Supporting pupils' knowledge sharing process by using a script in a collaborative context in primary education.

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Preface

The results of the master thesis contribute to research in collaborative learning in primary education. The master's thesis is the final assessment in order to successfully complete the master programme of Educational Science and Technolgy at the University of Twente. During my thesis process, I have learnt how to apply research methodology skills in educational practice and I have also learnt how to write proper scientific research. My special thanks go to Hannie Gijlers. She gave me constructive feedback and spent a lot of time and effort in the frequent meetings we have had. In addition, I would like to thank Elise Eshuis for her contributions and clear insight in my data analysis part, software programmes and the do's and don'ts in teaching the STIP module material. I would also like to thank Tessa Eysink for her critical and clear feedback and advice to improve the quality of my thesis. Furthermore, my thanks go to all schools and teachers who participated in this research in order to be able to do my research in their busy school programme. Finally, thanks to my parents, my boyfriend, and family who supported me and gave me good advice through the process. Also to my friends who gave me critical feedback about the writing procedure during the development of my thesis.

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Samenvatting

Het doel van dit onderzoek is om het kennisdelingsproces in de groepen 6, 7, en 8 in het basisonderwijs te ondersteunen door middel van een script (een instructie) binnen het samenwerkend leren. Het is belangrijk bij samenwerkend leren dat leerlingen in staat zijn om kennis te delen met anderen en om de gedeelde kennis van anderen te begrijpen, wat kan leiden tot hogere leeruitkomsten. Wanneer leerlingen samenwerken in het basisonderwijs weten ze vaak niet hoe ze effectief kennis kunnen delen. Om de kennisdeling te faciliteren is het script voorzien van sequentiële instructiestappen, zoals het stellen van vragen. De leerlingen werkten in twee lessen samen aan een STIP module met als onderwerp ‘‘het weer’’. De Jigsaw methode in de STIP module biedt het samenwerken zo aan dat iedere leerling verantwoordelijk is voor een deelonderwerp om vervolgens de deelonderwerpen over het weer uit te wisselen. Om de invloed van het script te meten, zijn de groepen verdeeld in een experimentele groep (n=67), die met het script heeft gewerkt, en een controlegroep (n=56), die zonder script heeft gewerkt. Het design van dit onderzoek is gebaseerd op convergent parallel mixed-methods methode. Dit betekent dat de beantwoording van onderzoeksvragen en de dataverzamelingsmethode zowel kwantitatief als kwalitatief is benaderd. Een belangrijk resultaat uit de kwalitatieve analyse van de gesprekken van leerlingen is, dat leerlingen uit alle groepen en competentie niveaus die met het script werken het script proberen te integreren en de kennisdeling positief beïnvloedt. Het script leidt echter niet tot hogere leeruitkomsten. Uit kwantitatieve analyse blijkt dat het script het proces van vragen stellen ondersteunt. Leerlingen stellen meer en specifiekere typen vragen wat leidt tot het delen van meer domein specifieke kennis. Tot slot blijkt uit de kwalitatieve analyse dat er twee deelprocessen binnen het kennisdelingsproces positief worden beïnvloed door het script. Dit zijn het externalisation deelproces (uitwisselen van kennis) en het elicitation process (het stellen van vragen, wat leidt tot het delen van specifiekere kennis).

Trefwoorden: Samenwerkend leren, Kennis delen, Script, Vragen stellen.

Abstract

The aim of the present study is to examine how a type of instructional support that is called a script influences the knowledge sharing process in grade 4, 5, and 6 of primary education in a collaborative context. In collaborative learning it is important that pupils are able to share knowledge and are able to understand the shared contribution of their learning partner in order to improve pupils' learning outcomes. Pupils in primary education do not always have a clear understanding of how to share knowledge effectively with their peers in a collaborative setting. In order to facilitate the knowledge sharing process, the script provided a sequence of instructions, for example asking questions. In this study, pupils collaborated according to the STIP module within the context of a series of lessons on meteorology. This Jigsaw method stimulates pupils to share information of the topic of their own expertise. The pupils were divided in groups with regard to their ability level in an experimental condition (n=67) provided with a script and control condition (n=56) that received no script. The design of the study is based on the convergent parallel mixed-methods design. In order to answer the research questions, the collection of the data (quantitative and qualitative) happened at the same time. A key finding of the present study, which was revealed by through qualitative analyses of the dialogues, is that pupils in all grade levels and ability levels in the scripted condition, made attempts to internalise or adopt the script in order to share domain-specific knowledge in a collaborative learning context. However, the script did not have an effect on pupils' learning outcomes. Quantitative analyses illustrated that the questioning in the script increased the amount and specific type of questioning in pupils' dialogue that leads to more domain-specific knowledge compared to the control group. Furthermore, qualitative analyses of the dialogues have shown that the script based on questioning influenced the externalisation (i.e., exchange of ideas) and elicitation process (i.e., asking questions to provoke additional information from collaboration partners) of the knowledge sharing process.

Key words: Collaborative learning, Knowledge sharing, Script, Questioning.

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Introduction

Collaboration is one of the skills that has always been important in education, but is becoming more important in the present information-based society. Being able to share knowledge with others and work with information that is provided by others is an important skill for pupils in primary education to develop (Bell, 2010). The results of various meta-analytic studies reveal that, when collaborative learning is successfully implemented, pupils' learning outcomes in collaborative learning arrangements often are higher than those of pupils who work individually on comparable tasks (Lou et al., 1996; Lou, Abrami, & d'Apollonia, 2001; Tolmie et al., 2010; Kyndt et al., 2013). An important prerequisite for successful collaborative learning is the extent to which pupils are able to share and explain their own ideas and are able to understand the contribution of their learning partner (Weinberger, 2003). Research indicates that not all pupils in primary schools already have a sufficient understanding of the implicit rules that guide successful communication in a collaborative learning arrangement (van Dijk, Gijlers, & Weinberger, 2013). Pupils often have difficulty in dealing with the problems that occur during the collaborative learning process, such as when pupils attempt to present their ideas as clearly as possible to their learning partner (Mercer, 1996). Therefore, support aimed at the collaborative learning processes is needed to fully exploit the benefits of collaboration. In the present study, the effect of a collaboration script that focusses on supporting knowledge sharing processes is studied within the context of a series of lessons on meteorology.

Collaborative learning

In many studies, collaborative learning is defined as follows: two or more pupils are involved in a situation in which they have to work together on a task in order to achieve the same goal (Dillenbourg, 2002; Saleh, 2005; Saab, van Joolingen, & Hout-Wolters, 2007). This definition stresses that pupils actually work towards a common goal (Dillenbourg, 2002). Collaborative learning is a well-known method in primary education as well as in secondary education (Dillenbourg, 2002; Saleh, 2005).

The results of a meta-analyses by Lou et al. (1996) and Kyndt et al. (2013) support the idea that pupils in all educational levels (i.e., primary, secondary and higher) learn more when they collaborate with their peers compared to pupils who work individually on comparable tasks. Results of other meta-analyses have demonstrated that in collaborative learning, the characteristics of the collaborative task can also affect pupils' communication and pupils' cognitive learning outcomes (Johnson, Maruyama, Johnson, Nelson, & Skon, 1981; Lou et al., 1996; Lou et al., 2001; Tolmie et al., 2010). A meta-analysis by Gegenfurtner, Veermans, and Vauras (2013) reveals that pupils' communication in collaborative learning can be increased by providing instructional support (Gegenfurtner et al., 2013).

However, an observational study by Wegerif and Scrimshaw (1997) indicated difficulties in collaboration between pupils. Wegerif and Scrimshaw (1997) observed the interaction between pupils 8 to 10 while they collaborated on a computer-supported learning task. While the pupils worked together on the task and talked during the execution of the task, for the majority of time they did not share and discuss information on a deeper level, and the amount of shared knowledge construction was rather small (Howe & Mercer, 2007). A more recent study by Mercer and Howe (2012) reveals that interactions between pupils at primary school level are rarely productive, because pupils often do not know what productive talk is exactly. In other words, pupils do not fully understand what is expected from of in terms of communication during collaborative activities (Mercer & Howe, 2012). It is remarkable that although the review studies report mainly positive effects with regard to collaborative learning in all educational levels, observational studies that are not included in the reviews often report difficulties with regard to collaborative learning in primary education. According to Dillenbourg (1999), the existing body of research in effective collaborative learning in terms of communication in primary education is smaller in comparison to secondary or higher education. Therefore, within the present study, the focus is on collaborative learning in the context of primary education.

Pupils in primary education often do not know how to collaborate successfully, as for many pupils, collaboration involves sitting in small groups and being allowed to talk (Van Dijk et al., 2013). According to Mercer (1996) there is no reason to assume that pupils are aware or understand how to deal with the incorporated processes of collaborative learning in everyday classroom situations. For example, a process where pupils often experience a problem in is the extent to which pupils are able to

share and explain their own ideas and are able to understand the contribution of their learning partner (Weinberger, 2003). When pupils receive little information about what is expected form them in a collaborative setting, this creates insecurity and behaviour that is not in line with effective collaboration (Mercer, 1996; Van Dijk et al., 2013).

Knowledge sharing

In a collaborative learning context, pupils often do not seem to realise the importance of sharing information with their peers in order to construct new information into their own knowledge (Saleh, 2005; Howe & Mercer, 2007; Saab et al., 2007). According to many studies, the definition of knowledge sharing is defined as: pupils that have different viewpoints that are brought into contact in order share their information with each other and to reconstruct the shared information in their own understanding (Mercer, 1996; Weinberger, 2003; Weinberger, Ertl, Fischer, & Mandl, 2005). A definition of knowledge sharing by Weinberger, Stegmann, and Fischer (2007) for primary school pupils is as follows: when pupils deliver their own shared ideas and information to their collaboration partners, they adopt ideas from their peers in order to construct their own knowledge.

