Scripted collaborative drawing in elementary education

The role of working preference

Master's thesis Alieke van Dijk

First supervisor: Dr. A.H. Gijlers

Second supervisor: Prof. Dr. A. Weinberger

University of Twente

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Abstract

This study investigated the effects of scripting and working preference on collaborative drawing in elementary education. It was hypothesized that the use of a script and grouping by working preference enhances discourse quality, equal distribution of discourse, drawing quality and knowledge acquisition. This quasi-experimental field study included 88 students in four different classes who worked collaboratively on a drawing assignment. The instructional goal was to develop a joint drawing, that completely explained the process of photosynthesis. This collaborative drawing assignment was expected to go together with a high-quality discourse and should eventually lead to knowledge acquisition. According to data of a working preferences-questionnaire, the students were grouped into dyads by either positive working preference or negative working preference. Each class was subscribed to one of the two conditions: the scripted or the non-scripted condition. The findings indicate that students in the scripted condition show a more equal distribution of their discourse and higher levels of knowledge acquisition. In addition, students and dyads in the non-scripted condition show a higher discourse quality and drawing quality. The results indicate a relation between discourse and drawing quality. The findings concerning working preference differences indicate a higher drawing quality for the students grouped by positive working preference.

Keywords: Collaborative learning; Drawing; Elementary education; Knowledge acquisition; Scientific education; Script; Transactivity; Working preference

1. Theoretical framework

In the current curriculum of elementary education, the use of graphical representations is prevalent. Illustrations, tables and graphs are frequently used to elucidate the presented information. Thus, it seems safe to say that most elementary school students have experience with exploring graphical representations in the context of informative texts. Creating representations seems to have benefits exceeding simply examining them (Chi, Slotta, & de Leeuw, 1994). Consequently, it would be interesting to examine the added value of the creation of representations.

1.1 Drawing

Graphical representations play a major role in knowledge acquisition (Zhang, 1997). They help students transform abstract information into a more concrete and understandable subject (Rennie & Jarvis, 1995). Research also shows that graphical representations influence the deeper understanding of scientific topics, like photosynthesis, whereas just examining the representations could lead to difficulties with processing the material (Chi, et al., 1994). Enabling students to create a representation themselves might lead to better acquisition of the material (Savinainen, Scott, & Viiri, 2004). The easiest way for elementary students to create a representation could be by drawing the process, an activity most elementary students are familiar with (Rennie & Jarvis, 1995). Drawing a scientific topic like photosynthesis or the water cycle could be motivating and might arouse prior knowledge on the subject (Rennie & Jarvis, 1995). The drawing process provides students with the opportunity to evaluate the accuracy of their prior knowledge (Moore & Caldwell, 1993). This way, the students could activate their own knowledge base, and might even be able to revise and integrate new ideas during the drawing process.

Self-created external representations have to potential to serve collaborative learning (Suthers & Hundhausen, 2003). It is possible for a representation to initiate elaboration on the subject. While creating a joint drawing, students might engage in elaborative discussion and build on their partner's contributions. The representations students jointly create could evoke critical reflection of the students' own ideas and their prior knowledge on the subject. This might lead to the opportunity for students to extend their knowledge (Joshi & Rosé, 2007).

1.2 Collaborative interaction

Knowledge acquisition could also be enhanced by collaboration (King, 1999). For that reason, connecting drawing and collaboration might further enhance the advantages of knowledge sharing activities. Contrary to drawing in education, collaboration is a widely used and studied learning method (Slavin, 1995). In order to develop this learning method fairly, knowledge about how to implement it should be rich and therefore easy to be generalized to the contemporary educational environment. Because this knowledge is not sufficiently present, there is a growing interest in successful implementing and shaping of collaborative learning into elementary education.

The general advantages of collaborative learning are demonstrated by different studies. According to King (1999), interaction and activity with others encourages students to share their ideas, information, and perspectives. As a result of this sharing, they mediate each other's learning process in constructing new knowledge and significance together. This positive result of collaborative learning is most likely caused by the fact that, to collaborate successfully, students must externalize their own knowledge and engage in processes like questioning, clarifying and elaborating.

Thus, the major advantage of collaborative learning seems to be that the partners could expand their one knowledge base with complementary knowledge of the others. To completely understand and process this 'new' knowledge, it is imperative the students operate on the reasoning of their partner (Berkowitz & Gibbs, 1983), as is reflected in the concept of 'transactivity'. Transactive discourse is defined as a cognitive act upon the way of thinking of the collaboration partner (Berkowitz, 1980-I, 1980-II; Teasley, 1997). Berkowitz (1980-II) hereby states that transactivity will occur in the context of resolving efforts, and explaining or understanding possible existing differences in reasoning. For an utterance to be transactive, and to be called a transact, it always has to include the way of thinking of the other. To specify this, it is said that collaborative learning groups use a transactive dialogue when they think through, build upon, doubt, or argue about the opinion and thoughts of the other with regard to the understanding of the task or the possible solutions (Joshi & Rosé, 2007; Teasley, 1997). The degree in which learners refer to input from their collaboration partner is an important aspect in argumentative knowledge construction in dyadic discourse (Weinberger & Fischer, 2006).

To describe to what extent students engage in transactive talk, Weinberger and Fischer (2006) distinguished five social modes of co-construction: (1) *externalization*, which means that students make a contribution to the collaboration without referring to the other's input, (2) *elicitation*, which means that students use their partners to receive information. Most of the time this precedes by asking questions to their partner, (3) *quick consensus building*, which means that students accept the thoughts of their partners not because they are convinced but to be able to continue with the conversation, (4) *integration-oriented consensus building*, which stands for integration of new knowledge by making use of the reasoning of their partner. In this case, the students will show a willingness to reconsider their own opinions as a consequence of persuasive argumentation of the partner, and (5) *conflict-oriented consensus building*, which means that students will test multiple perspectives to evaluate their own reasoning. Doing so, they identify useful aspects of their partners' thoughts, and use these to modify or alter their own reasoning and knowledge. Within this scale, externalization is thought of as the least transactive form, and conflict-oriented consensus building as the most transactive form (Teasley, 1997). These social modes can best be determined by observing how students work on the task and formulate arguments together (Weinberger & Fischer, 2006).

To value the potential of collaborative learning, and with this the quality of the discourse, it is important to look at the social modes of co-construction in the discourse as well as the mere content of the discourse (Berkowitz & Gibbs, 1983). To define the degree in which the students refer to the content of the task, the collaboration process could be analyzed by means of the epistemic dimension of argumentative knowledge construction (Weinberger & Fischer, 2006). The category focussing on the explicit mentioning of the subject-related concepts is called: construction of conceptual space (Weinberger & Fischer, 2006). The construction of conceptual space depends of the degree of summarizing, rephrasing, and discussing the subject. This category indicates whether learners are able to construct relations between concepts and define those relations and concepts. An important requirement for argumentative knowledge construction to happen is that learners need to construct and balance arguments and counterarguments, in order to completely understand the material (Weinberger & Fischer, 2006).

For the content-related and transactive discourse to be effective for all collaborative partners, every student should participate equally in the discourse (Teasley, et al., 2008; Weinberger & Fischer, 2006). Only this way can discourse be effective for the individual knowledge acquisition. Therefore, it is important to also examine the participation of the students in the transactive and content-related discourse. With this, one should examine the participation dimension (Weinberger & Fischer, 2006), that distinguishes between the actual participation (quantity of participation), and the participation being on an equal basis (equality of participation). A study by Cohen and Lotan (1995) shows that collaborative learning in small groups enhances equality of participation, because all students have the chance to contribute to the discussion. So, it might be that collaboration in dyads enhances the participation distribution even more.

To conclude, collaborative learning is more than just sitting next to each other. For collaborative learning to be effective, it is important that the discourse is sufficient in terms of its transactive and epistemic quality, and that the participation of the collaborative partners comes near equality. To create an advantageous collaboration, scripting might be necessary. This way, possible advantages of collaborative learning in elementary education could be best supported.

1.3 Script

Discourse quality and equal participation in collaboration cannot be taken for granted. Berkowitz and Gibbs (1983) state that the reason why transactive and epistemic quality occurs in some dialogues and not in others, is not clear. Collaborative discourse rarely results in equal participation of the partners (Weinberger, Fischer, & Mandl, 2001). Various studies suggest that scripting can raise the quality of the discourse and facilitate equal distribution in a collaborative setting (Dillenbourg & Jermann, 2007; Dillenbourg & Tchounikine, 2007). Scripts structure the interaction to make sure that the students will participate in high-quality discourse (Dillenbourg & Jermann, 2007; King, 1999), and that they will participate equally in the discourse (Weinberger, et al., 2001). Furthermore, a script also might stimulate learners to carry out activities beneficial to collaborative learning, that they might otherwise not do (O'Donnell, 1999). Hereby, the script will state a set of rules that spell out the way partners should collaborate with each other. Therefore, scripted collaboration might increase students' knowledge construction.

Just making students work in dyads will not guarantee discourse quality and equal distribution of participation to occur, or drawing quality and knowledge acquisition for that matter. Scripting could address this problem. A combination of a macro and micro script might be the best way to ensure that discourse quality, discourse participation, drawing quality and knowledge acquisition are supported. Macro scripts aim at the creation of learning situations in which the students are supported in their collaborative knowledge acquisition-enhancing activities (Dillenbourg & Tchounikine, 2007). One way to influence collaborative knowledge acquisition activities the script could be to include an individual preparation phase in the script. An individual preparation phase would provide students with the opportunity to activate their prior knowledge and improve understanding of the subject (van Boxtel, van der Linden, & Kanselaar, 2000). Van Boxtel, van der Linden and Kanselaar (2000) report that individual preparation resulted in better knowledge acquisition and higher discourse quality. Their findings suggest that individual preparation enhanced the degree in which the students operated on each other's reasoning, which might have positively affected the knowledge acquisition.

A micro script focuses on the individual activities of the students, scaffolding the discourse itself. An example of a micro script solution to guide the interaction between the students are prompt cards, that could guide the necessity that students need to be instructed in how to use interpersonal and small-group skills, which are required in successful collaboration (Johnson & Johnson, 1994; Terwel, Gillies, Eeden, & Hoek, 2001). Open-ended and thought-provoking questions improve the communication by inciting explaining and reasoning (King, 1999). The discourse which includes information seeking, responding to and receiving information is seen as a very important influence on the quality of the collaborative learning process. Within a script certain measures can be taken to ensure that the discourse is evenly distributed over the participating individuals (Dillenbourg, 2002).

However, scripting could also have a limiting effect on the students. It is important to make sure that a script leaves room for creativity and innovation of the students (O'Donnell, 1999), and that the script does not interrupt with natural collaborative mechanisms (Dillenbourg, 2002). A collaborative script spells out for the students how to behave and what to elaborate about, and therefore might hinder students to think for themselves (Weinberger, Ertl, Fischer, & Mandl, 2005). Students tend to follow the instructions of the script, without fully understanding their functions (Dillenbourg, 2002; Gijlers & de Jong, 2009). When the script does cross this line, it could impede the learning process of the students. To make sure this does not happen, it is important to create a working environment in which the students can behave freely, even though they are instructed in what to do.

1.4 Working preference

Students themselves indicate that collaboration functions as a foundation for making and, especially, keeping friends (Bigelow, 1977). When asking elementary students to group themselves, they will probably form friendship-based groups. Children generally seem to be more motivated to work with friends (Zajac & Hartup, 1997). To fully employ the advantages of collaborative learning, it seems important to group the students in a most beneficial way. Nevertheless, research shows that students indicate a difference between a 'good friend' and a 'good worker' (Mitchell, Reilly, Bramwell, Solnosky, & Lilly, 2004). This might lead to ambiguous and unexpected choices in selecting a collaboration partner. Hence, it seems useful to examine how working preference will affect students' collaborative drawing process and learning outcomes.

Positive social contact with the other might enhance the effectiveness of collaboration (Kagan & Kagan, 1994). Students who like each other learn the most in collaborative learning situations. Zajac and Hartup (1997) reviewed 13 studies on the relation between friendship and collaboration. Their review reveals that friends tend to support each others' cognitive performance. Students who cooperated with friends differed in behavior during collaboration from those who cooperated with non-friends (Azmitia & Montgomery, 1993; Zajac & Hartup, 1997). Friends demonstrated higher levels of transactive discourse, visible in elaborative discussions and conflicts. A study on boys by Newcomb and Brady (1982) demonstrated that friends were more task oriented, engaged in more mutually oriented discourse, and showed more positive affect than non-friends did. These findings could be generalized to the female gender and mixed collaborative groups, whereas it is stated that gender differences do not influence the degree in which friendship facilitates communicative and reciprocal aspects of social interaction (Newcomb, Brady, & Hartup, 1979).

Disagreements between collaboration partners may influence the outcomes of the collaboration process positively (Hartup, Laursen, Stewart, & Eastenson, 1988). Referring back to the social mode dimension of Weinberger and Fischer (2006), conflict-oriented consensus building is seen as the most transactive form of communication (Teasley, 1997). This benefit is visible in the assertion of Zajac and Hartup (1997), who conclude that "friends are, in comparison to non-friends, more concerned with resolving their conflicts through negotiation and disengagement than through power assertion"(pp. 9). It shows that working preference may ease performance not only through a higher degree of discourse, but also by using disagreements to their advantage.

1.5 Summary

Elementary school students are acquainted with the use of graphical representations to elucidate scientific learning material. Making elementary students create a drawing on a scientific topic by themselves might enhance their knowledge acquisition (Savinainen, et al., 2004). Drawing collaboratively might improve the students' knowledge acquisition even more, while students are able to share and expand their knowledge. Discourse quality – visible in epistemic and transactive discourse, and in the equality of the participation – might positively affect knowledge acquisition of the students (Berkowitz & Gibbs, 1983; Weinberger & Fischer, 2006). Just letting the students work in groups does not guarantee this to occur. The above cited literature suggests that scripting might enhance high-quality drawing, discourse quality and equal distribution of participation (Dillenbourg & Jermann, 2007; Dillenbourg & Tchounikine, 2007). By combining a micro and a macro script, the entire collaborative phase should be covered. Elementary school students prefer collaboration with a friend. Research indicates that a positive working preference toward the partner has a positive effect on students' cognitive performance as well as their collaboration process.

1.6 Present study and Research Questions

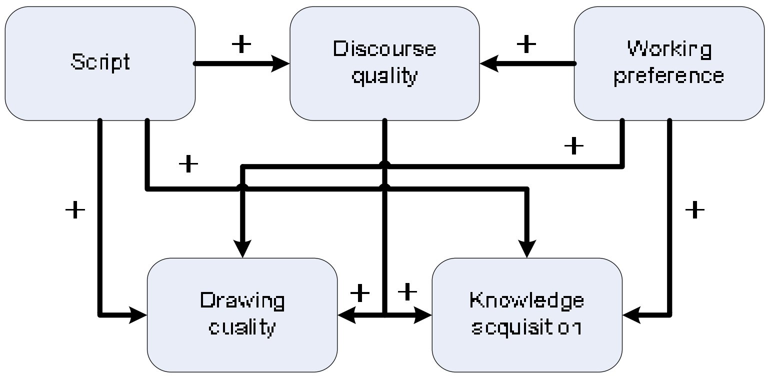
The aim of this study is to investigate the effects of scripting and grouping by working preference on discourse quality, drawing quality, and individual knowledge acquisition. Elementary school students were invited to create drawings on the process of photosynthesis. The learning task required students to relate theoretical concepts with each other, and to explain relevant theoretical principles. The findings from the studies discussed in the previous sections, suggest that scripting might support the students in the collaborative drawing process, and might lead to higher discourse quality and a higher knowledge acquisition. In the present study we evaluate scripting in a collaborative drawing context, comparing a group of students who are supported by a script with a control group that did not receive additional support in the form of a script.

For the present study a script was created that combines an individual preparation phase (macro level) with prompts (micro level). It is expected that the script will support students' collaborative drawing process and will positively affect the discourse quality as well as students' knowledge acquisition. The script provides students with concrete and more extensive instructions, which might stimulate students to engage in task-oriented behavior and influence knowledge acquisition. Besides this, the individual drawing phase provides the students with an additional preparation possibility before starting the collaborative phase. Therefore it is expected that the scripted condition will fare better on the drawing quality than the non-scripted condition.

From literature on group composition it became clear that working preference could influence the course of the collaboration process, and consequently the knowledge acquisition of the students. To examine this possible influence, the students were grouped in dyads with a positive or a negative working preference. It is expected that a positive working preference contributes to the discourse quality of the students, while working preference seems to enhance elaborative discussion. Grouping by positive working preference is also expected to enhance drawing quality and knowledge acquisition. The latter expectations derive from the hypothesis that discourse quality enhances both drawing quality and knowledge acquisition. Since the positive working preference group is expected to show higher discourse quality, it is therefore anticipated that this group will also show higher drawing quality and knowledge acquisition.

Since research indicates that students in positive working preference groups show a higher level of discourse quality, it seems interesting to examine what the additional effect of the script might be. Would the script further enhance the discourse quality, or would it hinder the students in their natural way of communication with each other?

FIGURE 1.1
Research model



In the long run, knowledge acquisition might also be influencing the drawing and the discourse quality. The same goes for working preference, which might be affected by the discourse quality, drawing quality and the knowledge acquisition, because the collaborative experiences might be changing the image the students have created of their collaborative partner. This study does not investigate these long-term relations. We shall address the following research questions:

1. To what extent can a script facilitate knowledge acquisition concerning the photosynthesis process?
2. To what extent can a script facilitate discourse quality and discourse distribution during collaboration?
3. To what extent can a script facilitate drawing quality?
4. To what extent can grouping by positive working preference facilitate knowledge acquisition concerning the photosynthesis process?
5. To what extent can grouping by positive working preference facilitate discourse quality and discourse distribution during collaboration?
6. To what extent can grouping by positive working preference facilitate drawing quality during collaboration?
7. To what extent are interaction effects of scripting and working preference on the discourse quality, discourse distribution, drawing quality and knowledge acquisition to be expected?
8. To what extent is discourse quality related to knowledge acquisition?
9. To what extent is discourse quality and distribution related to drawing quality?
10. To what extent is drawing quality related to knowledge acquisition?

2. Method

2.1 Participants

Eighty-eight, fifth and sixth grade elementary school students (aged 10-12) from three different schools and four different classes participated in this study. Each class was assigned to a condition, resulting in two experimental classes and two control classes. The control group consisted of 50 students (25 male, 25 female) and the experimental group included 38 students (23 male, 15 female). All students completed an identical first session of the study (see also section 2.3.1), in which they all received the same preparation in the second session (see also section 2.3.2) by the same experimenter (the researcher), who was video controlled to identify and control for differences in her behavior.

Dyads were based on students' working preference. Working preference was assessed with a questionnaire in the first session (see also section 2.4.1). The dyads were grouped by means of the outcomes of this questionnaire, together with previously received information from the teacher about amity between the students. This led to 21 dyads with a positive working preference and 20 dyads with a negative working preference. The positive working preference group included 42 students (20 male, 22 female), and the negative working preference group consisted of 40 students (25 male, 15 female). Students were paired with a student from their own class. The teachers were asked to check the dyads for possible problematic pairs among the paired students. The condition the dyads were assigned to was defined by the assigned condition to their class. The division of the working preference dyads over the two conditions was approximately equivalent (see Table 2.1). Six students were not to be grouped according to the working preference information. Due to absence of some students on the second school visit, last-minute changes in grouping led to the creation of three dyads with unknown preference. These dyads were excluded from the analyses.

TABLE 2.1
Division conditions and preferences for the students

	Scripted condition	*Non-scripted condition*
Negative working preference	20	20
Positive working preference	18	24

During the collaborative phase, two of the recording devices did not record the discourse of the dyads. This means that two of the dyads were not included in the discourse analyses. Therefore, the division of conditions and preferences for the dyads differed to some extent from abovementioned (see Table 2.2).

TABLE 2.2
Division conditions and preferences for the dyads

	Scripted condition	*Non-scripted condition*
Negative working preference	10	10
Positive working preference	9	10

2.2 Learning domain

Groups in both conditions worked collaboratively on a drawing task concerning the photosynthesis process. Photosynthesis contains the process in which vegetation fabricates organic ingredients, like sugar (nutrient) and oxygen, by means of carbon oxide, sunlight and water. The curriculum rules for elementary education in the Netherlands by the SLO (Stichting Leerplanontwikkeling Nederland), expressed in Tule (2009), state that elementary school students should be taught the different aspects of the photosynthesis process, but the process as a whole is not a part of the Dutch elementary school curriculum. Therefore the process of photosynthesis is relatively new for the students but ought to be comprehensible.

Students were invited to make a joint drawing of the photosynthesis process that was suitable to explain it to another student. This joint drawing had to be the result of their collaborative partnership; immediately resulting from discussing their differences and communalities on the subject and their vision on how the drawing should look like.

Learning materials. To get acquainted with the 'new' subject, the students in both the scripted and the unscripted condition were introduced to photosynthesis by a video clip and text (see also Appendix VI). Both the video clip and the text were adjusted to the students' level of understanding. The text was based on materials developed by two acknowledged educative organizations in the Netherlands: Klokhuis (Klokhuis, 2010) and SchoolTV (SchoolTV, 2010). By means of this text , the students should be able to behold the important concepts and processes of photosynthesis, and to process these by creating a drawing.

Before starting with the official sessions of the study, a pilot was completed to test the important elements of the study. It seemed that the students did not experience trouble with understanding the instructions and completing the tests.

2.3 Procedure/Script

The study was conducted in two separate sessions with a couple of weeks in between. Both sessions took place in the classroom of the selected class under the guidance of an experimenter (the researcher), and were performed on regular school days, after consultation with the teachers. Time between the first and the second session was two to three weeks, depending on the schedule of the school.

2.3.1 First session

The first session was primarily meant to be a preparation session for the second session, and lasted 50 minutes. The session took place in the classroom of the selected class, in which each student sat on his/her own desk.

Introduction and first cued recall test (5 minutes) The first session started with a brief introduction on the experiment in which the experimenter explained the reason of the school visit. Subsequently, the students completed their first cued recall list.

Training in the drawing assignment (15 minutes) Students received a training in how to make a graphical representation of an informative text, to make sure that they will be able to do this themselves in the next sessions (see Appendix II for the training).

