The Impact of Cognitive Group Awareness on Communication, Coordination, and Learning Outcomes of Primary School Students in the Netherlands

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Keywords: Computer-Supported-Collaborative Learning, Cognitive Group Awareness, Communication, Coordination, Learning Outcomes, Primary Education

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August, 2024

Summary

Computer-Supported Collaborative Learning (CSCL) can be seen as a promising approach in education, for several reasons. One of these reasons is that CSCL is effective, efficient, and enjoyable (Janssen & Bodemer, 2013). Another reason is that CSCL can have a positive impact on the development of collaboration skills, and learning outcomes, among students (Kolodner, 2007; Sangin et al., 2011). However, students can also face challenges in CSCL, concerning e.g. communication and coordination (Erkens et al., 2005; Janssen et al., 2007). One way to overcome these challenges is by promoting Cognitive Group Awareness (CGA). Therefore, this mixed-method study investigated three research questions: "Is there a difference in the communication between a group of eleven-year-old primary school students that is supported by CGA in CSCL, and a group that is not supported by CGA in CSCL?", "Is there a difference in the coordination between a group of eleven-year-old primary school students that is supported by CGA in CSCL, and a group that is not supported by CGA in CSCL?" and "Is there a difference in the learning outcomes of a group of eleven-year-old primary school students that is supported by CGA in CSCL, and a group that is not supported by CGA in CSCL?" This investigation was done via an experimental pre- and post-test design with CGA as the independent variable and communication, coordination, and learning outcomes as the dependent variables. Based on prior research, it was hypothesised that CGA would have a positive effect on all dependent variables. The sample of this study consisted of 48 primary school students of approximately eleven-years-old. The participants of the study were randomly assigned to the experimental or control condition. During the experiment, both conditions worked, in dyads, on the same writing assignment. After the experiment, data was analysed and focus groups were used to examine students' experiences and opinions. Results showed that students who were supported by CGA did not have significantly better communication, coordination, and learning outcomes than students who were not supported by CGA. Thus, all three hypotheses were rejected. One explanation could be that the effects of CGA need more time to materialize. In this study, there was a deadline within two weeks. Students indicated to have experienced stress and time pressure because of this strict deadline. It was also found that some of the participating students felt overwhelmed and did not know what to do with the CGA support offered. Thus, based on the current study, it is recommended to use a prolonged timeline, and support and monitor students in their communication and coordination process, and the usage of CGA support. Additionally, it is recommended to take into account the level of participating students.

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1. Introduction

Computer-Supported Collaborative Learning (CSCL) is a promising educational approach that teachers can use in their classrooms. This approach arose around 1990, stimulated by the potential of technology to connect people in innovative ways. The latter is what CSCL entails. It is a branch of the learning sciences and studies how people can learn together with the help of technology (Dillenbourg, 1999; Stahl et al., 2006). Janssen and Bodemer (2013) explained one of the key reasons why CSCL can be seen as a promising educational approach. According to them, several studies demonstrated that a combination of the usage of Information and Communication Technology (ICT) and collaborative learning can be effective, efficient, and enjoyable. Another reason is that, according to Yamada et al. (2016), CSCL promotes cognitive change, which leads to better learning outcomes. Kolodner (2007) and Sangin et al. (2011) supported this by mentioning that CSCL can have a positive impact on the development of collaboration skills, and learning outcomes.

However, students can also face challenges when they collaborate in CSCL (Erkens et al., 2005; Janssen et al., 2007). According to Fischer et al. (2013), CSCL allows for new learning experiences that many students have never encountered before, such as joint writing and editing of assignments (Cress & Kimmerle, 2008). These activities aim at a collaborative construction of knowledge. However, the more CSCL differs from traditional teaching and learning, the more difficult it may be for students to collaborate efficiently and thus construct a solid knowledge base. Then, they might face challenges concerning, for instance, communication with group members and coordination of learning activities. Eventually, this can lead to frustration (Capdeferro & Romero, 2012; Erkens et al., 2005; Janssen et al., 2007). Especially for primary school students, who were the participants in this study, it is safe to say that they may experience more difficulties in CSCL or collaborative learning in general. Both communication and coordination are two difficult aspects of collaborative learning that require several skills, and that might be challenging for (primary school) students.

One way to overcome these challenges and thus enable students to collaborate efficiently is by making use of guidance (Schnaubert & Bodemer, 2019). Guidance can be considered important in supporting collaborative learning, because research has repeatedly shown that students typically do not engage in high-level collaboration processes without guidance (Dillenbourg & Fischer, 2007; Lou et al., 2001; Weinberger et al., 2007). Concerning guidance of students' activities in CSCL settings, it can be provided with many different approaches. One approach is by supporting Group Awareness (GA) to the individual

students, the group as a whole, or both (Bodemer & Dehler, 2011; Janssen & Bodemer, 2013). GA is an increasingly discussed issue in the field of collaborative learning, and can be defined as being aware of specific aspects, such as knowledge, skills, behaviour, interests, and opinions of group members, or the group as a whole (Bodemer & Dehler, 2011; Bodemer et al., 2018; Gross et al., 2005). Three types of GA can be distinguished (Bodemer & Dehler, 2011): Behavioural GA (BGA), Cognitive GA (CGA), and Social GA (SGA). BGA gives information about students' activities in the CSCL environment (Janssen et al., 2011), CGA gives information about the knowledge and skills of group members (Bodemer, 2011; Dehler et al., 2011; Sangin et al., 2011), and SGA gives information about the functioning of the group as perceived by the collaborating students (Phielix et al., 2011). The provision of GA is needed to effectively steer the collaboration process, and adjust it to the needs of the collaborating group of students (Bodemer & Dehler, 2011; Fransen et al., 2011; Soller et al., 2005). If this information about group members is missing, students may tend to overestimate similarities, and might thus fail to detect relevant differences in, for instance, (prior) knowledge and opinions between group members (Nickerson, 1999). Hence, to enable effective collaborative learning that can have a positive impact on collaboration skills and learning outcomes, the provision of GA is important.

The aim of the current study was to gain insight into the effect of CGA on communication, coordination, and learning outcomes among eleven-year-old primary school students in the Netherlands. This was investigated by making use of a mixed-method research design with CGA as the independent variable, and communication, coordination, and learning outcomes as the dependent variables.

2. Theoretical Framework

2.1 Computer-Supported Collaborative Learning

In the last years, there has been a trend of using Computer-Mediated Communication (CMC) tools, such as social media, in education. It is found that the usage of these CMC tools is most effective when it is combined with small-group learning. Nowadays, primary schools have sufficient technological resources to provide all students with their own CMC tool (Lou et al., 2001). This gives students the opportunity to share knowledge and experiences with their group members and teachers, while collaboratively working on a learning activity online. This is called CSCL (Goda & Yamada, 2013). CSCL provides the opportunity to integrate technological tools and features, which potentially enhances collaboration (Lou et al., 2001).

There are many different definitions for CSCL (Dillenbourg, 1999). Sometimes, CSCL is defined as a form of educational technology where students communicate online by making use of network devices (Stahl & Hakkarainen, 2021). Other studies defined CSCL as a branch of the learning sciences, which investigates how students can learn together with the help of technology (Dillenbourg, 1999; Stahl et al., 2006). The definition of CSCL can thus be divided into learning through or learning around CSCL technology (Lehtinen et al., 1999). With learning through CSCL technology, the CSCL technology is used mainly as a medium for online communication. With learning around CSCL technology, students can communicate in an offline setting, and then work on a learning activity with the help of CSCL technology (Stahl & Hakkarainen, 2021). The usage of this CSCL technology enables flexible, interactive, and individualized instruction, meaning that students work at their own pace, on materials at their own difficulty level. Also, CSCL technology provides immediate feedback on what students make and do (Lou et al., 2001). This allows students to develop themselves further. According to Lou et al. (2001), the enormous growth of CSCL technologies is changing the world. However, not only the world is changing. The way education is conducted will also change because of the growth of CSCL technologies.

It should be noted that successful and effective CSCL must rely on solid instruction and training (Lou et al., 2001). When these circumstances are met, CSCL can be seen as a promising educational approach. Goda and Yamada (2013) displayed two important reasons for that. First, sharing knowledge and experiences through CSCL will promote active group interaction. And second, CSCL is necessary for constructing new knowledge, and building upon each other's knowledge. Yamada et al. (2016) elaborated on this by mentioning that CSCL promotes cognitive change through group interaction. Third, CSCL can have a positive

impact on the development of collaboration skills among students. This will eventually lead to better learning outcomes (Kolodner, 2007).