Primary school pupils experience difficulties with regard to what the expected sequence in the knowledge sharing process is and how to exchange knowledge in a collaborative context (Mercer, 1996; Saab et al., 2007). According to Clark and Schaefer (1989), it is also difficult for primary school pupils to monitor whether their ideas have been understood correctly by their collaboration partners. In collaborative situation pupils often forget to actively check the level of understanding of their peer. If they detect insecurity or misunderstanding, they find it difficult to successfully repair this situation by giving more information or elaborated explanations (Clark & Schaefer, 1989). In another study by Clark and Brennan (1991) pupils often are not willing to expand their own efforts by explaining a shared idea extensively until their peers understand (Clark & Brennan, 1991). In other words, pupils often share the information as concisely as possible to their collaboration partners in a collaborative context, but find it difficult to provide alternative explanations or provide repeated help (Clark & Brennan, 1991). Another problem in the knowledge sharing process is that pupils do not ask questions in order to stimulate the

elaboration of the shared contribution from their collaboration partners (King, 1997; Saleh, 2005). In the knowledge sharing process, asking questions is important to generate additional knowledge about the shared concept (King, 1997). Furthermore, the regulation and coordination of the collaborative task also seems a complex process for pupils in primary education (Van Dijk et al., 2013). If the topic of the task is too complex for primary school pupils, the knowledge they are familiar with is discussed and is shared rather than that additional information is provided from the task (Fischer & Mandl, 2001). Overall, the reports of observational studies reveal that the communication in the knowledge sharing process in primary education often is of limited educational value, because when the knowledge sharing process is disturbed by one or even more of these problems, pupils' knowledge construction is inhibited (Mercer & Howe, 2012).

In order to improve the knowledge sharing process for primary school pupils, pupils have to be aware of ground rules and the five knowledge sharing sub-processes within the knowledge sharing process. Ground rules are implicit norms and expectations that are important for pupils to participate successfully in a collaborative dialogue (Mercer, 1996). These ground rules are a prerequisite, because these rules are clear and well-structured and important to internalise before pupils are actually able to share knowledge (Slof, Erkens, Kirschner, Jaspers, & Janssen, 2010). An example of a ground rule in order to understand each other's information is that that pupils need to listen carefully to each other (Saleh, 2005). These rules are investigated thoroughly in primary education and are effective for structuring interaction (Weinberger, 2003; Saleh, 2003).

The way pupils interact and respond to each other's domain-related contributions in the knowledge sharing process is important for effective knowledge sharing. According to Weinberger (2003) there are five essential sub-processes within the knowledge sharing process. When pupils are aware of these sub-processes, effective knowledge sharing is achieved (Howe & Mercer, 2007). The extent to which pupils respond to the contributions of their collaboration partner is called the transactivity in the dialogue (Weinberger, 2003). The level of transactivity is related to the five sub-processes within the knowledge sharing process. The specific order of the indicated sub-processes of knowledge sharing increases the level of transactivity within the dialogue (Weinberger, 2003). When

the level of transactivity increases, positive learning outcomes is enhanced (Gijlers, Weinberger, van Dijk, Bollen, & van Joolingen, 2013).

The first sub-process in the knowledge sharing process is the externalisation process (Weinberger, 2003; Janssen, 2008). Pupils share knowledge by exchanging (i.e., externalising) their own ideas (Weinberger et al., 2007). A prerequisite is that pupils share their knowledge and do not interrupt or react to their peers' shared contributions (Weinberger & Fischer, 2006). This externalisation process is described as the lowest level of transactivity.

The second sub-process is the elicitation process (Weinberger, 2003). After pupils externalised their knowledge, collaboration partners ask questions in order to provoke additional information from them (Weinberger & Fischer, 2006; Weinberger et al., 2007; Janssen, 2008). In the elicitation process, the level of transactivity increases, because pupils react to each other's contributions (Weinberger, Stegmann, & Fischer, 2010). The challenge in this sub-process of knowledge sharing is that pupils provoke as much information as they can receive from their peers until they have understood all shared contributions so as to prevent misunderstanding (Weinberger et al., 2010).

The third sub-process is described as quick consensus building. This quick consensus building process is related to communicative acts that refer to agreement between pupils without further exchange of domain-related information (Weinberger & Fischer, 2006). This sub-process is essential to foster knowledge sharing, because when pupils build consensus they are able to monitor their progress related to the task in order to continue with knowledge sharing activities (Weinberger, 2003; Weinberger & Fischer, 2006).

Integration-oriented consensus building is the fourth sub-process with regard to the knowledge sharing process. Pupils in this process agree knowledge and ideas form different collaboration partners (Weinberger & Fischer, 2006). An important condition is that when pupils share their information they wait for their peers to process to these ideas in order to build their own understanding (Dillenbourg, 1999; Gijlers et al., 2013). Pupils try to integrate and construct their own knowledge, because pupils actively operate on each others contribution this is a high transactive process (Weinberger & Fischer, 2006; Weinberger et al., 2007).

Finally, the fifth sub-process is the conflict-oriented consensus building (Weinberger, 2003). In this process, pupils not only rely on the reasoning and contributions from their peers, but they are also able to construct the modified shared information into their own knowledge (Gijlers et al., 2013). (Weinberger, 2003; Weinberger & Fischer, 2006). When pupils disagree about the content of the shared information they do not simply express their disagreement, but provide reasons, alternatives or modified information (Weinberger, 2003). According to Gijlers et al. (2013) conflict-oriented consensus building is associated with positive learning outcomes in a scripted condition. The last two sub-processes are the ideal state of knowledge sharing processes in primary education, because primary school pupils need knowledge sharing skills and practice to reach the highest level of transactivity that usually is developed in secondary education (Weinberger, 2003).

The overall conclusion of the effective knowledge sharing processes in a collaborative learning context is rather an exception to the rule for primary school pupils (Fischer & Mandl, 2001). Primary school pupils find it difficult: (1) to share knowledge in a collaborative context; (2) to check if their collaboration partner understood the shared information; (3) to ask domain-related questions about the shared concept; (4) to deal with the complexity of the collaborative task. It is important that pupils share information, engage in the externalisation process and elicitation process, but also actively operate on the shared knowledge by integration and conflict-oriented consensus building activities (Weinberger, 2003; Janssen, 2008). In order to deal with the problem that may arise in the knowledge sharing process, there is a need for instructional guidance in a collaborative learning context (Fischer & Mandl, 2001). In the present study, the focus is on the evaluation of instructional support. When pupils are guided by instructional support in the knowledge sharing process, pupils are able to interact with and respond to each other's domain-related contributions and their knowledge construction is influenced (Weinberger, 2003).

Support that enhance collaboration of the knowledge sharing process

Script

In collaborative learning arrangements, a script is a type of support that provides structure and sequence in pupils' learning activities and communication in order to enhance the knowledge sharing

process (Weinberger, 2003; Gijlers et al., 2013). For example, a sequence in a script stimulates pupils to externalise knowledge in a collaborative context (Slof et al., 2010). According to Dillenbourg (2002) a script can be defined as a set of instructions that guide pupils in how they should interact and collaborate in order to solve the problem. With regard to knowledge sharing process, scripts differ in their design (Weinberger, 2003). In order to establish knowledge sharing and cognitive processes in collaborative learning, a script needs to be carefully designed according to the five sub-processes of the knowledge sharing process (Weinberger, 2003; Tolmie et al., 2010). Sequenced and structured communication among primary school pupils is important with regard to the sub-processes externalisation (i.e., exchanging information) and elicitation (i.e., asking questions about the shared concept) in a script could positively influence the knowledge sharing process (King, 1997; Saleh, 2005; Saab, 2012).

The implementation of ground rules supports the effectiveness of a script, because these rules are fruitful for pupils' communication in the sharing knowledge process (Weinberger, 2003; Saleh, 2003). These ground rules are a prerequisite in establishing the sub-processes of the knowledge sharing process, because these rules are clear and well-structured and important to internalise before pupils are actually able to share knowledge (Slof et al., 2010). When ground rules are applied consistently, the regulation of the interaction in collaborative learning improves (Saab, 2012). An example of a ground rule in order to understand each other's information is that if one team member talks, the other members do not interrupt (Saleh, 2005). With regard to coordination of collaborative activities for primary school pupils, these rules are specific guidelines in how to interact that make it easier for them to solve the collaborative task (Dillenbourg, 2002; Tolmie et al., 2010). However, ground rules in collaborative learning in primary schools are rarely made explicit (Howe & Mercer, 2007). When pupils are supposed to learn together, it is often unclear of what they are expected to achieve with regard to the rules (Mercer, 1996). It may be that teachers often do not have a clear notion of what kind of strategies and rules they are trying to stimulate and for what reason (Mercer, 1996).

To enhance the effectiveness of a script, the implementation of questions in the pupils' collaborative communication is important as well. With regard to the knowledge sharing process, the second sub-process, the elicitation process, is related to questioning where pupils ask questions in order

to receive information from their collaboration partner (Weinberger & Fischer, 2006; Weinberger et al., 2007). When questioning support is given within the script, pupils are reminded to actively use their collaboration partners as a resource to gain more information (Weinberger & Fischer, 2006). A study by King (1997) reveals that the type of question influences pupils' responses in the shared knowledge that in turn affects pupils' knowledge construction. When the explainer is expected to clarify concepts and elaborate on the asked questions, this requires the explainer to present the material in a new way or generating new examples that can lead to construction of new knowledge (King, 1997). For example, factual questions suggest pupils to reproduce the information from their memory, whereas an integrated question can lead to elaboration processes (King, 1997). When pupils are assisted in asking questions, the elaboration of answers often stimulates effective communication (Gijlers, Saab, van Joolingen, de Jong, & van Hout-Wolters, 2009). King (1994) and Saleh (2005) used the peer-questioning-approach in their studies. This approach assists pupils in giving more elaborate explanations when they asked questions in order to satisfy their information needs from their peers (King, 1994; Saleh, 2005). Sample questions of the peer questioning approach can be implemented in a script in order to enhance the knowledge sharing process (King, 1997; Saleh, 2005). When pupils try to internalise the questions themselves with the aim of sharing more information, the elicitation process might improve, which has a positive effect on pupils' learning and understanding of the domain-related content (Dillenbourg, 1999; Saleh, 2005; Gijlers et al., 2013). The implementation of ground rules and asking questions in a script may fill in gaps in pupils' knowledge when additional knowledge is shared and may improve their knowledge construction (Gijlers et al., 2009).

A characteristic of a script is that it structures not only the communication but also structures the task into phases and defines roles to interfere in pupils' interaction (Dillenbourg, 2006). This is related to the third-sub-process quick consensus building of the knowledge sharing process, where coordination of the task (e.g., assigning roles and turn-taking) is important to continue with the task (Weinberger, 2003).