Questionnaire on working preference and collaboration skills (15 minutes) The students were asked to answer four questions, presented in the working preferences questionnaire (see also section 2.4.1). Together with this questionnaire, the students addressed the statements of the collaboration skills questionnaire (see also section 2.4.2).

Introduction to the domain, second cued recall, and first open recall test (15 minutes) The students were presented to the domain by a short movie on photosynthesis, produced by SchoolTV (SchoolTV, 2010) and a text based on this movie (see also Appendix VI). Finally, the students were asked to do the cued recall test once more, accompanied with an open recall test on the same topic.

TABLE 2.3
Time plan of the first session for the experimental and the control group

Experimental group (Scripted condition)		*Control group (Non-scripted condition)*	
Phase	Time	Phase	Time
Introduction, including first cued recall test	5 minutes	Introduction, including first cued recall test	5 minutes
Training in the drawing assignment	15 minutes	Training in the drawing assignment	15 minutes
Questionnaire on working preference and collaboration skills	15 minutes	Questionnaire working preference and collaboration skills	15 minutes
Introduction to the domain, second cued recall, and first open recall test	15 minutes	Introduction to the domain, second cued recall, and first open recall test	15 minutes
Total	*50 minutes*	*Total*	*50 minutes*

2.3.2 Second session

The second session differed primarily for the experimental and the control group, as was visible in some differences in the script. The control group received no additional support on the collaborative drawing process. The script for the experimental condition foresaw step-by-step instructions guiding the entire collaborative drawing process. The differences between the control group and the experimental group are reflected in the script (Appendix II).

Grouping procedure and explanation (5 minutes) The second session for both groups started with the announcement of the dyads. With entering the classroom, the students were immediately be seated next to their collaborative partner. To avoid questions, the session started with an elaborate explanation about the schedule for this morning/afternoon.

Third cued recall test and training refresher (5 minutes) The second session continued with the same cued recall test on photosynthesis, after which the students were provided with a short refresher of the training.

Questionnaire on collaboration expectations and a pre-test on satisfaction (10 minutes) The students were asked to answer another questionnaire. This questionnaire consisted of the collaboration expectations questionnaire (see also section 2.4.3) and the pre-questionnaire on satisfaction with their assigned partner (see also section 2.4.5).

Refresher on the photosynthesis subject (3 minutes) Before starting the collaborative phase, the students were exposed to the short movie on photosynthesis once more to refresh their memory on the subject.

Collaborative phase (35 minutes) This phase included the major differences between the scripted and the non-scripted conditions. The start of the collaborative phase for the experimental group started with the individual phase, in which the students created an individual drawing on the photosynthesis process by means of the text on this topic. Subsequently, the students swapped their drawing with their collaborative partner, and searched the other's drawing for differences and commonalities. This comparison got them started with the next phase: creating their joint drawing. In this phase the students were told to elaborate on the differences and commonalities found in their drawings to come to an agreement: a joint drawing. To guide them through the elaborative processes, prompt cards were generated. These cards contained discussion starters and different responses (see also Table 2.4). The students each received a desk of three cards. They were told that they should use these cards during the discussion of the identified differences and to make the necessary concessions on the final elements in their joint drawing. This way the students might spend more time on task-related talk (and especially content related talk) than without the guidance of the prompt cards. The control group did not get such instructions, and were simply told to work together on a joint drawing which includes the elementary components of the photosynthesis as clear and elaborate as possible.

TABLE 2.4
Prompt cards, translated into English

Number	*Text*
1	Would you please explain to me why you drew or did not drew ... ?
2	I drew ... differently, because ...
3	We should draw ... differently, that is ...

Questionnaire on collaboration experiences and the post-test on satisfaction (10 minutes) The second session ended with another round of testing. The students were asked to complete a last questionnaire, concerning their experiences with the collaboration phase (see also section 2.4.4) and on their satisfaction with their assigned collaboration partner (see also section 2.4.5).

Fourth cued recall and second open recall (5 minutes) The last phase of the second session ended with a final cued and open recall test.

2.4 Tests and Self-Reports

During the two different sessions of the study, the students were presented with six questionnaires (see also section 2.3). Some of the questionnaires were bundled together. The students were asked to answer questions and give their opinion about different statements, as discussed below.

TABLE 2.5

Time plan of the second session for the experimental and the control group

Experimental group (Scripted condition)		*Control group (Non-scripted condition)*	
Phase	Time	Phase	Time
Grouping procedure and explanation	5 minutes	Grouping procedure and explanation	5 minutes
Third cued recall test and training refresher	5 minutes	Third cued recall test and training refresher	5 minutes
Questionnaire on collaboration expectations and a pre-test on satisfaction	10 minutes	Questionnaire on collaboration expectations and a pre-test on satisfaction	10 minutes
Refresher on the Photosynthesis Subject	3 minutes	Introduction to the photosynthesis subject	3 minutes
Individual phase	10 minutes	Collaborative phase	35 minutes
Identifying differences phase	5 minutes		
Discussion and collaboration phase	20 minutes		
Questionnaire on collaboration experiences and a post-test on satisfaction	10 minutes	Questionnaire on collaboration experiences and a post-test on satisfaction	10 minutes
Total	*68 minutes*	*Total*	*68 minutes*

2.4.1 The working preference questionnaire

For the assessment of students' amity towards their classmates, a working preference test was created. The test consisted of four different items, of which two items focused on social preferences in general and two items focused on working preference. Additionally, a distinction was made between 'preference to play with' and 'preference to work with'. Both dimensions are combined to create the positive working preference-scale and the negative working preference-scale. The questions covering the positive working preference-scale required the student to fill out three names of fellow students whom he/she will invite to his/her birthday party, and three of whom he/she will like to work with during a collaboration assignment. The other two questions covered the negative working preference-scale, in which the questions concerning the birthday party and the collaboration assignment were stated negatively.

2.4.2 The collaboration skills-questionnaire

To assess the students' perceived collaboration skills, the students were confronted with 14 statements that addressed different collaboration skills. The statements were based on work of McLoughlin and Luca (2004), and included skills like the ability to listen to your collaboration partner, explaining the material to your collaboration partner, and being able to cooperate in general. The students were asked to rate the statements according the five answering categories of the Likert scale: strongly disagree – disagree – neither agree nor disagree – agree – strongly agree. The reliability analysis of the items resulted in a Cronbach's alpha coefficient of .65

2.4.3 The collaboration expectations-questionnaire

To assess the students' expectations of the collaboration, a questionnaire consisting of 12 statements was created. The statements referred to the expectations the students had about the upcoming collaborative phase with their assigned collaboration partner. The formulated statements are interconnected to the issues cited in the collaboration skills-questionnaire, now focusing on the application of these skills. The students could rate these statements using the Likert scale. The reliability analysis of the items resulted in a Cronbach's alpha of .91.

2.4.4 The satisfaction with the collaboration partner-questionnaire

To assess the satisfaction with the collaboration partner, another questionnaire was developed. The questionnaire was administered prior to the collaborative phase, and consisted of eight statements, focusing on the degree in which the students liked to work with their assigned partner. The issues addressed here are connected to the collaboration skills, collaboration expectations, and collaboration experiences tests, and are based on work by McLoughlin and Luca (2004). The students could rate these statements by means of the Likert scale. The reliability analysis of the items of the satisfaction questionnaire resulted in a Cronbach's alpha coefficient of .89.

2.4.5 The cued recall test on photosynthesis

To measure the knowledge acquisition on photosynthesis of the students during their participation, a cued recall test was used. This test consists of a list of 36 words, from which eleven are related to the photosynthesis process. The students were to select the proper related items by circling them. They were given 2 minutes to complete this test, which was administered before and after both sessions. In total, the students completed the test four times in this study. Assuming that they are not informed about the process, the first test will measure their prior knowledge on the topic. The reliability analysis of the items of the four cued recall tests resulted in KR20-coefficients of .75 on the first test moment, .69 on the second moment, .68 on the third moment, and .79 the last time the students finished the test.

2.4.6 The open recall test on photosynthesis

An additional way to measure the student's knowledge acquisition is an open recall test. This test consisted of one assignment, in which the students were asked to answer the question "What is photosynthesis?". Answering had to occur in full sentences; citing single words did not suffice. The test was administered at the end of both sessions, and was completed twice during this study.

2.5 Data analysis

In order to investigate the influence of scripting and working preference on the discourse quality, knowledge acquisition and drawing quality of the students, the gathered data were coded and further analyzed. To evaluate the collaboration process, the discourse of the dyads had to be analyzed, and to assess the knowledge acquisition of both the individual students and the dyads, the drawings and the open recall tests had to be coded.

2.5.1 Discourse analysis

To assess the degree of transactivity in the collaboration discourse, a coding scheme was developed (see Appendix III) based on a classification made by Weinberger and Fischer (2006). It focuses on the epistemic and social mode segments in the discourse of the dyads. First, the audio file was segmented into utterances. This occurred by means of speaking turns, in which the social mode segments were taken into account as well. An utterance now covered a speaking turn of one of the speakers in the dyad. Second, the segments were coded according to the epistemic and social mode dimensions (see Table 2.6 and 2.7).

TABLE 2.6
Overview and examples of the collaborative process codes on the epistemic dimension

Categories	*Examples from Students' Interaction*
-Content talk	
Concept Naming	"We should draw a plant."
Concept Definition	"Carbon oxide is what we breathe out."
Process Definition	"It will travel from the stalk to the leaves."
Concept-process connection	"The roots extract water from the ground."
-Coordinative talk	
Coordination	"Let's draw carbon oxide in orange."
-Off-task talk	
Off-task talk	"I have to go to the gym this evening."
Unspecified references	"Why did you draw this?"
-Other	
Paraverbal utterances	"Pfffft."
Uncodable	"….."

TABLE 2.7

Overview and examples of the collaborative process codes on the social mode dimension

Categories	*Examples from Students' Interaction*
-Informative talk	
Externalization	"We should draw a plant."
Elicitation	"Is it okay for me to draw the roots?"
-Quick consensus building	
Agreeing	"Okay."
Disagreeing	"No."
-Transactive talk	
Integrating	"I see what you mean."
Elaborate critiques and modification	"Okay, but isn't it like that?"
-Off-task talk	
Conflict off-task talk	"Stop being so mean and annoying!"
Non-conflict off-task talk	"I have to go to the gym this evening."
-Other	
Paraverbal utterance	"Pfffft.
Uncodable	"….."

To measure the inter-rater reliability of the coding process, a second coder was included. The second coder completed two 35-minute audio files, consisting of 1158 spoken segments. To assess the reliability coefficient, the coded segments of both coders were analyzed and compared. Subsequently, inclusion of this second coder resulted in the inter-rater reliability coefficient for coding utterances on the epistemic dimension of .82 (Krippendorff's alpha). The inter-rater reliability coefficient for coding utterances on the social mode dimension reached .83 (Krippendorff's alpha) as well. The results presented in this study are based on coding from both coders.

For each sub-category on the epistemic dimension and the social mode dimension percentagewise scores were calculated, showing the proportional amount of talk spent and showing the distribution of participation on these categories. In addition, the percentagewise scores were calculated for the combined categories on both dimensions (see Table 2.6 and 2.7 for an overview of the categories).

2.5.2 Drawing analysis

To code the content of the drawings, another coding scheme was created (see Appendix IV). This scheme focused on the presence of the different concepts, properties and processes that define the process of photosynthesis. A flower resembled the concept of vegetation, sunlight shining on its leaves was coded a process, and sugar as the plant's own nutrition is regarded as a property (see Figure 2.1 and 2.2). To code the drawings an expert drawing was used to define the concepts, processes and properties that should be present in the drawing. With this the scoring system for the drawings was developed. A second coder coded about 25% of the drawings. After comparison, the inter-rater reliability coefficient for coding the drawings on the presence of concepts, processes and properties reached .97 (Krippendorff's alpha) in total, with an alpha for the different items between .92 and 1 (Krippendorff's alpha).

FIGURE 2.1
Drawing of the process of photosynthesis by a negative working preference dyad in the scripted condition (with Dutch annotations)

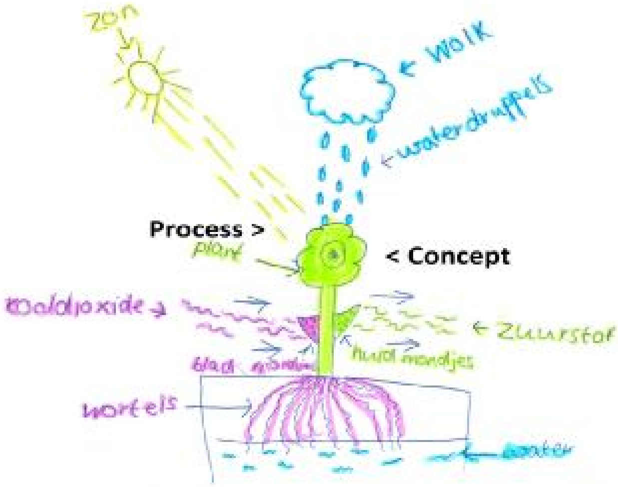
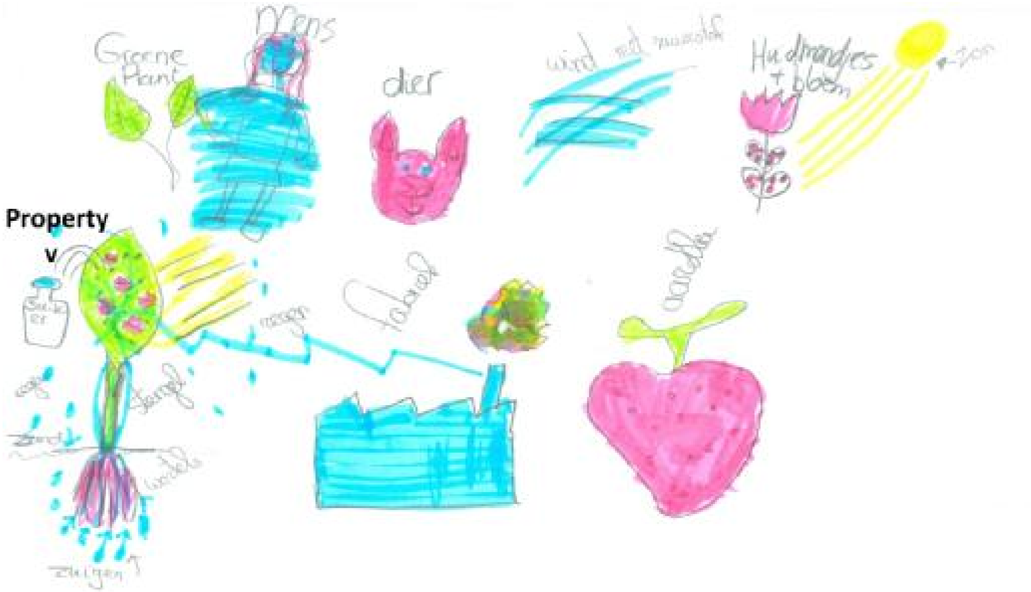


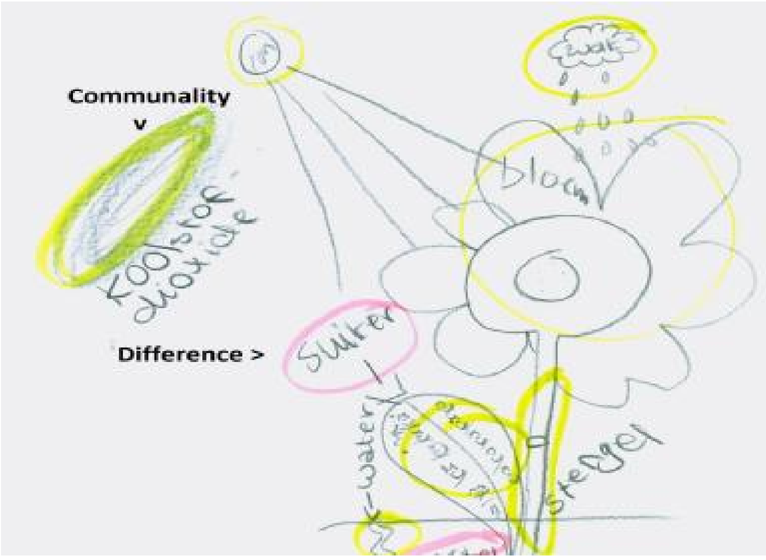
FIGURE 2.2
Drawing of the process of photosynthesis by a positive working preference dyad in the scripted condition (with Dutch annotations)



The scores were calculated for the presence of the concepts, processes, properties and their annotations, showing the absolute presence of these elements. In addition, the total scores were calculated on the representations (combining the drawn concepts, processes and properties), annotations (combining the annotated concepts, processes and properties), and the overall drawing.

Another aspect of the drawings that needed to be analyzed were the communalities and differences marked on the individual drawings only during the comparison phase for the scripted condition. The students circled the communalities with a green marker and the differences with a pink marker. To code this, another coding scheme was developed (see Appendix V). This scheme focused on the counting of the marked concepts, processes and properties (see Figure 2.3).

FIGURE 2.3
Drawing of the process of photosynthesis by a positive working preference dyad in the scripted condition (with Dutch annotations)



2.5.3 Open recall

In order to investigate the influences of the script on the knowledge acquisition of the students, a coding scheme was developed to analyze the open recall answering (see Appendix IV). It focused on the mentioning of the major concepts, processes and properties of the photosynthesis process. To measure the knowledge level of the students, it was important to see if they mentioned the related concepts, properties and processes, and were able to connect these items together into a correct explanation of the entire photosynthesis process. To analyze the inter-rater reliability, a second coder coded about 20% of the data, after which this was analyzed and compared. The inter-rater reliability coefficient for coding the open recall tests on the presence of concepts, processes and properties in the answering reached Krippendorff's alpha .96 in total, with an alpha for the different items between .87 and 1. The alpha for the concepts reached .98, for the properties reached .96, and the alpha for the processes reached .93.

To gain insight in the knowledge acquisition on the open recall tests, knowledge acquisition scores were calculated for the presence of the concepts, processes and properties. These scores showed the increase in presence of these elements in the answers given by the students. In addition, the total scores were calculated on the overall knowledge acquisition (combining the concepts, processes and properties).

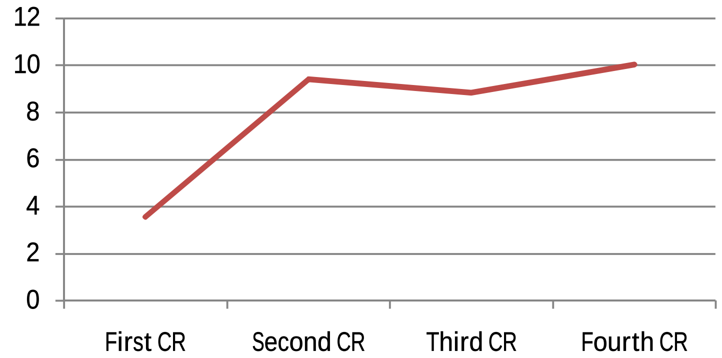
3. Results

In this section, the results of analyses of the differences between the conditions and the working preferences, the interactions between them, and the (correlational) relations between the different dependent variables are presented. First the overall knowledge acquisition in the study was examined by means of a repeated measures analysis. After this, the differences between the conditions and preferences were assessed by univariate and multivariate analyses of covariance. Subsequently, the interactions between condition and working preference were examined. And finally, correlations and regressions were conducted to analyze the hypothesized relations between the independent variables.

3.1 Overall knowledge acquisition

In this section the results of the repeated measures analysis on the overall knowledge acquisition of the students on the cued and open recall tests are reported. Knowledge acquisition on the cued recall tests was measured across four time periods (beginning and ending of the first session, and the beginning and ending of the second session). There is a significant effect for the cued recall tests, F $(3, 85) = .02$, $p < .001$, Wilks Lambda = .14, $\eta^2 = .86$. The students show a significant increase from the third to the fourth, and from the first to the fourth cued recall tests (see Figure 3.1 for a complete overview). There is no significant effect for the open recall tests which was measured across two time periods (ending of both sessions), F $(1, 87) = .52$, $p = .47$, Wilks Lambda = .99, $\eta^2 = .01$. Nevertheless, the students show a small increase in their open recall scores.

FIGURE 3.1
Knowledge acquisition on the cued recall test for the individual students



3.1 Differences on knowledge acquisition and drawing quality for the individual students

In this sub-section, the differences between the conditions and working preferences in knowledge acquisition and drawing quality of the individual students are reported. Although the drawing quality resulted from a collaborative activity, individual drawing quality scores for each student were calculated (see section 2.5.2). This procedure is necessary to gain insight in the relation between scripting/working preference and drawing quality for the individual students. Four one-way between-groups multivariate analyses of covariance were performed, and 36 one-way between-groups analyses of covariance were conducted to specify the differences. First condition (scripted vs. non-scripted) was the independent variable interchanged by working preference (negative vs. positive). Knowledge acquisition on the cued recall tests, the knowledge acquisition on the open recall tests, and the quality of the joint drawing were the dependent variables.

3.1.1 Scripting influences on knowledge acquisition and drawing quality

One-way ANOVA's with school/class, age, prior knowledge and ability as dependent variables, and condition as independent variable, reveal conditional differences for students from different schools (school/class) (F (1, 86) = 35.12, p < .001, η^2 = .29) and age (F (1, 86) = 5.84, p < .05, η^2 =.06). Consequently, school/class and age are used as covariates. No significant conditional differences were found for prior knowledge and ability.

First all scores on the different subcategories of knowledge acquisition and drawing quality (as listed in Table 3.1) were included in the analyses. The MANCOVA showed that there is a statistically significant difference between the scripted and the non-scripted condition on the dependent variables, F (12, 73) = 5.12, p < .001, Wilks Lambda = .54, η^2 = .46. A second MANCOVA examined the combined total scores regarding knowledge acquisition and the combined total scores of all aspects regarding drawing quality (as listed in Table 3.1). No statistically significant difference between the scripted and the non-scripted condition on these dependent variables, F (6, 79) = 1.78, p = .12, Wilks Lambda = .88, η^2 = .12 is found.

