Transactivity in heterogeneous cooperative dialogues in elementary education

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Abstract

Transactive communication (i.e. reasoning upon information provided by an interlocutor) is considered to enhance learners' dialogues and therewith learners' individual learning gain while cooperative learning. However, studies on cooperative learning do not always show to increase learning gain. This study built upon existing research and investigated whether the extent of transactive communication elementary school learners (n=56) engaged in enhanced the quality of the dialogue and therewith individual learning gain. To determine the extent of transactive communication learners used, learners' heterogeneous group' dialogues were coded. Discourse analysis revealed that learners hardly engaged in transactive communication. In addition, possibly as a consequence, results showed transactive communication to not affect learners' individual learning gain. This suggests that learners need support to learn how to engage in transactive communication before transactivity can positively affect learners' individual learning gain. Future studies should examine the support needed for learners to engage in transactive communication.

Keywords

cooperative learning, transactive communication, dialogue analysis, elementary school.

Research has shown positive effects of heterogeneous cooperative learning. Researchers acknowledge cooperative learning to be affecting learning positively by means of providing and receiving explanations (Webb, Nemer & Chizhik, 1998; Gillies, 2003; Slavin, 2015). In cooperative learning, learners are instructed to work on an assignment in small groups (Slavin, 2015; Abrami, Chambers, Poulsen, De Simone, d'Apollonia & Howden, 1995). In these groups, learners learn with and from each other as they are helping each other throughout the process by discussing information (Slavin, 2015). However, enhancement in learning through cooperation is not self-evident (Gillies, 2003) and seems to greatly depend on the quality of the interaction between learners (e.g., how information is shared, discussed and explained (Slavin, 2015; Webb et al., 1998; Cohen, 1994).

Research shows that learners do not always engage in effective interaction that involves sharing and discussing information (Gijlers, Weinberger, Van Dijk, Bollen & Van Joolingen, 2013; Webb et al., 1998), as learners do not know how to engage in effective interaction (Gijlers et al., 2013). This causes learners to easily fall into discussing non-task or non-content related information, which decreases the quality of the interaction (Gijlers et al., 2013). Additionally, learners might lack a shared task focus, as they are often unaware what is expected from them (Mercer, Dawes, Wegerif & Sams, 2014; Saab, Joolingen && Van Hout-Wolters, 2007; Mercer, 1996). This could lead to discussing more non-task information (Gijlers et al., 2013) and sharing less on-task domain-specific information needed for effective interaction and learning (Mercer, 1996).

Furthermore, even though heterogeneous cooperation offers great benefits for learning (Lou et al., 1996), having heterogeneous groups can also make cooperative learning more difficult (Webb et al., 1998; Slavin, 2015). As learners of different ability levels learn differently and in different paces (Lou et al., 1996), this could diminish the information being shared and discussed (Lou et al., 1996). Therewith the quality of the interaction decrease (Lou et al., 1996). Therefore, supporting the discussion of information in heterogeneous groups and, therewith, enhance the quality of the interaction while cooperative learning is necessary.

An effective method for promoting learners' interaction is the jigsaw method (Aronson, Blaney, Stephan, Sikes, & Snapp, 1978). In the jigsaw method, learners are assigned to cooperate in heterogeneous groups in which every group member first learns an unique piece of information essential for completing the assignment (Aronson et al., 1978; Walker & Crogan, 1998). Subsequently, they have to share this information with their group members. Through this structure, learners need each other to achieve the desired goal (i.e. interdependency) forcing them to actively contribute to the cooperation. This enhances the information sharing process (Johnson, Johnson & Smith, 2007).

However, even when the jigsaw method is applied, learning gains are not guaranteed and additional support is necessary (Van Dijk et al., 2019). In their research, van Dijk et al. (2019) applied the jigsaw method and used a worksheet that scripted the learning process. Additionally, the worksheet intended to emphasize learners' interaction with a specific focus on providing and receiving explanations. In the results, it was found that the worksheet had positive effects on the quality of the dialogue. Learners in the scripted condition provided more theoretical explanations and spent a larger proportion of the dialogue on domain-related content. Furthermore, it was found that the domain-related dialogue was distributed more equally among group members. However, the improved quality of the dialogue did not result in an increasement in learning gain for all learners. Only low-ability level learners demonstrated a significant improvement in learning gain. As suggested by van Dijk et al. (2019), it is possible learners did not know how to engage in the shared information. However, this engagement is important to enhance learning (i.e. transactivity; Berkowitz, 1980; Gijlers et al., 2013). Hence, it would be relevant to investigate to what degree learners engage in information when receiving more theoretical explanations (Van Dijk, et al., 2019). Therefore, this study examines to what extent learners' heterogeneous dialogues display characteristics of transactivity that are expected to be important for learning gain, and its relation to learners' individual knowledge gain.

Cooperative learning

Slavin (2015) defines cooperative learning as a teaching method that assigns students to work together in small heterogeneous groups to assist each other to learn new information. In research, cooperative learning has proven itself to be a fruitful approach to enhance learning (Slavin, 1983; Slavin, 2015; Abrami et al., 1995; Tadesse, Gillies & Manathunga, 2020). In their study, Tadesse et al. (2020) found cooperative learning to positively affect learners' perceptions of learning, the personal and social development of learners, and the interaction between learners. Additionally, it was found that cooperative learning increases the learning achievements of learners for the fact that higher exam scores were found for learners being assigned to cooperative learning compared to a control group (Yamarick, 2010). Similarly, Webb (1982) states that cooperative learning can enhance learners' achievements as a result of high-level elaborations given during the cooperative process that enhance the quality of the dialogue. Moreover, research showed that as in cooperative learning learners can discuss the information from their perspectives and reason upon each other's elaborations, learners construct conceptual knowledge and build a shared mental model (Weinberger & Fischer, 2006; Johnson et al., 2007; Jurkowski & Hänze, 2015). These models can

increase learners' learning gain (Weinberger & Fischer, 2006). However, for cooperative learning to show positive effects, five basic elements essential for cooperation are determined in the Social Interdependence Theory by Johnson et al. (2007). In the worksheet of van Dijk et al. (2019) these elements were incorporated.