Scripts can lead to too much structuring of the collaborative processes that can disturb the learning process (Weinberger et al., 2005). For example, a script may interfere with pupils' personal ideas and procedures in order to complete the task (Gijlers et al., 2013). For primary school pupils,

scripts can incorporate extra activities that influence pupils' monitoring process in the collaborative process (van Dijk et al., 2013). Therefore, it is important that scripts do not interfere with their collaborative activities, but only support the knowledge sharing process within the collaborative context.

Jigsaw

In a collaborative learning setting, pupils are often confronted with a joint collaborative task that stimulates communication (Mercer, 1996). One particular type of task that facilitates collaborative learning and knowledge sharing is the Jigsaw method (Aronson, Bridgeman, & Geffner, 1978; Sangin, Molinari, Nüssli, & Dillenbourg, 2010). A Jigsaw method is shaped in such a way that pupils with different viewpoints about a topic need to collaborate in order to successfully complete the task (Dillenbourg, 2002; Howe & Mercer, 2007; Sangin et al., 2010). In a Jigsaw method, every pupil works on a specific sub-topic of a larger task (Weinberger, 2003). The pupil becomes an expert on this particular sub-topic (Aronson et al., 1978; Weinberger, 2003). In the next phase, pupils are invited to share their information on the topic of their expertise (Aronson et al., 1978; Weinberger, 2003). In other words, every pupil is responsible for their own contribution to the task (Aronson et al., 1978; Weinberger, 2003). A study by Howe and Mercer (2007) reveals that the Jigsaw method can lead to effective collaborative learning and is a stepping stone towards the knowledge sharing process.

In the present study, the STIP modules are developed by the University of Twente and Stichting Katholiek Onderwijs Enschede (SKOE) in order to enhance collaborative learning and knowledge sharing through the Jigsaw method (Hulsbeek & Eysink, 2015). Within a STIP module, information is divided among groups members and every pupil is responsible for a piece of information (Aronson et al., 1978). This is in line with the designing a collaborative task, where the task has to encourage co-operation rather than competition (Mercer, 1996). The STIP modules provide task, content, and process differentiation to stimulate interaction among pupils (Hulsbeek & Eysink, 2015). In order for pupils to construct knowledge themselves, the Jigsaw method needs to be as clear as possible to support successful collaboration (Mercer, 1996). The STIP modules are developed for primary education (Hulsbeek & Eysink, 2015). According to Mercer (1996), it is important that the information of the task is clear for the target audience in order to stimulate the knowledge sharing process.

Present study

Within the present study, a script that is focussed on knowledge sharing process is developed and evaluated. The script is implemented in a collaborative learning context that is based on the Jigsaw method. The effect of a script on pupils' learning outcomes are measured by tests. Furthermore, with regard to the knowledge sharing process, the effect of a script on questioning is determined by video analyses. Finally, qualitative analysis is used to describe how the knowledge sharing process differs between the experimental condition (i.e., with a script) and control condition (i.e., no script).

More specifically, the study focusses on the following three research questions:

1. What is the effect of a script on pupils' learning outcomes in grade 4, 5, and 6 (US K-12 system) in primary education?
2. What is the effect of a script on questioning in the knowledge sharing process in grade 4, 5, and 6 (US K-12 system) in primary education?
3. How does the use of a script by pupils differ from pupils with no script with regard to the interaction in the knowledge sharing process in grade 4, 5, and 6 (US K-12 system) in primary education?

It is expected that when a script is provided with a clear and well-structured design, pupils' knowledge sharing process and their learning outcomes are positively influenced (Dillenbourg, 2002; Weinberger, 2003; Gijlers et al., 2013). When primary school pupils follow the sequence of the script, the knowledge sharing process is influenced that may lead to the acquisition of new knowledge and may improve pupils' learning outcomes (Weinberger, 2003; Tolmie et al., 2010).

Second, it is assumed that questioning in a script affects pupils' interaction in the knowledge sharing process. When pupils are assisted in asking questions, the elicitation sub-process of the knowledge sharing process may improve (Weinberger, 2003; Gijlers et al., 2009).

Last, it is expected that in a collaborative learning arrangement a script is a type of support that structures and sequences pupils' interaction and enhance the knowledge sharing process (Weinberger,

2003). With regard to the process of knowledge sharing, the specific sequence of the interaction is increased by the use of questions and assigned roles that stimulate pupils to externalise knowledge and ideas (Slof et al., 2010). When primary school pupils have clear guidance with regard to a script and become aware of the knowledge sharing process, they often ask and share more domain-related content in the collaborative context (Mercer, 1996; Van Dijk et al., 2013).

Method

Participants

In total, 123 pupils of *K*-grade 4, 5, and 6 participated in this research (70 boys, 53 girls; M_{age} = 10.6, SD = 1.04, varying from 8 to 13 years old), out of four schools in the east of the Netherlands. In total, 67 participants were assigned to the experimental condition (40 boys, 27 girls; M_{age} = 10.7, SD = 0.99). In the control condition, a total of 56 pupils participated (30 boys, 26 girls; M_{age} = 10.6, SD = 1.11). Initially, 141 pupils participated in this research, however 18 participants were excluded from data analysis, because these pupils were absent either during the pre-test or post-test.

The participants were classified with regard to their ability level (low, average, high) according to the Dutch standardised reading comprehension CITO test. In the first session, the teachers divided the pupils in heterogeneous groups in four sub-topics of the weather; temperature, rainbow, rain and wind. In the second session, the pupils were assigned to homogenous groups with regard to ability level. A condition of the homogenous group composition was that all pupils within the group were to become an expert on a sub-topic from the previous lesson. This is in line with the Jigsaw method, where every pupil within the group becomes an expert on a sub-topic. According to the meta-analysis of Lou et al. (1996) and the study of Saleh (2005), low-ability pupils learn better in heterogeneous groups and high-ability pupils learn just as much well in either group. However, average-ability pupils learn more in homogeneous groups (Lou et al., 1996). According to Lou et al. (1996) it is important to minimise the spread in ability level in order to facilitate knowledge sharing. The groups consisted of 4 pupils. The teachers were also asked to divide the class into two conditions based on the ability scores. The experimental condition received a script and the control condition did not receive a script. The teachers attempted to divide the groups equally in the conditions with regard to the ability level. In total, 36

groups were formed. Because of the inequality of the number of pupils in a class, some group compositions consisted of less than 4 pupils.

Context

STIP module. The STIP modules, developed by the University of Twente and Stichting Katholiek Onderwijs Enschede (SKOE) are designed to enhance collaborative learning and knowledge sharing through the Jigsaw method (Hulsbeek & Eysink, 2015). The researcher, together with the STIP team and the teachers of the schools, developed the content of the sessions. STIP modules consist of six themes. Within a STIP module, information is divided among group members and every pupil is responsible for a piece of information (Aronson et al., 1978; Eshuis, 2015). Each theme, in turn, consists of two sessions each that are related to science and technology education. In the present study, the selected theme is the weather. This theme consists of five subtopics: temperature, rainbow, rain, wind and thunderstorm. However, the sub-topic thunderstorm was excluded from the materials for this study, because previous research indicated that this topic was rather complex for the pupils (Eshuis, 2015).

Pupils need to have a good and shared understanding of the point and purpose of the task (Mercer, 1996). In the first session, pupils accomplished experiments to gather information about the sub-topic. The sub-topics were related to learning goals: (1) how to measure temperature (measuring the degree Celsius with a thermometer); (2) describe how a rainbow appears (imitate a rainbow with a flashlight, mirror and water); (3) describe how rain appears (the moisture of hot water in a pot); (4) and how wind appears (air pressure in a bottle). In the second session, groups were formed based on different expertise in order to complete the group assignment about the weather; to create a poster about the water cycle.

Instrumentation

Script. The main goal of the script is to facilitate structured guidance in five repeated steps in the participants' communication in a collaborative learning context. The participants in the script need to apply the ground rules and ask questions in sequenced order to expand information. The experimental

condition received the script in the second session (see Appendix A). Within these structured steps, the participants need to externalise their knowledge on a placemat, share their knowledge, ask questions about the shared knowledge and agree on the learning content. The first step of the script is that pupils write down their information about the sub-topic of the task that is for no one else to see.

Step 2 focusses on the following two ground rules (see Appendix A). The first rule in the script states that pupils need to listen carefully. The second rule dictates that when one member in the team talks, the other collaboration partners do not interrupt. These ground rules for communication are adapted from Saleh (2005). These ground rules are instructed by the researcher and are repeated when a participant shared the knowledge.

In step 3, the participants are stimulated to ask questions in order to facilitate the elaboration of shared knowledge (see Appendix A). The script provides sample questions that are based on the work of King (1994) and Saleh (2005). An example of a sample question 'What do you think would happen to … if … happened?' (King, 1997; Saleh, 2005).

In step 4, the participants need to write down the shared information in order to continue with the task. Pupils are able to construct their knowledge from the shared information. Step 5, is related to quick consensus building of the knowledge sharing process, where coordination of the task (e.g., assigning roles) is important to continue with the task (Weinberger, 2003). The participants in the experimental condition received a scheme and cards in order make the sequenced steps more explicit in the script. For example, in round one in the scheme, the participant with role number 1 shares the information, while the participants with numbers 2, 3, and 4 ask questions about the information. In the second round, participant with number 2 shares the information, while the other peers ask questions, etcetera (see Appendix A). The general framework of this script is applicable to every Jigsaw method and does not require specific training beforehand. Based on a pilot test, the script was simplified in language, shortened in the number of steps and provided with a clearer lay-out.

Material and domain

Task overview in the STIP module. In Table 1, an overview of the learning content of the STIP module about the weather related to the sub-topics temperature, rainbow, rain and wind is presented. Every sub-topic consists of three learning goals that pupils should share with others during the collaboration in session 2.