Additionally, ANCOVA's were performed to identify the differences between the conditions on knowledge acquisition as assesses with the cued and open recall tests. Knowledge acquisition between the different cued and open recall tests were determined. Significant differences between both conditions are found on students' knowledge acquisition from the third to the fourth cued recall test (F (1, 84) = 4.61, p < .05, η^2 = .05) as well as students' knowledge acquisition from the first to the fourth cued recall test (F (1, 84) = 6.70, p < .05, η^2 = .07). Examining differences between condition was continued regarding the drawing quality. Significant differences are found between conditions concerning the amount of properties students represented in their drawings (F (1, 84) =

15.04, $p < .001$, $\eta^2 = .15$) as well as the amount of processes that were annotated (F (1, 84) = 9.04, $p < .01$, $\eta^2 = .10$). All other univariate ANCOVA's revealed insignificant results (see Table 3.1).

TABLE 3.1
Individual scores of the dependent variables for the scripted and the non-scripted condition

	Scripted condition			Non-scripted condition		
-Knowledge acquisition	*n*	*M*	*SD*	*n*	*M*	*SD*
First to second Cued Recall	38	6.34	2.20	50	5.50	3.08
Second to third Cued Recall	38	-.89	1.78	50	-.34	1.27
Third to fourth Cued Recall	38	1.50*	2.08*	50	.96*	1.25*
First to fourth Cued Recall	38	6.95*	2.47*	50	6.12*	2.69*
Second to fourth Cued Recall	38	.61	2.05	50	.62	1.48
Concepts Open Recall	38	-.21	2.97	50	.68	2.82
Processes Open Recall	38	-.26	2.09	50	-.02	1.99
Properties Open Recall	38	.00	.70	50	.32	.62
Open Recall total	38	-.47	4.79	50	.98	4.39
-Drawing quality						
Concepts	38	9.42	2.19	50	9.92	1.64
Processes	38	2.95	2.04	50	2.84	1.95
Properties	38	.00**	.00**	50	.24**	.43**
Representations total	38	12.37	3.78	50	13.00	3.36
Annotations concepts	38	6.53	2.51	50	7.52	2.70
Annotations processes	38	.00*	.00*	50	.12*	.44*
Annotations properties	38	.00	.00	50	.08	.27
Annotations total	38	6.53	2.51	50	7.72	2.81
Drawing total	38	18.89	5.60	50	20.72	5.52

Note. * $p < .05$;** $p < .001$

3.1.2 Grouping influences on knowledge acquisition and drawing quality

One-way ANOVA's with school/class, age, prior knowledge and ability as dependent variables, and preference as independent variable indicate that the ability of the students (F (1, 80) = 11.05, $p < .005$, $\eta^2 = .12$) significantly differs between the working preferences (positive vs. negative working preference), and therefore should be included as a covariate. Age, prior knowledge and class/school do not show significant differences between the working preferences.

The first MANCOVA focused on the scores on all subcategories regarding knowledge acquisition and drawing quality (as listed in Table 3.2), indicating a statistically significant difference between the working preferences on the dependent variables, F (12, 68) = 2.15, $p < .05$, Wilks Lambda = .73, $\eta^2 = .28$. The second MANCOVA examined the combined total scores regarding knowledge acquisition and drawing quality (as listed in Table 3.2). No statistically significant difference is found between the working preferences, F (6, 74) = 1.40, $p = .23$, Wilks Lambda = .90, $\eta^2 = .10$.

Additionally, univarate ANCOVA's were conducted for each independent variable to identify the nature of the differences between the preferences. A significant difference between the working preferences is found on the amount of concepts represented in the drawing (F (1, 79) = 6.24, p < .05, η^2 = .07), the amount of annotated concepts (F (1, 79) = 3.99, p < .05, η^2 = .05), the amount of annotated processes (F (1, 79) = 5.78, p < .05, η^2 = .07), the overall amount of annotations (F (1, 79) = 5.19, p < .05, η^2 = .06), and the overall drawing quality score (F (1, 79) = 4.63, p < .05, η^2 = .06). All other UNIANCOVA's showed insignificant results (see Table 3.2).

TABLE 3.2
Individual scores of the dependent variables for the different working preferences

	Negative working preference			Positive working preference		
-Knowledge acquisition	*n*	*M*	*SD*	*n*	*M*	*SD*
First to second Cued Recall	40	5.67	2.53	42	5.74	2.88
Second to third Cued Recall	40	-.75	1.74	42	-.38	1.34
Third to fourth Cued Recall	40	1.18	1.66	42	1.29	1.77
First to fourth Cued Recall	40	6.10	2.60	42	6.64	2.46
Second to fourth Cued Recall	40	.42	1.53	42	.90	1.96
Concepts Open Recall	40	-.45	3.13	42	.93	2.61
Processes Open Recall	40	-.22	2.09	42	-.02	2.03
Properties Open Recall	40	.22	0.77	42	.07	.59
Open Recall total	40	-.45	5.12	42	.98	4.09
-Drawing						
Concepts	40	9.20*	2.26*	42	10.38*	.80*
Processes	40	2.65	2.11	42	3.10	1.76
Properties	40	.15	.36	42	.10	.30
Representations total	40	12.00	4.11	42	13.57	2.06
Annotated concepts	40	6.60*	2.55*	42	7.86*	2.28*
Annotated processes	40	.00*	.00*	42	.14*	.47*
Annotated properties	40	.05	.22	42	.05	.22
Annotations total	40	6.65*	2.65*	42	8.05*	2.33*
Drawing total	40	18.65*	6.27*	42	21.62*	3.13*

Note. * p < .05

3.2 Process analyses for the individual students

In this sub-section, the differences between the conditions and working preference in discourse quality for the individual students are reported. Although the discourse quality resulted from a collaborative activity, individual discourse quality scores for each student were calculated (see section 2.5.1). This procedure is necessary to gain insight in the relation between scripting/working preference and discourse quality for the individual students. Four one-way between-groups multivariate analyses of covariance were performed, and 40 one-way between-groups analyses of covariance were conducted to specify the differences. First condition (scripted vs. non-scripted) was the independent variable interchanged by working preference (negative vs. positive), and discourse quality was the dependent variable.

3.2.1 Scripting influences on the discourse quality

One-way ANOVA's (see section 3.1.1) reveal conditional differences for students from different schools (school/class) and age. Consequently, school/class and age are used as covariates. No significant conditional differences are found for prior knowledge and ability.

First all scores on the different subcategories of drawing quality (as listed in Table 3.3) were included in the analyses. A MANCOVA shows that there is a statistically significant difference between conditions on the dependent variables, F (20, 61) = 2.63, p < .005, Wilks Lambda = .54, η^2 = .46. A second MANCOVA examined the combined total scores regarding discourse quality (as listed in Table 3.3). There is a statistically significant difference between the two conditions on the combined variables, F (9, 72) = 2.73, p < .001, Wilks Lambda = .75, η^2 = .26.

In addition, univarate ANCOVA's were performed for each independent variable to identify the exact differences between the conditions. There is a significant difference between the conditions on the total amount of talking by the students (F (1, 80) = 1-.89, p < .01, η^2 = .12), on concept definition in the epistemic dimension F (1, 80) = 11.45, p < .01, η^2 = .13), on process definition in the epistemic dimension (F (1, 80) = 9.17, p = .01, η^2 = .10), and on coordination-related talk in the epistemic dimension (F (1, 80) = 4.59, p < .05, η^2 = .05). The other UNIANCOVA's show insignificant results (see Table 3.3).

3.2.2 Grouping influences on the discourse quality

By means of previously reported one-way ANOVA's, ability was indicated as covariate. From this instant collaboration expectations (F (2, 81) = 44,22, p < .001, η^2 = .52) and the satisfaction with the partner as indicated beforehand (F (2, 80) = 44,74, p < .001, η^2 = .53) are also included as covariates in the analyses since significant differences between working preferences were found regarding these variables.

The first MANCOVA focused on the sub-categorical scores regarding the epistemic and social mode dimensions of discourse. There is no significant difference between the preferences, F (40, 110) = 1.27, p = .17, Wilks Lambda = .47, η^2 = .32. A second MANCOVA focused on the combined total scores regarding discourse quality. There is no statistically significant difference between the two preferences on the combined variables, F (18, 132) = .96, p = .51, Wilks Lambda = .78, η^2 = .12. Further univariate ANCOVA's on each independent variable to identify the exact differences between the working preferences reveal no significant results.

TABLE 3.3
Individual scores of the dependent variables for the scripted and the non-scripted condition

	Scripted condition			Non-scripted condition		
-General discourse	*n*	*M*	*SD*	*n*	*M*	*SD*
Total amount of talk	38	134.50**	50.56**	46	183.04**	59.40**
-Epistemic						
Concept Naming	38	.26	.10	46	.23	.08
Concept Definition	38	.00**	.01**	46	.01**	.01**
Process Definition	38	.00**	.01**	46	.01**	.01**
Concept-Process conn.	38	.01	.03	46	.03	.03
Off-task talk	38	.28	.13	46	.26	.12
Coordination	38	.30*	.10*	46	.37*	.13*
Concept/Process talk total	38	.28	.12	46	.27	.10
-Social mode						
Externalization	38	.38	.09	46	.40	.10
Elicitation	38	.10	.05	46	.11	.05
Agreeing	38	.06	.04	46	.07	.05
Disagreeing	38	.02	.02	46	.02	.01
Integration	38	.01	.01	46	.01	.01
Critiques/Modifications	38	.05	.03	46	.05	.05
Conflicted Off-task	38	.00	.01	46	.00	.00
Non-conflicted Off-task	38	.27	.13	46	.25	.12
Informative talk total	38	.48	.11	46	.51	.11
Quick Consensus Building total	38	.07	.04	46	.04	.05
Transactivity total	38	.06	.04	46	.06	.04
Off-task talk total	38	.28	.13	46	.26	.12

Note. * $p < .05$; ** $p < .01$

3.3 Process analyses for the dyads

In this sub-section, the differences between the conditions and working preference in discourse quality for the dyads are reported. Six one-way between-groups multivariate analyses of covariance were performed, and 88 one-way between-groups analyses of covariance were conducted to specify the differences. First condition (scripted vs. non-scripted) was the independent variable interchanged by working preference (negative vs. positive). Discourse quality, discourse distribution and drawing quality were the dependent variables.

3.3.1 Scripting influences on discourse quality, distribution and drawing quality

One-way ANOVA's showed conditional differences for school/class, F (1, 40) = 14.48, $p < .001$, η^2 = .27. Therefore, school/class is included as a covariate in upcoming analyses. No other significant conditional differences are found.

The first MANCOVA focused on the percentagewise sub-categorical scores of the dyads regarding the epistemic and social mode dimensions of discourse and regarding drawing quality (as indicated in Table 3.4). There is a statistically significant difference for condition, F (21, 19) = 2.27, $p < .05$, Wilks Lambda = .29, η^2 = .72. The second MANCOVA examined the differences in condition on the combined total scores regarding the epistemic and social mode dimensions of discourse and regarding drawing quality for the dyads (as indicated in Table 3.4). There is no significant difference between the conditions, F (10, 30) = 1.59, p = .16, Wilks Lambda = .65, η^2 = .35.

A third MANCOVA focused on the participation distribution scores of discourse (as indicated in Table 3.4). There is no statistically significant difference between conditions, F (15, 25) = .66, p = 80, Wilks Lambda = .72, η^2 = .28.

Additionally, univarate ANCOVA's were performed for each independent variable to identify the exact differences between the conditions on discourse quality and participation distribution as assessed in the epistemic and social mode dimensions. Significant differences between both conditions are found on students' use of concept definition on the epistemic dimension (F (1, 39) = 7.46, $p < .01$, η^2 = .16), the use of process definition on the epistemic dimension (F (1, 39) = 75.73 $p < .05$, η^2 = .13), the total amount of talking (F (1, 39) = 5.16, $p < .05$, η^2 = .12), and the distribution in integration-talk on the social mode dimension (F (1, 39) = 5.22, $p < .05$, η^2 = .12). Examining differences between condition was continued regarding the drawing quality. A significant difference is found between conditions regarding the amount of properties represented in the drawing (F (1, 39) = 7.36, $p < .05$, η^2 = .16). All other UNIANCOVA's showed insignificant results (see Table 3.4).

TABLE 3.4
Dyadic scores of the dependent variables for the scripted and the non-scripted condition

	Scripted condition			Non-scripted condition		
-General discourse	*n*	*M*	*SD*	*n*	*M*	*SD*
Amount of talk total	19	266.89*	95.74*	23	386.87*	130.28*
Distribution of talk	19	82.05	17.44	23	85.70	10.89
-Epistemic						
Concept Naming	19	.26	.10	23	.23	.08
Concept Definition	19	.00**	.01**	23	.01**	.01**
Process Definition	19	.00*	.01*	23	.01*	.01*
Concept-Process conn.	19	.02	.03	23	.03	.03
Off-task talk	19	.28	.13	23	.26	.12
Coordination	19	.30	.10	23	.37	.13

TABLE 3.4 (Continued)
Dyadic scores of the dependent variables for the scripted and the non-scripted condition

	Scripted condition			Non-scripted condition		
-Epistemic	*n*	*M*	*SD*	*n*	*M*	*SD*
Concept/Process talk total	19	.29	.11	23	.27	.10
Distribution Concept Naming	19	79.42	18.82	23	81.35	15.81
Distribution Concept Definition	19	73.68	42.06	23	66.09	36.63
Distribution Process Definition	19	59.63	49.18	23	73.96	40.01
Distribution Concept-Process conn.	19	61.68	39.51	23	62.09	32.60
Distribution Off-task talk	19	73.89	26.82	23	76.48	13.52
Distribution Coordination	19	78.89	16.96	23	85.43	10.54
-Social mode						
Externalization	19	.38	.08	23	.40	.09
Elicitation	19	.10	.03	23	.11	.04
Agreeing	19	.05	.03	23	.07	.04
Disagreeing	19	.01	.01	23	.02	.01
Integration	19	.01	.01	23	.01	.01
Critiques/Modifications	19	.05	.03	23	.05	.03
Conflicted Off-task	19	.00	.01	23	.00	.00
Non-conflicted Off-task	19	.28	.12	23	.25	.12
Informative talk total	19	.48	.11	23	.51	.10
Quick consensus building total	19	.07	.03	23	.09	.04
Transactivity total	19	.06	.03	23	.06	.03
Off-task talk total	19	.28	.12	23	.26	.12
Distribution Externalization	19	72.79	22.41	23	77.74	18.19
Distribution Elicitation	19	66.95	25.56	23	67.70	18.62
Distribution Agreeing	19	59.16	22.76	23	65.61	23.74
Distribution Disagreeing	19	45.16	42.80	23	48.96	38.83
Distribution Integration	19	65.42*	32,68*	23	41.61*	29.00*
Distribution Critiques/Modifications	19	49.11	29.44	23	55.78	31.94
Distribution Conflicted Off-task	19	84.21	37.46	23	84.78	35.15
Distribution Non-conflicted Off-task	19	73.79	26.90	23	76.78	14.32
- Drawing quality						
Concepts	19	9.42	2.20	23	9.83	1.70
Processes	19	2.95	2.06	23	2.91	2.02
Properties	19	.00*	.00*	23	.26*	.45*
Representations total	19	12.37	3.83	23	13.00	3.53
Annotated concepts	19	6.53	2.55	23	7.26	2.68
Annotated processes	19	.00	.00	23	.13	.46
Annotated properties	19	.00	.00	23	.09	.29
Annotations total	19	6.53	2.55	23	7.48	2.83
Drawing total	19	18.89	5.68	23	20.48	5.74

Note. * $p < .05$; ** $p < .01$

3.3.2 Grouping influences on the discourse quality, discourse distribution and drawing quality

One-way ANOVA's show no significant conditional differences for school/class. A first MANOVA focused on the percentagewise sub-categorical scores of the dyads regarding the epistemic and social mode dimensions of discourse and regarding drawing quality (as indicated in Table 3.5). A second MANOVA examined the differences in working preferences on the combined total scores regarding the epistemic and social mode dimensions of discourse and regarding drawing quality for the dyads (as indicated in Table 3.5). Both analyses reveal no significant differences between the working preferences; resp. F (22, 16) = .89, p = .61, Wilks Lambda = .45, η^2 = .55, and F (11, 27) = .80, p = .64, Wilks Lambda = .76, η^2 = .25.

A third MANOVA focused on the participation distribution scores of discourse (as indicated in Table 3.5). There is no statistically significant difference between preferences, F (15, 23) = 1.15, p = .37, Wilks Lambda = .57, η^2 = .43.

Additionally, univarate ANCOVA's were performed for each independent variable to identify the exact differences between the working preferences on discourse quality and participation distribution as assessed in the epistemic and social mode dimensions. Significant differences between both the working preferences are found on the distribution of off-task talk on the epistemic dimension (F (1, 37) = 4.64, p < .05, η^2 = .11), and for the distribution of non-conflicted off-task talk on the social mode dimension (F (1, 37) = 4.83, p < .05, η^2 = .12). Examining differences between working preference was continued regarding the drawing quality. However, all other UNIANCOVA's show insignificant results (see Table 3.5).

TABLE 3.5
Dyadic scores of the dependent variables for the two working preferences

	Negative working preference			Positive working preference		
-General discourse	*n*	*M*	*SD*	*n*	*M*	*SD*
Amount of talk total	20	288.75	106.13	19	344.53	143.13
Distribution of talk	20	79.40	18.23	19	88.26	7.14
-Epistemic						
Concept Naming	20	.23	.09	19	.26	.10
Concept Definition	20	.01	.01	19	.01	.01
Process Definition	20	.00	.01	19	.01	.01
Concept-Process conn.	20	.02	.03	19	.02	.03
Off-task talk	20	.29	.15	19	.24	.09
Coordination	20	.32	.08	19	.34	.15
Concept/Process talk total	20	.26	.10	19	.30	.10
Distribution Concept Naming	20	76.65	19.05	19	84.79	14.98
Distribution Concept Definition	20	76.15	37.45	19	59.84	41.30
Distribution Process Definition	20	80.00	41.04	19	52.42	46.22

TABLE 3.5 (Continued)
Dyadic scores of the dependent variables for the two working preferences

	Negative working preference			Positive working preference		
-Epistemic	*n*	*M*	*SD*	*n*	*M*	*SD*
Distribution Concept-Process conn.	20	55.30	42.13	19	69.58	29.16
Distribution Off-task talk	20	69.30*	24.82*	19	82.89*	12.14*
Distribution Coordination	20	80.85	16.98	19	84.84	11.01
-Social mode						
Externalization	20	.38	.09	19	.41	.08
Elicitation	20	.10	.04	19	.10	.04
Agreeing	20	.05	.03	19	.07	.03
Disagreeing	20	.02	.01	19	.01	.01
Integration	20	.01	.01	19	.02	.01
Critiques/Modifications	20	.05	.03	19	.05	.03
Conflicted Off-task	20	.00	.01	19	.00	.00
Non-conflicted Off-task	20	.29*	.15*	19	.24*	.09*
Informative talk total	20	.48	.11	19	.51	.09
Quick Consensus Building total	20	.07	.03	19	.09	.04
Transactivity total	20	.06	.03	19	.06	.04
Off-task talk total	20	.29	.14	19	.24	.09
Distribution Externalization	20	71.40	23.36	19	80.26	14.87
Distribution Elicitation	20	68.10	21.25	19	65.26	23.99
Distribution Agreeing	20	61.95	19.83	19	65.63	27.05
Distribution Disagreeing	20	54.25	36.15	19	46.74	43.90
Distribution Integration	20	58.60	36.93	19	45.84	29.59
Distribution Critiques/Modifications	20	51.10	32.99	19	51.58	30.11
Distribution Conflicted Off-task	20	85.00	36.64	19	84.21	37.46
Distribution Non-conflicted Off-task	20	69.15	25.03	19	83.21	12.62
-Drawing quality						
Concepts	20	9.20	2.29	19	10.32	.82
Processes	20	2.65	2.13	19	3.21	1.81
Properties	20	.15	.37	19	.11	.32
Representations total	20	12.00	4.17	19	13.63	2.17
Annotated concepts	20	6.60	2.58	19	7.58	2.24
Annotated processes	20	.00	.00	19	.16	.50
Annotated properties	20	.05	.22	19	.05	.23
Annotations total	20	6.65	2.68	19	7.79	2.32
Drawing total	20	18.65	6.35	19	21.42	3.24

Note. * $p < .05$

3.4 Interactions between the conditions and the working preferences

In this paragraph the interactions between the experimental conditions and working preference are reported. Two one-way between-groups multivariate analyses of covariance were conducted, with working preference and conditions as the independent variables. Subsequently, one-way between-groups analyses of covariance were performed to specify the interactions. The covariates used in these analyses resembled the ones used in foregoing analyses; age, school/class, ability, collaboration expectations and satisfaction with the partner beforehand in the analyses for the individual students, and class/school for the dyadic analyses.

3.4.1 Interactions on the discourse quality, drawing quality and knowledge acquisition for the individual students

To examine the interactions between condition and working preference for the individual students, a MANCOVA was conducted with the individual data on discourse quality, drawing quality and knowledge acquisition as dependent variables. A statistically significant interaction, F (28, 38) = 1.95, $p < .05$, Wilks Lambda = .41, $\eta^2 = .59$, is found.

In addition, the nature of the interactions were identified. They manifest themselves in the knowledge acquisition regarding concepts on the open recall tests (F (1, 69) = 4.35, $p < .05$, $\eta^2 = .06$), in the score on the concepts in the joint drawing (F (1, 69) = 7.00, $p < .05$, $\eta^2 = .09$), on the amount of off-task talk on the epistemic dimension (F (1, 69) = 12.95, $p < .01$, $\eta^2 = .17$), on the use of coordination-related talk on the epistemic dimension (F (1, 65) = 16.81, $p < .001$, $\eta^2 = .21$), on the use of externalization on the social mode dimension (F (1, 65) = 7.96, $p < .01$, $\eta^2 = .11$), on the use of disagreement on the social mode dimension (F (1, 69) = 7.90, $p < .01$, $\eta^2 = .11$), on the use of non-conflicted off-task talk on the social mode dimension (F (1, 69) = 13.21, $p < .01$, $\eta^2 = .17$), on the use of informative talk (combined variable of externalizations and elicitation) on the social mode dimension (F (1, 65) = 11.65, $p < .01$, $\eta^2 = .15$), on the amount of quick consensus building (combined variable of agreeing and disagreeing) on the social mode dimension (F (1, 65) = 6.21, $p < .05$, $\eta^2 = .09$), on the total amount of off-task talk (combined variable of conflicted and non-conflicted off-task talk) on the social mode dimension (F (1, 65) = 13.02, $p < .01$, $\eta^2 = .17$). The other UNIANOVA's show insignificant results (see Table 3.1-3.3 for the descriptive statistics).