Nevertheless, CSCL can also bring along some challenges, concerning for instance communication with group members, and coordination of learning activities. This might lead to frustration (Capdeferro & Romero, 2012; Erkens et al., 2005; Janssen et al., 2007). Therefore it is important that students function as a group where they trust each other (Dillenbourg & Fisher, 2007; Kirschner & Erkens, 2013). The existence of trust will namely ensure that students react positively and constructively to feedback of other group members (Fransen et al., 2011). Besides, it is important that students know each other's strengths and weaknesses, are able to use these strengths and weaknesses, and share the same norms, goals, and understanding for their collaboration (Dillenbourg & Fisher, 2007; Kirschner & Erkens, 2013). However, these characteristics need to develop over time (Fransen et al., 2011; Kirschner & Erkens, 2013). Students thus need time to become a group that learns and develops (Fransen et al., 2011). Besides, it is important that they feel motivated to work in a group, and believe, and trust, that some extra time to communicate and coordinate will have a positive impact on their learning (Kirschner & Erkens, 2013).

2.2 Collaboration Skills

Although CSCL can bring along some challenges, it has been implemented at all levels of education (Kirschner & Erkens, 2013). There are several reasons for that, that are discussed above. One of these reasons is that CSCL can have a positive impact on the development of collaboration skills among students (Kolodner, 2007). There are several collaboration skills, of which the focus will be on communication and coordination. That is because, according to Cho et al. (2007) and Kirschner and Erkens (2013), communication and coordination are two important factors in collaborative learning.

The term 'communication' refers to the social and communicational knowledge and skills that students use to collaborate effectively. This knowledge and skills can e.g. determine how students explain to one another, give arguments avoiding confrontation, resolve conflicts, communicate clearly, and respect each other's contributions (Kirschner & Erkens, 2013).

For the term 'coordination', it is difficult to find one definition (Malone & Crowston, 1994). It is found that coordination refers to organizing group activities and managing dependencies among tasks, to achieve a common goal (Kirschner, 2002; Kirschner et al., 2006; Kirschner et al., 2018; Malone & Crowston, 1994). It should be noted that coordination can occur in several types of systems: human, computational, etc. Therefore, coordination is a

broad concept, that includes several processes, e.g. task management, transfer, and planning (Malone & Crowston, 1994; Shah, 2013). To coordinate effectively, students are asked to behave as a leader, be confident, possess problem solving skills, adapt to changes, have knowledge of all possible and available resources, allocate resources, take responsibility for the learning process and -outcomes, communicate effectively, and listen actively (Shah, 2013). Besides, it is important that students build a relationship with all their group members, meaning they trust each other and radiate this, understand each other and their, sometimes complex, motivations and emotions, and encourage perseverance (Malone & Crowston, 1994). Finally, students are asked to evaluate all aspects of a learning activity and categorize these in terms of complexity, allocate all tasks accordingly (Fransen et al., 2011; Kirschner & Erkens, 2013), plan strategically, monitor time, and check whether all tasks are done correctly (Malone & Crowston, 1994).

2.3 Cognitive Group Awareness

To overcome the challenges that CSCL might bring along, and to ensure that CSCL has the desired effect on the development of collaboration skills and learning outcomes, the provision of GA is important (Bodemer & Dehler, 2011; Janssen & Bodemer, 2013). Three types of GA can be distinguished that are considered crucial for effective collaborative learning: BGA, CGA and SGA (Bodemer & Dehler, 2011). BGA gives information about students' activities in the CSCL environment (Janssen et al., 2011), CGA gives information about the knowledge and skills of group members (Bodemer, 2011; Dehler et al., 2011; Sangin et al., 2011), and SGA gives information about the functioning of the group as perceived by the collaborating students (Phielix et al., 2011).

In the current study, the focus will be on CGA. That is because, as mentioned above, communication and coordination, two collaboration skills, can be seen as important factors within CSCL. Therefore, CGA was the most logical option, as it provides information about the (prior) knowledge and skills of group members, and visualizes their strengths and weaknesses (Chavez & Romero, 2012). This is needed to effectively steer the collaboration process, and adjust it to the needs of the collaborating group of students (Bodemer & Dehler, 2011; Fransen et al., 2011; Soller et al., 2005). By being aware of the (prior) knowledge, skills, strengths and weaknesses of group members, students can tailor their communication to be more relevant and comprehensible for all different group members (Buder et al., 2021; Kirschner, 2002; Kirschner et al., 2018; Weinberger, 2003). This is important, because

effective communication is essential for clarifying misunderstandings, sharing knowledge, and building upon each other's knowledge.

Besides, CGA also influences the coordination of students on several aspects (Sangin et al., 2011). First, CGA enables a more efficient task allocation. After evaluating the complexity of the different aspects of a learning activity, tasks can be allocated in an efficient way. Tasks can namely be allocated with the cognitive load and capacities of individual students in mind. Therefore, students can work on a task where they can leverage their strengths (Fransen et al., 2011; Kirschner & Erkens, 2013; Weinberger, 2003). Second, because students are aware of each other's knowledge and skills, it is easier to interpret the amount of time each group member might need to complete their task. This helps in making a strategic planning (Kirschner, 2002; Kirschner et al., 2006; Kirschner et al., 2018). Third, CGA clarifies what resources and/or support students need, and on what aspects (Kirschner & Erkens, 2013). Fourth, CGA ensures that students continuously monitor the progress and group dynamics. It might be that they identify an issue or misalignment, and that the planning needs to change because of that. Students are then able to quickly understand and adapt to these changes, because they are aware of how these changes might affect the cognitive load and capacities of other group members. This will ensure a smooth collaboration. Fifth, CGA enables more targeted feedback. This will help students to improve, and stay aligned with common goals. As a result, the cognitive load is reduced (Bodemer & Dehler, 2011; Fransen et al., 2011). This could result in better performance during a project (Janssen & Bodemer, 2013) and better learning outcomes at the end of the project (Kolodner, 2007; Shin et al., 2018).

According to Kirschner and Erkens (2013), the benefited learning outcomes are due to e.g. the efficient task allocation. Tasks allocated based on individual strengths and weaknesses namely lead to more efficient completion of tasks, with a higher quality. Besides, CGA encourages students to set higher standards for themselves, and to participate more actively during the whole assignment. Students will namely continuously monitor the progress and group dynamics, and give feedback accordingly (Dehler et al., 2011). This helps students to correct mistakes and refine their own learning.

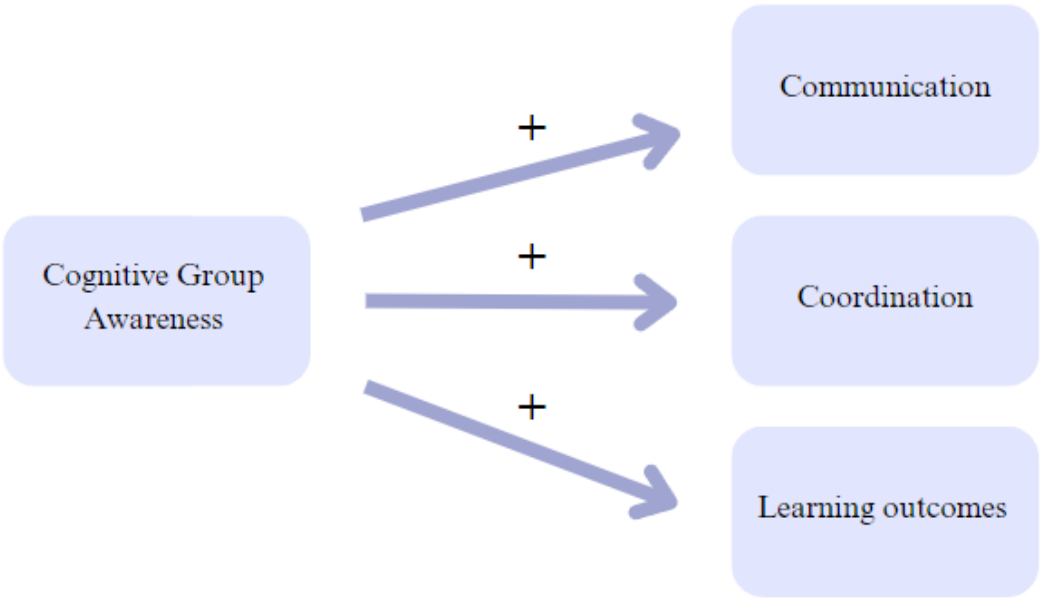
2.4 Research questions and model

This study aimed to gain insight into the effect of CGA on the communication, coordination, and learning outcomes of primary school students, see Figure 1 for the research model. Hence, the research questions of this study were stated as follows:

RQ1: “Is there a difference in the communication between a group of eleven-year-old primary school students that is supported by CGA in CSCL, and a group that is not supported by CGA in CSCL?”
RQ2: “Is there a difference in the coordination between a group of eleven-year-old primary school students that is supported by CGA in CSCL, and a group that is not supported by CGA in CSCL?”
RQ3: “Is there a difference in the learning outcomes of a group of eleven-year-old primary school students that is supported by CGA in CSCL, and a group that is not supported by CGA in CSCL?”