Positive interdependence is the first element of the Social Interdependence Theory and by Johnson et al. (2007) stated to be the core element of cooperative learning. When positive interdependence is established, group members can only reach their goal when every individual reaches their own goal. Every individual achievement should strengthen the accomplishments of their group members, enhancing their groups' work as well as their individual outcomes (Lou et al., 1996). Learners should be made dependent of each other to promote their learning and for interaction between learners to become cooperation (Johnson et al., 200). This can be stimulated through achieving a goal or by receiving a reward (Johnson et al., 2007). If learners strive to achieve a goal or reward together, learners experience a need to cooperate, and positive interdependence can be established (Slavin, 1983; Johnson et al., 2007). Accordingly, positive interdependence increases the second element of the Social Interdependence Theory, promotive interaction, which is also needed to achieve goals and affect learners' learning gain positively (Johnson et al., 2007). Through promotive interaction, learners encourage each other's efforts to achieve their goal by means of offering help, exchanging needed information and by engaging in effective communication (Johnson et al., 2007). This enhances the quality of the dialogue and provides learners the opportunity to develop a greater conceptual understanding of the information shared by group members (Johnson et al., 2007). In the jigsaw method, positive interdependence is present as learners are dependent on each other for information. Within the jigsaw method learners are stimulated to share information and discuss this information together (Aronson et al., 1978). However, the jigsaw method does not explicitly state the importance of positive interdependency to share and discuss information (Van Dijk et al., 2019). This means learners need to be made explicitly aware of the need to cooperate in order for promotive interaction to occur (Van Dijk et al., 2019). Therefore, the worksheet used, tried to establish positive interdependence between learners, to stimulate promotive interaction.

Individual accountability is considered the third element of the Social Interdependence Theory which means that every individual is held responsible for his or her contribution to the groups' task and has an equal share in the groups' work and outcome (Johnson et al., 2007). This means that each group member is given responsibility for their part of the groups' work as well as their own work (Johnson et al., 2007; Lou et al, 1996). However, students do not always commit to their responsibilities when working in heterogeneous groups (Cohen, 1994; Hancock, 2004). In some cases, few group members can dominate groups' actions, consequently discouraging others to contribute to the process (Hancock, 2004). This is often the case for high-ability learners who take

the lead, leaving low-ability learners out of the conversation (Webb et al., 2002). The high participating learners are motivated and therefore learn more, whereas the less participating learners lose motivation and miss out on learning gains (Hancock, 2004). A possible way to promote individual accountability could be providing group members with transparent roles and tasks (Lou et al., 1996). This will make individuals aware of their and each other's responsibility (Johnson et al., 2007). Therewith, individual responsibilities lessen the possibility for learners to not engage in the groups' assignment (Johnson et al., 2007; Lou et al, 1996; Aranzabal, Epelde & Artetxe, 2019). In fact, this might actually boost them to contribute to the groups' work (Johnson, et al., 2007) as learners can feel pressured by the fact that they are held accountable for their contribution. Moreover, having transparent roles and tasks will make it easier for groups to evaluate and assess every individuals' contributions as well as the groups' work, which stimulates learners to cooperate as well (Johnson et al., 2007). When learners know they cannot hitch-hike, their participation will increase (Johnson et al., 2007). Furthermore, when learners know which group members might need help or encouragement, learners' communication will become more effective (Johnson et al., 2007). Subsequently, this will help group members to enhance their individual learning as they learn from and with each other (Johnson et al., 2007). In the jigsaw method, individual accountability is incorporated by the division of information among group members and their responsibility to share it. Every group member is assigned an expert of a subtopic and should share the information of that subtopic. However, the jigsaw method does not explicitly emphasize the importance of this responsibility of learners to achieve their goals, which can, if focused on, be an additional motivator to contribute to the group (Collazos, Padilla-Zea, Pozzi, Guerrero & Gutierrez, 2014). Therefore, learners should be made explicitly aware of their responsibility in the groups' work when learning cooperatively (Collazos et al., 2014; Mercer et al., 1996). Within the worksheet, Van Dijk et al. (2019) tried to explicitly emphasize the division of roles and learners' individual accountability. Additionally, in the jigsaw method learners are not told how to engage in more effective communication. However, learners do not always have the skills to engage in discussions that are effective for learning (Gijlers et al., 2013). This means learners need additional support on engaging in effective communication (Gijlers et al., 2013; Mercer et al., 1996). Therefore, the worksheet tried to explicitly support learners to share information by instructing learners to tell what they have learned.

The fourth element of the Social Interdependence Theory concerns learners' groups process, as effective group work is necessary for learners to achieve the cooperative learning goals together. The processes learners engage in can determine which actions learners take and the decisions they make, which ,if effective, can improve the quality of the cooperation and the interaction. Therefore, in order to achieve effective group work, learners need to evaluate and reflect on how the group is functioning regularly. Only when learners evaluate on a regular basis, they can discover needs for

improvements in their groups' process and enable themselves with the possibility to improve their group process. However, within the jigsaw method, the explicit need for evaluation is not present. For this reason, the worksheet intended to include multiple options on evaluating the groups process, trying to stimulate effective group work.