Table 1

Overview of the learning content in the STIP module about the weather

Subtopic	Learning content
Temperature	A thermometer consists of mercury which expands when the temperature is getting warmer.
	It is colder in the mountains compared to valleys, because the mountains are further away from the earth's surface.
	The weather forecast is the average temperature per place.
Rainbow	A rainbow occurs when sunbeams are reverberated by raindrops and fall apart in different colours.
	A rainbow occurs when sunlight and raindrops are together at the same time.
	The colours of the rainbow are red, orange, yellow, green, blue, indigo and violet.
Rain	Water evaporates, cools down in the air, becomes a cloud and becomes rain that returns to the earth. That is the cycle of water.
	Hailstones appear in a cloud, because raindrops are moved up and down within the cloud due to the strong wind.
	Snow is a raindrop that falls down from the cloud, that has become a crystal due to the cold air.
Wind	Cold air is heavier than warm air; warm air expands and is lighter than cold air.
	Warm air particles move faster than cold air particles. That is why warm air particles need to have more space.
	Cold air falls and hot air rises which creates a flow. This is called wind.

Pre-test. A paper-based-open-answer pre-test, about the subtopics temperature, rainbow, rain, and wind was administrated to gather information about their prior knowledge (Hulsbeek & Eysink, 2015). The pre-test was adapted from Eshuis (2015). Every sub-topic consisted of 3 questions out of a total of 16 questions. As mentioned, in this study, the items on thunderstorms were omitted. The pupils were able to answer the remaining 13 questions in 30 minutes (see Appendix B). The reliability of the open answers pre-test was 0.72 (Cronbach's α).

Post-test. After completing session 2 of the STIP module, a paper-based-open-answer post-test, about the subtopics temperature, rainbow, rain, and wind was administrated. In order to gather information about their knowledge received from the STIP module to measure the learning gains after the collaboration (Hulsbeek & Eysink, 2015). The post-test was adapted from Eshuis (2015) as well. The three items pertaining to thunderstorm were also omitted in the post-test. The pupils were able to answer the remaining 13 questions in 30 minutes (see Appendix C). The reliability of the open answers post-test was 0.70 (Cronbach's α).

Procedure

Before conducting this study, the research proposal was approved by the department of Educational Science and Technology at the University of Twente. In addition, the parents of the participants received an email to inform them about this research. Parents were given the opportunity to withdraw their children at any time during the research. The study was approved by the Ethics Commission of University of Twente.

In this study, the researcher was responsible for teaching the sessions in all schools, because the researcher is legally qualified to teach primary school children. Each grade received two lessons (in two days) about the weather according to the STIP module. The two sessions were taught within one week.

In the first session, a 30-minute pre-test about the weather of the STIP module was administrated. After that, the pupils were divided into heterogeneous groups with regard to their ability level (low, average and high) into the sub-topics temperature, rain, rainbow and wind. The participants performed experiments according to their sub-topic in 60 minutes. At the end of these 60 minutes the researcher highlighted in each group the important findings from the experiment and related the findings to the learning goals of that particular sub-topic.

In the second session, the participants were divided in conditions. The experimental group received a script. The control group did not receive a script. In both conditions, the groups were homogenously formed with regard to their ability level (low, average or high). Both conditions were videotaped. The experimental condition received a 15-minute instruction about reading the script, how

to ask the sample questions, how to implement questioning in the task, and read the information from their sub-topic in session 1. After that, the participants shared knowledge about the different sub-topics according to session 2 of the STIP module about weather for 45 minutes. To complete the session, a 30-minute pre-test about the weather was administrated. The control condition was instructed for 15 minutes to read the task information and their information from their sub-topic in session 1. After that, the participants shared knowledge about the different sub-topics of the weather according to session 2 of the STIP module for 45-minutes. After that a 30-minute pre-test about the weather was administrated.

Data analysis

Data collection. Both qualitative and quantitative methods were used in order to evaluate how the designed script influenced the knowledge sharing process as well as the learning gains (Mercer et al., 2004). The design of the study is based on the convergent parallel mixed-methods design (Cresswell, 2014). In order to answer the research questions, the collection of the data (quantitative and qualitative) happened at the same time. Both types of collected data are of equal importance to interpret the research questions, because the outcomes of the quantitative data needs qualitative analyses to gain insight in pupils' knowledge sharing and learning outcomes.

The quantitative data was obtained by the methods pre-test, post-test and scoring of video data. The more qualitative data provided insight into the process of knowledge sharing (e.g., in questioning, regulation and explaining concepts) from the recorded video data. The dialogues of the groups were coded to interpret the knowledge sharing process in collaborative learning.

Coding and analyses. In order to assess the pre- and post-tests, pupils were able to score 10 points for every sub-topic out of a total score of 40 points. In order to measure an improvement in learning outcomes, the gain score (post-test minus pre-test) was measured. To assess the inter-rater reliability of the pre-test and post-test, a second coder rated twenty pre-tests (14% of total pre-tests) and twenty post-tests (14% of total post-tests). The inter-rater reliability coefficient was measured with a sufficient $k = .96$ (Cohen's Kappa).

Coding dialogue. In order to analyse the dialogue, specific utterances have been assigned with codes to evaluate pupils' comments and questions within the dialogue (Ormrod, 2010). The objective of quantitative coding the dialogue is to analyse if there are differences between the control condition and the experimental condition with regard to knowledge sharing, questioning and monitoring. Qualitative analysis of the dialogue might give a possible explanation for quantitative findings in variances between the two conditions.

Coding procedure. In order to code the dialogue, a time point sampling method was used to assign one main code of the coding scheme in a 30-second segment. All utterances within these 30 seconds were segmented into one main code *regulation or coordination*, *content-related* or *asking questions, off task talk, non-applicable* (see Table 2). Only the dialogue processes in this space of time entered the dataset for measuring absolute and relative frequencies. After that, each segment was divided in a sub-category (e.g., sub-category monitoring). The *regulation or coordination codes* were adapted from Janssen (2008). The *regulation or coordination* code indicated the influence of the task or script in pupils' regulation process. An example of this can be seen when pupils discuss how much time was left in order to complete the task. The *content-related* codes were adapted from Eshuis (2015). The *content-related* code is related to the knowledge sharing process in which pupils share information about the context or experiment. One pupil, for instance, shared information about the purpose of mercury in a thermometer that is related to the concept temperature. The *asking questions* code specified the type of questions the pupils ask each other. This code is also related to the knowledge sharing process, because pupils use the questions in order to receive shared information from their collaboration partner. The questions are ranged in difficulty in cognitive processes and are adapted from SLO (2010). For example, pupils asked questions about how snow arises; this question is a perception question. The codes *Off-task talk* is applied when pupils talked about no content-related information. The *Non-applicable* code indicated the interference of the teacher or that pupils processed the information by writing down the answers.

Table 2

Coding scheme including the description and example utterances

Categories	Description	Example from pupils' interaction
Regulation and coordination		
Planning	Talking about the strategies that are necessary to complete the task.	'First, we are going to explain our ideas and then we should write down all information and answer the questions.'
Monitoring	Monitoring task performance and progress and assessing the amount of time available and no relation to content of the task.	'We have only one minute left for this assignment.'
Positive evaluations	Appraisal and discussion of task performance and progress.	'You have given me the right information to answer this question.'
Negative evaluations	Appraisal and discussion of task performance and progress.	'I'm not going to work in this group; he prompts everything, but it's not his turn.'
Content-related		
Information exchange on content/concepts	Sharing facts about concept related to the content about the weather.	'Mercury expands when the temperature is warm.'
Information exchange on the experiment	Sharing the procedure of the experiment without relation to the content about the weather.	'We have filled the bottle with water and have put a coin on top of it.'
Information connection between experiment and content	Sharing and connecting the experiment to the content about the weather.	'The hot air in the bottle expands and that's why the coin flipped on the bottle.'
Concept naming	Identify concept or experiment without further explanation.	'I have learned about water, rain and hailstones.'
Asking questions		
Formulation error	Incorrect questions that have no connection to the concept(s).	'What are the advantages and disadvantages of measuring temperature?'
Reproducing	Asking questions about the concept/experiment to acquire additional information.	'What does reflection mean?'
Perception	Asking questions about the procedure or facts or knowledge of the concepts.	'How does a rainbow appear?'
Applied	Questions related to prior knowledge that are used to solve new situations.	'How do we sustain the cycle of water?'

Analytic	Focusing on important aspects of a (sub)problem.	'What are the disadvantages/advantages of the intervention of a human in the cycle of water?'
Off-task talk	Talk that is not related to the topic.	'I'm going to the dentist, because I have pain.'
Non-applicable	Teachers say something, writing procedure, quietness.	'Uhm…hmm…I'm still writing.'

Note. Coding scheme. Adapted from ''*Using Visualisations to Support Collaboration and Coordination during Compter-Supported Collaborative Learning''* by J. Jannsen, 2006, p. 49. and *''Effectiviteit van de STIP-aanpak''* by E. Eshuis, 2015, p. 21. and ''*Checklist 'taxonomie van Bloom''* by SLO, 2010, p. 1- 4.

Before the coding procedure actually started, in total 13 videos (protocols), consisting of 528 spoken segments were analysed. All video recordings that were selected for analysis had the same starting point. Each video fragment started with pupils that shared their knowledge of each sub-topic with each other. The video fragment stopped when the pupils started to work on the group assignment (creating the poster about the weather). These video fragments differed in length between 12 minutes to 30 minutes. The coding software that was used was ELAN. To assess the inter-rater reliability of the coding procedure, a second coder coded 5 protocols, consisting of 226 spoken segments. The inter-rater reliability coefficient was measured with a sufficient $k = .92$ (Cohen's Kappa).

Results

Learning outcomes. In order to check the assumptions of normality, the dependent variable learning outcomes, and independent variables ability level, grade level and condition were analysed. The ability level, condition and grade level were significantly normally distributed. However, the *K-S* test of the 5th grade $D(36) = 0.18$, $p < .05$, was significantly non-normal and is analysed with non-parametric tests.

Analysis of the pre-test scores was used to determine possible differences in prior knowledge (Table 3). Univariate analysis of variance (ANOVA) revealed no significant differences in prior knowledge between the experimental and control condition ($F(1,132) = 0.807$, $p = .371$), assuming that pupils in both conditions were equally knowledgeable about the subject being taught.