Figure 1

Model of the variables from this study



To better answer these research questions, the following hypotheses were formulated:

H1: The support of CGA in CSCL will have a positive effect on the communication of eleven-year-old primary school students in the Netherlands.
H2: The support of CGA in CSCL will have a positive effect on the coordination of eleven-year-old primary school students in the Netherlands.
H3: The support of CGA in CSCL will have a positive effect on the learning outcomes of eleven-year-old primary school students in the Netherlands.

All hypotheses were based on prior research. Concerning the first hypothesis, Buder et al. (2021), Kirschner et al. (2018) and Weinberger (2003) showed that being aware of the (prior) knowledge, skills, strengths and weaknesses of group members enable students to tailor their communication, so that it is more relevant and comprehensible for all different group members. This is important, because effective communication is essential for clarifying misunderstandings, sharing knowledge, and building upon each other's knowledge. Concerning the second hypothesis, Sangin et al. (2011) showed that CGA can increase awareness of group member's knowledge and skills, which might lead to improved coordination. Several studies elaborated on this. First, Fransen et al. (2011), Kirschner and Erkens (2013) and Weinberger (2003) mentioned that CGA enables a more efficient task allocation. After evaluating the complexity of the different aspects of a learning activity, tasks can be allocated with the cognitive load and capacities of individual students in mind. Second, Kirschner (2002) and Kirschner et al. (2018) mentioned that CGA makes it easier to interpret the amount of time each group member might need to complete their task. This will help in making a strategic planning. And third, Bodemer and Dehler (2011) and Fransen et al. (2011) mentioned that CGA enables more targeted feedback, helping students improve and stay aligned with common goals. This reduces the cognitive load. Concerning the third hypothesis, Janssen and Bodemer (2013), Nickerson (1999) and Shin et al. (2018) mentioned that a reduced cognitive load could result in better performance during a project, and better learning outcomes at the end of the project. Also, Dehler et al. (2011) mentioned that, with an understanding of group member's knowledge and skills, students know who to ask for help, and how to offer help themselves. Besides, tasks allocated based on individual strengths and weaknesses lead to more efficient completion of tasks, with a higher quality. An explanation for this might be that the provision of CGA encourages more active participation and engagement from all group members (Kirschner & Erkens, 2013).

3. Research design and methods

3.1 Research design

This study has used a mixed-method design to compare two study conditions: experimental *versus* control condition. Concerning the quantitative part, an experimental pre- and post-test design was used to analyse the effect of CGA (independent variable) on communication, coordination, and learning outcomes (dependent variables). Concerning the qualitative part, focus groups were used to examine students' experiences with and opinions about the experiment. Figure 2 presents an overview of this research design, in which the dark blue arrow represents the students in the experimental condition and the light blue arrow represents the students in the control condition. As can be seen, all students participated in the pre-test, experiment, post-test and interviews. However, the experiment differed for both conditions.

Figure 2

Model of the mixed-methods design of this study

3.2 Participants

At first, the primary school was asked if it was approved to conduct the experiment there. The primary school is located in the eastern part of the Netherlands. The researcher works there as a teacher. Then, before data could be gathered, the Ethics Committee of the University of Twente approved the study design. To gather participants, homogenous sampling was used, by approaching all students in grade 8. Because the experiment needed to be performed

during school hours, all students were obliged to participate. In total, the sample consisted of 48 students. These participating students and their parents were informed about the study and its purpose. It was mentioned that the participants stayed anonymous, and were able to withdraw from the experiment at any time. Afterwards, the parents were asked for active consent because all participants were under eighteen years old. The average age of these students namely was 11.3 years old. Of these students, 44% were girls and 56% were boys.

The 48 participating students were consciously divided into 24 dyads based on the results of the pre-test. Then, to assure that differences in the outcomes could not be ascribed to individual factors, the dyads were randomly assigned to the experimental or control condition. In both conditions, twelve dyads participated, which was responsible for 80% power (VanVoorhis & Morgan, 2007).

3.3 Instrumentation

In this study, a combination of quantitative and qualitative instruments was used to collect relevant data.

Self-assessment questionnaire

The same self-assessment questionnaire was used for the pre- and post-test. The questionnaire contained closed-type questions measuring students' communication and coordination (Texas Education Agency, 2014; Toering, 2011). In the self-assessment questionnaire, students used metacognitive judgement, meaning they were asked what they think they know, and what skills they think they possess. For this questionnaire with measurement level interval, a five-point Likert Scale was used, with 1 = totally disagree and 5 = totally agree. Example questions of this questionnaire are: "When I talk to my peer, I am open and honest." and "I make a plan before I start to write an assignment." The students answered the sixteen questions of the self-assessment questionnaire on paper. The questionnaire is included in Appendix A.

Knowledge test

Besides the self-assessment questionnaire described above, all students also took a knowledge test during the pre- and post-test, which examined their knowledge about history, specifically about Greeks and Romans. The researcher used a test from Blink Wereld, which is a history method for primary school teachers in the Netherlands. The test consisted of ten multiple-choice questions. Example questions of this test are: "Why must a Roman soldier have been

very strong and fit?" and "What did Romans do in their spare time?" The students answered the questions of the knowledge test on paper. The knowledge test is included in Appendix B.

To prevent misconceptions of the questions from the pre- and post-test, a pilot was done with five eleven-year-old primary school students who did not participate in this study. This pilot aimed to check whether all questions from the self-assessment questionnaire and knowledge test were clear. During the pilot, it was noticeable that the students completed the questionnaire and test seriously and attentively. The students managed to make quick decisions on all of the questions. Afterwards, the students were asked for their opinions about the questionnaire and test. It was checked whether there were any uncertainties or misconceptions. The students indicated that it was fun and easy to complete the questionnaire and test. The questions were clear and easy to understand. There were no misconceptions. Completing both the self-assessment questionnaire and knowledge test took approximately twenty minutes.

Cognitive Group Awareness instrument

In the pre-test, students filled in both the self-assessment questionnaire and knowledge test. The results of the pre-test were shared with the students in the experimental condition. According to Ainsworth (2006) and Janssen et al. (2011), one approach to develop a GA tool is to visualize information that is important. Erkens et al. (2005) elaborated on that by mentioning that visualizations make it easier to collect and interpret this information. Therefore the researcher chose to share the results of the pre-test in the form of a double bar chart, displaying the results of both students. The answers on the self-assessment questionnaire were presented in numbers from 1-5, and the grade of the knowledge test was depicted as well. This visualization was printed, but also send to the Chromebooks of the students. In that way, it was visible throughout the entire experiment, so that the students could look at it, and use it whenever they want.

Interview guide

A semi-structured interview guide was used to examine students' experiences with and opinions about the experiment. Students in the experimental and control condition were interviewed in focus groups. Examples of questions that were asked, are: "How did the collaboration go?" and "How did you divide the tasks?" The semi-structured interview guide is included in Appendix C.

3.4 Procedure

After the Ethics Committee of the University of Twente had approved the study design, and the parents of the participating students were asked for active consent, the experiment could start. The experiment was performed during school hours at the primary school of the students, and was finished within two weeks. During the first meeting, the pre-test was administered in which the students filled in a self-assessment questionnaire measuring their communication and coordination, and a history knowledge test measuring their knowledge concerning Greeks and Romans.

By analysing the results on the pre-test, the 48 participating students were divided into 24 dyads. The students with a lower score were matched with students with an average score, and the students with a higher score were also matched with students with an average score. Then, these dyads were randomly assigned to the experimental or control condition.

After the pre-test was administered and the students were assigned to the conditions, a second meeting was planned in which the assignment was explained in more detail. Afterwards, the experiment started. During the experiment, the students in both the experimental and control condition worked on a joint writing assignment about Greeks and Romans. However, only the 12 dyads in the experimental condition were supported by CGA. These dyads were thus aware of each others' results on the pre-test. The 12 dyads in the control condition were not supported by CGA, which means these dyads were not aware of each others' results on the pre-test. The dyads have worked on the assignment almost every schoolday for approximately one hour. The researcher was always present while the students worked on the assignment at school. After two weeks, the assignment was handed in and evaluated by the researcher. One day after the deadline, a last meeting was scheduled to administer the post-test. Focus groups were used that day to examine students' experiences with and opinions about the experiment. From both the experimental and control condition, there were randomly chosen thirteen students to participate in the focus groups. So, in total, this were twenty-six students. Then, these twenty-six students were consciously divided into the four focus groups, so that the division of students from the experimental and control condition would be as equal as possible. There were two focus groups with seven students. One of these focus groups included four students from the experimental condition and three students from the control condition. The other focus group included three students from the experimental condition and four students from the control condition. The other two focus groups included six students, with three students from the experimental condition and three

students from the control condition. After this last meeting, all data was collected and the researcher started to analyse all data.