Finally, the fifth element of the Social Interdependence Theory involves learners' social skills. If learners are expected to engage in effective, promotive interaction, learners require a certain level of social skills (e.g. communication, leadership). However, as social skills are seen as a requirement, this element should be obtained prior to the cooperative process (Saab et al., 2007). This requires extensive training and was therefore not included in the worksheet that was intended to offer support right away (Van Dijk et al., 2019).

However, even though the worksheet based on the Social Interdependence Theory improved the dialogue, the worksheet did not enhance all learners' learning gain. A possible explanation for this inconsistency could be that many difficulties can arise when being assigned to cooperate that cause learners to fall into non-task and non-content discussions (i.e. discussions that are unrelated to the task or the information that should be discussed) (Van Dijk et al., 2014). Moreover, it is important for learners' interactions to not just share and discuss information, but to engage in transactive communication (Teasley, 1997). In transactive communication, learners use each other's input to the group's dialogue to reason upon, which is important for learners to improve their learning (Teasley, 1997). Only when learners use each other's contributions to the dialogue in their own reasoning, their understanding improves and their individual learning gain enhances (Teasley, 1997; Berkowitz, 1980; Weinberger & Fischer, 2006). Learning gain can improve from an improved dialogue by means of more explanations given and more theoretical information discussed, however, reasoning upon each other's explanations and information is required to enhance learners' individual learning gain (Teasley, 1997). Nevertheless, previous research showed that learners find it difficult to engage in transactive interactions as learners do not always know how to use and how to respond to the given explanations to learn from them (Gijlers et al., 2013; Van Dijk et al., 2014). Consequently, learners are not able to engage in transactive communication, which influences the learning process negatively (Berkowitz, 1980). This means that additional support to the jigsaw method should be given to stimulate learners to elaborate on, reason upon and discuss information, to enhance the quality of the learner's dialogue further and therewith learners' learning gain.

Learners' groups' dialogue

Within the cooperative process, two dimensions of interaction exist to examine and support the quality of the interaction of learners' groups' dialogues: the epistemic dimension and the social mode of construction (Weinberger et al., 2005).

Firstly, in the epistemic dimension, learners perform activities that enhance their knowledge construction, such as defining new concepts, verbalizing ideas, and providing each other with information supported by explanations (Fischer, Bruhn, Gräsel & Mandl, 2002; Weinberger et al., 2005; Weinberger & Fischer, 2006). These activities increase the theoretical information being discussed, which enhances the quality of the dialogue and therewith increases learners' individual learning gain (Fischer et al., 2002; Weinberger et al., 2005). When learners discuss and explain information to each other, learners discover and construct theoretical relations and build a cooperative knowledge construction (Teasley, 1997; Weinberger & Fischer, 2006).

Nevertheless, Weinberger et al., (2005) state that learners do not always engage in such epistemic activities (e.g. providing explanations) easily themselves. This means learners need to be encouraged to provide explanations. In using the jigsaw method, learners are given the necessity to share information and the opportunity to self-explain. However, the jigsaw method does not incorporate explicit guidance for learners on such epistemic activities as sharing information, providing self-explanations, and verbalizing ideas. On the contrary, the scripted support of van Dijk et al. (2019) did include support to stimulate such epistemic activities. As the worksheet intended to increase the information-sharing process and the amount of explanations given, learners were given scripted instructions when to share information or when to verbalize ideas.

Secondly, in the dimension 'social mode of co-construction', learners' interaction is specified and classified as different levels of transactive communication that learners can engage in (Weinberger et al., 2015; Teasley, 1997). This can enhance learners' individual learning gain, however, the extent to which learners engage in transactivity (i.e. different levels of transactivity) influences its effectiveness (Teasley, 1997). The higher the transactivity within learners' dialogue, the more they profit from each other's argumentations and develop a greater understanding (Noroozi et al., 2013; Berkowitz, 1980; Teasley, 1997; Weinberger & Fischer, 2006).

For this reason, having scientific insight and knowledge on the processes of shared knowledge construction is necessary, as it can help create effective situations for learners to learn together (Fischer et al., 2002). Therefore, research has been conducted to investigate the different categories of transactive communication needed to determine the transactivity in learners' dialogues (e.g. Berkowitz & Gibbs, 1983; Teasley, 1997; Weinberger & Fischer, 2006). In their research, Berkowitz and Gibbs (1983) divided transactive behavior in two main types: representative- and

operational transactive behavior. When learners engage in representative transactive behavior, learners only paraphrase prior reasonings or evoke reactions (e.g. ask for feedback). Therefore, this type of transactive behavior contains a low level of transactivity. When learners make use of operational transactive behavior, learners reason upon each other's reasoning as defined as transactive behavior. This can therefore be seen as a high level of transactivity. Learners providing clarification, refining or elaborating their opinion, addressing contradictions noticed in earlier provided arguments, or critically addressing misconceptions made, are exemplary types of such operational transactive behavior.

More specified to learners in heterogeneous cooperative settings, Weinberger and Fischer (2006) described five categories increasing in degrees of transactivity to identify the level of transactivity within learner's dialogues. The five categories are (1) externalization, (2) elicitation, (3) quick consensus building, (4) integration-oriented consensus building, and (5) conflict-oriented consensus building. Firstly, when externalizing, learners express their own knowledge to others without reasoning upon earlier made statements by group members. This category demands the least amount of transactivity, as learners only share information without making connections. More transactivity can be found in the dimension of elicitation where learners specifically ask group members for information. Thirdly, quick consensus building occurs when learners come to an agreement on how to pursue a task. This requires them to engage in more transactive behavior as consensus needs to be achieved. However, as the main reason is to be able to continue and learners would want to move on quickly, this form of consensus building does not support perspective changes of learners. In the integration-oriented consensus building learners do discuss perspectives using more arguments to eventually reach a shared understanding of a concept. Finally, the conflict-oriented consensus building requires the most transactive behavior as learners need to be critical on other's contributions to the dialogue. Learners need to provide more and detailed arguments when reasoning upon each other's perspectives to refine shared knowledge.