Inspections of the means, showed in profile plots (see Figure 3.2), suggests the effect of the interactions. It seems that the scripted students fared well on drawing the concepts and mentioning concepts in the open recall tests when they were grouped by positive working preference. The graphs also show that non-scripted students grouped by positive working preference show higher scores on externalization, disagreement, informative talk, quick consensus building, and coordination-related talk. The non-scripted students grouped by a negative working preference demonstrate higher scores on the off-task talk categories.

FIGURE 3.2
Graphs on the estimated marginal means (vertical axes) to examine the interactions

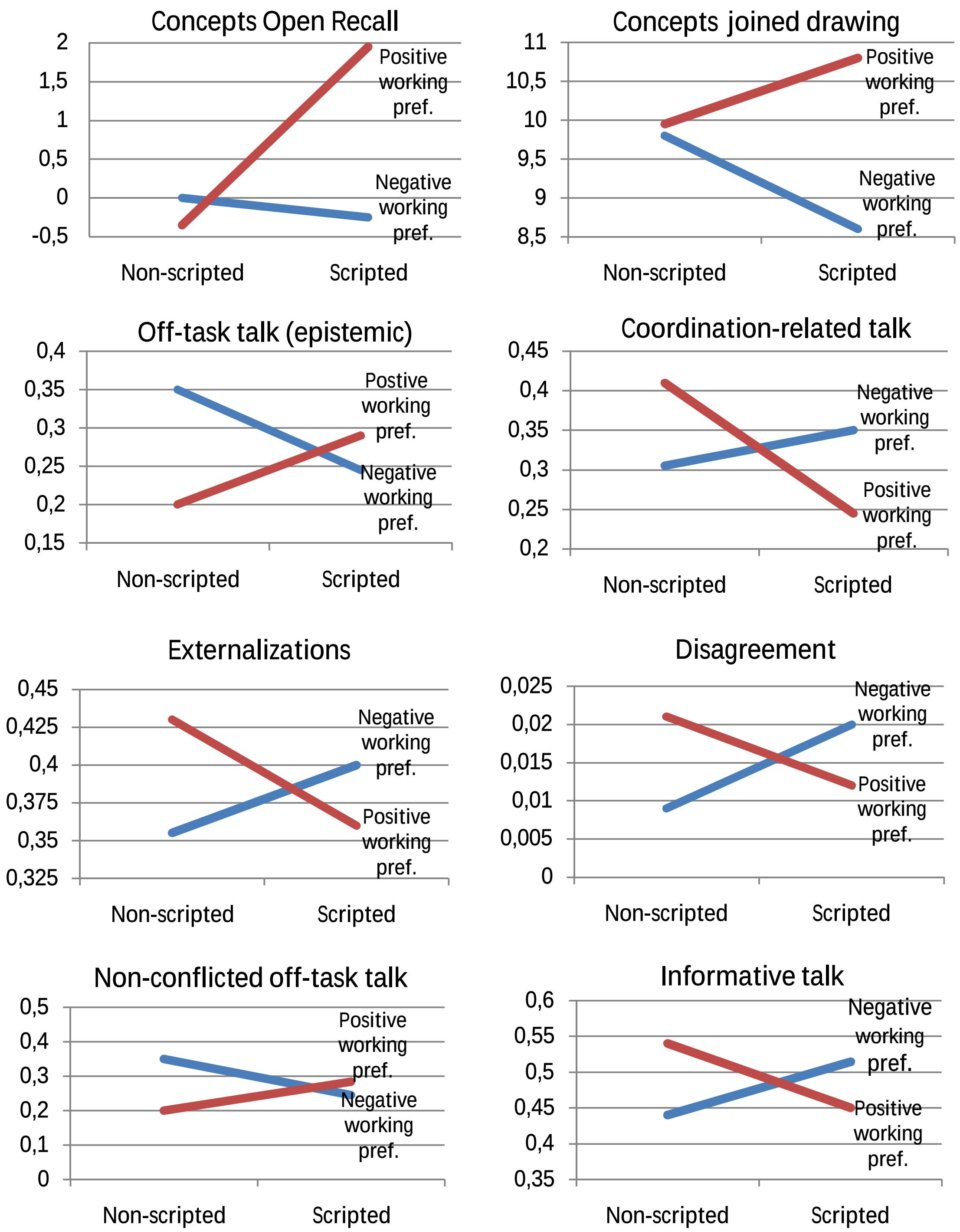
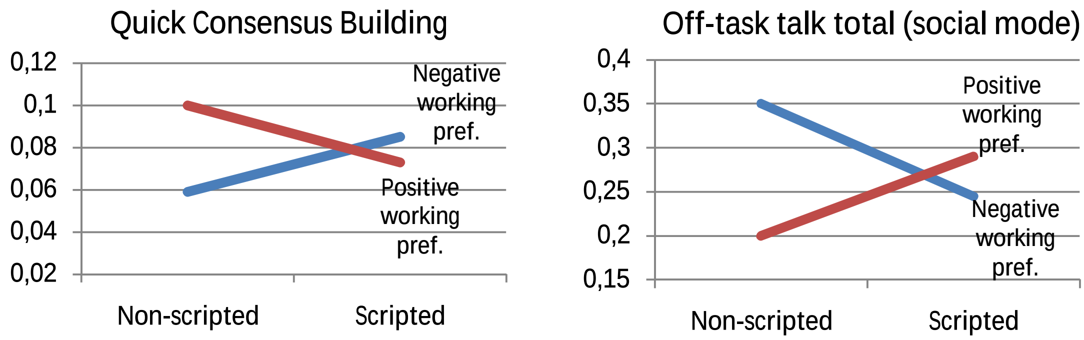


FIGURE 3.2 (Continued)
Graphs on the estimated marginal means (vertical axes) to examine the interactions



3.4.2 Interactions on the discourse quality, drawing quality and discourse participation for the dyads

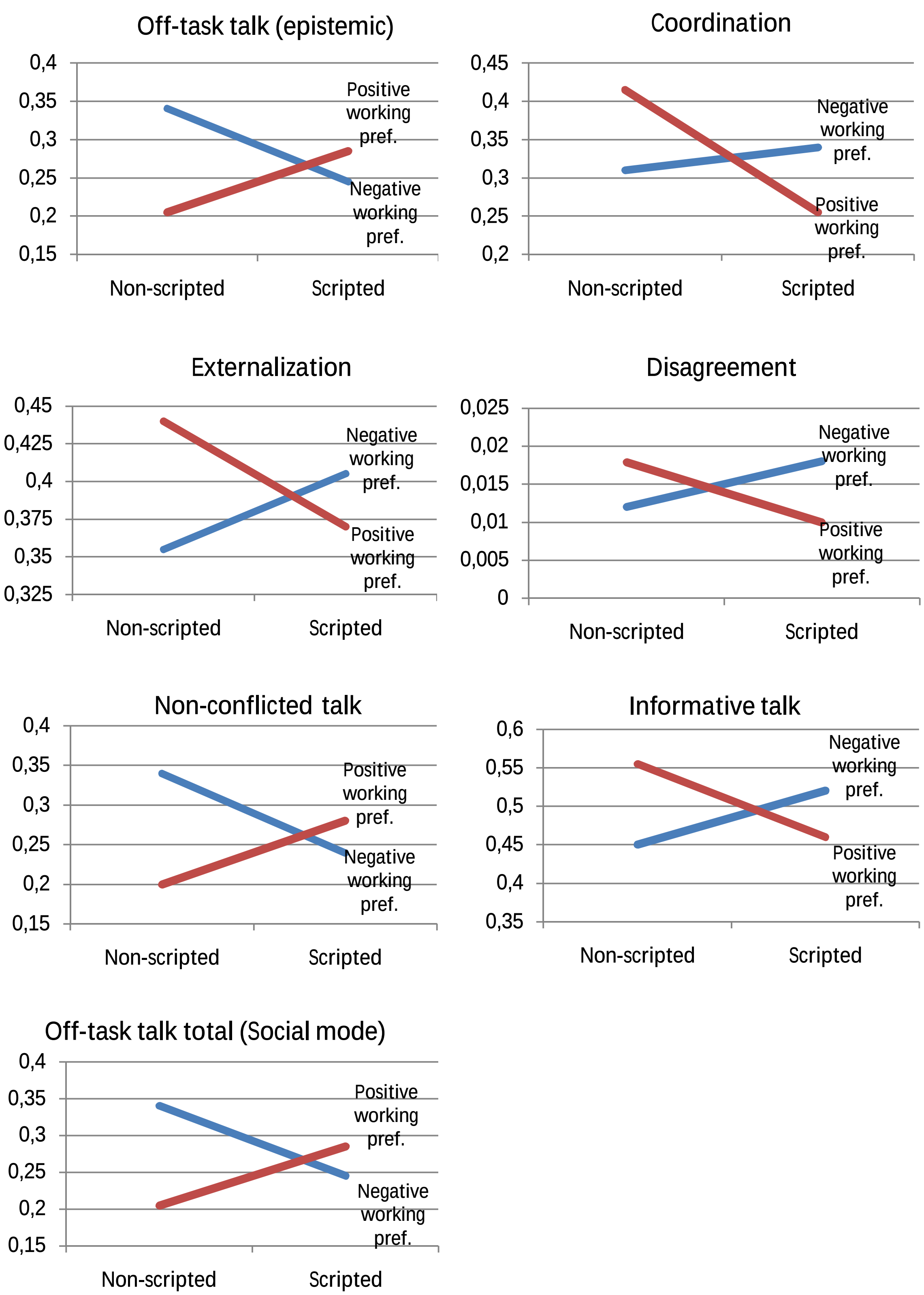
To examine the interactions for the dyads between condition and working preference, a MANCOVA was conducted with discourse quality, drawing quality and discourse participation as dependent variables. There is no statistically significant interaction between condition and working preference, *F* (34, 1) = 3.07, *p* = .43, Wilks Lambda = .01, η^2 = .99.

In addition, the nature of the interactions were identified. They manifest themselves in the use of off-task talk on the epistemic dimension (*F* (1, 34) = 5.25, p < .05, η^2 = .13), on the coordination-related talk on the epistemic dimension (*F* (1, 34) = 9.16, p < .01, η^2 = .21), on the use of externalizations in discourse (*F* (1, 34) = 4.88, p < .05, η^2 = .13), on the amount of disagreement in discourse (*F* (1, 34) = 4.50, p < .05, η^2 = .12), the amount of non-conflicted off-task talk in discourse (*F* (1, 34) = 5.42, p < .05, η^2 = .14), on the use of informative talk (combined variable of externalizations and elicitation) in discourse (*F* (1, 34) = 6.56, *p* < .05, η^2 = .16), and on the total amount of off-task talk (combined variable of conflicted and non-conflicted off-task talk)on the social mode dimension (*F* (1, 34) = 5.30, *p* < .05, η^2 = .14). The other UNIANOVA's show insignificant results (see Table 3.4 and 3.4 for the descriptive statistics).

Inspections of the means, showed in Figure 3.3, suggests the effect of the interactions. It seems that the scripted dyads scored better on the amount of disagreement and coordination-related talk when they were grouped by negative working preference. The graphs also show that non-scripted dyads grouped by positive working preference showed higher scores on the use of externalizations and informative talk (combined score of externalizations and elicitations). The non-scripted dyads grouped by a negative working preference demonstrate higher scores on the off-task talk categories.

FIGURE 3.3

Graphs on the estimated marginal means (vertical axes) to examine the interactions



3.5 Correlational results

To examine whether the independent variables of this study (discourse quality and discourse participation, drawing quality and knowledge acquisition) are connected, the relations between the dependent variables are assessed. Not all of the possible relations required inspection. A selection has been made by means of the significant results from the above mentioned analyses. Correlational and regression analyses were conducted on the relation between discourse quality and drawing quality, whereas the relation between drawing quality or discourse quality and knowledge acquisition lacked significant differences to lead up to further analysis. In addition, the direct relation between the individual drawing and the joint drawing was examined to determine the role of this script component. All analyses included the significant sub-categories from preceding univariate and multivariate analyses.

3.5.1 Relation between discourse and drawing quality for the non-scripted students

The non-scripted condition shows a higher drawing quality, specified in the properties and the annotated processes, and scores higher on the discourse quality, visible in their total amount of talking, their use of concept definitions, their use of process definitions, and their coordination related talk. In order to examine the relation, the students' individual scores on these discourse categories were correlated with the significant sub-categorical drawing quality scores (see Table 3.6). Significant correlations are found between students' use of concept definition during discourse and the manifestation of properties in the joint drawing (r = .38, p < .001), and between students' use of concept definition and the manifestation of annotated processes in the drawing (r = .24, p < .05). There is also a significant correlation between students' use of process definition during discourse and the manifestation of properties in the joint drawing (r = .45, p < .001).

TABLE 3.6

Correlations Between Discourse quality and Drawing quality for the non-scripted condition

	Properties	*Annotated Processes*
Total amount of talking	.021	- .037
Concept definition	.375**	.241*
Process definition	.447**	.023
Coordination	.102	- .079

Note. * p < .05; ** p < .001

A stepwise regression analysis, with the students' use of properties in the drawing as the dependent variable, resulted in a significant model, adjusted R^2 = .22, F (2, 81) = 12.89, p < .001, with the manifestation of process definition (β = .351, p < .01) and concept definition (β = .226, p < .05) as significant predictors. The total amount of talking and the students' coordination-related talk provides no significant contribution to the prediction model. Subsequently, the same analysis have been performed with the students' use of annotated processes in the drawing being the dependent variable, and results in another significant model, adjusted $R^2 = .05$, $F(1, 82) = 5.04$, $p < .05$, with the manifestation of concept definition as significant predictor ($\beta = .241$, $p < .05$). The other three variables do not contribute to the model.

3.5.2 Relation between discourse and drawing quality for the non-scripted dyads

The non-scripted dyads show higher drawing quality, specified in the properties, and score higher on discourse quality, visible in their amount of talking, use of concept definitions, and use of process definitions. In order to examine the relation, the students' individual discourse scores on these sub-categories were correlated with the significant sub-categorical drawing quality scores (see Table 3.7). Significant correlations are found between students' use of concept definition during discourse and the manifestation of properties in the joint drawing ($r = .40$, $p < .01$), and between students' use of process definition during discourse and the manifestation of properties in the joint drawing ($r = .49$, $p < .01$).

TABLE 3.7
Correlations Between Discourse quality and Drawing quality for the non-scripted dyads

	Properties
Total amount of talking	.015
Concept definition	.404**
Process definition	.492**

Note. ***p* < .01

A stepwise regression analysis resulted in a significant model, adjusted $R^2 = .22$, $F(1, 40) = 12.80$, $p < .01$, with the manifestation of process definition ($\beta = .492$, $p < .01$) as significant predictor. The total amount of talking, the manifestation of concept definition, and the students' coordination-related talk provide no significant contribution to the prediction model.

3.5.3. Relation between discourse and drawing quality for the positive working preference

The positive working preference group shows a higher drawing quality, specified in the concepts, annotated concepts, annotated processes, overall annotations and the total score on the drawing, and scores higher on the discourse participation, visible in the distribution of off-task talk on the epistemic dimension. In order to examine the relation the significant scores on participation distribution were correlated with the significant sub-categorical scores on drawing quality. There are no significant correlations.

3.5.4 Relation between the individual and the joint drawing

To further explore the influence of the script on the creation of the joint drawing, the relation between the individual drawing, the students in the scripted condition were assigned to be doing, and the joint drawing was assessed. In order to examine this, the students' scores on the individual drawing were correlated with the students' final score on the joint drawing. There are no significant correlations.

4. Conclusion and Discussion

The main aim of the present study is to examine the effects of scripting and working preference on discourse quality and its distribution, the drawing quality, and the knowledge acquisition. Accordingly, there were two conditions (scripted vs. non-scripted), and two working preferences (negative vs. positive). The scripted condition received more and deeper instructions than the non-scripted condition. The preference groups differed in their indicated working preference towards their assigned collaborative partner.

The first research question investigated the role of the script on the knowledge acquisition of the students. It shows that overall knowledge acquisition on the cued recall tests has been accomplished. This effect is very strong (partial eta squared reached .86). An explanation might be that the students started their participation on this study with minimal prior knowledge on the process of photosynthesis. Their knowledge level increased significantly during the two sessions of the study, which might have caused the major effect size.

Results indicated differences between the scripted and the non-scripted condition on knowledge acquisition. Individual students in the scripted condition demonstrated higher knowledge acquisition, visible in the third to fourth, and first to fourth cued recall tests. Even though effect sizes show that these effects are relatively small, the findings support the hypothesized idea that scripting leads to higher knowledge acquisition. However, it remains impossible to conclude which specific components of the script contributed to this result, while the script was examined in its totality.

The second research question explored the influence of the script on discourse quality. It was hypothesized that the script would enhance discourse quality. Especially the social mode categories, referring to transactive talk, should benefit from the script (Dillenbourg & Jermann, 2007; Dillenbourg & Tchounikine, 2007; King, 1994; O'Donnell, 1999; Weinberger, et al., 2001). However, the results indicate that this hypothesis is not correct. Both students and dyads in the non-scripted condition showed a higher discourse quality. This higher scores can be defined in the amount of talking, concept definition, process definition and coordination-related talk, and showed a small to medium effect size. It is worth mentioning though, that the scripted dyads do show more equal distribution of the discourse, only visible in the participation in integrative talk. The findings concerning the scripted condition showing equal distribution of integration in discourse with a small to medium effect size give little support for the hypothesized relation between the script and discourse quality.

The third research question investigated to what extend the script could facilitate drawing quality. It was expected that the scripted condition would benefit from the individual drawing phase, as a result of which the drawing quality of the joint drawing would be higher. However, the results indicate otherwise; the non-scripted condition shows higher drawing quality. This shows itself in higher scores for both students and dyads on the drawn properties, and for the students separately at the annotated processes, and demonstrated small to medium effect sizes. This finding contradicts with the expectation that scripting could positively affect the drawing quality of the students.

The fourth research question addressed the role of positive working preference in the knowledge acquisition of the students. It was hypothesized that the students with a positive working preference towards each other would fare better in knowledge acquisition. Whereas the literature indicates that a positive working preference creates a lucrative condition in which knowledge acquisition should be enhanced (Azmitia & Montgomery, 1993; Kagan & Kagan, 1994; Zajac & Hartup, 1997), there are no significant differences found between the different working preferences.

The fifth research question investigated to what extent grouping by positive working preference could contribute to discourse quality. It was hypothesized that positive working preference would show higher discourse quality. In particular, the score on the social mode should be positively affected (Zajac & Hartup, 1997). Positive working preference dyads demonstrate a more equal discourse participation, only visible in participation in off-task talk on the epistemic level. However, the negative working preference shows a more equal participation on the non-conflicting part of off-task talk. These results, being somewhat contradicting, fail to provide an definite relation between working preference and discourse quality. Since the outcomes focused on off-task talk, and the on-task talk dimensions did not show any significant findings, it is possible to conclude that the findings contradict the idea that positive working preference positively affects discourse quality.

The sixth research question explored the effect of grouping by positive working preference on the drawing quality. It was expected that positive working preference would contribute to the drawing quality of the joint drawing. The findings support this idea, as the positive working preference group show higher drawing quality. They score higher on the drawn concepts, the annotations on the concepts and processes, the overall annotations and on the overall score on the drawing, in which they show small effect sizes.

The seventh research question focused on the existence of interaction effects between scripting and working preference, and their effects on discourse quality, distribution of discourse, drawing quality and knowledge acquisition. The results demonstrate 17 interaction effects, most of which are related to the discourse quality of both students and dyads. There are however two interactions that are interesting concerning the above mentioned significant results. Even though the non-scripted students show higher drawing quality, it seems that the scripted students fared well on drawing the concepts when they were grouped by positive working preference. In addition, the non-scripted students engaged more in coordination-related talk when they were grouped by positive working preference, which might indicate that non-scripted students in positive working preference dyads show more coordinative behavior than the non-scripted students in negative working preference dyads. For this effect being medium to large, partial eta squared reached .21, this interaction seems to play a large role in the outcome of this variable. A possible explanation is that the students with mutual positive working preference communicated easily. Following Kagan and Kagan (1994), who stated that positive social contact increases the effectiveness of the collaborative process, it is likely that these students experienced no trouble understanding each other ideas and suggestions, and progressed relatively fast in their drawing process. Additionally, they operated frequently on quick consensus building, visible in the results revealing that non-scripted students engaged more in quick consensus building discourse when grouped by positive working preference. Positive working preference students in the non-scripted condition seem to easily accept each other's opinions and proposals, as a result of which discussion stays out in situations discussion is not necessary. This gives the impression that positive working preference dyads do not engage in discussion 'just to discuss'. However, this tendency might have caused the insufficiency of significant knowledge acquisition for the non-scripted students, whereas the scripted students show higher knowledge acquisition. As stated by Weinberger and Fischer (2006) and Teasley (1997), conflict-oriented consensus building plays a major role in the quality level of discourse. Therefore, quick consensus building might have hindered the students' knowledge acquisition.

The eighth research question was whether discourse quality is related to knowledge acquisition. It was expected that there would in fact be a relation between discourse quality and knowledge acquisition. However, whereas only the scripted condition shows higher knowledge acquisition, and discourse quality is better performed on by the non-scripted condition and the positive working preference group, there are no indications for a possible relation between discourse quality and knowledge acquisition.

The ninth research question focused on the extent in which discourse quality and discourse distribution are related to drawing quality. It was hypothesized that there would be a positive relation between the variables. Results support the hypothesis, by showing that discourse quality does influence the drawing quality of the non-scripted condition positively. The effect found is medium to large for both the individual students and the dyads, which indicates that it is important to create a learning environment in which students are able to engage in high-quality discourse and collaboration. On the other hand, there was no significant evidence for the existence of a relation between those variables for the positive working preference group.