3.5 Data analysis

Concerning the quantitative analysis, inferential statistical analyses were performed in IBM SPSS version 25. All quantitative analyses were performed for both an individual analysis and a dyad analysis. To be able to do the dyad analysis, the average scores were calculated for the questions asked in the self-assessment questionnaire and knowledge test.

First, the descriptive statistics of all dependent variables were calculated. Second, for all statistical tests, all assumptions were tested. Third, Cronbach's α was calculated to measure the reliability of the self-assessment questionnaire and knowledge test during the pre- and post-test. Fourth, Independent Samples T-Tests were performed for the pre- and post-test to compare the means of the dependent variables for the two conditions. Fifth, one-way Analyses of Covariance (ANCOVA) were performed to test whether the two conditions statistically differed based on the dependent variables. Sixth, Paired Samples T-Tests were performed to test whether the scores on the post-test differed compared to the scores on the pre-test. For all statistical tests, $\alpha = 0.05$ was used. For the ANCOVA tests, partial η^2 was used to measure the corresponding effect size.

Concerning the qualitative analysis of the interviews in focus groups, a summary of the answers was presented. All focus groups were recorded with a separate recording device to document all questions and answers. The researcher also made notes to keep the interviews structured. Afterwards, the recording was transcribed verbatim in the spoken language, which was Dutch. For the qualitative analysis, only relevant quotes of the transcribed focus groups were translated to English. The transcribed focus groups were uploaded into ATLAS.ti. At first, inductive coding was used to create an initial set of codes with a returning pattern. More than 40 codes were created. Then, axial coding was used to organize these initial codes into fewer, more meaningful groups of codes. Finally, selective coding was used to combine the codes into final themes. The final themes are discussed in paragraph 4.5.

4. Results

The self-assessment questionnaire both during the pre-test (16 items; $\alpha = 0.761$) and the post-test (16 items; $\alpha = 0.770$) was reliable. This also applies to the knowledge test for both the pre-test (10 items; $\alpha = 0.776$) and the post-test (10 items; $\alpha = 0.785$).

4.1 Assumption testing

All test assumptions were checked for communication, coordination, and learning outcomes. This was checked for both the pre- and post-test, and none of the assumptions were violated. Therefore, parametric tests were performed.

4.2 The effect of CGA on communication

Below, Table 1 and 2 are depicted. Table 1 shows the descriptive statistics on communication from the individual analysis. Table 2 shows the descriptive statistics on communication from the dyad analysis.

Table 1

Descriptive statistics on communication from the individual analysis

	Communication			
	Pre-test		Post-test	
	Experimental (n = 24)	Control (n = 24)	Experimental (n = 24)	Control (n = 24)
Mean	4.02	4.10	4.10	4.22
SD	0.36	0.35	0.33	0.36
Min	3.25	3.50	3.38	3.50
Max	4.50	4.75	4.50	5.00

Table 2

Descriptive statistics on communication from the dyad analysis

	Communication			
	Pre-test		Post-test	
	Experimental (n = 12)	Control (n = 12)	Experimental (n = 12)	Control (n = 12)
Mean	4.02	4.10	4.10	4.22
SD	0.27	0.24	0.26	0.22
Min	3.63	3.81	3.69	3.94
Max	4.44	4.44	4.50	4.56

4.2.1 Individual analysis

For the pre-test, t-test results showed that this study found no difference between students who had a presence of CGA and students who had an absence of CGA, $t(46) = 0.764$, $p = 0.449$. For the post-test, this study also found that students who had a presence of CGA and students who had an absence of CGA were comparable in terms of communication, $t(46) = 1.193$, $p = 0.239$.

One-way ANCOVA showed that, after adjustment for pre-intervention communication, there was no statistically significant difference in post-intervention communication between the interventions, $F(1, 45) = 0.933$, $p = .339$.

Paired samples t-tests revealed that there was a statistically significant improvement in communication for students with CGA, $t(23) = 2.223$, $p = 0.036$. The same conclusion was drawn for students without CGA, $t(23) = 2.361$, $p = 0.027$.

4.2.2 Dyad analysis

T-tests results showed that, for the pre-test, this study found no difference between dyads who had a presence of CGA and dyads who had an absence of CGA, $t(22) = 0.749$, $p = 0.462$. For the post-test, this study also found that dyads who had a presence of CGA and dyads who had an absence of CGA were comparable in terms of communication, $t(22) = 1.205$, $p = 0.241$.

One way ANCOVA revealed that, after adjustment for pre-intervention communication, there was no statistically significant difference in post-intervention communication between the interventions, $F(1, 21) = 1.136$, $p = .299$.

Paired samples t-tests revealed a trend between the scores on the pre- and post-test for dyads who had a presence of CGA, with the score on the post-test being higher, $t(11) = 2.159$, $p = 0.054$. For the dyads without CGA, a statistically significant improvement was found in communication, $t(11) = 3.027$, $p = 0.012$.

4.3 The effect of CGA on coordination

On the next page, Table 3 and 4 are depicted. Table 3 shows the descriptive statistics on coordination from the individual analysis. Table 4 shows the descriptive statistics on coordination from the dyad analysis.

Table 3

Descriptive statistics on coordination from the individual analysis

	Coordination			
	Pre-test		Post-test	
	Experimental (n = 24)	Control (n = 24)	Experimental (n = 24)	Control (n = 24)
Mean	4.11	4.21	4.28	4.54
SD	0.59	0.70	0.53	0.50
Min	2.75	2.50	3.13	3.63
Max	5.00	5.00	5.00	5.00

Table 4

Descriptive statistics on coordination from the dyad analysis

	Coordination			
	Pre-test		Post-test	
	Experimental (n = 12)	Control (n = 12)	Experimental (n = 12)	Control (n = 12)
Mean	4.11	4.21	4.28	4.54
SD	0.40	0.43	0.40	0.28
Min	3.50	3.56	3.75	4.13
Max	4.75	5.00	4.81	5.00

4.3.1 Individual analysis

For the pre-test, t-tests results showed that there was no difference between students who had a presence of CGA and students who had an absence of CGA, $t(46) = 0.502$, $p = 0.618$. Concerning the post-test, t-tests results revealed a trend between students who had a presence of CGA and students who had an absence of CGA, with the students with absence of CGA scoring higher, $t(46) = 1.747$, $p = 0.087$.

By running a one-way ANCOVA, it is found that, after adjustment for pre-intervention coordination, there was a statistically significant difference in post-intervention coordination between the interventions, $F(1, 45) = 4.420$, $p = .041$, partial $\eta^2 = 0.089$.

Paired samples t-tests revealed a trend between the scores on the pre- and post-test for students who had a presence of CGA, with the score on the post-test being higher, $t(23) = 1.963$, $p = 0.062$. A conclusion could also be drawn for the students without CGA. There was a statistically significant improvement in coordination for those students, $t(23) = 3.798$, $p < 0.001$.

4.3.2 Dyad analysis

For the pre-test, t-tests results showed no difference between dyads who had a presence of CGA and dyads who had an absence of CGA, $t(22) = 0.556$, $p = 0.584$. Concerning the post-test, a trend was revealed between dyads who had a presence of CGA and dyads who had an absence of CGA, with the dyads with absence of CGA scoring higher, $t(22) = 1.836$, $p = 0.080$.

One-way ANCOVA found that, after adjustment for pre-intervention coordination, there was a statistically significant difference in post-intervention coordination between the interventions, $F(1, 21) = 4.650$, $p = .043$, partial $\eta^2 = 0.181$.

Paired-samples t-tests revealed a trend between the scores on the pre- and post-test for dyads with presence of CGA, with the score on the post-test being higher, $t(11) = 2.104$, $p = 0.059$. For the dyads with absence of CGA, a conclusion could be drawn that there was a statistically significant improvement in coordination, $t(11) = 4.373$, $p = 0.001$.

4.4 The effect of CGA on learning outcomes

4.4.1 Individual analysis

Below, Table 5 is displayed, showing the descriptive statistics on learning outcomes from the individual analysis.

Table 5

Descriptive statistics on learning outcomes from the individual analysis

	Learning outcomes			
	Pre-test		Post-test	
	Experimental (n = 24)	Control (n = 24)	Experimental (n = 24)	Control (n = 24)
Mean	7.03	6.59	7.41	7.65
SD	1.25	1.18	1.29	1.23
Min	4.00	3.60	5.00	5.30
Max	9.00	8.30	9.60	10.00

T-tests results showed that, for the pre-test, there was no difference between students who had a presence of CGA and students who had an absence of CGA, $t(46) = 1.246$, $p = 0.219$. Concerning the post-test, it was found that students who had a presence of CGA and students who had an absence of CGA were comparable in terms of learning outcomes, $t(46) = 0.677$, $p = 0.502$.