However, learners find it difficult to, and do therefore not always engage in higher levels of transactive communication for different reasons (Weinberger et al., 2005). Firstly, learners seem to handle given information somewhat superficial (Chinn & Brewer, 1993). Instead of building upon each other's reasoning critically, learners are more inclined to stick to their own prior knowledge and therefore do not try to achieve a conflict-oriented consensus building (Chinn & Brewer, 1993; Weinberger et al. 2005). Moreover, learners settle easier for quick consensus building to be able to move on rather than changing their own opinion through critical discussions (Chinn & Brewer, 1993; Weinberger et al., 2005). On the other hand, it is also possible for learners to change their opinions too easily, based on only a small amount of information given (Chinn & Brewer, 1993). For this

reason, awareness of the importance of being critical and how to be critical seems necessary for learners to engage in higher transactive communication (Chinn & Brewer, 1993).

Secondly, to build upon each other's reasoning, it is important for learners to have a mutual understanding of what is being discussed (Baker, Hansen, Joiner & Traum, 1999). However, learners do not always understand each other's reasoning (Baker et al., 1999). This decreases the transactivity within the dialogue, as learners cannot build upon something they do not understand (Baker et al., 1999). Therefore, it is important for learners to check up on each other's understanding (Baker et al., 1999).

Thirdly, as heterogeneous groups concern group members with different ability levels, this can make transactive communication more difficult as learners with different ability levels carry out cooperative tasks in different ways (Lou et al., 1996; Webb et al., 1998). The dialogue of learners can be affected negatively as learners have different knowledge levels and learn in different paces (Lou et al., 1996). Low ability level learners might not follow the higher ability level learners and for high ability level learners, the pace might be below their competence (Lou et al., 1996). This decreases the groups' mutual understanding and shared task-focus (Baker et al., 1999; Mercer, 1996). Additionally, it is possible for some group members to dominate the dialogue, decreasing the effectiveness of the learning outcomes (Webb et al., 1998; Hancock, 2004). Where high ability level learners tend to provide explanations easier and group members generally turn to the smartest group member for help, the interaction between learners shortens and becomes less critical, leading to less transactivity (Cohen, 1994; Nodding, 1998, as cited in Lou et al., 1996). This means that learners need guidance that supports them to engage in higher levels of transactivity.

Present study

The aim of this study is to build upon the findings of van Dijk et al. (2019) to examine the effect of transactivity within heterogeneous groups' dialogues on learners' individual learning gain when support is offered to enhance the quality of the dialogue. In cooperative learning, it is important to create positive interdependence and individual accountability amongst group members to ensure cooperative learning to enhance learning (Johnson et al., 2007). Learners need to be made dependent of each other in order to achieve their goals. Moreover, it is important to divide group members with clear tasks and roles and make them aware of their own responsibility (Lou et al., 1996). In using the jigsaw method these conditions are strengthened, however, additional support is needed to support the learners' dialogue (Gijlers et al., 2013), especially for information sharing and providing more theoretical explanations (Van Dijk et al., 2019). Nonetheless, it is not only important

to enhance learners' dialogues in quality by more theory being shared and explained (Berkowitz, 1980). It is also crucial what learners do with the received information for it to be effective on learners' learning gain (Berkowitz, 1980; Teasley, 1997). When learners reason upon the given information (i.e. transactivity), learners enhance their understanding and improve their individual learning gain (Teasley, 1997). However, it was stressed that learners find it difficult to engage in transactive communication (Weinberger et al., 2005). Therefore, it remains uncertain whether learners engage in transactive communication during cooperative learning. Additionally, it remains undetermined whether transactivity positively affects learners' individual learning gain. Hence, this study investigated the extent of transactivity shown by learners within heterogeneous cooperative dialogues and its effect on learners' learning gain. Using the data of the study of Van Dijk et al. (2019), this resulted in the following research questions:

R1: 'To what extent is there a relation between learners' engagement in transactive communication and their individual knowledge gain?'
H1: It is proven that when learners engage in transactive communication, learners' understanding of the concepts improve and therewith learners' individual learning gain can improve (Teasley, 1997). For this reason, it is expected that when learners engage in more transactive communication, their individual learning improves compared to learners that do not engage or engage less in transactive communication. Therefore, it is hypothesized that the extent of transactivity influences learners' individual learning gain positively.

R2: 'To what extent is there a relation between learners' engagement in the highest degrees of transactivity and their individual knowledge gain?'
H2: Considering that the higher degree of transactivity learners engage in, the more they can profit from reasoning upon each other and enhance their individual learning gain, it was hypothesized that learners that showed improvement in their learning gain, engaged in higher levels of transactivity.

R3: 'To what extent do ability levels influence the extent to which learners engage in transactive communication?'
H3: As different ability level learners approach tasks differently and have different needs to learn, this can influence the extent of transactive communication learners to engage in (Webb et al., 1998; Lou et al., 1996). Even though the worksheet supported each learner regardless of their ability to share information together, the way in which learners reacted upon the shared information was not supported. Therefore, it is expected that differences between different ability level learners could still appear in the extent to which learners engaged in transactivity. More specifically, considering

that higher ability level learners engage in discussions easier and explain easier than lower ability level learners, it is hypothesized that high ability level learners might also engage in higher degrees of transactivity easier compared to average ability level learners and low-ability level learners.