Analysis of the post-test score was used to determine a difference in learning outcomes (Table 3). Univariate analysis of variance (ANOVA) revealed no main effect of learning outcomes ($F(1,128) = 1.768$, $p = .19$). The analysis of the post-test produced no significant difference between the experimental and control condition in learning outcomes ($F(1, 121) = 0.555$, $p = .46$). This indicates that the effect of the collaborative script in the learning gains is not significant. In addition, no main effect of condition and ability level was found ($F(2,120) = 0.378$, $p = .69$). However, a *paired samples t-test* comparing the means between pre-test and post-test indicated in the 5th grade a significant gain score in the experimental condition ($M = 2.0278$, $SE = 3,02$), $t(17) = 2,85$, $p < 0.11$. compared to the control condition ($M = 0.4545$, $SE = 2.56$), $t(10) = 0,59$, $p = .57$. Thus, the script revealed an effect in the 5th grade. *Post hoc* comparison showed that there is a significant difference between pre-test and post-test in the 5th grade (experimental condition: $p = .014$; control condition: $p = 1.00$).

Table 3

Means and standard deviations for pre-test, post-test, gain score per condition

Tests	Condition			
	Experimental (N = 67)		Control (N = 56)	
	M	*SD*	*M*	*SD*
Pre-test	10.65	3.99	11.64	4.92
Post-test	11.16	4.59	12.65	4.89
Gain score	11.10	4.45	11.84	4.77

Coding dialogue. A total of 528 spoken segments were analysed, ranging from 25 spoken segments up to 61 segments per group ($M = 41.62$, $SD = 10.86$). The time of the selected spoken segments in total was 269 minutes, ranging from 13 minutes up to 31 minutes per group ($M = 20.69$, $SD = 5.48$).

Univariate analysis of variance (ANOVA) revealed that there is a significant difference with regard to regulation of the task between the experimental condition and control condition ($F(1,11) = 6.690$, $p < 0.05$). In the experimental condition, pupils monitor the task more often when a script is provided compared to the control condition (Table 4).

Univariate analysis of variance (ANOVA) also revealed that there is a significant difference with regard to number of the questions between the experimental condition and control condition ($F(1,11) = 6.187$, $p < 0.05$). This indicates that the number of questions is higher in the experimental condition compared to the control condition (Table 4).

However, the univariate analysis of variance (ANOVA) revealed no significant difference with regard to knowledge sharing between the experimental condition and the control condition ($F(1,11) = 1.613$, $p = 0.230$). Pupils in both conditions shared information or received information in the same proportion (Table 4).

Table 4

Means and standard deviations for regulation, asking questions, content-related per condition

Codes	Condition			
	Experimental		Control	
	M	*SD*	*M*	*SD*
Regulation	6.14	3.19	2.67	0.82
Asking questions	10.57	3.16	6.50	2.67
Content-related	19.43	5.35	16.33	2.80

Knowledge sharing. In order to explain the differences between conditions in the quantitative results, the qualitative case analyses give possible explanations for the quantitative significant findings. An overview of the percentages of the sub-codes from the main codes regulation, content-related and asking questions of 13 groups is presented in Table 5 in order to select cases to interpret the quantitative findings. The characteristics of each group are also presented, such as the grade level, ability level and the experimental condition (including a script) or the control condition. According to the characteristics of group A, D, F, G, J, M, N are selected for qualitative cases analyses in to explain the effect of the script on the knowledge sharing process more in detail (Table 5).

Table 5 *Overview of the percentages per sub-code and the group characteristics*

	Group												
	A	B	C	D	F	G	H	I	J	K	L	M	N
(Sub)-segments	40	48	30	45	37	41	59	30	61	25	43	31	38
Time (in minutes)	20	24	15	23	19	21	30	15	31	13	22	16	20
Grade	6	6	6	6	7	7	7	8	8	8	8	8	8
Ability	Average	Average	Average	Average	Low	Low	Low	Low	Low	Average	Average	High	High
Condition	Control	Experiment	Control	Experiment	Control	Experiment	Experiment	Control	Experiment	Control	Experiment	Control	Experiment
Planning	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Monitoring	1 (2.3%)	2 (4.5%)	3 (6.8%)	6 (13.6%)	1 (2.3%)	11 (25.0%)	1 (2.3%)	3 (6.8%)	7 (15.9%)	2 (4.5%)	2 (4.5%)	3 (6.8%)	2 (4.5%)
Positive evaluation	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Negative evaluation	0 (0.0%)	1 (7.7%)	0 (0.0%)	0 (0.0%)	2 (15.4%)	0 (0.0%)	4 (30.8%)	0 (0.0%)	2 (15.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	4 (30.8%)
Explain concept	11 (5.9%)	9 (4.8%)	17 (9.0%)	21 (11.2%)	13 (6.9%)	14 (7.4%)	9 (4.8%)	5 (2.7%)	20 (10.6%)	17 (9.0%)	15 (8.0%)	19 (10.1%)	18 (9.6%)
Explain Experiment	3 (10.7%)	12 (42.9%)	0 (0.0%)	2 (7.1%)	4 (14.3%)	0 (0.0%)	0 (0.0%)	4 (14.3%)	1 (3.6%)	0 (0.0%)	2 (7.1%)	0 (0.0%)	0 (0.0%)
Connection	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)
Concept naming	2 (11.8%)	1 (5.9%)	1 (5.9%)	1 (5.9%)	0 (0.0%)	0 (0.0%)	3 (17.6%)	2 (11.8%)	6 (35.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (5.9%)
Formulation error	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (11.1%)	0 (0.0%)	0 (0.0%)	3 (33.3%)	0 (0.0%)	3 (33.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (22.2%)
Reproducing	5 (8.8%)	4 (7.0%)	2 (3.5%)	5 (8.8%)	5 (8.8%)	5 (8.8%)	2 (3.5%)	3 (5.3%)	8 (14.0%)	4 (7.0%)	6 (10.5%)	4 (7.0%)	4 (7.0%)
Perception	1 (2.0%)	8 (16.3%)	1 (2.0%)	6 (12.2%)	6 (12.2%)	3 (6.1%)	3 (6.1%)	4 (8.2%)	5 (10.2%)	3 (6.1%)	6 (12.2%)	1 (2.0%)	2 (4.1%)
Applied	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (25.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (25.0%)	0 (0.0%)	2 (50.0%)
Analytic	0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Off-task	1 (2.6%)	1 (2.6%)	0 (0.0%)	2 (5.1%)	0 (0.0%)	6 (15.4%)	13 (33.3%)	4 (10.3%)	0 (0.0%)	1 (2.6%)	8 (20.5%)	2 (5.1%)	1 (2.6%)
Non applicable	21 (13.0%)	17 (10.5%)	9 (5.6%)	11 (6.8%)	13 (8.0%)	8 (4.9%)	26 (16.0%)	11 (6.8%)	18 (11.1%)	2 (1.2%)	9 (5.6%)	7 (4.3%)	10 (6.2%)

Regulation. According to the quantitative analysis of the dialogue, the experimental condition regulated or coordinated the task more often, which can be explained the processes in the script that pupils need to undertake that affects the regulation processes. This is in contrast to the control condition, where regulation processes between pupils in collaborative learning were less frequent. In Table 6, excerpts of pupils in the low-ability level in the scripted condition are presented. In group G, the sub-topics temperature and rain were discussed. In turn 6, the question 'Whose turn is it to speak?' is an example of a monitoring code, where pupils monitored the task performance with regard to the assigned roles of the script. In response to the pupil in turn 6, a pupil monitored the sequence of the script in order to continue the progress of the task performance. The answer is related to the coordination of the script where pupils have to ask questions before another pupil shared the knowledge (turn 7).

Another example of regulation in the scripted condition is group J, which discussed the sub-topic temperature. In turn 13 of group J, the sequence and monitoring process of the script related to the task is very clearly described by the pupil: 'You are next and will receive the speaking card after he shared his information.' The assigned roles and the sequence of the script is an extra monitoring process that pupils have dealt with in this collaboration process. These excerpts revealed that pupils in low-ability groups monitored and regulated the script more often in relation to the task compared to the control condition. A possible explanation for explaining the variances between the conditions is that a script has not yet been internalised by the pupils which leads to more regulation of the task performance.

Table 6

Excerpts with regard to monitoring and coordination of the task in the experimental condition

Group	Code	Turn	Utterance
G *Low*	Monitoring	1.	'Wait it is my turn? …What is mercury?'
	Explain concept	2.	'That is the red liquid in the thermometer and that liquid rises.'
	Monitoring	3.	'Okay, whose turn is it?'
	Monitoring	4.	'You are first and I'm the second one.'
	Monitoring	5.	'I have to ask a question, because I'm first according to the turn-taking scheme'
	Monitoring	6.	'(…) Whose turn is it to speak?'
	Monitoring	7.	'Wait, we have to ask questions.'

	Reproducing question	8.	‘What did you say about the rainbow?’
	Explain concept	9.	‘The sunbeams were reflected by the raindrops and that’s how a rainbow appears.’
J	Monitoring	9.	‘We have to ask question to you, right?’
Low	Monitoring	10.	‘But I have to tell them some more about temperature.’
	Monitoring	11.	‘But I have to ask you a question; you are finished with saying your things.’
	Monitoring	12.	‘(…) It is your turn to share your information.’
	Monitoring	13.	‘You are next and will receive the speaking card after he said his information.’

Questioning. According to the quantitative analysis of the dialogue, the number of questions in the experimental condition is significantly higher compared to the control condition. In Table 7, the excerpts of three dialogues of the scripted condition are presented in order to explain the variances between conditions. Qualitative analysis of the excerpts revealed that there is a difference in the type of questions related to the ability level. For example, in the low-ability group G in turn 4, a reproducing question was asked: ‘What are the colours in the sunlight?’ this question leads to information about a shared concept that has been shared in turn 1, namely: ‘The colours of the rainbow are green, yellow, red, orange, blue, indigo and purple.’ When considering a pupil in group D of average-ability level where the sub-topic rain was discussed, a contrast can be observed. The pupil in turn 6 looked at the sample questions of the script and asked the analytic question: ‘How important is the cycle of water for nature?’ This analytic question indicated the important aspects of a (sub)problem. In turn 7, the peer explained the concept using prior knowledge that goes beyond what they have learnt in the task in order to answer the question. In group N, the pupils with a high-ability level also used the sample questions in order to share additional information. In turn 10, an applied question was asked: ‘What is the difference between hailstones and rain?’ This applied question indicated that the pupils need to use prior knowledge to solve new situations. The pupil replied in turn 11 and shared the concept of the cycle of water. The overall conclusion of the excerpts is that incorporated scripts with regard to type and amount of questioning in group G (low-ability) remained at a more superficial level in the exchange of information compared to group D (average-ability) and group N (high-ability). Considering the ability level, pupils with a higher ability (e.g., average to high) level were able to use sample content-specific

questions of the script that lead to additional shared content information compared to the low-ability level pupils who asked more reproducing related questions.