One-way ANCOVA revealed that, after adjustment for pre-intervention learning outcomes, there was a trend in post-intervention learning outcomes between the scores on the two conditions, with the students with absence of CGA scoring higher, $F(1, 45) = 3.227$, $p = 0.079$, partial $\eta^2 = 0.067$.

Paired samples t-tests revealed a trend between the scores on the pre- and post-test for students with presence of CGA, with the score on the post-test being higher, $t(23) = 1.835$, $p = 0.079$. Concerning the students with absence of CGA, a conclusion could be drawn that there was a statistically significant improvement in learning outcomes, $t(23) = 4.553$, $p < 0.001$.

4.4.2 Dyad analysis

In Table 6, the descriptive statistics on learning outcomes from the dyad analysis are shown.

Table 6

Descriptive statistics on learning outcomes from the dyad analysis

	Learning outcomes			
	Pre-test		Post-test	
	Experimental (n = 12)	Control (n = 12)	Experimental (n = 12)	Control (n = 12)
Mean	7.03	6.59	7.41	7.65
SD	1.03	0.99	0.83	0.85
Min	5.15	4.80	5.50	5.95
Max	8.50	8.00	8.95	8.80

For the pre-test, t-tests results found no difference between dyads who had a presence of CGA and dyads who had an absence of CGA, $t(22) = 1.060$, $p = 0.301$. For the post-test, it was also found that dyads who had a presence of CGA and dyads who had an absence of CGA were comparable, $t(22) = 0.719$, $p = 0.480$.

By running a one-way ANCOVA, a conclusion could be drawn that, after adjustment for pre-intervention learning outcomes, there was no statistically significant difference in post-intervention learning outcomes between the interventions, $F(1, 21) = 2.273$, $p = .147$.

Paired samples t-tests revealed a trend between the scores on the pre- and post-test for dyads who had a presence of CGA, with the score on the post-test being higher, $t(11) = 1.821$, $p = 0.096$. For the dyads without CGA, a statistically significant improvement was found in learning outcomes, $t(11) = 3.621$, $p = 0.004$.

4.5 Qualitative analysis of the interviews

After the experiment, focus groups were used to examine students' experiences with and opinions about the experiment. At first, it is important to mention that the experiences and opinions from the students were very divided. A more detailed explanation of the results of the focus groups will be discussed below.

4.5.1 Communication

Table 7 presents the themes identified in the focus groups while discussing the communication of the students, along with the number of students (divided into the experimental and control condition) that mentioned each theme (i.e., frequency). The themes are divided into positive and negative aspects.

Table 7

Themes related to communication (quotes were translated from Dutch)

Theme	Frequency	Example quote
Positive aspects		
Helping each other	Experimental: 9/13 Control: 8/13	"I have dyslexia, so I found the writing difficult. I questioned the spelling of the words I wrote. Luckily, [my peer] was able to help me with that!" [S3]
Respect	Experimental: 4/13 Control: 7/13	"We communicated very well with each other. We let each other talk, and listened to each other. I think we also adhered to the class rules and talked to each other very respectfully." [S9]
Negative aspects		
Ineffective communication	Experimental: 6/13 Control: 4/13	"[My peer] just kept chatting and joking about stupid stuff. He did not listen to what I said at all. It was really annoying. I hope I do not have to work with him ever again." [S8]

There were two themes that focused on the positive aspects of communication. The first positive theme that was mentioned was *helping each other.* What became clear is that

seventeen students were helping their peer during the experiment, for instance with the spelling of words, working on Chromebooks, searching for information, or clarifying the meaning of words or sentences found on the internet. Concerning this theme, there were no big differences within the conditions. The students from both the experimental and the control condition helped their peer, and learned from each other.

The second positive theme was about *respect*, referring to peers letting each other talk, listening to each other, taking each other into consideration, or just talking respectfully to each other. Especially students from the control condition, so without CGA support, communicated respectfully with each other.

Besides, there also was one theme that focused on the negative aspects of communication. This negative theme was *ineffective communication.* Concerning this theme, there were no big differences within the conditions. Six students from the experimental condition, and four students from the control condition indicated the communication within their dyad as ineffective. This caused conflicts, for instance, because one of the peers was too controlling, because the peers did not listen to each other, or because the peers could not find an agreement about which information to share and which information not to share in their writing assignment.

4.5.2 Coordination

Table 8 presents the themes identified in the focus groups while discussing the coordination of the students, along with the number of students (divided into the experimental and control condition) that mentioned each theme (i.e., frequency). The themes are divided into positive and negative aspects.

Table 8

Themes related to coordination (quotes were translated from Dutch)

Theme	Frequency	Example quote
Positive aspects		
Effective task division	Experimental: 6/13 Control: 5/13	"We discussed respectfully what we both wanted to work on, and listened carefully to each other. Then we divided the tasks, and we could both work on what we wanted to. That was nice!" [S4]

Positive evaluation	Experimental: 6/13 Control: 5/13	"I liked that we learned so much and it was nice to do it together with [my peer] because we understood each other well. Besides, we took each other into consideration while dividing the tasks." [S7]
Negative aspects		
Controlling behaviour	Experimental: 8/13 Control: 4/13	"[My peer] wanted to check and improve everything that I wrote, so he hardly looked for any information himself. It was annoying. As if I cannot write a good assignment myself!" [S21]
Negative evaluation	Experimental: 4/13 Control: 4/13	"I found it difficult and annoying to work together with [my peer]. Like I said, it was not very nice to work on this assignment together." [S17]
Ineffective task division	Experimental: 5/13 Control: 3/13	"We have not divided any tasks. I actually had to search for all the information, and come up with additional questions to discuss in the assignment. [My peer] only looked at some pictures!" [S2]
Time pressure	Experimental: 4/13 Control: 4/13	"I found it difficult that the assignment had to be finished within two weeks. We really had to hurry, and that made me feel pressured." [S15]

There were two themes that focused on the positive aspects of coordination. The first positive theme that was mentioned was *effective task division*. Eleven students mentioned they divided the tasks equally while working on the assignment. Some dyads even discussed the specific parts of the assignment, so they could both indicate the part they would prefer to work on. Concerning this theme, there were no big differences within the conditions.

The second positive theme was *positive evaluation*. The participating students were not used to collaborate. Assignments were usually done individually, and most of the assignments were offered in workbooks. Only rarely, students were allowed to work on a

creative writing assignment like this, which is why this experiment generated enthusiasm and eagerness among eleven of the students: six from the experimental condition and five from the control condition.

Besides, there were four themes that focused on the negative aspects of coordination. The first negative theme that emerged was *controlling behaviour*. Twelve students mentioned their peer behaved controlling while working on the assignment, referring to checking everything, not listening to their peer, or wanting to decide everything themselves. Especially students from the experimental condition, so with CGA support, behaved controlling in relation to their peer.

The second negative theme was *negative evaluation*. There were three more students who evaluated the coordination part of the assignment positively compared to negatively. And again, concerning this theme as well, there were no differences within the conditions. Eight students, four from the experimental condition and four from the control condition, did not like this assignment, e.g. because it was too difficult to divide the tasks on their own, there was no leader in their dyad, they experienced stress because of the deadline, or because they did not like the subject or level of difficulty of the assignment.

The third negative theme that was mentioned was *ineffective task division*. Eight students mentioned their task division did not go well. These were five students from the experimental condition and three students from the control condition. Some dyads did not manage to divide the tasks, because they did not know what to do exactly, they did not communicate clearly, or because they disagreed while trying to divide the tasks. There also were dyads who did not have a leader within their dyad, and dyads in which one of the peers refused to work on the assignment. This latter is called free rider behaviour. It became clear that the participating students, maybe because of their age, found it difficult to stand up for themselves in situations like this.

The fourth negative theme was *time pressure.* Eight students mentioned the deadline of two weeks causing a lot of stress. Within these eight students, there were no differences within the conditions. The participating students were not used to assignments like this, so it took some time to really understand the assignment, divide the tasks, find the right information, etc. Also, some students who were grouped to work with their (best) friend, chatted too much about other topics, which resulted in them eventually having to hurry.

4.5.3 Learning outcomes

Table 9 presents the themes identified in the focus groups while discussing the learning outcomes of the students, along with the number of students (divided into the experimental and control condition) that mentioned each theme (i.e., frequency). The themes are divided into positive and negative aspects.