Method

Participants

The data from the study of Van Dijk et al. (2019) included 136 participating learners grouped in heterogeneous groups of four based on their ability level (based on intelligence). Learners were categorized as low-ability level learner, average ability level learner, and high-ability level learner by usage of the Dutch students' monitoring system (Centraal Instituut voor Toetsontwikkeling, 2012). This standardized scoring system determines learners' ability level based on their relative position within their age group for various subjects. For each subject, scores vary from I (20% highest scoring learners) to V (20% lowest-scoring learners). In the study, scores for four academic subjects (i.e. technical reading skills, mathematics, spelling, and reading comprehension) were taken to categorize them into the ability levels. When a learner scored a V on two of the four subjects, they were categorized as a low-ability level learner. Learners that scored I on three of the four subjects, as well as learners who were identified as gifted, were categorized as high-ability level learner. The remaining learners were categorized as average ability level learners. Each group included four learners: one high-ability level learner, one low-ability level learner, and two average ability level learners. From the total sample of Van Dijk et al. (2019), which included a control group, 14 heterogeneous groups (24 boys, 32 girls; M_{age} = 10.96 years, sd = 0.80) were examined in the present study. For all participants, active consent was given by their parents for participation in the study and usage of the data for research purposes.

Materials

Script.

For the study of Van Dijk et al., (2019) a script (i.e. worksheet) was developed to structure the cooperative process for the heterogeneous groups (see Figure 1). This worksheet was designed with the intention to increase the elements of the Social Interdependence Theory (i.e. positive social

interdependence, individual accountability, promotive interaction, and evaluation of the group process). The aim of the worksheet was to stimulate learners to share all information on their topic as topics were divided over learners according to the jigsaw method. In order to do so, the worksheet scripted the process into four steps that helped students to share information based on the conditions necessary for cooperative learning according to the Social Interdependence Theory (Johnson et al., 2007). In the first step, learners had to tell group members the topic they were assigned to, to enhance the feeling of responsibility amongst learners (i.e. positive interdependence and individual accountability). Secondly, learners were asked to write down two concepts explained by other group members to stimulate learners to listen to each other (i.e. positive interdependence and individual accountability). In the third step, learners were instructed to construct a list of eight concepts together named by group members that should be used to complete their task to develop a moonhouse. Fourthly, the group was instructed to reflect on the cooperative process and fulfilled task (i.e. evaluation of the groups process). By usage of clear references throughout the worksheet to the different topics, learners were supported on the content necessary to discuss, to support the quality of the dialogue towards a more content-related dialogue. For the same reason, the worksheet had a specific focus to emphasize providing and receiving of explanations within learners' interactions to enhance the quality of learners' dialogue further.

Knowledge tests.

In the study of Van Dijk et al. (2019) learners were assigned to complete multiple tests to evaluate their individual learning gain. Firstly, learners were asked to make a parallel pretest and posttest on their knowledge concerning the to them assigned topic (i.e. light and heat, oxygen, water, and nutrition). Therefore, for each topic two tests were developed, each consisting of eight questions. Within each topic, four subtopics were selected to cover the content learners learned about during the process. For each subtopic, two questions were developed: a question to determine whether learners were able to name and define a main concept of their subject (1), and a question to examine whether learners could apply the knowledge learned (2). Secondly, learners were assigned an open recall test on the other topics they discussed during cooperative learning twice, one prior to the project and one afterward as a pretest-posttest design. In the first open recall test, learners were asked to write down as much as they knew about the subject using single words or short sentences to examine learners' prior knowledge. No maximum or minimum amount of words were set or required. Afterward, learners were instructed to write down everything they learned.

Video files.

To gain insight in the transactivity present within the heterogeneous groups cooperative dialogues, video files of learners' cooperative dialogues were obtained from the study of Van Dijk et al. (2019). These video files were recorded using an individual camera with a Bluetooth connected

microphone for audio recording and taped the process of learners fulfilling their task (i.e. creating a moonhouse) cooperatively in heterogeneous groups. Therewith, the video files included learners' dialogue including the process of sharing information and the discussions that took place.