Table 7

Different excerpts with regard to the asked questions in the experimental condition

Group	Code	Turn	Utterance
G *Low*	Explain concept	1.	'The colours of the rainbow are green, yellow, red, orange, blue, indigo, and purple.'
	Perception question	2.	'How do colours appear in the rainbow?'
	Explain concept	3.	'Sunlight is reverberated by raindrops. In sunlight there are colours that you can't see. These colours appear when there is a rainbow.'
	Reproducing question	4.	'(…) What are the colours in the sunlight?'
	Explain Concept	5.	'Red, orange, yellow, green, blue, purple and indigo.'
D *Average*	Analytic question	6.	'How important is the cycle of water in nature for plants, animals and humans?'
	Explain concept	7.	'This is very important, otherwise we would be dead. There will not be any water.'
	Analytic question	8.	(…) 'How exactly does hot air and cold air move?'
	Explain concept	9.	'Cold air goes down and hot air goes up and they confront each other.'
N *High*	Applied question	10.	'What is the difference between hailstones and rain?'
	Explain concept	11.	'Rain comes from the clouds and returns to earth. That is all I have learned.'
	Applied question	12.	(…) 'What is de cycle of wind?'
	Explain concept	13.	'Well, hot air goes up and cold air goes down and that's how wind starts blowing.'

To compare the difference in the type of questioning in both conditions, the excerpts of three dialogues in the control condition are presented in Table 8. Qualitative analysis of the dialogues revealed that when pupils asked questions, these questions remained more often at a reproducing level in all three ability levels. In group F, the pupils of the low-ability level discussed the sub-topic temperature. A pupil asked a reproducing question in turn 4 about whether or not there is a difference in the changing liquid levels when temperature goes down. The information related to this question had already been explained

in the previous turn 3: ‘The red liquid that rises in the thermometer is called mercury and goes down when it is cold.’ In group A, pupils of the average-ability level also discussed the sub-topic temperature and asked in turn 8 a similar reproducing question as group F. The question in turn 8 was: ‘Does snow melt?’ This information that relates to the question had already been shared in the previous turn 7. Another example is group M, where pupils of a high-ability level discussed the sub-topic rain. In turn 10, a pupil asked a perception question to peers about the phenomenon that is rain. This question is related to the knowledge of a specific concept of rain. In turn 11 and 12, different explanations were given about whether the cycle is called rain or water. As a consequence, the pupil in turn 13 asked the question in such a way both answers are involved, for example ‘So, what’s it called: the cycle of rain or the cycle of water?’ Questions such as these are a way for pupils to verify whether or not the shared information has been understood correctly instead of trying to provoke new information. The overall conclusion of the analysis of these excerpts in the control condition is that pupils use many reproducing questions in order to repeat the shared information that does not necessarily deliver new information.

Table 8

Excerpt of questioning in the control condition of pupils that have different ability levels

Group	Code	Turn	Utterance
F *Low*	Explain concept	1.	‘I have learnt what mercury is.’
	Reproducing Question	2.	‘What is mercury?’
	Explain concept	3.	‘The red liquid that rises in the thermometer is called mercury, and goes down when it is cold.’
	Reproducing Question	4.	(…) ‘Does mercury go down too?’
A *Average*	Explain concept	5.	‘It goes up when it's warm. The mercury goes down when it is cold.’
	Reproducing Question	6.	‘What about the sunlight and the snow?’
	Explain concept	7.	‘When the sunlight shines, the snow melts and goes into the sea.’
	Reproducing Question	8.	‘Does snow melt?’
	Explain concept	9.	‘Yes, snow melts and goes into the river and eventually goes into the sea.’

M *High*	Perception question	10.	'How do we call the cycle where water evaporates from the sea?'
	Explain concept	11.	'That is called the cycle of rain.'
	Explain concept	12.	'No, this is called the cycle of water.'
	Perception Question	13.	'Okay, what's it called: the cycle of rain or cycle of water?'
	Explain concept	14.	'The cycle of water.'

The conclusion of the results is that quantitative analysis and the case analysis revealed that the type and amount of questioning is facilitated in the script. The qualitative analysis of pupils' dialogues in the experimental condition illustrated that pupils try to adopt and try to internalise the script in order to share domain-specific knowledge. The examination of the case analysis in the experimental condition revealed that considering the ability level, pupils with a higher ability (e.g., average to high) level were able to use sample content-specific questions of the script that lead to additional shared content information compared to the low-ability level pupils who asked more reproducing-related questions. The pupils in the control condition, regardless of ability levels, generally asked reproducing questions that did not necessarily contribute to shared information. However, due to the new type of support that the script provided, and according to the quantitative findings the regulation process dominated the knowledge sharing process that did not lead to a significant difference between conditions in sharing content-related knowledge and no higher learning outcomes.

Conclusion and Discussion

The aim of the present study was to examine how a script influenced pupils' knowledge sharing processes in a collaborative learning context in primary education. A key finding of the present study, is that analyses of the dialogues revealed that pupils in all grade levels and ability levels in the scripted condition, made attempts to internalise or adopt the script in order to share domain specific knowledge a collaborative learning context in. Qualitative findings revealed that the script positively influenced the externalisation and elicitation sub-processes of knowledge sharing process. This finding is based on the quantitative results that there is a significant difference in asking questions between the control and the

experimental condition. Qualitative analyses of the dialogues revealed that in the scripted condition, pupils use the sample questions of the script in order to provoke additional information from their collaboration partner.

With regard to the first research question, the test results revealed no significant difference in pupils' learning outcomes between the experimental condition and the control condition. However, with respect to the grade level, the pupils in the 5th grade have shown a significantly higher learning gain score in the experimental condition compared to the control condition. A possible explanation for this finding is that the script and/or task affects their learning outcomes compared to the 4th and 6th grade. No learning outcomes in 4th and 6th grade may be allocated to the monitoring processes in a script. Quantitative analyses of the dialogues revealed that in the experimental condition pupils monitored and regulated the script more often in relation to the task compared to the control condition. A study by Van Dijk et al. (2013) confirmed that a script can lead to extra monitoring processes that reduces the amount of knowledge sharing and affect pupils' learning outcomes.

With respect to the second research question, quantitative analyses as well as qualitative results of the dialogues revealed that the script influenced the sub-processes externalisation and elicitation of the knowledge sharing process. The qualitative results revealed that the type of questioning between conditions influenced the knowledge sharing process. For instance, pupils with a higher ability level (e.g., average to high) used more sample or content-specific questions that resulted in externalisation of shared content information. A sample question that a pupil asked in the dialogue was 'How exactly does hot air and cold air move?' This analytic question improved their shared domain knowledge, because pupils need to think and share important aspects of the problem. The questioning is also in line with the elicitation sub-process of the knowledge sharing process, where pupils actively use their collaboration partners as a resource to gain more information (Weinberger & Fischer, 2006; Weinberger et al., 2007). This is in contrast to qualitative analyses of the dialogues in the control condition that illustrated that pupils more often asked reproducing-related questions in order to check if the shared content was being understood by their peers. According to King (1997) reproducing-related questions are reproduced from pupils' memories, whereas integrated questions (e.g., applied questions in the script) lead to elaboration of a shared concept. However, the low-ability-level pupils in the experimental asked more reproducing-

related questions in order to check or repeat the shared information. This indicates that the script needs improvement in the design for low-ability pupils in order to improve the elicitation sub-process of the knowledge sharing process.

The last research question refers to how the interaction differs in the knowledge sharing process between the scripted and the control condition. The pupils in the experimental condition were confronted with the different collaborative processes such as a script, the STIP module, and learning content that influenced the knowledge sharing processes, whereas the control condition only needs to regulate the task. Because pupils in the experimental condition dealt with so many processes it is difficult to measure the effectiveness of knowledge sharing process and the learning outcomes. According to a study by Weinberger et al. (2010), process losses occurred because all of the additional collaborative processes inhibit pupils in sharing content-related knowledge in an effective way. Quantitative findings revealed that shared content-related information was not significant between conditions. According to Mercer and Howe (2007) a possible reason why pupils in the scripted condition do not share knowledge more knowledge, is because pupils that ask questions because of the script are sometimes not aware of understanding the underlying principle to improve their knowledge sharing process (Howe & Mercer, 2007). The STIP module also influenced the interaction in the knowledge sharing process. Although, the idea of the Jigsaw method is that pupils share information of the topic of their expertise, the qualitative analysis revealed that pupils often do not exchange all of the information in both conditions. As a consequence, pupils in all different grades had difficulties in successfully completing the collaborative task. In order to improve the knowledge sharing process, and the implementation of the script, there is need for time and practice for primary school pupils to deal with all these different processes (Weinberger, 2003).

Future research is needed to examine to what extent a script influences the knowledge sharing processes in a longitudinal study in primary education. According to a study by Mercer, Dawes, Wegerif, and Sams (2004), the process of internalising a type of support such as a script requires time and practise in primary education in order to improve the knowledge sharing process. Moreover, the design of the script needs improvement with regard to the sample questions. These questions need to be simplified and adapted in order to make pupils aware of the asking questions to all ability levels. Additional

research is also needed to what extent pupils are able to accomplish the five sub-process of the knowledge process according to their learning progression in primary education.

The overall conclusion of this study is that the script based on questioning influenced the externalisation and elicitation process of the knowledge sharing process. Pupils made attempts to internalise or adopt the script in all grades and ability levels. However, due to process losses, such as monitoring the STIP module method, the script, and new learning content, they did not significantly share more content-related information and no higher learning outcomes were guaranteed in the scripted condition.

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Appendix A

Collaborative Script

Step 1. *Placemat information*

1) All team members have 3 minutes to write down all their information about their sub-topic on their placemat. Go to step 2.

Step 2. *Ground rules for effective interaction*

1) Listen carefully to your team members.
2) If one team member talks, the other members do not interrupt. Go to step 3.