Table 9

Themes related to learning outcomes (quotes were translated from Dutch)

Theme	Frequency	Example quote
Positive aspects		
Positive evaluation	Experimental: 5/13 Control: 2/13	"I really appreciated knowing how good [my peer] was at history. We both had a good grade and that gives you confidence in each other. We were able to help each other well." [S11]
Negative aspects		
Negative evaluation	Experimental: 8/13 Control: 5/13	"No, the CGA did not help us. I did not like that [my peer] knew my grade. It made me a little insecure. " [S12]
Difficulty of the assignment	Experimental: 7/13 Control: 5/13	"We both found it difficult because we did not know much about the subject yet. We had to search carefully and it was difficult to find the right information." [S23]
Unusual assignment	Experimental: 6/13 Control: 5/13	"It made me stressed. We don't work together that often. Usually, we have to complete assignments in our workbook individually. So, when [my teacher] said that we were going to work together without a workbook or strict assignment, I found it tensive. Also, [my teacher] always says that we do not need to share our grade if we do not want to. And now, my grade was shared. I did not like that!" [S5]

Grade awareness	Experimental: 10/13 Control: n.a.	"[My peer] was really annoying. He was so pedantic and controlling. Only because I had a lower grade than him!" [S17]
Difficulty to start	Experimental: 5/13 Control: 2/13	"We did not really know how to start. The assignment was to difficult. It made us a little insecure. Or at least I was insecure. And I think [my peer] too." [S6]

There was one theme that focused on the positive aspects of learning outcomes. This positive theme was *positive evaluation*. There were seven students, mostly from the experimental condition, that explicitly evaluated this assignment positively. Especially students who worked in dyads where both students had a high grade on the pre-test evaluated the assignment positively. Because they knew they both had some knowledge about Greeks and Romans already, they trusted each other. Therefore, they were able to help each other, learn together and make a great assignment by collaborating effectively.

Besides, there were five themes that focused on the negative aspects of learning outcomes. The first negative theme that emerged here was *negative evaluation*. Thirteen students, again mostly from the experimental condition, indicated that they disliked this assignment, mainly because their peer knew their grade on the pre-test. The participating students were not used to sharing their grade. This caused insecurity. In some dyads, the peer with the highest grade became interfering and controlling. This, again, caused insecurity and annoyance among the other peer. What also became clear is that some students did not think about the CGA because they, for instance, were too busy working on the assignment. Other students did think about the CGA, but did not know what to do with it.

The second negative theme was *difficulty of the assignment*. Some students did not know much about Greeks and Romans at the start of the assignment. Also, as mentioned in paragraph 4.5.2, the participating students were not used to joint writing assignments like this. This resulted in twelve students indicating the difficulty of the assignment as too high. Concerning this theme, there were no big differences within the conditions.

The third negative theme that was mentioned was *unusual assignment*. This theme is overlapping a bit with the theme mentioned above. Eleven students, six from the experimental condition and five from the control condition, indicated this writing assignment as an unusual assignment. The participating students often work individually on assignments in their

workbook. This experiment contained a joint writing assignment in which the students could decide a lot for themselves. This resulted in stress and a tensive working environment for some of the dyads.

The fourth negative theme that was identified was *grade awareness*. This theme was only applicable for students in the experimental condition. For ten of these students, knowing each other's grade has resulted in a conflict, e.g. because the students with the highest grade became interfering and controlling. This caused insecurity among their peer which resulted in their peer not daring to stand up for themselves.

The fifth and last negative theme was *difficulty to start*. It was, especially for students from the experimental condition, difficult to start working on the assignment because some students did not understand the explanation of the assignment. After asking their teacher or other dyads to explain the assignment one more time, a lot of students were able to write a great assignment.

5. Discussion

5.1 Communication: no effects of CGA

The first research question of this study was: "Is there a difference in the communication between a group of eleven-year-old primary school students that is supported by CGA in CSCL, and a group that is not supported by CGA in CSCL?" Concerning communication, the results showed that CGA did not make a difference. This means that students who were supported by CGA did not have significantly better communication than students who were not supported by CGA. With these results, the H1 hypothesis that the support of CGA will have a positive effect on communication, is rejected. This finding is not aligned with previous studies that suggested the presence of CGA could lead to more relevant and comprehensible communication (Buder et al., 2021; Kirschner et al., 2018; Weinberger, 2003).

The results of the current study could be explained by Engelmann and Hesse (2010) and Yamada et al. (2016), who already mentioned that, to realise CGA, active social interaction and communication are needed. These two variables will allow knowledge and skills to be exchanged. So, when students are facing challenges concerning ineffective communication, students might not know what to do with the CGA support offered. During the focus groups, there were six students from the experimental condition who evaluated their communication as ineffective. Besides, it became clear that some students did not know what to do with the CGA support offered. This emphasized that indeed the challenges concerning ineffective communication resulted in overwhelmed students who did not know what to do with the CGA support offered. Therefore, this can be seen as an explanation of why CGA did not have the expected effect on communication.

5.2 Coordination: negative effects of CGA

The second research question of this study was: "Is there a difference in the coordination between a group of eleven-year-old primary school students that is supported by CGA in CSCL, and a group that is not supported by CGA in CSCL?" Concerning coordination, the results revealed a trend between the scores on the two conditions, with the students without CGA scoring higher. This means that students who were supported by CGA did not have significantly better coordination than students who were not supported by CGA. With these results, the H2 hypothesis that the support of CGA will have a positive effect on coordination, is rejected. This finding is not aligned with previous studies that suggested the presence of CGA would lead to improved coordination (Sangin et al., 2011).

The results of the current study could be explained by Erkens et al. (2005) and Janssen et al. (2017), who already mentioned that students can face challenges when they collaborate in CSCL. As discussed in paragraph 2.3, CGA could influence coordination on several aspects. However, this process demands a lot from students. Especially for primary school students it might be difficult to actively engage in this process. Students are namely asked to continuously observe and actively interact with their group members, to be able to understand their knowledge and skills. They also need to share their own personal experiences, knowledge and skills with their group members, which might be scary for some students. For the students that participated in this study, it was the first time working with CGA support. That might make it more difficult as well. Besides, students need to define clear, achievable goals for their group and ensure that all group members understand, and are committed to, these goals. And finally, students should provide constructive feedback, and embrace feedback from their group members. They need to use this feedback to improve their individual and group performance (Bodemer & Dehler, 2011; Fransen et al., 2011; Kirschner & Erkens, 2013). The students that participated in this study have barely defined their own goals. They also have little experience with giving or receiving feedback from group members. It is safe to say that, for students of this age, it is difficult to give constructive feedback and embrace feedback they have received themselves. This has caused insecurity among the students. Therefore, this can be seen as an explanation of why these students experienced challenges concerning ineffective coordination, and why the CGA support did not have the expected result on coordination.

Another explanation was mentioned by Fischer et al. (2013). They suggested that the more CSCL differs from traditional teaching and learning, the more difficult it may be for students to collaborate efficiently. Then, students might face challenges concerning, for instance, coordination (Erkens et al., 2005; Janssen et al., 2007). To elaborate on this, there were eleven students who indicated this joint writing assignment as an unusual assignment. The participating students usually completed exercises in their workbook individually. Also, these students were not used to work with CGA. Normally, the grades of the students are not shared with the rest of the group. These students were not supported enough in how to understand and work with this CGA. As a result, there were eight students who evaluated the CGA negatively. It was found that, because of the CGA, some group members became interfering and controlling. That, in combination with the grade awareness in general, caused insecurity among some of the students, which made it hard to focus on the assignment completely. Additionally, there were eight students, four from the experimental condition,

who evaluated their coordination as ineffective. So, it might be that, because this assignment and the usage of CGA was unusual for the participating students, they have experienced challenges with ineffective coordination.

Fransen et al. (2011) and Kirschner and Erkens (2013) indicated a third and last possible explanation for the results of this study. According to them, it is important for students to function as a group where they trust each other, know each other's strengths and weaknesses, are able to use these strengths and weaknesses, and share the same norms, goals, and understanding. However, these characteristics need to develop over time. Students thus need time and trust to become a group that learns and develops (Fransen et al., 2011). It is safe to say that students from this age have difficulties trusting this. Besides, the experiment in this study had a deadline within two weeks. This might not be enough time for the characteristics to develop. To elaborate, eight of the participating students mentioned that the deadline caused stress and time pressure. This clarifies that some students were not focused on the assignment completely. That can be seen as another explanation of why CGA did not have the expected effect on coordination.

5.3 Learning outcomes: negative effects of CGA

The third research question of this study was: "Is there a difference in the learning outcomes of a group of eleven-year-old primary school students that is supported by CGA in CSCL, and a group that is not supported by CGA in CSCL?" The results revealed a trend between the scores on the two conditions, with the students without CGA scoring higher. This means that students who were supported by CGA did not have significantly better learning outcomes than students who were not supported by CGA. With these results, the H3 hypothesis that the support of CGA will have a positive effect on learning outcomes, is rejected. These results were not in line with what the literature suggested. Bodemer and Dehler (2011), Fransen et al. (2011) and Janssen and Bodemer (2013) mentioned that CGA helps to better regulate the collaboration process, which reduces the cognitive load. This could lead to better performance during a project (Janssen & Bodemer, 2013) and better learning outcomes at the end of the project (Kolodner, 2007; Shin et al., 2018). Grudin (2002) and Gutwin and Greenberg (2002) elaborated on this by showing that CGA improves communication and coordination, which ultimately will lead to better learning outcomes. However, for CGA to lead to improved communication and coordination, a lot is demanded from students (see paragraph 5.2). Especially for primary school students, who were the participants in this study, this process might be difficult. The qualitative analysis showed this as well. As mentioned in paragraph

5.1 and 5.2, the participating students experienced challenges concerning ineffective communication and coordination. It was mentioned that the students did not know what to do, or how to improve their communication and coordination. Thus, it can be noted that these students were not trained and supported enough in their communication and coordination process. Lou et al. (2001) already mentioned that successful and effective CSCL should rely on solid instruction and training. So, it might be that, because of the ineffective communication and coordination and the lack of support, the learning outcomes were not benefited as well. Namely, if students are experiencing that amount of challenges during a collaboration process, they will not be focused on their learning outcomes, but only on finishing the assignment quickly.