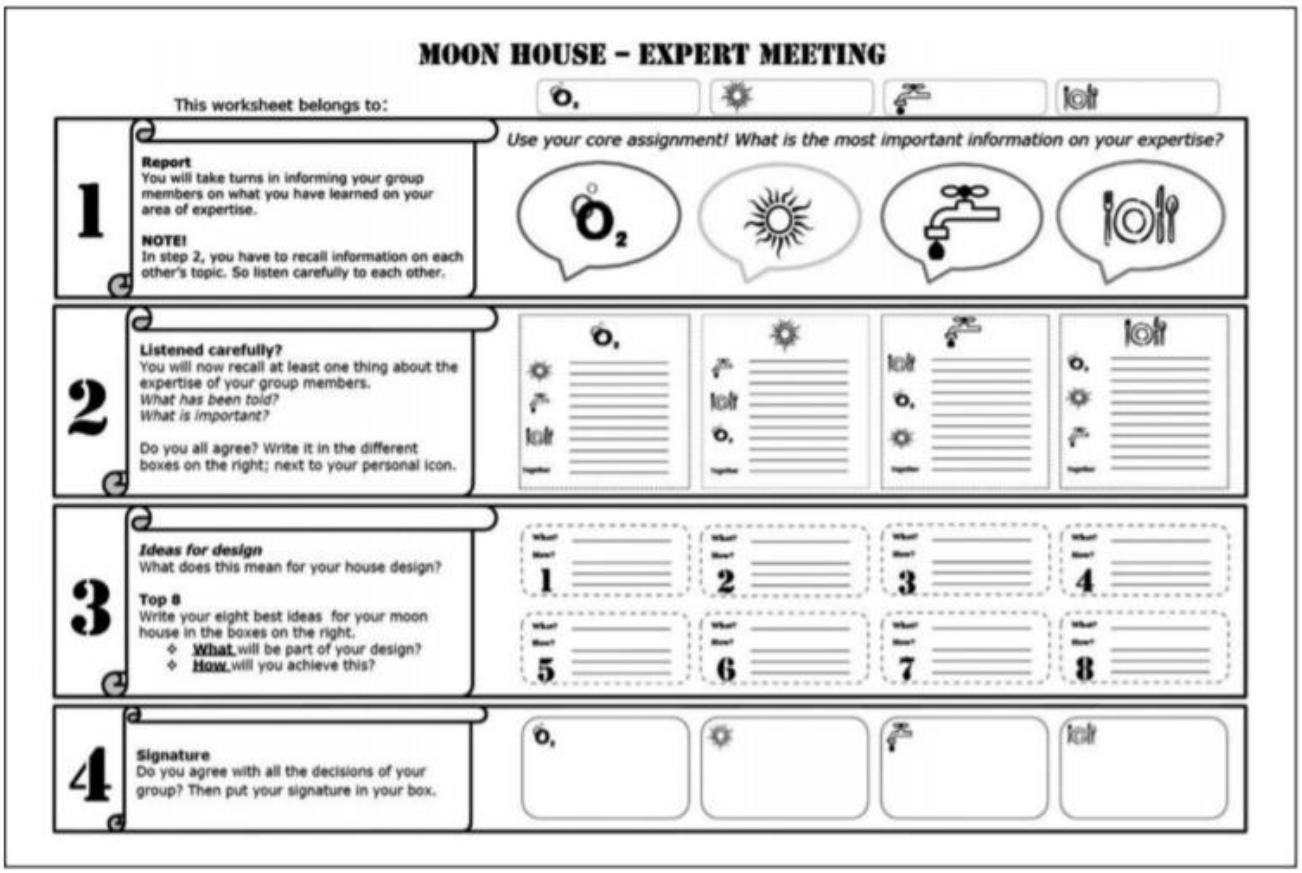

Figure 1: Worksheet. Adapted from "Supporting Cooperative Dialogue in Heterogeneous Groups in Elementary Education, " by A. M. Van Dijk, T. Eysink, and T. Jong, de, 2019, *Small Group Research,* p. 9. Copyright 2019 by The Author(s).

Data analysis

Knowledge tests analysis.

To analyze the answers given to the knowledge test on their assigned topic, Van Dijk et al. (2019) developed a coding scheme. Answers were scored with 0 to 3 points, based on the presence of the required concepts and explanations of processes. As each test had 8 questions, in total, learners could score a maximum of 24 points.

To analyze the open knowledge recall test, eight key concepts per topic were determined as the basis for a coding scheme. As the pretest and posttest differed in instructions, Van Dijk et al. (2019) calculated normalized learning gain. First, for awarding the pretest, every correct answer

present was awarded 1 point. On the test, a maximum of 24 points could be scored, as for three topics, eight points could be scored. Secondly, for every additional new concept present in the posttest in comparison to the pretest, 1 point was awarded. Finally, as the pretest and posttest had different instructions, normalized learning gain was calculated to determine learners' learning gain. To do so, the number of new concepts was divided by the possible total learning gain (i.e. maximum score minus score on the pretest).

Discourse analysis.

To assess the degree of the transactivity within learners' dialogues, the coding scheme from Van Dijk et al. (2014) was adjusted. This coding scheme was based on the work of Weinberger and Fischer (2006) coding the dialogue in both the epistemic dimension and the social mode of co-construction (i.e. transactive communication). As this study focused on the transactivity within the learners' dialogues, the coding scheme was adapted only to use the part for coding transactive communication. In the coding scheme, the five categories of transactive communication increasing in degrees of transactivity: externalization (1), elicitation (2), quick consensus building (3), integration-oriented consensus building (4), and conflict-oriented consensus building (5), as stressed prior were identified (Weinberger & Fischer, 2006; Teasley, 1997).

To analyze the video files, ELAN software ("ELAN Multimedia Annotation Tool,"2013; Sloetjes & Wittenburg, 2008) was used. The video files were first segmented into utterances based on learners' speaking turns within each group. A speaking turn started when a learner started talking and ended when the learner stopped talking or was interrupted by another learner starting to talk or by a third party (e.g. researcher, a learner from a different group, teacher). Secondly, the utterances were coded according to the coding scheme (see Table 1). For every utterance, it was determined whether learners engaged in *transactive communication* concerning the sharing of information or whether a sentence should be identified as *other*. Accordingly, when a utterance was identified as *transactive*, the degree of transactivity present within the learner's utterance was identified. When a learner engaged in multiple degrees of transactivity within one utterance, it was coded as the highest degree of transactivity present in the utterance. When an utterance was identified as *other*, two sub-codes were distinguished to gain more insight into the flow of learner's dialogues: *off-task* and *on-task* (i.e. coordinative talk). Incomprehensible utterances were coded as such and were excluded from further analysis. A second coder coded 7% of the video recordings (i.e., 429 segments). An inter-rater reliability of .80 (Cohen's kappa) was reached on *transactive communication* and .72 (Cohen's kappa) on *other* was reached.

Learners' dialogues were analyzed on an individual as well as on group level. Within each code, the total utterances were calculated. To see differences between the degree of transactivity learners engaged in, percentages per code on the total dialogue were calculated by means of dividing

the number of utterances in the code by the total number of utterances provided by the group or individual. Combined with the scores on the test and learners' calculated individual learning gains, these differences were used to assess the possible effect of transactivity on learners' individual learning gain.

Table 1

Coding Scheme

Categories	Description	Examples
Transactive		
Information sharing		
Externalization	Externalizing content to cooperative partner	Heat is important to live on the moon
Elicitation	Requesting information from cooperative partner	Why did you do this?
Quick consensus		
Agreement	Quick-consensus building: agreeing with a partner	Okay
Disagreement	Disagreeing without showing comprehension	No
Transactivity		
Integrating	Evidence that the speaker learned from partner	I see what you mean
Critiquing	Critiquing or correcting input from partner	Okay, but isn't it…
Other		
On-task	On-task, talk that does not concern the content, but concerns learners actions within the task	I am going to write that down
Off-task	Off-task talk	Stop being so annoying!