Step 3. *Team discussion*

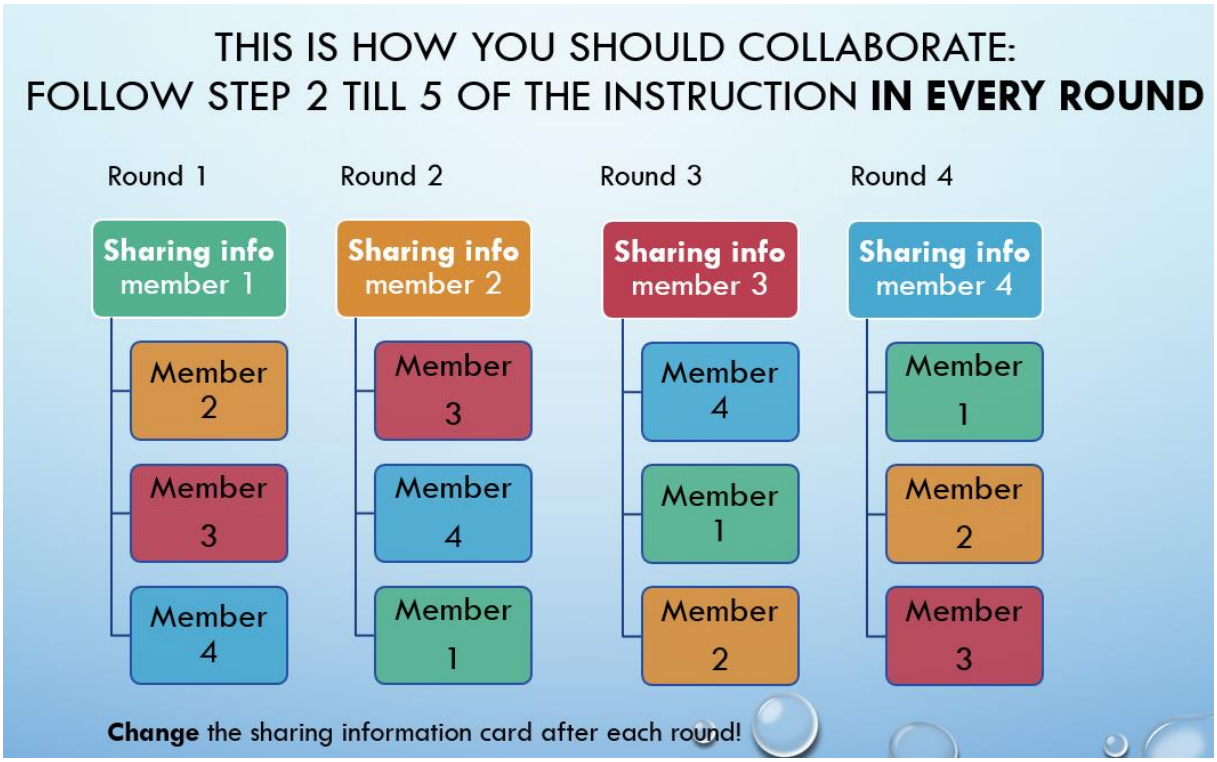
1) Team member 1 explains his/her expertise about the sub-topic.
2) Check the schema for turn taking to agree or ask questions to further elaborate (see step 3.3)
3) Ask clear questions till you understand, you can use examples like:
   - Describe… in your own words
   - What does… mean?
   - Why is… important?
   - Explain how…
   - Explain why…
   - How are… and… similar?
   - What is the difference between... and...?
   - How does… affect…?
   - What are the strengths and weakness of…?
   - What causes…?
   - How could…be used to…?
   - What would happen if…?
   - How does… tie in with… that we learned before?
4) When he/she agrees, next team member agrees or ask questions until all members agree within the team. Go to step 4.

Step 4. *Writing down the answer*

1) Every team member writes his/her own answer down on their assignment. Go to step 5.

Step 5. *Repeat* step 2 until 4 till all team members *have shared* their information. Go to step 2.

Schema for asking questions



Note. Collaborative script. Adapted from ‘‘*Structureel Coöperatief Leren*’’ by S. Kagan, 2003, p. 48 and ‘‘*Optimizing Grouping Practices in Elementary Classrooms*’’ by M. Saleh, 2005, p. 77.

Appendix B

Pre-test

Het weer

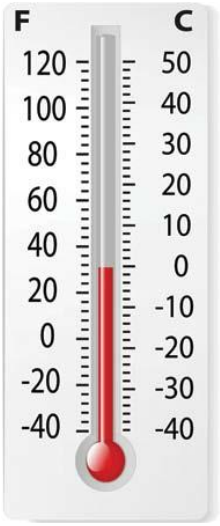
Voornaam en achternaam: ……

Groep: ……

School: ……

Geboortedatum: ……..(dag)……..(maand)……(jaar)

Probeer de volgende 13 vragen zo goed mogelijk te beantwoorden. Het kan zijn dat je op sommige vragen het antwoord niet weet. Dat is helemaal niet erg! Als je bij een vraag echt niet weet wat je moet opschrijven, zet er dan een vraagteken neer. ***Succes!***



1. Kijk naar de thermometer hiernaast. Hoe warm is het volgens deze thermometer? Ga uit van de temperatuursverdeling die we in Nederland gebruiken.

2. Lisa wil weten hoe warm het buiten is. ’s Ochtends kijkt ze op de thermometer. Ze ziet dat het 12 graden is. ’s Middags kijkt ze nog een keer. Dan is het 17 graden. Wat is er met het kwik in het buisje van de thermometer gebeurd en hoe komt dat? Leg je antwoord uit.

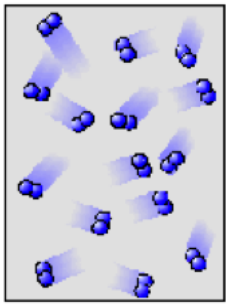
3. In de tabel hiernaast zie je de gemiddelde temperatuur van de eerste vier weken van 2015. In week 1 was het gemiddeld 5 graden Celsius. Wat wordt daarmee bedoeld?

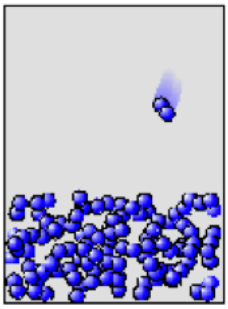
Gemiddelde temperaturen	
Week 1	5 graden Celsius
Week 2	9 graden Celsius
Week 3	4 graden Celsius
Week 4	2 graden Celsius

4. Marieke en Peter wonen allebei in Oostenrijk. Marieke woont op de berg. Peter woont lager, in het dal. Ze hebben allebei een thermometer in de tuin hangen.

Zijn de temperaturen die de thermometers aangeven dezelfde? Leg je antwoord uit.

5. De moeder van Joost is aan het koken. Ze heeft net een pan water opgezet om spaghetti in te koken. Als het water kookt ziet ze waterdamp van de pan komen.
Hieronder zie je twee plaatjes van de deeltjes van water en waterdamp. Schrijf onder het plaatje of het gaat om ***waterdamp*** of om ***water*** en leg uit waarom.





…… ……

6. Maak een tekening van de kringloop van het water. Leg in je eigen woorden uit wat er in je tekening gebeurt.

7. Vul op de stippellijntjes de volgende woorden in: ***zomer – winter – ijskristallen – hagel – sneeuw – ijslaagjes***. Je mag elk woord maar één keer gebruiken.

…….... komt voor als de lucht koud is. Het ontstaat doordat waterdruppels in een wolk …….... vormen.

…….... ontstaat doordat er door sterke koude luchtstromen in een wolk waterdruppels keer op keer omhoog worden gedrukt. Daardoor groeien er telkens nieuwe …….... omheen.

Sneeuw komt in Nederland alleen in de …….... voor. Hagel kan ook in de …….... voorkomen.

8. Licht, bijvoorbeeld van een zaklantaarn, bestaat uit verschillende kleuren. Welke kleuren zijn dat?

9. Mark is buiten aan het spelen en wil graag een regenboog zien. Wat is er bij het weer nodig om een regenboog te krijgen?

10. Wouter geeft de planten water met een plantenspuit. Er schijnt licht op de waterdruppels die uit de plantenspuit komen. Daardoor ziet Wouter een regenboog. Hoe werkt dat? Leg je antwoord uit.

11. Vul op de stippellijntjes de volgende woorden in: ***sneller – stijgt – lichter – deeltjes – daalt – langzamer – zwaarder.*** Je mag elk woord maar één keer gebruiken.

Warme lucht ……..……..……..……. en koude lucht ……..……..……..……..

Lucht bestaat uit kleine ……..……..……..……. . Die gaan ……..……..……..…….
bewegen als de lucht opwarmt. Ze gaan ……..……..……..……. bewegen als de lucht
afkoelt. Warme lucht zet uit en wordt daardoor ……..……..……..……. .

Koude lucht krimpt in en wordt daardoor ……..……..……..……. .

12. Kijk naar de afbeelding hiernaast. In de plastic flessen zit alleen lucht. Door de doppen op de flessen kan de lucht er niet uit. Eén van beide flessen heeft in een bak met ijswater gelegen. De lucht in die fles is daardoor kouder geworden dan de lucht eromheen.

De andere fles heeft in een bak met warm water gelegen. De lucht in die fles is daardoor warmer geworden dan de lucht eromheen.

Welke fles heeft in de bak met ijswater gelegen? Kruis de juiste fles aan en leg je antwoord uit.

13. Leg uit hoe wind ontstaat. Je mag er een tekening bij maken.

Note. Pre-test het weer. Adapted from ‘‘Samen in de klas met Stip: Samenwerken tijdens Taak-,Inhoud-en Procesdifferentiatie’’ by M. Hulsbeek, T. Eysink, 2015, *Didactief, 45*(9), p. 44-55.

Appendix C

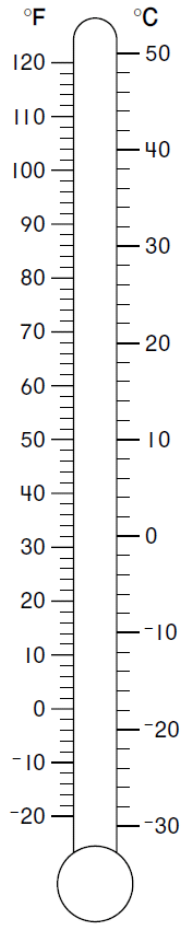
Post-test

Het weer

Voornaam en achternaam: …….
Groep: ……
School: ……
Geboortedatum: ……..(dag)……..(maand)……(jaar)

Probeer de volgende dertien vragen zo goed mogelijk te beantwoorden. Het kan zijn dat je op sommige vragen het antwoord niet weet. Dat is helemaal niet erg! Probeer dan zo goed mogelijk op te schrijven wat je weet over het onderwerp van die vraag. ***Succes!***

1. Kleur de thermometer hiernaast in zodat je kunt zien dat het 20 graden is. Ga uit van de temperatuursverdeling die we in Nederland gebruiken.