Additionally, there were ten students who indicated the grade awareness as a negative aspect of the assignment. The participating students were not used to know the knowledge, skills, strengths and weaknesses of their group members. Because the students were not enough supported in this, they did not know what to do with the CGA support offered. It was difficult to remember and/or recognize the strengths and weaknesses while working on the assignment. When they did remember it, it was difficult to apply this awareness while working on the assignment. Besides, the participating students were not used to sharing their own knowledge and skills as well. In some dyads, the group member with the highest grade became interfering and controlling. This caused insecurity among some of the students, which could also explain why students were not completely focused on their learning outcomes.

Finally, twelve students had struggles with the difficulty of the assignment. Besides, for seven students, mostly students from the experimental condition, it was difficult to start writing the assignment. The CGA support offered might have overwhelmed students, and thus resulted in students not knowing what to do at the start of the assignment. This can be seen as another explanation of why CGA did not have the expected effect on learning outcomes.

5.4 Implications for teachers and learning designers

The current study showed that CGA has no effect on communication among eleven-year-old primary school students. As mentioned before, CGA provides information about the (prior) knowledge and skills of group members, and visualizes their strengths and weaknesses (Chavez & Romero, 2012). As a result, students would be able to tailor their communication to be more relevant and comprehensible for all different group members (Buder et al., 2021; Kirschner et al., 2018; Weinberger, 2003). However, the qualitative results of this study revealed that the participants struggled with ineffective communication. So, when teachers or

instructional designers do want to apply CGA, it is important to support and monitor students in their communication process both before and during the assignment (Janssen et al., 2007; Savicki et al., 2002). Students namely need to be supported in how to communicate clearly and respectfully, but also in how to interpret and process what their group members say, etc.

Additionally, the current study showed that CGA has a negative effect on coordination among eleven-year-old primary school students. Although CGA should enable e.g. efficient task allocation, strategic planning, targeted feedback and a reduced cognitive load, this study showed the opposite. In the current study, the participating students struggled with ineffective coordination. So, when teachers or instructional designers do want to apply CGA, it is important to support and monitor students in their coordination process both before and during the assignment (Erkens et al., 2005; Janssen et al., 2007). Students namely need help to evaluate the complexity of the tasks, allocate the tasks based on individual strengths and weaknesses, make a strategic planning, give constructive feedback, and embrace received feedback from their group members. In that way, all students will work on an equal part of the assignment that leverages their strengths, and free rider behaviour is prevented (Buder & Bodemer, 2008). Besides, it is important to use a prolonged timeline so that students will not experience stress or time pressure, and have more time and trust to get used to work with CGA support (Janssen et al., 2011; Jiang et al., 2009).

Finally, the current study showed that CGA has a negative effect on learning outcomes among eleven-year-old primary school students. According to Janssen and Bodemer (2013), Kolodner (2007) and Shin et al. (2018), a reduced cognitive load would lead to better performance during a project and better learning outcomes at the end of the project. However, in this study, it became clear that the participating students did not like the CGA, because they did not want their grade to be shared with their peer. This caused stress and insecurity among some of the students, which, eventually, resulted in overwhelmed students who did not know what to do. Therefore, it is important to support and monitor students in understanding and using the CGA support both before and during the assignment (Schnaubert & Bodemer, 2019; Drachsler & Greller, 2012). It is important to explain to the students why they need to know each other's strengths and weaknesses, and how they can use this awareness. Then, they will be more likely to understand and apply it during the experiment. Besides, it would be better to not only share a grade or number, but also more information about the students' strengths and weaknesses. It is important to support students in sharing their own experiences, knowledge, skills, strengths and weaknesses, because this might be scary for students of this age. It also is

important to support students in monitoring their group members, so they will fully understand the knowledge, skills, strengths and weaknesses that their group members shared with them. Additionally, it should be noted that there were a lot of students who did not know what to do with CGA. So, if the support and monitoring do not provide the desired effect, it could be that not all students can handle CGA. If teachers or instructional designers do want to apply CGA, it then is important to take into account the level of the participating students (Ollesh et al., 2021).

5.5 Limitations

The first limitation of this study refers to the sample size of the study. The study was examined with a relatively small sample (n = 48) at only one primary school in the Netherlands, which makes it difficult to project the results to other primary schools. According to Button et al. (2013) and Tipton et al. (2017), a larger sample, preferably at more primary schools, would be more reliable and it would make it easier to interpret and generalise the results.

The second limitation of this study relates to the profiles of the participants in this study. The participating students were approximately eleven-years-old when they participated in the experiment. These students had never worked with CGA support before. They even barely worked on a collaborative writing assignment like this. Therefore, it was difficult for some students to start working on the assignment. That is why some students experienced pressure to complete the assignment within the deadline of two weeks. This all may have led to insecure, stressed and overwhelmed students who did not know how to handle the CGA support offered. In addition, the COVID-19 pandemic happened while these students were on primary school. As a result, schools in the Netherlands needed to close three times. Two times this closure was for a period of three months, one time it was for a period of three weeks. This period has had a huge psychosocial impact on children (Ghosh et al., 2020; Liu et al., 2020). According to Ghosh et al. (2020), school closure has disrupted children's usual lifestyle and could potentially have promoted stress, impatience and annoyance. Thus, this COVID-19 period might also have an effect on the results of this study.

The third limitation relates to the strict timeline of the study. The experiment had to fit the schedule of the primary school, which is why the experiment had a strict deadline. The students could work on the writing assignment for only two weeks, which resulted in stress and time pressure. It would have been better if this study could have followed a prolonged

timeline, because the effects of CGA may need more time to materialize (Janssen et al., 2011; Jiang et al., 2009). With a prolonged timeline, students have more time to (get used to) work with CGA support, and will not get stressed or overwhelmed that quickly. Thus, a longitudinal study could have provided a clearer and more reliable view of the effect of CGA.

The last limitation relates to the self-reported nature of the instruments used in this study. In the self-assessment questionnaire, the students have assessed themselves on various aspects of communication and coordination. However, students of this age may have low calibration, meaning there is a difference between a student's metacognitive judgments and the actual performance (Schraw et al., 2013). Young students, like the participants in this study, may not be able to accurately monitor their learning (Papadopoulos et al., 2021), which results in an unrealistic self-image (Mihalca et al., 2017). Therefore, students might not choose the most accurate answers on a self-assessment questionnaire (Katz et al., 1975). That might have affected the results of this study.

6. Conclusion and future research

This study analysed the effect of CGA on communication, coordination, and learning outcomes among eleven-year-old primary school students in the Netherlands. It was hypothesised that CGA would have a positive effect on all three dependent variables. However, results showed that students who were supported by CGA did not have significantly better communication, coordination, and learning outcomes than students who were not supported by CGA. Thus, all three hypotheses were rejected. It was found that the students that participated in this study were not used to work on joint writing assignments like this. They also had never worked with CGA before. However, even though a lot was demanded from the students, they were not supported enough. Therefore, some of the students experienced challenges concerning ineffective communication and coordination. There were students who did not know what to do with the CGA support offered. This, and the grade awareness, made some of the students insecure. Besides, some of the students experienced stress and time pressure because of the strict deadline. Because of this, it is recommended to make use of a prolonged timeline. Also, it is recommended to support and monitor students in their communication and coordination process, and in understanding and using the CGA support. If the support and monitoring do not provide the desired effect, it is recommended to take into account the level of the participating students.

Future studies could investigate whether CGA has an effect on communication, coordination, and learning outcomes when the participating students are supported and monitored in their communication and coordination process, and the usage of CGA. It is important that the students receive guidelines on which actions to take to communicate and coordinate effectively, and on how to understand and apply CGA. Previous studies have found that students are often not competent enough to learn with, and from, CGA while they are unsupported (Drachsler & Greller, 2012; Schnaubert & Bodemer, 2019). It would thus be valuable to investigate this further. Additionally, it would be interesting to investigate whether CGA, under the right circumstances as described above, has an effect on younger students, like the participants in this study. A last suggestion would be to do a longitudinal-experimental study. The current study needed to fit the schedule of the primary school, which is why the deadline for the assignment was within two weeks. This caused stress and time pressure among some of the students. An experiment with a prolonged timeline could provide a more clear and reliable view of the effect of CGA (Janssen et al., 2011; Jiang et al., 2009).