Results

Learning gain

To answer the former two research questions concerning to what extent learners' engagement in (the different degrees of) transactive communication is related to learners' individual learning, first, learners' learning gain was analyzed. From the results on both knowledge tests learners' individual learning gain per test was calculated. Table 2 shows learner's total individual learning gain and per ability level on the open knowledge recall test (i.e., number of new concepts named in the posttest as compared to the pretest as a percentage of possible new concepts mentioned) and the knowledge test (i.e., difference between pretest and posttest).

Table 2

Mean percentage gained on the Open Knowledge Recall Test and the Knowledge Test

	Total		High ability level		Average ability level		Low ability level	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Open knowledge recall	12.94	9.40	13.54	11.75	13.61	9.53	11.05	6.91
Knowledge test	5.55	4.92	4.58	4.91	6.12	5.18	5.33	4.58

Learners' dialogue

Secondly, in addition to learning gain, learners' dialogues were analyzed to investigate to what extent learners' engagement in (the different degrees of) transactive communication is related to learning gain. In total, 8.638 segments were produced within the learners' heterogeneous cooperative dialogues (*M* = 617, *SD* = 210). To take into account differences in the number of segments produced per group, proportional scores were used for the analyses. Table 3 presents the average percentage of the learners' dialogue focusing on the different forms of transactivity. To examine the effect of both learners' individual engagement in transactive communication, and the group's total engagement in transactive communication on learners' individual learning gain, scores are presented on both group level and individual level.

Table 3

Percentage-wise Scores of the Extent of Transactivity in Groups' Dialogue

		Group level		Individual-level	
		M	SD	M	SD
Information sharing	Externalization	29.2	5.9	30.2	8.5
	Elicitation	3.4	1.2	3.3	2.1
Quick consensus building	Agreement	5.4	2.1	7.3	13.1
	Disagreement	1.4	0.6	3.2	13.2
Transactivity	Integrating	2.3	1.2	2.0	1.7
	Critiquing	2.4	2.0	2.4	2.4
Other	Off-task	31.4	4.3	30.3	12.3
	On-task	24.5	8.2	24.8	8.6

From the learners' dialogues it becomes clear that most time was spent on discussing *other* talk (i.e. on-task and off-task talk). The remaining part of the learners' group dialogues focused on sharing and discussing information using transactive communication ($M_{\text{group level}}$ = 42.5%; $M_{\text{individual level}}$ = 45.4%). Within these groups' dialogues concerning the discussion of information, most time was spent on the lowest level of transactive communication: information sharing (i.e., $M_{\text{group level}}$ = 32.6%; $M_{\text{individual level}}$ = 33.5%). For the higher form of transactivity (i.e., Quick consensus building), learners engaged in agreeing and disagreeing 6.8% vs. 10.5%. Finally, learners spent only 4.7% vs. 4.4% of their dialogue on the highest form of transactive communication (i.e., transactivity). Concerning individual level and group level, no significant differences were found.

Transactivity.

Subsequently, tests were performed to answer the research questions. To test the first hypothesis to examine whether the extent learners' engaged in transactive communication is related to learners' individual learning gain, a correlation and regression analysis were performed. First, to test transactivity to be related to learning gain, a bivariate correlation (i.e. Spearman's Rho) test was conducted. As learning gain is examined within two different tests (i.e. knowledge test and open recall test), both were examined for correlation with the amount of transactivity used by learners on both group level and individual level. No correlation between the different learning gain results and the amount of transactivity used was found (see Table 4). Consequently, the linear regression analyses performed showed a non-significant outcome for the total amount of transactivity to affect learning gain. Within the analysis, learning gain as the dependent variable, and the total amount of transactive communication as the independent variable was investigated. None of the tests showed

to be a significant model for the amount of transactivity to predict learning gain. For the learning gain from the open recall test the total amount of transactivity on group level showed to predict F(1,49) = 0.023, *p* = .881, R2 = .000, and F(1,49) = 0.022, *p* = .882, R2 = .000 on individual level. For learning gain from the knowledge tests the total amount of transactivity on group level showed (F1,47) = 0.005, *p* = .945, R2 = .000, and F(1,47) = 1.190, *p* = .281, R2 = .025 on individual level.

Table 4

Summary of Correlations for Scores on Learning Gain in the Open Recall Test, Learning Gain in the Knowledge Test, and the Different Degrees of Transactivity on Group Level and Individual Level

		1	2	3	4
1.	Open recall test learning gain	-			
2.	Knowledge test learning gain	.043	-		
3.	Total amount of transactivity individual level	-.058	-.180	-	
4.	Total amount of transactivity Group level	-.065	-.053	.685**	-

Note: *p < .05, **p < .01, two tailed

To examine the second hypothesis to investigate to what extent learners' engagement in the highest degrees of transactive communication is related to learners' individual learning gain, an additional bivariate correlation test (i.e. Spearman's Rho) and regression analysis were conducted. All the different degrees of transactive communication were tested separately for correlation with learners' individual learning gain. None of the different degrees of transactivity showed to be correlated to learner's individual learning gain on the knowledge test or the open recall test, as shown in Tables 5 and 6. Nevertheless, a number of different degrees of transactivity showed to be significantly correlated between themselves. However, consequently, in a linear regression analysis, none of the different degrees of transactivity showed to be a predictor on learning gain (see Tables 7 and 8).