The final research question focused on the extent in which drawing quality contributes to knowledge acquisition. Although the scripted students show higher knowledge acquisition scores and the non-scripted students demonstrate a higher drawing quality, this study presents no indications to further explore the existence of the relation between drawing quality and knowledge acquisition.

In addition should be noted that a major difference between the scripted and the non-scripted condition was that the scripted students were given the possibility to draw the photosynthesis process individually, before starting with the collaborative phase. However, there is no significant relation found between the quality of the first and the second drawing. This means that the possible advantage of drawing the subject separately has not been demonstrated in this study.

A possible explanation for the results that favor the non-scripted condition on the discourse quality could be that the scripted interruptions of the collaborative phase have led to less efficacious discourse for the scripted condition. The scripted group received less time for the actual collaboration. This is mainly visible in the total amount of talking the students engaged in. Given that the students were provided with less time to elaborate on the different aspects of the photosynthesis process and it takes some time to develop a qualitative conversation, as noticed during the process analysis, they had less time to engage in knowledge-enhancing discourse. In addition, the students in the scripted condition were encouraged but not forced to use the prompt cards. They could use them whenever they want. It seems that most students used the cards very little. If using the cards was required, this might have produced higher discourse quality scores for the scripted condition. Moreover, the prompt cards could have interrupted the collaborative process. While it is important to provide prompts or cues without interfering the natural collaborative process (Dillenbourg, 2002), it might be that the scripted condition was held back because of these prompts.

Another way to explain the better results for the non-scripted condition on discourse and drawing quality, is that they were not limited by the script. O'Donnell (1999) and Dillenbourg (2002) explained that when the script does not correspond with the students' learning styles and limits the natural collaborative and elaborative process , it could impede the learning process of the students. Besides this, because scripts spell out for the students how to behave, they may obstruct students to think for themselves (Weinberger, et al., 2005). It might be that the non-scripted condition showed a better discourse quality and fared better on the drawing task because these students were able to define their own working strategy, which referred better to their own learning styles better. They were not interrupted or held back by the script. However, the script seems to have improved the overall knowledge acquisition of the students. The improved scores from the third to the fourth cued recall test suggest that the script contributed to attaining this goal, at certain process costs.

In interpreting the results of this study, some limitations and possible alternative interpretations should be considered. Both in the first and second session were the students informed on the content of the photosynthesis by means of a text and a short video. The video consisted partly of an animation, in which the students were given an idea on how to draw the photosynthesis concepts. It could be that the students draw things by means of their memories on the video. For that reason, it is difficult to discriminate whether the students actually understood the material or were just capable of duplicating the animated material. Future research might therefore study whether a text is enough to inform the students on a subject when a drawing-assignment is involved.

The grouping method has influenced some of the results. The students were grouped by working preference, in which other - possibly influencing - factors were not considered. Nevertheless, general ability level for instance could play a major role in the contribution of the collaborative partner to the discourse, the level of the discourse, and the individual knowledge acquisition whereas this could be related to the discourse quality. It would be interesting to group the students by combining working preference with ability level, since this could lead to more significant differences on the working preferences.

The increase of the students' knowledge acquisition in the scripted condition is a very promising result. Whereas very little is known about the use of scripting in elementary education, the results of this study revealed a positive outcome on this matter. However, it could not be discriminated to what extent the different elements of the script contributed to this outcomes. Therefore, it is interesting to gain more insight in the specific scripting elements that might contribute to the knowledge acquisition of this age group. Furthermore, it could be beneficial to examine the way the students behaved around the script to see if the script disturbs or stimulates their natural communication pattern.

Inspection of the means revealed that the students in both conditions and both working preferences showed little to none transactive talk during discourse. It could be interesting to investigate whether this result proves that engaging in transactive discourse is too hard for the students of this age group, or whether there is a more suitable way to support these students during discourse to enhance the occurrence of transactivity.

Due to unforeseen circumstances six students could not be grouped conform the working preference method. The results of these so called 'neutral dyads' had for that reason to be ignored in this study. Because the decision to exclude these dyads from the original study was made in the course of the study, they were included in orienting analyses on the data. The results revealed promising scores for the neutral working preference. Nevertheless, because of the relatively small group size the reliability of and the possibility to generalize these scores could not be warranted. Future research could implement this third working preference category to examine its effect in a proper sample size, given that orienting results showed potential.

Overall, the results of this study demonstrate the usefulness of a collaborative script on knowledge acquisition. However, the script did not enhance discourse and drawing quality. Furthermore, there was evidence for a positive influence of working preference on drawing quality and discourse quality. A promising result found in this study is the relation between discourse quality and drawing quality on some of the categories. Future research could further explore the benefits of scripting and the grouping by working preference procedure, by establishing some modifications.

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Appendix I – Informative text Photosynthesis (in Dutch)

Fotosynthese

Groene planten, onmisbaar voor het leven van mens en dier! Om te overleven hebben mensen en dieren zuurstof nodig. Groene planten zorgen hiervoor in een proces dat fotosynthese wordt genoemd.

Zuurstof zit in de lucht, maar het komt daar niet vanzelf. Zuurstof wordt gemaakt door planten. Een plant is eigenlijk een zuurstoffabriek. Dit doet hij door gebruik te maken van zonlicht, water en koolstofdioxide (ook een stof in de lucht). Hierbij wordt niet alleen zuurstof aangemaakt, maar ook suiker.

Die suikers, daar is het een plant eigenlijk om te doen. Suiker is een voedingsstof voor de plant zelf, en slaat de plant dus op in zichzelf om van te groeien en om vruchten mee te maken. Zuurstof, dat tegelijkertijd ontstaat, is voor de plant eigenlijk een afvalproduct.

De drie stoffen, zonlicht, water en kooldioxide, komen natuurlijk niet zomaar in een plant.

Daarvoor heeft hij een paar hulpmiddeltjes: de wortels, de stengels en de bladeren. Met de wortels haalt een plant water uit de grond. Van de wortels gaat het water naar de stengel, en vervolgens van de stengel naar de bladeren.

Het belangrijkste stuk gereedschap dat een plant bij het maken van zuurstof en suiker gebruikt is het bladgroen. Planten zijn groen omdat ze in hun bladeren allemaal groene korrels hebben zitten. Dit zijn bladgroenkorrels. In deze korrels vind de fotosynthese plaats.

Om fotosynthese te laten plaatsvinden, hebben planten water en kooldioxide nodig. Planten halen het water dat ze nodig hebben meestal uit de grond. Dit doen ze met hun wortels. Kooldioxide zit in de lucht. Het wordt door kleine gaatjes in de bladeren opgezogen. Deze gaatjes noemen we huidmondjes.

Bladeren kunnen zelf lucht opnemen. In de blaadjes zitten kleine openingen: de huidmondjes. Met die huidmondjes haalt een plant kooldioxide uit de lucht.

Voor het opnemen van licht gebruikt de plant ook de bladeren. De bladgroenkorrels in de blaadjes vangen het licht op.

Als de grondstoffen de plantenfabriek zijn binnengehaald kan het proces beginnen. Met behulp van het zonlicht, de stroom voor de fabriek, wordt van kooldioxide en water in de bladgroenkorrels suiker gemaakt. Die suiker houdt de plant zelf, om van te groeien en om lekkere zoete vruchten mee te maken. De zuurstof verdwijnt als afval door de “schoorsteen” (de huidmondjes) naar buiten.

Appendix II – Script

Scripting in this study

To examine whether working preference and scripting influences the discourse quality in collaboration and eventually also the drawing quality and the individual knowledge acquisition, a script will be used.

In this study, the students will be asked to make a graphical representation of the process of photosynthesis. They have to create a poster in such a way that it enables others (students of the same age group) to understand this process. The students will be imparted that it should be possible to explain the photosynthesis process by means of using their drawing they create. Thus, the drawing has to be a sufficient tool to explain the process of photosynthesis.

The script as prescribed here will support the entire research process. This includes the first research session, the grouping procedure, and the second research session – the actual observation. The creation process of the poster is part of the second research session. The script guides the students in the experimental condition during both phases of the second session – the individual and the collaborative phase.

The actual study consists of two sessions, which will be spread over two separate days. Between the two sessions there will be a recess of a couple of weeks to analyse the gathered data of the first session. From this analysis will follows the grouping of the students into dyads, while they will be working in dyads most of the second session. The study has a quasi-experimental structure, while the different conditions are assigned to different school classes.

First session

The first session consists of a first visit to the selected school class, and will start with a cued recall test on photosynthesis, followed by a training on how to make graphical representations by means of an informative text, followed by a questionnaire including a short sociogram and other pre testing questions. After that, the students will be presented with some domain knowledge about photosynthesis, which will end with reoccurring knowledge acquisition concerning photosynthesis. The first session will take 65 minutes in total to complete.

The instruction before starting the first session will begin with the explanation and goal of my visit to the students: this study. This explanation consists of my reason for visiting the school and the programme for that day. The students are being told that they will get a short training in model drawing, they have to fill out some question forms, and that they will be getting some information about photosynthesis. Figure 1 shows this explanation, which will take around 5 minutes. This is a rough estimate, for there is probably less time needed. But it is important to explain everything very carefully to the students. Time is needed to answer all of their possible, unscheduled questions.

In this explanation the focus will lie on explaining this study to the students in comprehensible language. It is best to be as concrete as possible if you deal with the relatively young age group, this study is dealing with. So, what should be clearly mentioned in the explanation is the purpose of their participation and the value of the research.

Hallo, ik ben Alieke. Ik ben van de Universiteit Twente in Enschede. Een tijdje geleden heb ik met jullie juf/meester afgesproken om vandaag en over één/een paar weken langs te komen om samen met jullie aan de slag te gaan met een kort project. Momenteel ben ik namelijk bezig met een onderzoek naar leren in de bovenbouw van de basisschool. Dat is de reden dat ik jullie vandaag bezoek.

Ik doe onderzoek naar hoe kinderen het beste een bepaald vak kunnen leren. Ik ben hierbij specifiek benieuwd naar: 'hoe jullie nieuwe onderwerpen leren, zoals fotosynthese'. Hierbij ben ik vooral benieuwd naar de effecten als jullie samenwerken met een klasgenoot, en daarbij ook nog eens gebruik maken van tekeningen.

Daarom gaan we vandaag en over een aantal weken aan de slag. Vandaag zullen we allereerst aan de slag gaan met het maken van tekeningen tijdens het leren. Omdat het bewezen is dat het maken van tekeningen bij het begrijpen van verschillende leeronderwerpen een positief effect heeft, zullen we dit vanmiddag een keer met zijn allen oefenen. Het onderwerp dat we daarbij gaan bekijken, is de waterkringloop.

Daarnaast gaan we vanmiddag ook alvast kijken naar fotosynthese. Straks zal ik jullie uitleggen wat dat is. Ook zullen we een paar andere oefeningen gaan doen. Maar nu eerst: de training.

Figure 1: Explanation beforehand for all the children in Dutch (Part 1)

Training

To get the students acquainted with drawing models during the learning process, and to make sure that they know how to draw an appropriate model out of an instructional/informative text, training is provided. The training will take about 15 minutes to complete.

The training starts with a short explanation. In this explanation, the students will be informed about the drawing task in session 2, and the significance of practicing this learning method. This explanation is shown in figure 2.

We gaan nu beginnen met het eerste onderdeel van deze middag: het maken van een tekening tijdens het leren. Onderzoekers hebben ontdekt dat je veel kunt leren van het maken van tekeningen bij leren begrijpen van verschillende leeronderwerpen. Vanmiddag gaan we dit een keer met zijn allen oefenen. Het onderwerp dat we daarbij gaan bekijken is de watercyclus.

Ik deel nu een papier uit met een tekst over de watercyclus. [Deelt uit.] Lees deze tekst voor jezelf, jullie krijgen hiervoor 3 minuten de tijd.

***

We gaan nu klassikaal, op het bord, een tekening maken welke het watercyclusproces weergeeft. We gaan eigenlijk 'gewoon' de woorden omzetten in afbeeldingen en pijlen. We zullen met zijn allen de tekst doorlopen. Ik teken op het bord, maar jullie moeten zelf meetekenen op jullie eigen blaadje. Mocht je tijdens deze opdracht vragen of opmerkingen hebben, stel ze gerust.

Belangrijk om te weten is dat dit onderwerp alleen een voorbeeld is, je hoeft het dus niet per se te onthouden. Daarnaast gaat het er niet om dat je zo mooi mogelijk moet tekenen. Dat is helemaal niet belangrijk. Als het voor jezelf maar duidelijk is wat je bedoelt. Het is daarom wel erg handig om erbij te zetten wat je getekend hebt.

Oké, we gaan beginnen.

Figure 2: Explanation before starting with the training to all the children in Dutch

The training will start after all the materials are distributed in the classroom, and possible questions are answered. The instructor will read the text (figure 3) sentence by sentence, will locate the main concepts and will explain and relate those concepts. Doing so, input will be asked from the students.

Waar blijft alle regen? Bijvoorbeeld van een onweersbui.Water op aarde is constant in beweging. Alle regen die uit de lucht valt, komt terecht op het land. Het water zakt de grond in, waardoor bijvoorbeeld de planten er lekker van kunnen drinken. Maar soms valt er zoveel regen dat de grond al vol zit met water. Dus stroomt het water weg. Het water stroomt nu naar sloten, rivieren en kanalen in het landschap. Die sloten, rivieren en kanalen worden alsmaar groter en groter. Mede hierdoor stroomt het water richting de oceaan.
De energie die nodig is voor de waterkringloop wordt geleverd door de zon. Ongeveer de helft van de zonne-energie die het aardoppervlak bereikt, wordt gebruikt voor de verdamping van water.
Wanneer dus boven de zee de zon schijnt, verdampt het water van de zee. Deze waterdamp gaat omhoog, waar het zich een wolk vormt. Deze wolk wordt door de wind naar het land geblazen, waar boven het land de waterdamp afkoelt. De damp wordt nu weer druppeltjes en het gaat regenen. Alle regen die uit de lucht valt, komt terecht op het land.

Zo zie je dat de kring maar rond gaat... De circulatie van water via de atmosfeer (lucht) de rivieren en de ondergrond wordt de kringloop van het water genoemd. Kort gezegd: de waterkringloop.

Figure 3: Complete text about the watercycle in Dutch

Every time a concept and/or a relation is located, the instructor will visualize this by means of a (part of a) drawing on the black board. Simultaneously, the instructor will use the drawings to explain what it means and why it is drawn. Below follows a step-by-step overview of the construction of the drawing.

Waar blijft alle regen? Bijvoorbeeld van een onweersbui. Water op aarde is constant in beweging.

These sentences describe the purpose and subject of the text: (explaining) the watercycle. The students have to be explained that not every sentence provides drawing material information, and that these sentences are an example of that.

Alle regen die uit de lucht valt, komt terecht op het land. Het water zakt de grond in, waardoor bijvoorbeeld de planten er lekker van kunnen drinken.

This sentence contains a lot of information. To demonstrate the fundamental ideas of making a drawing by reading and analyzing an informative text, this sentence will provide as an example. The first concept is 'regen', followed by the first relation 'het (regen)water zakt de grond in'.

To consolidate this information, the drawing will be made during the analyzing phase. So, the rain will be drawn, where it will take form of a cloud.

Maar soms valt er zoveel regen dat de grond al vol zit met water. Dus stroomt het water weg. Het water stroomt nu naar sloten, rivieren en kanalen in het landschap. Die sloten, rivieren en kanalen worden alsmaar groter en groter. Mede hierdoor stroomt het water richting de oceaan.

The most important information in these sentences, can be described by the phrases 'het water stroomt weg en komt terecht in sloten, rivieren en kanalen' en 'het water stroomt via sloten, rivieren en kanalen naar de oceaan'.

This information will be drawn in the model, by means of conceptual illustrations and process-aimed arrows.

De energie die nodig is voor de waterkringloop wordt geleverd door de zon. Ongeveer de helft van de zonne-energie die het aardoppervlak bereikt, wordt gebruikt voor de verdamping van water. Wanneer dus boven de zee de zon schijnt, verdampt het water van de zee.

The most important information in these sentences, can be described by the concepts and phrases 'de zon (schijnt boven de zee)' en 'wanneer de zon schijnt boven de zee, verdampt het water van de zee'.

These concepts and phrases will be shaped by drawing them into the model, by means of conceptual illustrations (the sun) and process-aimed arrows.

Deze waterdamp gaat omhoog, waar het zich een wolk vormt.

The most important information in this sentence, can be described by the phrases 'de waterdamp gaat omhoog' en 'de waterdamp vormt zich een wolk in de lucht'.

These concepts and phrases will be shaped by drawing them into the model, by means of conceptual illustrations (the sun) and process-aimed arrows.

Deze wolk wordt door de wind naar het land geblazen, waar boven het land de waterdamp afkoelt. De damp wordt nu weer druppeltjes en het gaat regenen. Alle regen die uit de lucht valt, komt terecht op het land.

The most important information in this sentence, can be described by the phrases 'de wolk wordt door de wind naar het land geblazen', 'de waterdamp wordt druppeltjes', 'het gaat regenen' en 'de regen komt weer neer op het land'. Here ends the water cycle. This means that the drawing should be completed.

These concepts and phrases will be shaped by drawing them into the model, by means of conceptual illustrations (the sun) and process-aimed arrows.

Zo zie je dat de kring maar rond gaat… De circulatie van water via de atmosfeer (lucht), de rivieren en de ondergrond wordt de kringloop van het water genoemd. Kort gezegd: de waterkringloop.

This information confirms the information that the cycle is completed. The cycle is shortly described, in order that the students can verify their drawing of the model.

After the training in model drawing, the students will be presented with the question forms. They will have to be filling out questions which will indicate their working preference, their domain knowledge on photosynthesis, and their perceptive collaboration skills. It will be explained to them that they will have to answer the questions as truthful as possible, that they do not have to be afraid of the answers they will give because nobody else will read them, and that they have 15 minutes to finish answering the questions. This explanation is shown in Figure 4.

Ik zal nu een vragenlijst uitdelen. Hierop worden voornamelijk vragen gesteld die gaan over jou en jouw (!) mening. Hierbij geldt dat antwoorden niet goed of fout zijn, en dat niemand anders de antwoorden te zien krijgt. Volg je gevoel bij het beantwoorden van de vragen en vul het antwoord in dat het eerste bij je opkomt.

Ook worden een paar vragen gesteld over fotosynthese. Fotosynthese is een nieuw onderwerp en we zijn benieuwd of jullie al iets over dit onderwerp weten. Ook voor de vragen over fotosynthese geldt, wees niet bang om het fout te doen. Kies voor het woord waarvan jij denkt dat het met fotosynthese te maken heeft. is wel belangrijk dat jullie op alle vragen een antwoord geven. Dus sla geen vragen over. Omdat het belangrijk is dat iedereen een eigen antwoord geeft, mogen jullie niet met elkaar overleggen. Daarom staan jullie tafels ook in een toetsopstelling. In totaal krijgen jullie ongeveer een half uur om de vragen te beantwoorden. Als jullie klaar zijn, leg dan het blaadje op de kop (!) op de hoek van je tafel. Jullie krijgen voor dit onderdeel 15 minuten de tijd. Succes!

Figure 4: Explanation beforehand to all the children in Dutch (part 2)

After all the students have finished the question forms and the questionnaires have been gathered, a first introduction to the base subject of the second session, photosynthesis, will be provided. This introduction will consist of a short animation/movie of photosynthesis, used by a Dutch organisation specialised in and directed to edutainment television: SchoolTV. This animation/movie will be preceded by a text about the process, which text will be used in the second session. In total this part of the first session will take 10 minutes, including the explanation. The students will need 3 minutes to finish reading the text, where after the animation/video will be shown.

Nu gaan we over naar het derde onderdeel van deze middag. Ik wil jullie laten kennismaken met fotosynthese. Jullie hebben net al wat vragen beantwoord over dit onderwerp.

Ik deel nu allereerst een tekst uit over dit onderwerp. Ik geef jullie 3 minuten de tijd om deze door te lezen. Als jullie klaar zijn, leg dan het blaadje op de hoek van je tafel. {Onderzoeker deelt tekst uit.}

****

Nu jullie allemaal de tekst hebben kunnen lezen, weet je als het goed is nu ongeveer wat fotosynthese inhoudt. Omdat het waarschijnlijk nog beter te begrijpen is als je het proces ook kunt bekijken, gaan we nu een filmpje bekijken. Dit filmpje duurt ongeveer 2 minuten. Ik laat hem maar een keer zien, dus let goed op. {Onderzoeker start videomateriaal.}

Figure 5: Explanation about the acquaintance with photosynthesis

After the first acquaintance with photosyntheses, a last short questionnaire will be distributed. This questionnaire will consist only of a cued recall list and an open question about the subject photosynthesis, and will take about 5 minutes to complete.

Nu volgt de twee laatste onderdelen van vanmiddag. Ik wil jullie vragen om nog twee korte oefeningen te doen. Jullie krijgen allereerst dezelfde woordenlijst over fotosynthese te zien. Deze zelfde lijst hebben jullie al eerder gezien, bij de eerste vragenlijstronde. De bedoeling is hetzelfde: Omcirkel de woorden die volgens jou te maken hebben met het fotosyntheseproces. Wees niet bang om fouten te maken. Fouten maken mag! Jullie krijgen hiervoor 2 minuten de tijd. Succes! Als jullie klaar zijn, leg dan het blaadje op de kop (!) op de hoek van je tafel.

***

We gaan nu beginnen met het allerlaatste onderdeel van vandaag. Ik deel jullie zo een blaadje uit met een vraag over fotosynthese. Probeer deze vraag zo duidelijk en uitgebreid mogelijk te beantwoorden. Ook hierbij geldt weer dat het niet erg is om fouten te maken. Jullie krijgen 3 minuten de tijd. Succes! Als jullie klaar zijn, leg dan het blaadje op de kop (!) op de hoek van je tafel.

Figure 6: Explanation about second questionnaire of the first session

When all the students finished filling out the last questionnaire, they will be thanked and explained ones more what the following procedure will look like. The students will be told that the researcher will be coming a second time, when that will be, and what to expect that day. This is shown in figure 7.