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Appendices

Appendix A: Self-Assessment Questionnaire

Naam: ……

Hieronder staan allemaal zinnen die gaan over communicatie.
Dat is een moeilijk woord. Het gaat over hoe je praat en overlegt met jouw vrienden en klasgenoten.
Hier een voorbeeld: Ben jij open en duidelijk tijdens het overleggen als je met klasgenoten samenwerkt aan een opdracht?

Lees de zinnen goed door en arceer het vakje dat het beste bij jou past.
Elk antwoord is goed dus probeer zo eerlijk mogelijk antwoord te geven.

1. Ik ben open en eerlijk als ik overleg met de klasgenoten met wie ik samenwerk.					
	Helemaal oneens	Oneens	Geen mening	Eens	Helemaal eens
					
2. Ik denk na voordat ik praat tegen de klasgenoten met wie ik samenwerk.					
	Helemaal oneens	Oneens	Geen mening	Eens	Helemaal eens
					
3. Ik praat anders tegen verschillende vrienden en klasgenoten omdat ik weet dat de ene iets eerder begrijpt dan de andere.					
	Helemaal oneens	Oneens	Geen mening	Eens	Helemaal eens
					
4. Ik praat altijd zo duidelijk mogelijk.					
	Helemaal oneens	Oneens	Geen mening	Eens	Helemaal eens
					

5. Als ik praat, gebruik ik soms moeilijke en onduidelijke woorden.

	Helemaal oneens	Oneens	Geen mening	Eens	Helemaal eens
					

6. Ik gebruik geen scheldwoorden tegen iemand die dat niet leuk vindt.

	Helemaal oneens	Oneens	Geen mening	Eens	Helemaal eens
					

7. Ik probeer te begrijpen wat mijn lichaamshouding en gezichtsuitdrukking kunnen zeggen.

	Helemaal oneens	Oneens	Geen mening	Eens	Helemaal eens
					

8. Ik luister naar de ideeën en meningen van de klasgenoten met wie ik samenwerk.

	Helemaal oneens	Oneens	Geen mening	Eens	Helemaal eens
					

Hieronder staan allemaal zinnen die gaan over coördinatie.
Dat is weer een moeilijk woord. Maar het betekent bijvoorbeeld hoe goed je nadenkt voordat je aan een opdracht begint. Controleer jij, tijdens de rekenles, hoe goed je de opdrachten maakt? En verbeter je al jouw fouten? Dat heeft allemaal te maken met coördinatie!

Lees de zinnen goed door en arceer het vakje dat het beste bij jou past.
Probeer weer zo eerlijk mogelijk antwoord te geven. Dankjewel!

1. Ik bedenk wat ik (nog) moet doen om mijn opdracht(en) af te maken.					
	Helemaal oneens	Oneens	Geen mening	Eens	Helemaal eens
					
2. Ik probeer het doel van de les of een opdracht te snappen voordat ik eraan begin.					
	Helemaal oneens	Oneens	Geen mening	Eens	Helemaal eens
					
3. Ik stel vragen aan juf als ik ze heb.					
	Helemaal oneens	Oneens	Geen mening	Eens	Helemaal eens
					
4. Ik controleer hoe goed ik het doe als ik bezig ben met een opdracht.					
	Helemaal oneens	Oneens	Geen mening	Eens	Helemaal eens
					

5. Ik weet hoeveel ik van de les of opdrachten moet maken voordat ik klaar ben.					
	Helemaal oneens 	Oneens 	Geen mening 	Eens 	Helemaal eens 
6. Ik verbeter mijn fouten als ik die maak.					
	Helemaal oneens 	Oneens 	Geen mening 	Eens 	Helemaal eens 
7. Ik controleer mijn antwoorden als ik bezig ben met een opdracht.					
	Helemaal oneens 	Oneens 	Geen mening 	Eens 	Helemaal eens 
8. Ik controleer hoe netjes ik werk als ik bezig ben met een opdracht.					
	Helemaal oneens 	Oneens 	Geen mening 	Eens 	Helemaal eens 

Appendix B: Knowledge Test

Geschiedenis
Toets
Thema 5.2 – Grieken en Romeinen

1. Romeinse limes

Wat is waar?

- ☐ Limes is een Latijns woord voor tempel. Resten van een limes zijn gevonden in Groningen.
- ☐ De limes was de grens van het Romeinse rijk. In Nederland was dat de rivier de Rijn.
- ☐ De limes was een legerkamp. Er woonden meestal 500 soldaten in een limes.

2. Het Romeinse Rijk

Waarom moet een Romeinse voetsoldaat wel heel sterk en fit zijn geweest?

- ☐ Hij moest de grenzen van het rijk bewaken. Hij liep soms wel 40 kilometer op een dag en droeg wel 30 kilo met zich mee.
- ☐ Hij moest de grenzen van het rijk bewaken. Hij trainde iedere dag na zijn werk om fit te blijven.
- ☐ Hij moest de grenzen van het rijk bewaken. Hij vocht veel tegen de Germanen. Soms moest hij er wel twee tegelijk verslaan.

3. Handel met de Romeinen

Germanen en Romeinen handelden met elkaar. Wat weet je daarvan?

- ☐ Dat Germanen geen handel met elkaar dreven voordat de Romeinen kwamen.
- ☐ Dat Germanen aan geld kwamen door spullen te ruilen met Romeinen.
- ☐ Dat Germanen graag geld wilden hebben.

4. Germanen en Romeinen

Welke vorm van handel was nieuw voor de Germanen?

- ☐ Handel door spullen te ruilen voor geld.
- ☐ Handel door spullen te ruilen met andere spullen.
- ☐ Handel door spullen te veroveren.

5. Goede bouwers

Er zijn veel resten van Romeinse bouwwerken ontdekt, ook in ons land. Wat weten we daardoor?

- ☐ Hoe Romeinen leefden. Veel van hun gebouwen kennen we nu nog.
- ☐ Dat Romeinen kleine bouwwerken maakten van hout en stro. De gebouwen gingen snel kapot.
- ☐ Dat de Romeinen stenen bouwwerken overnamen van de Germanen. Die gebouwen gebruiken we nu nog.

6. Bouwwerken

Welke bouwwerken die de Romeinen al bouwden gebruiken we nu nog? Er zijn drie antwoorden goed.

- ☐ Fabrieken.
- ☐ Kantoorgebouwen.
- ☐ Stenen wegen.
- ☐ Theaters.

7. Romeinse smulpapen

Wat aten arme Romeinen en soldaten?

- ☐ Dieren zoals pauwentongetjes.
- ☐ Granen en peulvruchten.
- ☐ Gladiatoren.

8. Relax!

Wat deden Romeinen in hun vrije tijd?

- ☐ Ze speelden spelletjes, gingen naar de arena en bezochten het badhuis.
- ☐ Ze gingen naar de arena om te vechten met de gladiatoren.
- ☐ Ze wandelden langs de limes en hielden riddertoernooien.

9. Romeinse goden

Romeinen hadden meerdere goden. Je kunt ze herkennen aan hun attributen. Wat hoort bij de godin van de wijsheid?

- ☐ Uil.
- ☐ Zwaard.
- ☐ Wereldbol.
- ☐ Pijl en boog.

10. Taak

Hoe zat het met de taken van de Romeinse goden?

- ☐ De Romeinse goden hadden allemaal dezelfde taak; ze moesten goed zijn voor de mensen.
- ☐ De Romeinse goden hadden geen taken.
- ☐ Elke Romeinse god had zijn eigen taak.

Appendix C: Semi Structured Interview Guide

- Hoe ging het samenwerken?
- Was het fijn dat je wist hoe goed je groepsgenoot was in geschiedenis?
- Denk je dat jullie daardoor een beter werkstuk hebben gemaakt?
- Hoe ging het communiceren in jullie groepje?
- Denk je dat jullie beter met elkaar konden communiceren doordat je van elkaar wist hoe goed je in geschiedenis was?
- Hoe hebben jullie de taken verdeeld?
- Hebben jullie conflicten gehad tijdens het schrijven?
- Hoe hebben jullie deze opgelost?
- Wat was jouw bijdrage aan de opdracht?
- Hebben jullie elkaar soms ook geholpen of feedback gegeven?
- Hoe reageerden jullie dan op elkaar?
- Wat vonden jullie het moeilijkste aan de opdracht?
- Hoe zijn jullie daarmee omgegaan?
- Wat vonden jullie het leukste aan de opdracht?
- Denk je dat je in de toekomst beter zou kunnen samenwerken?
- Wat zou je willen verbeteren of veranderen als je weer zou moeten samenwerken?