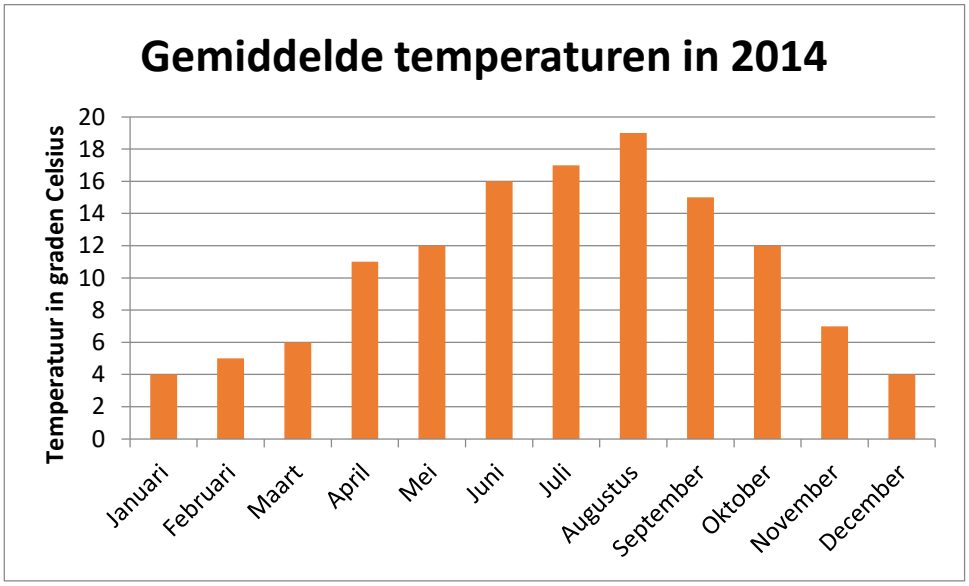


2. Maarten heeft gisteren de temperatuur buiten gemeten met een thermometer. Hieronder zie je wat hij heeft opgeschreven:

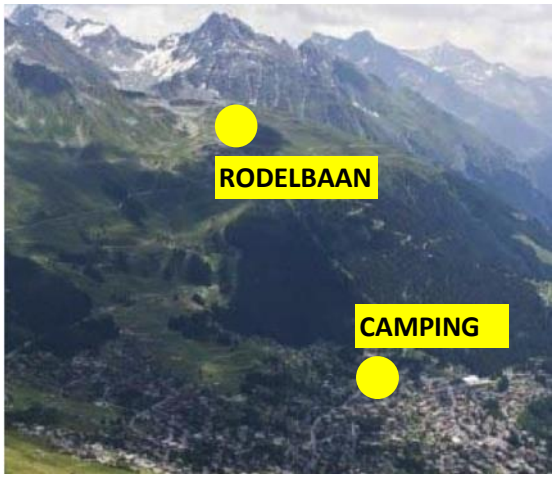
12 uur ‘s middags 7 graden Celsius
6 uur ‘s avonds 5 graden Celsius

Wat is er met het kwik in het buisje van de thermometer gebeurd en hoe komt dat? Leg je antwoord uit.

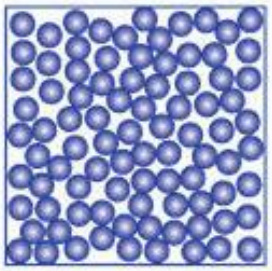
3. Op de grafiek hieronder zie je de gemiddelde temperaturen in 2014 in Nederland. In mei was het gemiddeld 12 graden Celsius. Wat wordt daarmee bedoeld?

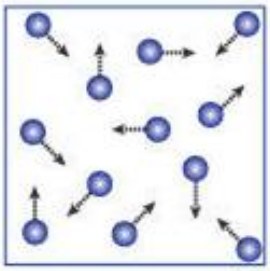


4. Anne is met haar ouders op vakantie in Oostenrijk. Ze gaan een dagje naar de rodelbaan op de berg. Ze rijden met de auto van de camping naar de rodelbaan op de berg. Is de temperatuur op de camping hetzelfde als bij de rodelbaan? Leg je antwoord uit.



5. Lotte zet thee. Ze heeft een kop water in de magnetron gezet en zet de magnetron aan. Als de magnetron klaar is, haalt ze de beker voorzichtig uit de magnetron. De damp komt eraf. Hieronder zie je twee plaatjes van de deeltjes van water en waterdamp. Schrijf onder het plaatje of het gaat om ***waterdamp*** of om ***water*** en leg uit waarom.





…… ……

Uitleg:

6. Beschrijf in je eigen woorden de kringloop van water. Maak er ook een tekening bij.

7. Vul op de stippellijntjes de volgende woorden in: ***winter – ijslaagjes – sneeuw – zomer – hagel – ijskristallen***. Je mag elk woord maar één keer gebruiken.

Sneeuw komt in Nederland alleen in de ……... voor. Hagel kan ook in de ……... voorkomen.

……... ontstaat doordat er door sterke koude luchtstromen in een wolk waterdruppels keer op keer omhoog worden gedrukt. Daardoor groeien er telkens nieuwe ……... omheen.

……... komt voor als de lucht koud is. Het ontstaat doordat waterdruppels in een wolk ……... vormen.

8. Licht, bijvoorbeeld van de zon, bestaat uit verschillende kleuren. Welke kleuren zijn dat?

9. Lars kijkt naar buiten en ziet een regenboog in de lucht. Wat is er bij het weer nodig om een regenboog te krijgen?

10. Iris zit op de bank. Er staat een glas water op tafel. Het licht van de lamp schijnt op het glas water. Daardoor ziet Iris een kleine regenboog. Hoe werkt dat? Leg je antwoord uit.

11. Vul op de stippellijntjes de volgende woorden in: ***zwaarder – sneller – lichter – langzamer – stijgt – deeltjes – daalt .*** Je mag elk woord maar één keer gebruiken.

12. Kijk naar de afbeelding hiernaast. In de plastic flessen die je daar ziet zit alleen lucht. Door de doppen op de flessen kan de lucht er niet uit. Eén van beide flessen heeft in de vriezer gelegen. De lucht in die fles is daardoor kouder geworden dan de lucht eromheen.
De andere fles heeft eventjes in de zon gestaan. De lucht in die fles is daardoor warmer geworden dan de lucht eromheen.

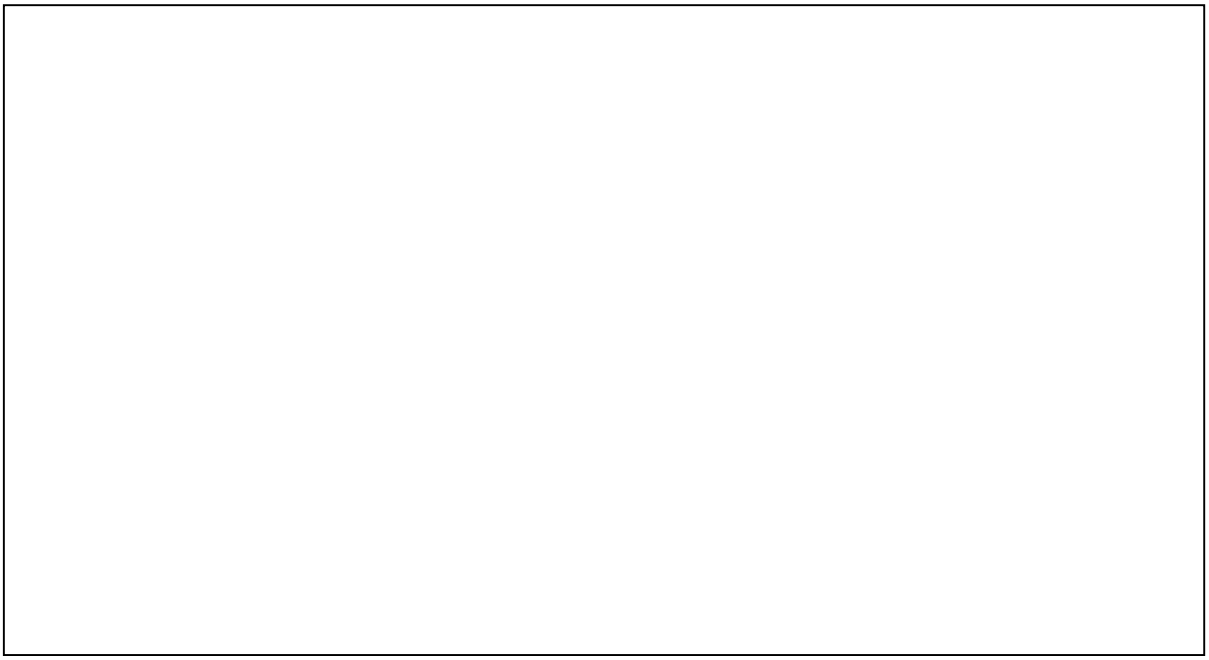
Welke fles heeft in de vriezer gelegen? Kruis de juiste fles aan en leg je antwoord uit.

Lucht bestaat uit kleine ……..……..……..……. . Die gaan ……..……..……..…….
bewegen als de lucht afkoelt. Ze gaan ……..……..……..……. bewegen als de lucht opwarmt.

Koude lucht krimpt in en wordt daardoor ……..……..……..……. .

Warme lucht zet uit en wordt daardoor ……..……..……..……. .

13. Hoe ontstaat wind? Leg het in je eigen woorden uit. Je mag er een tekening bij maken.



Note. Post-test het weer. Adapted from ‘‘Samen in de klas met Stip: Samenwerken tijdens Taak-,Inhoud-en Procesdifferentiatie’’ by M. Hulsbeek, T. Eysink, 2015, *Didactief, 45*(9), p. 44-55.