us. We look forward to your valuable feedback and are willing to provide the necessary support and information.

## Kontaktinformationen für Fragen über ihre Rechte als Teilhabender einer Studie.

Sollten noch irgendwelche Fragen über ihre rechte als Teilnehmer bei dieser Studie offen sein oder sollten sie noch Fragen, Informations- oder Redebedarf mit jemand anderem als dem durchführenden Studenten haben, können Sie sich an das Secretary of Ethics Committee/ domain Humanities & Social Sciences of the faculty of Behavioural, Management and Social Sciences der Universität Twente unter folgender Email melden:

[ethicscommittee-hss@utwente.nl](mailto:ethicscommittee-hss@utwente.nl)