Dit was het alweer voor vanmiddag. Ik wil jullie allemaal heel erg bedanken voor jullie inzet. Jullie hebben me nu al erg geholpen.

Zoals jullie ondertussen weten zal ik nog een keer terugkomen, namelijk over {aantal} weken. Dan gaan jullie zelf aan de slag met een nieuw onderwerp.

Tot de volgende keer!

Figure 7: Explanation at the end of the first session to all children in Dutch

Time plan of the first session			
Experimental group (Scripted condition)		*Control group (Non-scripted condition)*	
Phase	Time	Phase	Time
Instruction, including first cued recall test	5 min.	Instruction	5 min.
Training	15 min.	Training	15 min.
Questionnaire (pre)	15 min.	Questionnaire (pre)	15 min.
Photosynthesis	10 min.	Photosynthesis	10 min.
Questionnaire (post)	5 min.	Questionnaire (post)	5 min.
	Total: 50 minutes		Total: 50 minutes

Table 1: Time plan of the first session

Pre-research information from the teacher

Complementary to the information from the questionnaires, information coming from the teachers will be used. The teachers will be asked to give information about the current seating plan in the classroom. Besides that, the teacher will be asked to report existing close ties between classmates. An important purpose of these questions is to determine whether the seating plan shows these ties between the students.

To get this information, a short meeting will be scheduled with the teacher before or after the first session. It is important to possess this information before analyzing the data gathered in the first session, so that the teacher's information can be taken into account.

During this meeting, the teacher will also be asked to indicate the science skills of their students. Although this information is not of importance to the grouping procedure, the indications will be used later on in the study.

Grouping

The students will be grouped in dyads, by means of the analyzed data from the first session and the data provided by the teacher. The motivation for the use of dyads is that research states that collaborative learning in small groups can foster equal participation (Cohen & Lotan, 1995). All participants have the chance to contribute to the collaboration. So, it might be that collaboration in two-person-groups (dyads) enhances the participation distribution even more.

The grouping of the dyads will take place by virtue of their working preference. Heterogeneous and homogeneous dyads will be created by means of the degree of working preference. To make sure that friendship ties or prior working experience do not influence this possible relationship, the students are also selected on existing friendship ties and prior working experience in the group-to-be-sorted. Furthermore, to measure any change in individual knowledge acquisition, this has to be known in advance.

By means of the questionnaire in the first session, the students will be grouped in dyads. These dyads will be grouped according to a preference scale. To measure their preference for their classmates, they have answered four related questions. These questions concern their liking and their working preference, and had to be answered by writing down names of their classmates. Two questions determine the like scale together, and the other two determine the dislike scale.

To define the students' individual preference, a multiplying procedure is used. The answers of the students are scaled beforehand, with the first name being three points, the second name being two points, and the third name being one point. To create a defining scale for the like condition and the dislike condition, the questions concerning these conditions are taken together. The points related to these questions are added up.

The next step in the grouping procedure is to determine the relationship between the different dyads in the class. To do this, the convergence on the like and the dislike scale are calculated by multiplying the added scores per dyad. These multiplications have a range from 1 to 36 points.

Second session

Before the research will actually start, it is important to divide the dyads into the experimental and the control group. To measure differences between dyads who receive a script and dyads who do not receive a script during collaboration, the dyads will be divided in two groups: the experimental group and the control group. In the experimental group, the dyads will receive instruction about the topic, take part in an individual phase and will collaborate according to the script. In the control group, the dyads will just be joint to do the core assignment (making the graphical representation about photosynthesis).

To avoid possible difficulties during the study, the choice has been made to appoint different classes to the different conditions: a quasi-experimental design. Therefore, two classes will be participating as the experimental group, whereas the other two classes will form the control group. Moreover, the one school with two participating classes will be divided in an experimental group class and a control group class.

To ease the grouping procedure, the students will be seated following a previously made seating arrangement. The tables in the classroom are arranged in pairs. To make sure the students will be seating in the right place right away, name tags will be situated on the desks. By entering the classroom, the students will be explained to look for their own name tag and to get seated behind the desk pointed out to them. This procedure is showed in figure 8.

Hallo allemaal. Zoals jullie kunnen zien is de indeling vandaag iets anders dan normaal. Ik wil jullie vragen te gaan zitten aan de tafel waar jouw naam bij staat aangegeven op het kaartje, voor zover jullie dit nog niet gedaan hebben. Ik zal later vanmiddag uitleggen wat precies de bedoeling is.

Figure 8: Explanation about the seating plan for the second session to all children in Dutch

Second session for the experimental group

The second session for the experimental group contains of a cued recall test on photosynthesis, an individual drawing phase, a phase to identify differences (and commonalities), and discussion of those differences resulting in a joint drawing. The second session will take 63 minutes in total to complete. The instruction will start with a reminder of the first session, and an explanation about the grouping. Furthermore, an explanation will be given about the importance and schedule of this second session, and that the students will be working in dyads (see Figure 9).

Hallo allemaal. Vandaag gaan we verder met het tweede (en laatste) deel van mijn onderzoek. Zoals jullie waarschijnlijk nog weten, had ik beloofd om na een paar weken nog een keer langs te komen om samen met jullie verder aan de slag te gaan met een het project.

Ik zal even kort herhalen wat het onderzoek over gaat. Ik doe onderzoek naar hoe kinderen het beste een bepaald vak kunnen leren. Ik ben benieuwd naar: 'hoe jullie leren over een onderwerp als fotosynthese. Ik kijk hoe jullie samen met een klasgenootje met dit onderwerp aan de slag gaan en hoe jullie daarbij een tekening van dit onderwerp gaan maken'.

We gaan vandaag werken in tweetallen, en bezig met het onderwerp fotosynthese. Wat fotosynthese ook alweer precies is kan je straks in de tekst lezen. Voor aanvang van deze middag heb ik jullie in tweetallen ingedeeld. Dat was ook de reden waarom jullie moesten gaan zitten bij je naamkaartje. Je klasgenoot naast je is jouw samenwerkingspartner vanmiddag.

Het programma voor vanmiddag ziet er als volgt uit: we beginnen met een korte vragenlijst, waarna we aan de slag gaan met fotosynthese. Hierbij zullen jullie eerst alleen een opdracht doen, en daarna pas de opdracht met zijn tweeën. Bij dit laatste onderdeel zal ik gebruik maken van opnameapparatuur. Er zullen straks kleine apparaatjes op jullie tafel worden gelegd. Deze gaan jullie gesprek opnemen, zodat ik later terug kan luisteren naar wat jullie gezegd hebben tijdens het doen van de opdracht.

De videocamera voor in de klas is er om later eventueel te kunnen terugzien of alles goed gegaan is. Probeer je niet bezig te houden met deze opnames. Ze zijn niet belangrijk. Alles wat wordt opgenomen is alleen voor mijn onderzoek en laat ik dus niet horen of zien aan andere mensen die daar niets mee te maken hebben.

Figure 9 : Explanation beforehand to the experimental group in Dutch

After this, a short refreshment of the training (as provided in the first session) is given. This consists of a short explanation of how to find the main concepts and relations in a text. The introduction and refresher will take around 5 minutes. After this, the rest of the programme can start. Figure 10 shows this refresher.

Vorige keer hebben we met zijn allen een tekening gemaakt aan de hand van een korte tekst over de watercyclus. Kunnen jullie mij vertellen hoe we dat gedaan hebben?

***

We hebben gezien dat het belangrijk is om de tekst goed te lezen en de belangrijkste begrippen eruit te halen, en deze begrippen met elkaar in verband te brengen. Met andere woorden, kijken hoe het ene begrip te maken heeft met een ander begrip.

We hebben hierbij een tekening gemaakt waarin de belangrijkste punten uit de tekst naar voren kwamen. Het werd een tekening die het gehele verhaal in afbeeldingen en pijlen beschreef. Vandaag gaan jullie wederom een soortgelijke tekening maken. Het onderwerp is deze keer fotosynthese. {Onderzoeker laat de tekening zien, en wijst de belangrijke punten aan.}

Figure 10: Refresher of the training in the first session to the experimental group

After giving the explanation and refreshment, as illustrated above, the session will continue with a short questionnaire about the students' expectations of the collaboration, and their satisfaction with their collaboration partner. To answer the questions, the students will be given 10 minutes. Figure 11 shows the corresponding explanation to the students.

Voordat we vandaag met het programma beginnen, wil ik jullie weer vragen om een paar vragen in te vullen. Dit duurt een paar minuten. Er zal gevraagd worden naar jouw mening, en je zult gevraagd worde naar jouw kennis over fotsynthese.

Het is de bedoeling dat jullie deze vragen voor jezelf invullen en niet overleggen en/of kijken bij een ander. Het gaat alleen om jouw mening! Al jouw antwoorden blijven anoniem. Niemand anders zal deze te lezen krijgen.

Jullie hebben hiervoor 10 minuten de tijd. Succes!

Figure 10: Explanation about questionnaire to the experimental group in Dutch

Before starting the next phase of the study, the students will be shown the animation/movie of photosynthesis ones more, to refresh their memory. This animation/movie will take 2 to 3 minutes. The explanation is shown in figure 11.

Vorige keer heb ik jullie al laten kennismaken met fotosynthese. Jullie hebben toen een tekst gelezen welke fotosynthese uitlegt, en daarna een filmpje bekeken omdat het waarschijnlijk nog beter te begrijpen is als je het proces ook kunt bekijken.

We gaan dit filmpje nu nog eens bekijken. Daarna gaan jullie zelf met het onderwerp aan de slag. Dit filmpje duurt ongeveer 2 minuten. Ik laat hem nog maar een keer zien, dus let goed op. {Onderzoeker start videomateriaal.}

Figure 11: Explanation about the purpose of the video material on photosynthesis

The next step for the experimental group will be the beginning of the individual phase, for which they have 10 minutes to complete. The individual phase consists of a first version of the actual assignment (making a graphical representation of photosynthesis), which every participant will execute by himself before working with their partner. Doing so, the students should bring more knowledge into the task and should be able to discuss the existing differences in their drawings. This discussion process is supposed to be enhancing the learning process (Joshi & Rosé, 2007; Teasley, 1997).

All of the participants will first complete the assignment individually, before they will be working in dyads. That way, both participants will think about the matter first before collaborating about it with their partners. This might enhance transactive behaviour, while the students are probably more eager to defend their own opinion at first. The individual assignment provides the newly grouped dyad with two (different) opinions on photosynthesis, by which the dyad has to come to a joint solution. To make sure that the assignment in the individual phase will be prosecuted individually, the students are told to separate their desks during the assignment.

To start the individual phase, the students will be presented with the text about photosynthesis. They will get the instruction to read the text carefully, and make a graphical representation like the one made about the water cycle in the previous session. This instruction is shown in figure 12.

Nu gaan jullie zelf aan de slag met fotosynthese. Het is nu de bedoeling dat jullie individueel (dus alleen, zonder hulp van je samenwerkingspartner) deze tekst gaan lezen en vervolgens dit proces gaan tekenen. Vergeet hierbij niet aan de dingen die we vorige keer geoefend hebben. Zo is het erg belangrijk om woorden en begrippen in de tekening te verwerken.

Denk aan wat we de vorige keer gedaan hebben. Lees de tekst en haal de nuttige informatie eruit. Ook hierbij geldt weer dat een fout antwoord niet bestaat. Het gaat weer helemaal om jouw invulling. Wees dus niet bang om iets op papier te zetten!

Ik deel nu de tekst uit, en dan mogen jullie beginnen. Let op: Jullie moeten deze opdracht individueel doen. Dit is erg belangrijk! Maak voor jezelf een tekening, kijk niet bij de ander. Als jullie straks klaar zijn met de tekeningen, gaan jullie die van elkaar bekijken en vergelijken. {Deelt tekst uit.}

Dit onderdeel van de middag wordt opgenomen. Ik zal tijdens dat jullie bezig zijn de apparatuur aanzetten. Probeer je niet bezig te houden met deze opnames. Ze zijn niet belangrijk. Alles wat wordt opgenomen is alleen voor mijn onderzoek en we laten het dus niet horen of zien aan andere mensen.

Ik wil jullie wel vragen om niet op de tafels te gaan tikken (enz.), omdat dat de apparaatjes niet ten goede komt.

Jullie hebben 10 minuten de tijd. Succes!

Figure 12: Instruction before the individual phase for the experimental group in Dutch

Because the students are already sitting in a dyadic group composition, and have been explained that the person next to them will eventually be their collaboration partner during the study, it is very important to explicitly mention the first task (individual drawing phase) being an individual assignment.

When the individual phase is finished, the students will be told to swap their drawings. They then will be given each two markers, red/pink and green, to review the drawing of their partner. This review consists of the identification of differences (using the red/pink marker) and commonalities (using the green marker) between the drawing of their partner and their own drawing. During this phase, which takes 5 minutes, they must be able to check their own original drawing. The explanation about this phase is shown in figure 13.

Nu jullie klaar zijn met jullie tekening, mogen jullie je tekening omruilen met die van je buurman/buurvrouw. Het is de bedoeling dat je de tekening van je partner gaat bekijken en gaat analyseren. Dit houdt in dat je gaat zoeken naar verschillen en overeenkomsten tussen jouw tekening en die van je samenwerkingspartner. Let hierbij op de belangrijke onderdelen van een tekening, zoals we dit vorige keer geoefend hebben.

Jullie krijgen van mij allemaal een rode/roze en een groene markeerstift, waarmee je de verschillen en overeenkomsten kunt gaan aangeven. De rode/roze stift gebruik je voor de verschillen, en de groene voor de overeenkomsten.

Wees kritisch! Het is niet zo dat je de tekening van de ander afkraakt of belachelijk maakt. Integendeel! Je vult de tekening van de ander aan door ook jouw mening te geven over het resultaat. Houd dus in je achterhoofd dat het niet gaat om hoe goed de tekening is, maar alleen om de door jou gevonden verschillen en overeenkomsten tussen jullie beide tekeningen.

Ik wil jullie nu allebei vragen om omstebeurt duidelijk jullie naam in te spreken in het recordertje. Zodra ik de stiften heb uitgedeeld, mogen jullie direct beginnen. Jullie hebben 5 minuten de tijd voor deze opdracht, Succes! {Deelt stiften uit.}

Figure 13: Instruction about identification differences phase to the experimental group in Dutch

When time is over, the students are instructed to share their (vision on) the drawings. Now they can have a first glance on their own reviewed drawing, while the instructor explains the next step in the study: the discussion phase. In the discussion phase the students will be cooperating with their assigned partner, and discuss the differences they found in their drawings. They will do so by using prompt cards, which should steer the discussion into a task-related communication process.

These prompt cards will ‘instruct’ the students in how to indicate and explain differences, related to the red/pink markers. They will be able to state their opinion about a certain aspect of the drawing by asking why their partner drew it, or why their partner drew it the way he or she did. And they will be able to defend themselves. By using the cards, they will be steered in the right direction.

To integrate the prompt cards into the study, it is shaped as a game. In this game the students are provided with three prompt cards, which they have to 'play' during the discussion phase. They both receive a desk with the same three cards, which are sequenced. See figure 14 (a and b) for the three cards in English and Dutch.

Prompt card	Text
1	Would you please explain to me why you drew or did not drew...
2	I drew ... differently, because...
3	We should draw ... differently, that is...

Figure 14a: Prompt cards in English

Prompt card	Text
1	Wil je me alsjeblieft uitleggen waarom je ... wel of niet getekend hebt?
2	Ik heb ... anders getekend, omdat...
3	Wij zouden ... anders moeten tekenen, namelijk...

Figure 14b: Prompt cards in Dutch

The students will each receive a deck of three cards. After this, the cards and the game will be shortly explained. They will be told that they can use the three cards during discussing the drawings, that they have to discuss all selected differences on their drawings, and will have to draw their concessions into a joint drawing of the photosynthesis process. The explanation of the entire discussion phase, and the recording material, is shown in figure 15, and will take 10 minutes.

We gaan nu beginnen met het samenwerkingsgedeelte. Maar voordat we hiermee gaan beginnen, zal ik jullie even kort uitleggen wat precies de bedoeling is.

Jullie gaan samen met je samenwerkingspartner een tekening maken over fotosynthese. Hierbij overleggen jullie goed, zodat het echt een tekening van jullie tweeën wordt. Jullie moeten aan het einde van de middag vol overtuiging kunnen zeggen dat het een tekening van jullie beiden is. Het is hierbij de bedoeling dat de tekening zo duidelijk en compleet is dat deze gebruikt kan worden om het fotosyntheseproces uit te kunnen leggen aan kinderen van jullie eigen leeftijd. Ook aan kinderen die nog niets over fotosynthese weten. Met andere woorden: aan de hand van jullie tekening moet een korte presentatie kunnen geven waarin fotosynthese zo goed mogelijk wordt uitgelegd. Denk hierbij aan de dingen zoals we die de vorige keer geoefend hebben, zoals het gebruiken van woorden en begrippen in de tekening.

Om nu een tekening van jullie samen te maken, gaan jullie nu de resultaten van de vergelijkingsopdracht bespreken. Wat gaan we nou precies doen: Jullie hebben allemaal drie kaartjes gekregen met een tekst erop. Deze kaartjes gaan jullie gebruiken tijdens het bespreken van de verschillen in jullie tekeningen. Speel de kaarten elke keer opnieuw als je een nieuw onderdeel van de tekeningen gaat bespreken. Het is de bedoeling dat alle drie de kaarten bij elk onderdeel gespeeld worden. Ik zal jullie nu laten zien hoe de kaarten gebruikt worden. {Geeft met voorbeeld weer hoe de kaarten gespeeld moeten worden.}

Ik wil nog een keer benadrukken dat jullie niet bang hoeven te wezen om een andere mening te hebben dan je partner. Het is beter om iets een keer extra te bespreken, dan zomaar in te stemmen met de ideeën van een ander. Als jullie enkel instemmen met de ander en niet discussiëren, helpen jullie elkaar niet. De bedoeling van deze discussie is dat jullie het uiteindelijk per tweetal eens worden over een gezamenlijke tekening over fotosynthese die jullie gaan maken.

Jullie krijgen van mij een nieuw vel papier om deze gezamenlijke tekening te maken. Het is hierbij de bedoeling dat die tekening gebruikt kan worden om fotosynthese te kunnen presenteren en kunnen uitleggen aan een groep. De tekening moet dus zo duidelijk en uitgebreid mogelijk zijn. Denk hierbij ook aan de manier van tekenen zoals we dit de vorige keer geoefend hebben, zoals het gebruiken van woorden en begrippen in de tekening.

Kom dus per onderdeel tot een gezamenlijke conclusie. (Wel of niet in de tekening. Zo wel, waar en hoe.) Neem vervolgens die onderdelen van jullie tekeningen wel of niet op in een gezamenlijke tekening.

Als er nog vragen zijn, wil ik die graag beantwoorden. Zo niet, dan mogen jullie beginnen met de opdracht. Jullie hebben 35 minuten de tijd om gezamenlijk tot een mooie tekening te komen. Succes!

Figure 15: Explanation about the discussion phase to the experimental group in Dutch

When possible questions of the students are answered, the discussion phase can start. The students will all receive new paper, and will be set to work as soon as all the recording material is started. They will be told that they get 45 minutes to complete their joint drawing.

When the discussion is not progressing or progressing difficult, the students should be told that it is important to find and discuss differences. Even the very insignificant, tiny differences.

This second session will end with a post test questionnaire. The questionnaire will consist of questions about the students' experience with the collaboration, their satisfaction with their partner, and questions that measure individual knowledge acquisition (cued and open recall). The students will get 10 minutes to answer the questions. The instruction about the questionnaire is shown in figure 16.

Tot slot wil ik jullie vragen om nog wat vragen voor mij in te vullen. Dit zijn de laatste.

In deze vragenlijsten wordt jullie gevraagd naar een aantal dingen waar al eerder vragen over zijn gesteld. Voor dit onderzoek is het belangrijk dat jullie deze vragen nogmaals zo eerlijk mogelijk beantwoorden. Het is niet de bedoeling dat jullie bij elkaar kunnen meekijken, dus ik wil jullie vragen om jullie tafeltjes een stukje uit elkaar te schuiven. {Wijziging klassenindeling.}

Goede en foute antwoorden bestaan niet. Het gaat alleen om jouw mening. Niemand krijgt de antwoorden te zien, dus je kunt alles naar waarheid invullen.

Jullie krijgen weer 10 minuten de tijd. Succes!

Figure 16: Explanation about posttesting questionnaire to the experimental group in Dutch

Second session for the control group

The second session for the control group is much less complex than the session of the experimental group. Although the students in the control group receive the same global assignment as the experimental group, e.g. making a joint graphical representation about the process of photosynthesis, they will not get any side instructions. This session contains of a (short) refresher of the training given in the first session, and a collaborative drawing phase. This phase will last 103 minutes in total.

The instruction beforehand will start with a reminder of the first session, similar to the instruction for the experimental group. This instruction is given in order to let the students remember what they are participating in. Furthermore, an explanation will be given about the importance and schedule of this second session. This explanation is written out in figure 17.

Hallo allemaal. Vandaag gaan we verder met het tweede (en laatste) deel van mijn onderzoek. Zoals jullie waarschijnlijk nog weten, had ik beloofd om na een paar weken nog een keer langs te komen om samen met jullie verder aan de slag te gaan met een dit project.

Ik zal even kort herhalen waar het onderzoek over gaat. Ik doe onderzoek naar hoe kinderen het beste een bepaald vak kunnen leren. Ik ben benieuwd naar: 'hoe jullie leren over een onderwerp als fotosynthese. Ik kijk hoe jullie samen met een klasgenootje met dit onderwerp aan de slag gaan en hoe jullie daarbij een tekening van dit onderwerp gaan maken.'.

Daarom gaan we vandaag weer aan de slag. Deze keer werken we in tweetallen en met het onderwerp fotosynthese. Wat fotosynthese ook alweer precies is, zie je straks in het materiaal. Voor aanvang van deze middag heb ik jullie in tweetallen ingedeeld. Dat was ook de reden waarom jullie moesten gaan zitten bij je naamkaartje. Je klasgenoot naast je is jouw samenwerkingspartner voor vanmiddag. Ik wil zien hoe jullie samenwerken, ook hoe jullie werken in groepen waarin jullie normaal niet werken. Ik wil graag zien hoe jullie werken met verschillende klasgenoten.

Het programma voor vanmiddag ziet er als volgt uit: we beginnen met een korte vragenlijst, waarna we aan de slag gaan met fotosynthese. Bij dit laatste onderdeel zal ik gebruik maken van opnameapparatuur. Zowel een videocamera {Onderzoeken wijst videocamera aan}, als geluidsopname. Er zullen straks kleine apparaatjes op jullie tafel worden gelegd. Deze gaan jullie gesprek opnemen, zodat ik later terug kan luisteren naar wat jullie gezegd hebben tijdens het doen van de opdracht.

De videocamera voor in de klas is er om later eventueel te kunnen terugzien of alles goed gegaan is. Probeer je niet bezig te houden met deze opnames. Ze zijn niet belangrijk. Alles wat wordt opgenomen is alleen voor mijn onderzoek en laat ik dus niet horen of zien aan andere mensen die daar niets mee te maken hebben.

Figure 17: Explanation beforehand to the control group in Dutch

After this, a short refreshment of the training (as provided in the first session) is given. This consists of a short explanation of how to find the main concepts and relations in a text, and second look at a drawing like that of the first session. Because the control group should not be explained that they have to make a similar drawing about the process of photosynthesis, they will not be notified. But to guarantee a similar study environment, the students in the control group should receive the same refreshment of the training as the experimental group. The introduction and refreshment will take 5 minutes in total. Figure 18 shows this refresher.

Vorige keer hebben we met zijn allen een tekening gemaakt aan de hand van een korte tekst over de watercyclus. Kunnen jullie mij vertellen hoe we dat gedaan hebben?
***
We hebben gezien dat het belangrijk is om de tekst goed te lezen en de belangrijkste begrippen eruit te halen, en deze begrippen met elkaar in verband te brengen. Met andere woorden, kijken hoe het ene begrip te maken heeft met een ander begrip.

We hebben hierbij een tekening gemaakt waarin de belangrijkste punten uit de tekst naar voren kwamen. Het werd een tekening die het gehele verhaal in afbeeldingen en pijlen beschreef. {Onderzoeker laat de tekening zien, en wijst de belangrijke aspecten aan op de tekening.}

Figure 18: Refresher of the training in the first session to the control group

After giving the explanation and refreshment, as illustrated above, the session will continue with a short questionnaire about the students' expectations of the collaboration, their satisfaction with their collaboration partner, and a short cued recall list concerning the photosynthesis subject. Figure 19 shows the corresponding explanation to the students, which also shows them that they have 10 minutes to complete answering the questions.

Voordat we vandaag met het hoofdprogramma beginnen, wil ik jullie weer vragen om een paar vragen in te vullen. Dit duurt een paar minuten. Er zal gevraagd worden naar jouw mening, en je zult gevraagd worden naar jouw kennis over fotosynthese.

Het is de bedoeling dat jullie deze vragen voor jezelf invullen en niet overleggen en/of kijken bij een ander. Al jouw antwoorden blijven anoniem. Niemand anders zal deze te lezen krijgen.

Jullie hebben hiervoor 10 minuten de tijd. Succes!

Figure 19: Explanation about questionnaire to the control group in Dutch

Before starting the next phase of the study, the students will be shown the animation/movie of photosynthesis ones more, to refresh their memory. This animation/movie will take about 2 or 3 minutes.

Vorige keer heb ik jullie al laten kennismaken met fotosynthese. Jullie hebben toen een tekst gelezen welke fotosynthese uitlegt, en daarna een filmpje bekeken omdat het waarschijnlijk nog beter te begrijpen is als je het proces ook kunt bekijken.

We gaan dit filmpje nu nog eens bekijken. Daarna gaan jullie zelf met het onderwerp aan de slag. Dit filmpje duurt ongeveer 2 minuten. Ik laat hem nog maar een keer zien, dus let goed op. {Onderzoeker start videomateriaal.}

Figure 20: Explanation about the purpose of the video material on photosynthesis

After showing the video material about photosynthesis, a short break is scheduled. This break enables the students to focus their attention to something else, while the researcher can prepare and start the recording material for the subsequent collaborative phase. So, the researcher(s) will walk around, start the recording devices and explains to the students not to touch the material.

Ik zet het opname apparaatje aan. Het is de bedoeling dat jullie hier niet aan komen. Ik zal zometeen de volgende opdracht uitleggen, en dan zullen we eindelijk beginnen met de samenwerking.

Figure 21: Explanation about the recording material to the dyads

After the short break, all the students will first read the text about photosynthesis individually, before they will be working in dyads. That way, both participants will think about the matter first before collaborating about it with their partners. This might enhance transactive behaviour, while the students might probably more eager to defend their own opinion at first.

To let the students explore the text and subject by themselves first, they will read the text about photosynthesis separately before engaging in the collaborative drawing task. They het 15 minutes to read the text, and make notes/drawings/etc. Furthermore, the students will be given the opportunity to process the material by themselves before starting with the collaboration. Unlike the experimental group, they will not receive direct instructions to draw a representation of photosynthesis, but they may do so. They will be advised to make notes during reading. How they will shape these notes is entirely up to them.

So, the next step for the control group will be the beginning of the collaborative drawing phase. They will be explained that they will have to work together with their partner, in that they will have to make a joint graphical representation of the process of photosynthesis. The students will be told that they have 60 minutes to finish the joint drawing.

Because the students are already sitting in a dyadic group composition, and have been explained that the person next to them will eventually be their collaboration partner during the study, it is just necessary to explain the assignment to them. The explanation of the collaborative drawing phase, and the recording material, is shown in figure 22.

We gaan nu beginnen met het samenwerkingsgedeelte. Maar voordat we hiermee gaan beginnen, zal ik jullie even kort uitleggen wat precies de bedoeling is.

Jullie krijgen zo meteen een tekst over fotosynthese. Het is de bedoeling dat je die tekst goed leest. Jullie krijgen hierbij van mij pen, potloden, markeerstiften en papier, zodat je hierbij aantekeningen, enzo kunt maken. Vervolgens gaan jullie samen met je samenwerkingspartner een tekening maken over fotosynthese. Hierbij overleggen jullie goed, zodat het echt een tekening van jullie tweeën wordt. Jullie moeten aan het einde van de middag vol overtuiging kunnen zeggen dat het een tekening van jullie beiden is.

Het is de bedoeling dat de tekening zo duidelijk en compleet is dat deze gebruikt kan worden om het fotosyntheseproces uit te kunnen leggen aan kinderen van jullie eigen leeftijd. Ook aan kinderen die nog niets over fotosynthese weten. Met andere woorden: jullie moeten aan de hand van jullie tekening een korte presentatie kunnen geven waarin fotosynthese zo goed mogelijk wordt uitgelegd. Denk hierbij aan de dingen zoals we die de vorige keer geoefend hebben, zoals het gebruiken van woorden en begrippen in de tekening.

Dit onderdeel van de opdracht wordt opgenomen. Zoals jullie gezien hebben heb ik de apparatuur net aangezet. Probeer je niet bezig te houden met deze opnames. Ze zijn niet belangrijk. Alles wat wordt opgenomen is alleen voor mijn onderzoek en we laten het dus niet horen of zien aan andere mensen.

Ik wil jullie wel vragen om niet op de tafels te gaan tikken (enz.), omdat dat de apparaatjes niet ten goede komt. {Zet recorders en video aan.}

Als er nog vragen zijn, wil ik die graag beantwoorden. Zo niet, dan wil ik jullie vragen om allebei om de beurt je naam duidelijk in het apparaatje in te spreken. Dan mogen jullie nu beginnen met de opdracht. Jullie hebben 35 minuten de tijd om gezamenlijk tot een mooie tekening te komen.

Figure 22: Explanation about collaborative drawing phase to the control group in Dutch

When the possible questions of the students are answered, and all the students read the text and had time to make notes of make a drawing of their own, the collaborative drawing phase can start. The students will all receive paper, and will be set to work as soon as all the recording material is started.

This second session will end with a post test questionnaire. The questionnaire will consist of questions about the students’ experience with the collaboration, their satisfaction with their partner, and questions that measure individual knowledge acquisition (after the assignment). The students will have 10 minutes to finish answering the questions. The instruction about the questionnaire is shown in figure 23.

Tot slot wil ik jullie wederom vragen om een korte vragenlijst voor mij in te vullen. Dit is de laatste.

In deze vragenlijst wordt jullie gevraagd naar een aantal dingen waar al eerder vragen over zijn gesteld. Voor dit onderzoek is het belangrijk dat jullie deze vragen nogmaals zo eerlijk mogelijk beantwoorden. Het is niet de bedoeling dat jullie bij elkaar meekijken.

Goede en foute antwoorden bestaan niet. Het gaat alleen om jouw mening. Niemand krijgt de antwoorden te zien, dus je kunt alles naar waarheid invullen.

Jullie krijgen weer 10 minuten de tijd. Succes!

Figure 23: Explanation about post testing questionnaire to the experimental group in Dutch

To end the second session, the students will be thanked for participating and contributing to the research. After this, some questions will be asked to the class. These questions attend their experiences with the research, and their idea about the purpose of the research. This comversation with the class is shown in figure 24.

Dit was het voor vandaag. Ik wil jullie heel erg bedanken voor jullie deelname aan mijn onderzoek! Jullie hebben mij en het onderzoek heel erg geholpen.

Ik ben ook erg benieuwd naar wat jullie van de twee middagen dat ik jullie bezocht heb, hebben gevonden.

- *Wat vonden jullie van de eerste middag? En van de tweede?*
- *Hebben jullie het idee wat geleerd te hebben?*
- *Wat vonden jullie het leukste? En het minste leuke?*
- *Zouden jullie nog wel eens aan zoiets mee willen doen?*
- *Waar denken jullie dat het onderzoek over gaat?*

***

Tot slot zal ik jullie nog even kort vertellen waarom ik jullie heb laten samenwerken in tweetallen. Ik ben benieuwd naar hoe jullie leren door samenwerken. Of het leuker is, en of jullie daardoor 'beter' leren. Daarbij ben ik ook heel benieuwd naar hoe jullie samenwerken met iemand met wie je normaal niet (zo snel) zou samenwerken. Vandaar dat ik de indeling heb gemaakt, en niet jullie zelf.

Mochten jullie nou reuze nieuwsgierig zijn geworden naar de uitkomsten van dit onderzoek… Als jullie het leuk vinden, zal ik contact opnemen met jullie meester/juf over de resultaten. Hij/Zij kan jullie dan vertellen hoe het allemaal afgelopen is. Ik moet er wel bijzeggen dat het nog wel even kan duren voordat er iets bekend is. Zodra ik iets weet, beloof ik het gelijk door te geven aan jullie meester/juf.

Nou, heel erg bedankt! En tot ziens!

Figure 24: Word of thanks, interview and explanation about the research to the class

Time plan of the second session			
Experimental group (Scripted condition)		*Control group (Non-scripted condition)*	
Phase	Time	Phase	Time
Introduction, and refresher of the training (from the first session)	10 min.	Introduction, and refresher of the training (from the first session)	10 min.
Questionnaire (pre)	10 min.	Questionnaire (pre)	10 min.
Animation/movie photosynthesis	2/3 min.	Animation/movie photosynthesis	2/3 min.
Individual phase	10 min.	Collaborative drawing phase (incl. explanation)	35 min.
Identifying differences phase	5 min.		
Discussion and collaboration phase (incl. explanation)	20 min.		
Questionnaire (post)	10 min.	Questionnaire (post)	10 min.
	Total: 68 minutes		Total: 68 minutes

Table 2: Time plan of the second session

Appendix III – Coding scheme Discourse analysis

Coding rules Audio Segmentation

To analyze the audio fragments of this study, and make sure that inter-rater reliability will occur, a scoring system is developed. This system focuses on two major coding dimensions: Epistemic and Social mode. The scheme is based on an coding scheme by Weinberger, Fischer and Mandl (2002).

The coding in this study is interconnected to the coding schemes of the drawings and the answering of the open recall question on the photosynthesis process. With this, the identified concepts and processes of the photosynthesis process are playing a major role in coding (see Table 1 and 2). It is therefore important to keep this in mind while coding; the content analysis of the audio fragments is important to compare the outcomes of the collaboration process to the knowledge acquisition results. To do this, coding will take place on the two tiers. The epistemic tier shows the content of the talk, and the social mode tier shows the way of expression and conversation style of the talk. Together, these tiers will explore the content of the collaboration process.

The segmenting will occur by means of the social mode categories. This will help determining and measuring the transactivity in the process, and the course of the process best.

Concepts
(Groene) planten
Zuurstof
Zonlicht
Water
Kool(stof)dioxide
Suiker
Wortels
Stengels
Bladeren
Bladgroenkorrels
Lucht
Huidmondjes
Grond

Table 1: Concepts of the photosynthesis process

Processes
Met de wortels haalt een plant water uit de grond
Van de wortels gaat het water naar de stengel
Vervolgens gaat het water van de stengels naar de bladeren
Kool(stof)dioxide wordt door de huidmondjes in de bladeren opgezogen
Bladgroenkorrels in de bladeren vangen het licht op
Zuurstof wordt gemaakt door planten en verdwijnt als afval door de “schoorsteen” (de huidmondjes) naar buiten

Table 2: Processes of the photosynthesis process

Basic act

To start with, the audio fragment will be segmented by means of the basic act-dimension. This dimension defines the phases in the audio fragment, by means of discriminating between different speakers, silence, the unidentified speaker, and other (indefinable) situations (see Table 3).

Basic act	
A	Speaker A talking
B	Speaker B talking
AB	Both talking
S	Silence
O	Other
U	Unidentified speaker

Table 3: Categories of the basic act-dimension

While segmenting the audio file, it is important to keep in mind a certain hierarchy of importance. Using this hierarchy will help discriminating the different basic act-categories.

1. Decide if the fragment is a 'silence' or a spoken item. If it is a silence, code it as 'silence' (S). If not, continue with the next step.
2. Decide if one (or both) of the two speakers is talking, or that it is somebody else. If it is somebody else, code it as 'other' (O). If it is one of the two speakers, decide if they are talking to each other or to another, interfering person. If they are talking to someone else, code 'other' (O). If they are talking to each other, continue with step 3.
3. Decide which of the speakers is talking, or that they are talking simultaneously. If speaker A is talking, code 'speaker A talking'(A). If speaker B is talking, code 'speaker B talking'(B). If both speaker A and B are talking, code 'Both talking (AB). Problems could occur when segmenting a fragment in which both speakers are talking. When there is clear evidence for overlap between the talking, segment it as 'Both talking' (AB). Although, when there is evidence for a clear turn taking between the speakers, you can code the speakers separately. When not able to discriminate between the speakers, but there is real certainty about the fact that one of them is actually talking, code 'unidentified speaker' (U).

Speaker A talking

This category will be selected in case of recognizing that the speaker, determined as speaker A, is talking. (If not sure, then select category 'unidentified speaker'.)

Speaker B talking

This category will be selected in case of recognizing that the speaker, determined as speaker B, is talking. (If not sure, then select category 'unidentified speaker'.)

Both talking

This category will be selected in case of recognizing that both speakers, determined as speaker A and B, are talking. When coded with this category, the actual talk by the separate speakers will be determined on the Speaker A tier and Speaker B tier. This will be done by selecting the piece of the segment, dedicated to the specific talk of that speaker. This way, the time spent talking and the content of the talk could be coded separately for both speakers.

Silence

This category will be selected in case of recognizing a silence between two talking fragments of the speakers; in case of recognizing a silence. This category will only be selected if there is certainty about the failing of talking of (one of) the speakers to occur. When coded on this category, the fragment does not need coding on the social mode and epistemic dimensions.

N.B. A fragment can only be segmented as a silence when it lasts at least 0,5 second.

Other

This category will be selected in case of recognizing that the speakers are talking to somebody else besides their collaborative partner, like the supervisor of the study, their teacher, or a classmate. When coded on this category, the fragment does not need coding on the social mode and epistemic dimensions.

Unidentified speaker

This category will be selected in case of an unidentifiable speaker. In this case the coder has not to be sure that the speaker is one of the determined speakers (A or B) though. You should select this category if it is impossible to discriminate the speaker, or if it is impossible to discriminate if one of the two speakers is speaking at all. (If the speaker could be identified, but the content of what he/she is saying is unidentifiable, the speaker should be coded followed by the 'uncodable-category' of the epistemic dimension.)

Epistemic mode

After segmenting the audio fragment into different sections, these sections will be coded according to the epistemic dimension. The epistemic categories show the content of the 'talking'. With this, the question "What is the content of the conversation?" will be answered.

Differentiation could be made between concept definition, process definition, concept-process connection, off-task talk, drawing coordination, paraverbal utterance, unspecified references (to the drawing), and uncodable (see Table 2).

Epistemic	
CN	Concept naming
CD	Concept definition
P	Process definition
CP	Concept-process connection
O	Off-task talk
D	Coordination
PVU	Paraverbal utterance
UR	Unspecified references
UN	Uncodable

Table 4: Categories of the epistemic dimension

While coding the segments on the basic act tier, it is important to keep in mind a certain hierarchy of importance. Using this hierarchy will ease the coding process.

1. Listen to the segment and see if it is codable/understandable, or not. If it is uncodable, code ‘Uncodable’ (U). If it is codable, continue with the next step.
2. Listen to the segment and decide whether the talk is on-task or off-task. If it is off-task, code ‘Off-task talk’ (O). If not, continue with the next step.
3. Listen to the segment and decide on the talk being about the concepts/processes, or not. If it is, make a distinction between process and concept. If it is about a process, decide whether it is focused on the process alone (Process definition; P) or on a connection between a concept and a process (Concept-process connection; CP). If it is about a concept, decide whether the speaker is just naming the concept (Concept naming; CN) or if the speaker is elaborating on the concept (Concept definition; C). If the talk is not focused on a concept or a process, continue with the next step.
4. Decide if it is clear what the talk is referring to. If not, code ‘unspecified references’ (UR).
5. Decide it the talk is focused on the execution of the task. If so, code ‘coordination’ (D).
6. If you can’t place the talk/sound the speaker is making, code ‘paraverbal utterance’(PVU).

Concept naming

This category will be selected when a concept is mentioned in an audio fragment.

N.B. This concept has to be presented in Table 1.

E.g.: *“Laten we huidmondjes in het rood tekenen.”*

Concept definition

This category will be selected when the speaker(s) elaborate on an concept, instead of only just mentioning the concept..

N.B. This concept has to be presented in Table 1.

E.g.: “*Ik denk dat huidmondjes op de tekening moeten komen.”*

Process definition

This category will be selected when the content of the talk focuses on one of more processes of the photosynthesis process.

N.B. This process has to be presented in Table 2.

E.g.: *"De plant zuigt de koolstofdioxide op."*

Concept-process connection

This category will be selected when the content of the talk focuses on the connection between a concept and a process.

N.B. The concept and process have to be presented in Table 1 and 2.

E.g.: *"Ik denk dat de huidmondjes ervoor zorgen dat de plant koolstofdioxide opzuigt."*

Off-task talk

This category will be selected in case the content of the talk is not related to the subject or the task. If a fragment is coded as off-task talk on the epistemic dimension, it should be further coded on one of two categories on the social mode dimension focusing on the amount of conflict in the fragment: 'conflict off-task talk' of 'non-conflict off-task talk'.

E.g.: *"Ik wil ook zo'n mp3-speler die geluid op kan nemen."*

Coordination

This category will be selected in case the speaker(s) talk about the realization of the task and the joint drawing. If the coordination talk focuses on the content of the photosynthesis process, by mentioning one or more concepts of process, the categories 'concept definition', 'process definition', or 'concept-process connection' should be selected.

E.g.: *"Het is nu jouw beurt om de kaartjes te gebruiken." "Zullen we blauw gebruiken om water te tekenen?"*

Paraverbal utterance

This category will be selected when the speaker(s) show indefinable utterances, like giggling, humming, or sighing. Even though this utterance could be seen as a reaction to foregoing talk, because this can never be certified this category will be chosen.

E.g.: *"Hihi'. 'Pfff.."*

N.B. When this category is selected, the same category can be selected at the social mode dimension.

Unspecified references

This category will be selected when the speaker refers to something (specific) on the drawing. This could both be superficial or content-wise, but is not clear due to the exertion of determiners.

E.g.: *"Waarom heb jij dit getekend?"*

Uncodable

This category will be selected when the paraphrased segment is not clear/understandable. When using this category to code a segment, coding on the social mode will also be 'uncodable'.

Social mode

After segmenting the audio fragment into different sections, these sections will be coded according to the social mode dimension. This dimension focuses on the transactivity of the conversation; are the speakers interested in each other's opinion, and most important do the speakers integrate or criticize each other's opinion? With this, differentiation could be made between externalization, elicitation, agreeing, disagreeing, integrating, elaborate critiques and modifications, conflict off-task talk, non-conflict off-task talk (see Table 5), and uncodable.

Social mode	
Ex	Externalization/ explaining
El	Elicitation/ asking questions
A	Agreeing
D	Disagreeing
Int	Integrating
Crit	Elaborate critiques and modifications
Co	Conflict off-task talk
NCo	Non-conflict off-task talk
UN	Uncodable
PVU	Paraverbal utterance

Table 6: Categories of the social mode dimension

While coding the segments, it is important to keep in mind a certain hierarchy of importance. Using this hierarchy will ease the coding process.

1. Check the coding on the epistemic tier. If the segment was coded 'uncodable' on the epistemic dimension, code 'uncodable' (UN) on the social mode as well. If the segment was coded as ' off-task talk' on the epistemic dimension, it has to be classified as conflicting (Conflict off-task talk; Co) or non-conflicting Non-conflict off-task talk; NCo).
2. Listen to the segment and decide if the talk is a response to the other speaker, or if it is a separate externalization. If it is a response to talk of the other speaker, see if it is a agreeing or disagreeing response. When agreeing, decide between 'Agreeing' (A) and 'Integrating' (Int). When disagreeing decide between 'Disagreeing' (D) and 'Elaborate critiques and modifications' (Crit). If is not a response to the other speaker, continue with the next step.
3. Decide whether the talk is an externalization of explanation (Ex), or an elicitation/question (El).

Externalization/explaining

This category will be selected if the content of the talk focuses on the externalization of something to the other speaker, or to clear something op for themselves. It is about externalizing your knowledge.

E.g.: *"Huidmondjes zijn een belangrijk aspect van fotosynthese."*

Elicitation/asking questions

This category will be selected if the content of the talk focuses on extracting knowledge from your conversation partner. This is mostly expressed by using a question.

E.g.: *"Waarom heb je huidmondjes op de bladeren getekend?"*

Agreeing

This category will be selected in all cases of 'quick consensus building'. The speaker agrees with the partner, but not necessarily indicating understanding.

E.g.: *"Ik ben het met je eens."*

Disagreeing

This category will be selected when the speaker does not agree with the partner, without necessarily showing comprehension of the topic of discussion.

E.g.: *"Ik ben het niet met je eens."*

Integrating

This category will be selected when the content of the talk shows evidence that the speaker has learned from the partner. They take over information, and use it in their own line of argumentation. This has to be externalized and observable. It consists of an agreement with the other's opinion, including (!) a modification on the topic of talk.

E.g.: *"Het klinkt erg logisch wat je zegt. Waarschijnlijk is het waar dat huidmondjes verantwoordelijk zijn voor het opnemen van koolstofdioxide door de plant."*

Elaborate critiques and modifications

This category will be selected in case the speaker responds to the content of the talk of the partner, by criticizing or correcting the content. This has to be externalized and observable. It consists of an opinion about the other speaker's view, including (!) an elaboration on the topic of talk.

E.g.: *"Ik denk dat je geen gelijk hebt, omdat..."*

Conflict off-task talk

This category can only be selected in case of selection of the 'off-task talk category' on the epistemic dimension. When the off-task talk shows any sign of conflict between the two speakers, the fragment should be coded with this category. The meaning of conflict in this matters goes beyond disagreeing in general. Real dispute has to be the case. If it does not, see 'non-conflict off-task talk'.

Non-conflict off-task talk

This category can only be selected in case of selection of the 'off-task talk category' on the epistemic dimension. When the off-task talk shows no sign of conflict between the two speakers, the fragment should be coded with this category. With this, simple disagreement without a real argument could also be coded as 'non-conflict'. If there is an actual dispute between the conversation partners, see 'conflict off-task talk'.

Uncodable

This category will be selected when the paraphrased segment is not clear/understandable. When using this category to code a segment, coding on the epistemic mode is also 'uncodable'.

Para verbal utterance

This category will be selected when the speaker(s) show indefinable utterances, like giggling, humming, or sighing. Even though this utterance could be seen as a reaction to foregoing talk, because this can never be certified this category will be chosen.

E.g.: *"Hihi'. 'Pfff.."*

N.B. When this category is selected, the same category can be selected at the epistemic dimension.

Appendix IV – Coding scheme Drawing analysis (in Dutch)

Scoring System Drawings Photosynthesis

De analyse van de tekeningen over fotosynthese worden top-down benaderd. De analyse zal plaatsvinden aan de hand van een lijst van concepten, processen, en eigenschappen, waarnaast gebruik wordt gemaakt van een 'expert drawing' naar aanleiding van de tekst over fotosynthese aan de hand waarvan de leerlingen een (of meerdere) tekeningen van het fotosynthese hebben gemaakt. Door middel van 21 vragen wordt bepaald of iets al dan niet gerepresenteerd is.

CONCEPTEN	PROCESSEN
(Groene) planten	Met de wortels haalt een plant water uit de grond
Zuurstof	Van de wortels gaat het water naar de stengel
Zonlicht	Vervolgens gaat het water van de stengels naar de bladeren
Water	Kool(stof)dioxide wordt door de huidmondjes in de bladeren opgezogen
Kool(stof)dioxide	Bladgroenkorrels in de bladeren vangen het licht op
Suiker	Zuurstof wordt gemaakt door planten en verdwijnt als afval door de "schoorsteen" (de huidmondjes) naar buiten
Wortels	…
Stengel	
Bladeren	
Bladgroenkorrels	
Lucht	EIGENSCHAPPEN
Huidmondjes	Zuurstof als afvalproduct van de plant
Grond	Suiker als voedingsstof van en voor de plant
…	…

Figuur 1: Concepten, processen en eigenschappen fotosynthese

Vragenlijst

Concepten

1. Is er een representatie van de plant getekend? Is deze geannoteerd?
    - (Groene) plant
2. Wordt zuurstof gerepresenteerd? Is dit geannoteerd?
    - Zuurstof
3. Wordt zonlicht gerepresenteerd? Is dit geannoteerd?
    - Zonlicht
4. Wordt water gerepresenteerd? Is dit geannoteerd?

    - Water
5. Wordt (kool)stofdioxide gerepresenteerd? Is dit geannoteerd?
    - Kool(stof)dioxide
6. Wordt suiker gerepresenteerd? Is dit geannoteerd?
    - Suiker
7. Worden de wortels gerepresenteerd? Zijn deze geannoteerd?
    - Wortels
8. Wordt de stengel gerepresenteerd? Is dit geannoteerd?
    - Stengel
9. Worden de bladeren gerepresenteerd? Zijn deze geannoteerd?
    - Bladeren
10. Is er een representatie van de bladgroenkorrels getekend? Is deze geannoteerd?
    - Bladgroenkorrels
11. Wordt lucht gerepresenteerd? Is dit geannoteerd?
    - Lucht
12. Is er een representatie van de huidmondjes gerepresenteerd? Is deze geannoteerd?
    - Huidmondjes
13. Wordt grond gerepresenteerd? Is dit geannoteerd?
    - Grond

Eigenschappen

14. Wordt zuurstof als afvalproduct gerepresenteerd? Wordt dit geannoteerd?
    - Zuurstof als afvalproduct
15. Wordt suiker als voedingsstof gerepresenteerd? Wordt dit geannoteerd?
    - Suiker als voedingsstof

Processen

16. Haalt de plant met de wortels water uit de grond? Wordt dit geannoteerd?
    - Water wortels à grond
17. Verplaatst het water zich vanaf de wortels naar de stengel? Wordt dit geannoteerd?
    - Water wortels à stengel
18. Verplaatst het water zich vanaf de stengel naar de bladeren? Wordt dit geannoteerd?
    - Water stengel à bladeren
19. Zuigen de bladeren (via de huidmondjes) kool(stof)dioxide op? Wordt dit geannoteerd?
    - Kool(stof)dioxide bladeren (huidmondjes)
20. Vangen de bladeren (via de bladgroenkorrels)het licht op? Wordt dit geannoteerd?
    - Bladeren licht (bladgroenkorrels)
21. Verdwijnt zuurstof als afval door de “schoorsteen” van de plant (de huidmondjes) naar buiten, en is dit het product van de plant? Wordt dit geannoteerd?
    - Zuurstof huidmondjes à buiten

Coderingsregels

- Algemeen à Alle concepten, eigenschappen, en processen worden gelijk gewaardeerd.

- Algemeen **à** Een proces hoeft niet per se afgebeeld te worden aan de hand van een pijl (mág wel), zolang maar duidelijk is dat het proces afgebeeld is (dit mag/kan bijvoorbeeld ook aan de hand van een annotatie). Wanneer het echter door het ontbreken van de pijl niet duidelijk wordt wat er bedoeld wordt, dan wordt dit niet als het proces in kwestie beoordeeld.
- Algemeen **à** Een representatie in de vorm van een afbeelding moet wel duidelijk zijn en ergens op slaan. Zo niet, dan wordt het niet goedgekeurd. Ook niet wanneer de annotatie aangeeft wat het getekende zou moeten zijn. *Representaties moeten geen betekenis worden gegeven door de beoordelaar, maar moeten voor zich spreken.*
    - Bijv. Wanneer wortels getekend zijn en er staat stengel bijgeschreven, dan klopt dit niet. Of wanneer er geen onderscheid gemaakt kan worden tussen bladeren of bladgroenkorrels.
- Algemeen **à** De annotatie moet duidelijk met de representatie verbonden zijn. Het is dus niet voldoende als de annotatie zomaar ergens op het blad staat geschreven. Hiermee kunnen we niet aantonen of bedoeld is dat deze 'het getekende annoteert'.
- Vraag 1 **à** Er moet tenminste één plant getekend zijn. Andere vegetatie, zoals een boom of een bloem, kunnen op dezelfde manier worden geclassificeerd. Dit geldt zowel voor beide representatievormen.
- Vraag 2 **à** Zuurstof is niet zichtbaar in fysieke vorm, dus mag ook worden weergegeven aan de hand van een annotatie.
- Vraag 3 **à** Alleen een afbeelding van een zon is niet voldoende. Wanneer alleen de 'zon' geannoteerd wordt, is dit ook niet voldoende. 'Zonlicht' zelf moet ook worden geannoteerd. De zonnestralen moeten worden zijn weergegeven aan de hand van pijlen, of lange (gerichte) lijnen.
- Vraag 4 **à** Het maakt niet uit waar het water vandaan komt en in welke vorm het wordt weergegeven. Zo is regen ook een goede representatie, en voldoet een annotatie ook aan de eisen.
- Vraag 5 **à** Kool(stof)dioxide is niet zichtbaar in fysieke vorm, dus mag ook worden weergegeven aan de hand van een annotatie.
- Vraag 6 **à** Suiker mag ook worden weergegeven aan de hand van een annotatie.
- Vraag 10 **à** De bladgroenkorrels hoeven niet op elk blad te zijn gerepresenteerd.
- Vraag 11 **à** Lucht is niet zichtbaar in fysieke vorm, dus mag ook worden weergegeven aan de hand van een annotatie. De verwijzing 'wind' is hierbij niet afdoende. Dit is namelijk niet hetzelfde, en wordt ook niet genoemd in de tekst.

- Vraag 12 **à** De huidmondjes hoeven niet op elk blad te zijn gerepresenteerd.
- Vraag 14 **à** Omdat dit waarschijnlijk niet makkelijk af te beelden is in de tekening, wordt een annotatie ook goed gerekend als representatie.
- Vraag 15 **à** Omdat dit waarschijnlijk niet makkelijk af te beelden is in de tekening, wordt een annotatie ook goed gerekend als representatie.
- Vraag 19 **à** Kool(stof)dioxide moet door de plant worden opgenomen. Hierbij hoeven niet specifiek de huidmondjes voor worden gebruikt.
- Vraag 20 **à** Zonlicht moet in dit geval gericht zijn op de bladeren/plant, niet per se op de bladgroenkorrels.
- Vraag 21 **à** 'Schoorsteen' hoeft niet als zodanig benoemd te worden. Als het proces dat zuurstof door de plant (via de huidmondjes) naar buiten gaat gerepresenteerd is, is dit voldoende.

Appendix V – Coding scheme Drawing comparison

Comparison drawings

To code the comparison phase of the drawings, the individual drawings of the experimental group students will be counted. To differentiate correctly between similarities and differences, these aspects will be coded differently. Where as a pink marker has been used to identify the differences between the drawings of the collaboration partners, and a green marker has been used to identify the similarities between the drawings, these feature s will be coded differently as well.

When a concept, property or process has been identified as similar, by using the green marker, this aspect will be coded with '1'. When a concept, property or process has been identified as different, by using the pink marker, this aspect will be coded with '2'. When a concept, property or process has not been perceived as a difference or similarity, the aspect will be coded with '0'.

Coding rules

- The coding of the concepts will start with identifying if the concepts are present in the drawing. If present, the concepts that are judged as similar (green marker) of different (pink marker) will be identified. If a concept is marked green, this means that the student rated this as similar to his/her own drawing. This concept will then be coded with '1'. If a concept is marked pink, this means that the student rated this as different from his/her own drawing. This concept will then be coded with '2'.
- The concepts that are not present in the drawing could have been marked as similar or different to the coder's own drawing as well. If a student marked an empty spot on the drawing as similar of different, this will be coded as so – by coding the concept with '1' if similar or '2' if different.
  - For the students to identify a missing concept as similar, they had to be aware of it missing in their own drawing as well. This will probably not occur, while the student would have integrated the missing concept in his/her own drawing to begin with.
- When the concept is not present in the drawing ánd the partner did not identify this as a difference or similarity, the concept will be coded as '0'.
- The coding of the properties will start by identifying if the present properties in the drawing. If present, the properties that are judged as similar (green marker) of different (pink marker) will be identified. If a property is marked green, this means that the student rated this as similar to his/her own drawing. This property will then be coded with '1'. If a property is marked pink, this means that the student rated this as different from his/her own drawing. This property will then be coded with '2'.

- The properties that are not present in the drawing could have been marked as similar or different to the coder's own drawing as well. If a student marked an empty spot on the drawing as similar of different, this will be coded as so – by coding the property with '1' if similar or '2' if different.
    - For the students to identify a missing property as similar, they had to be aware of it missing in their own drawing as well. This will probably not occur, while the student would have integrated the missing property in his/her own drawing to begin with.
- When the property is not present in the drawing ánd the partner did not identify this as a difference or similarity, the property will be coded as '0'.
- The coding of the processes will start with identifying if the processes are present in the drawing. If present, the processes that are judged as similar (green marker) of different (pink marker) will be identified. If a process is marked green, this means that the student rated this as similar to his/her own drawing. This process will then be coded with '1'. If a process is marked pink, this means that the student rated this as different from his/her own drawing. This process will then be coded with '2'.
    - To make sure the student did mean to identify the process as similar or different and not just the concept, this needs to be checked. If any doubt occurs, this will be tested by checking the coder's drawing to see if the presumed process is present on this drawing. If not, the marking should not be identified as a similar or different process.
    - For a marking to be identified as a difference or similarity of a process, it has to be clear that the green or pink marking intended to indicate the process and not just the corresponding concept – for instance, by circling the arrows or the related concepts.
- The processes that are not present in the drawing could have been marked as similar or different to the coder's own drawing as well. If a student marked an empty spot on the drawing as similar of different, this will be coded as so – by coding the processes with '1' if similar or '2' if different.
    - For the students to identify a missing process as similar, they had to be aware of it missing in their own drawing as well. This will probably not occur, while the student would have integrated the missing process in his/her own drawing to begin with.
- When the process is not present in the drawing ánd the partner did not identify this as a difference or similarity, the concept will be coded as '0'.
- The coding of the annotations will start with identifying if the annotations are present in the drawing. If present, the annotations that are judged as similar (green marker) of different (pink marker) will be identified. If an annotation is marked green, this means that the

student rated this as similar to his/her own drawing. This annotation will then be coded with '1'. If an annotation is marked pink, this means that the student rated this as different from his/her own drawing. This annotation will then be coded with '2'.

    - For coding the annotations as different or similar, the annotations has to be marked separately. When representation and annotations are marked simultaneously, it should be obvious that the annotation was co-marked intentionally.

- The annotations that are not present in the drawing could have been marked as similar or different to the coder's own drawing as well. If a student marked an empty spot on the drawing as similar of different, this will be coded as so – by coding the annotation with '1' if similar or '2' if different.
    - For the students to identify a missing annotation as similar, they had to be aware of it missing in their own drawing as well. This will probably not occur, while the student would have integrated the missing annotation in his/her own drawing to begin with.
- When the annotation is not present in the drawing ánd the partner did not identify this as a difference or similarity, the annotation will be coded as '0'.

Appendix VI – Coding scheme Open Recall analysis (in Dutch)

Scoring System Open Recall Question Photosynthesis

De analyse van de beantwoording van de open vraag over fotosynthese worden top-down benaderd. De analyse zal plaatsvinden aan de hand van een lijst van concepten, processen, en de originele tekst over fotosynthese aan de hand waarvan de leerlingen een (of meerdere) tekeningen van het fotosynthese hebben gemaakt tijdens het onderzoek. Door middel van 22 vragen wordt bepaald of iets al dan niet gerepresenteerd is.

CONCEPTEN	PROCESSEN
(Groene) planten	Met de wortels haalt een plant water uit de grond
Zuurstof	Van de wortels gaat het water naar de stengel
Zonlicht	Vervolgens gaat het water van de stengels naar de bladeren
Water	Kool(stof)dioxide wordt door de huidmondjes in de bladeren opgezogen
Kool(stof)dioxide	Bladgroenkorrels in de blaadjes vangen het licht op
Suiker	Zuurstof wordt gemaakt door plantent en verdwijnt als afval door de "schoorsteen" (de huidmondjes) naar buiten
Wortels	Suiker wordt gemaakt door de plant voor eigen gebruik
Stengel	…
Bladeren	
Bladgroenkorrels	
Lucht	EIGENSCHAPPEN
Huidmondjes	Afvalproduct
Grond	Voedingsstof
…	…

Figuur 1: Concepten, processen en eigenschappen fotosynthese

Vragenlijst

Concepten

1. Is de plant genoemd in de beantwoording?
    - (Groene) plant
2. Is zuurstof genoemd in de beantwoording?
    - Zuurstof
3. Is zonlicht genoemd in de beantwoording?
    - Zonlicht

4. Is water genoemd in de beantwoording?
    - Water
5. Is kool(stof)dioxide genoemd in de beantwoording?
    - Kool(stof)dioxide
6. Is suiker genoemd in de beantwoording?
    - Suiker
7. Zijn de wortels genoemd in de beantwoording?
    - Wortels
8. Is de stengel genoemd in de beantwoording?
    - Stengel
9. Zijn de bladeren genoemd in de beantwoording?
    - Bladeren
10. Zijn de bladgroenkorrels genoemd in de beantwoording?
    - Bladgroenkorrels
11. Is de lucht genoemd in de beantwoording?
    - Lucht
12. Zijn de huidmondjes genoemd in de beantwoording?
    - Huidmondjes
13. Wordt de grond genoemd?
    - Grond

Eigenschappen

14. Wordt zuurstof als afvalproduct benoemd?
    - Zuurstof als afvalproduct
15. Wordt suiker als voedingsstof benoemd?
    - Suiker als voedingsstof

Processen

16. Wordt beschreven dat de plant met de wortels water uit de grond haalt?
    - Water grond à wortels
17. Wordt beschreven dat het water zich vanaf de wortels naar de stengel verplaatst?
    - Water wortels à stengel
18. Wordt beschreven dat het water zich vanaf de stengel naar de bladeren verplaatst?
    - Water stengel à bladeren
19. Wordt beschreven dat de planten met de bladeren (via de huidmondjes) kool(stof)dioxide opzuigen?
    - Kool(stof)dioxide bladeren (huidmondjes)
20. Wordt beschreven dat de bladeren (via de bladgroenkorrels) het licht opvangen?
    - Bladeren licht (bladgroenkorrels)
21. Wordt beschreven dat zuurstof als afval door de “schoorsteen” van de plant (de huidmondjes) naar buiten verdwijnt; dat zuurstof het product is van de plant?
    - Zuurstof huidmondjes à buiten
22. Wordt beschreven dat suiker wordt aangemaakt door de plant als voedingsstof voor de plant zelf?
    - Plant maakt suiker

Coderingsregels

- Algemeen **à** Aan bovenstaande vragen wordt alleen voldaan als de beantwoording heeft plaatsgevonden in volledige zinnen. Het enkel opschrijven van woorden telt niet als een correcte beantwoording.
- Algemeen **à** Concepten worden alleen goedgekeurd als ze worden genoemd in een volledige zin. Of deze zin correct is, dat is niet aan de orde.
- Algemeen **à** Aangezien het hier om beschrijvingen gaat, mag een wat bredere interpretatie van de verschillende begrippen gehandhaafd worden.
- Algemeen **à** Als een concept niet goed wordt benoemd, zoals 'wind' in plaats van 'kool(stof)dioxide', mag het proces waarin dit eventueel wordt beschreven wel worden goedgekeurd.
- Algemeen **à** Alle concepten, eigenschappen, en processen worden gelijk gewaardeerd.
- Vraag 1 **à** Een plant mag ook beschreven worden als een andere vegetatievorm, zoals een bloem, een boom, of een struik.
- Vraag 3 **à** Zonlicht hoeft niet per se met het woord 'zonlicht' beschreven te worden, zolang wel duidelijk is dat het gaat om van de zon afkomstig licht. En dat het dus niet verward kan worden met andersoortig licht, zoals lamplicht.
- Vraag 4 **à** Water mag ook beschreven worden aan de hand van aan water gerelateerde begrippen, zoals regen, oceaan, zee, of rivier.
- Vraag 5 **à** Het concept kool(stof)dioxide mag op verschillende manieren naar verwezen zijn: kooldioxide en koolstofdioxide. Daarbij mag rekening worden gehouden met de relatieve onbekendheid van het woord en de moeilijkheid van het woord, waardoor eventuele verbasteringen naar eigen inzicht mogen worden goedgekeurd; zolang duidelijk is dat naar het concept kool(stof)dioxide verwezen wordt.
- Vraag 10 **à** Verbasteringen van dit concept mogen ook goed worden gerekend, zoals bladgroen, bladkorrels, of groenkorrels.
- Vraag 11 **à** Wind is niet hetzelfde als lucht.
- Vraag 12 **à** Verbasteringen van dit concept mogen ook goed worden gerekend, zoals mondjes.
- Vraag 14 **à** Het gaat hier om de benoeming van de eigenschap 'afvalstof', in combinatie met zuurstof.
- Vraag 15 **à** Het gaat hier om de benoeming van de eigenschap 'voedingsstof', in combinatie met suiker.

- Vraag 19 **à** In dit proces is het belangrijk dat de leerling heeft genoteerd dat de plant op welke manier dan ook kool(stof)dioxide opzuigt/binnenhaalt. Hierbij hoeven de huidmondjes niet specifiek benoemd te worden.
- Vraag 20 **à** In dit proces is het belangrijk dat de leerling heeft genoteerd dat de plant op welke manier dan ook zonlicht opvangt. Hierbij hoeven de bladgroenkorrels niet specifiek benoemd te worden.
- Vraag 21 **à** De schoorsteen hoeft niet specifiek benoemd te worden. Wat belangrijk is dat duidelijk wordt gemaakt dat de plant zuurstof produceert.
- Vraag 22 **à** Hierbij is het van belang dat beschreven wordt dat de plant suiker aanmaakt en voor zichzelf gebruikt als voedingsstof. Het begrip 'energie' mag in deze plaats bijvoorbeeld ook gebruikt worden, in plaats van voedingsstof.