Table 5

Summary of Correlations for Scores on the Open Recall Test, Knowledge Test, and the Different Degrees of Transactivity on Group Level

		1	2	3	4	5	6	7	8
1.	Open recall test learning gain	-							
2.	Knowledge test learning gain	.043	-						
3.	Externalization	.227	-.575	-					
4.	Elicitation	.134	-.015	.271	-				
5.	Agreement	.177	-.360	.557*	.390	-			
6.	Disagreement	-.086	.272	.202	.034	-.139	-		
7.	Integrating	-.173	-.048	.384	.565*	.117	.270	-	
8.	Critiquing	-.219	-.332	.464	.452	.398	.153	.525	-

Note: *p < .05, **p < .01, two tailed.

Table 6

Summary of Correlations for Scores on the Open Recall Test, Knowledge Test, and the Different Degrees of Transactivity on Individual Level

		1	2	3	4	5	6	7	8
1.	Open recall test learning gain	-							
2.	Knowledge test learning gain	.043	-						
3.	Externalization	-.032	-.071	-					
4.	Elicitation	-.002	-.122	.052	-				
5.	Agreement	.025	-.066	.231	.023	-			
6.	Disagreement	-.050	-.041	.043	-.062	.265*	-		
7.	Integrating	.114	-.238	.164	.361**	.098	.301*	-	
8.	Critiquing	.008	-.157	.165	.413**	.124	.094	0.362**	-

Note: *p < .05, **p < .01, two tailed.

Table 7

Multiple Regression Analysis Predicting Learning Gain from the Open Recall Test

	Group level	Individual-level
Variable	B	B
Externalization	1.55	-0.01
Elicitation	0.52	-0.10
Agreement	-1.08	-0.01
Disagreement	-0.15	-0.01
Integrating	-0.33	0.02
Critiquing	-0.44	0.10
R2	0.67	0.02

Note: $*p < .05$, $**p < .01$, two tailed.

Table 8

Multiple Regression Analysis Predicting Learning Gain from the Knowledge Test

	Group level	Individual-level
Variable	B	B
Externalization	-1.02	0.02
Elicitation	-0.15	-0.83
Agreement	0.63	-0.34
Disagreement	0.52	0.27
Integrating	-0.06	-0.13
Critiquing	0.11	-0.01
R2	0.37	0.07

Note: $*p < .05$, $**p < .01$, two tailed.

Ability level.

In order to examine the last hypothesis investigating whether learners from different ability levels engage in transactive communication differently, a closer look was taken at learners' engagement in transactivity per ability level. Table 9 presents the average percentages for each form of transactivity learners engaged in per ability level. From Table 9 it seems that no outstanding differences in averages appear between the different ability levels. However, even though the differences between groups seem small on averages, the standard deviations seem to differ more extensively. To examine whether learners from different ability levels differed significantly in the

extent in which they engaged in transactive communication, a Kruskal-Wallis test was performed. For both the total amount of transactivity (H(2) = .359, *p* = .836), as well as the different forms of transactivity, no significant differences were found between the different ability levels: externalization: H(2) = 0.034, *p* = .983; elicitation: H(2) = 0.200, *p* = .905; agreement: H(2) = 0.219, *p* = .896; disagreement: H(2) =3.465, *p* = .177; integrating: H(2) = 4.956, *p* = .084; critiquing: H(2) = 0.045, *p* = .978.

Table 9

Percentage-wise Scores of the Extent of Transactivity in Groups' Dialogues per Ability Level

		High-ability		Average ability		Low-ability	
		M	*SD*	*M*	*SD*	*M*	*SD*
Information sharing	Externalization	30.1	7.1	30.4	9.1	29.9	9.1
	Elicitation	3.2	1.9	3.2	2.0	3.6	2.5
Quick consensus building	Agreement	5.2	2.7	8.6	18.1	6.8	5.3
	Disagreement	2.0	1.2	4.8	1.9	1.1	0.9
Transactivity	Integrating	2.7	1.8	2.0	1.7	1.3	1.5
	Critiquing	2.4	2.4	2.4	2.8	2.2	1.8
Other	Off-task	27.2	6.6	23.8	7.9	24.5	11.3
	On-task	27.1	11.8	31.7	10.8	30.5	15.6

Discussion

In the study of van Dijk et al. (2019) the information sharing process of learners' groups dialogues improved by implying the jigsaw method supported with a script based on the Social Interdependence Theory when learning cooperatively. However, not all learners' learning gain improved, possibly as learners might not have known how to engage in the received information. As demonstrated in previous studies (e.g., Teasley, 1997; Weinberger et al., 2005) transactive communication is an essential factor for cooperative learning to affect learners' learning gain. Nevertheless, transactive communication was not specifically supported nor investigated by Van Dijk et al (2019). Therefore, the present study aimed to examine the extent to which learners engaged in transactive communication to investigate the effect of transactivity on learners' individual learning gain. It was expected that learners that engaged in transactive communication more and engaged in

higher degrees of transactivity would show higher individual learning gain compared to learners that did not or engaged in lower degrees of transactive communication.

In contrast to the expectations, the results showed that transactive communication did not affect learners' individual learning gain. The results of the correlation and regression analyses revealed that the amount of transactive communication nor the different forms of transactivity predicted learners' learning gain. This finding is not in line with previous research that proved transactive communication to enhance learning gain (Teasley, 1997). However, this outcome is no surprise considering the amount of transactive communication learners engaged in. Learners spent most of their dialogue coordinating the task and talking about topics other than the content, and sharing information as assigned in the script. Only a small amount of the groups' dialogues was spent on transactive discussions that focused on the domain in question. This might have been too little to have an effect on learning. A similar result was found by Schuitema, Van Boxtel, Veugelers and Ten Dam (2011), in which learners focused primarily on finishing the assignment rather than discussing information. Possibly, as the script structured the task of sharing information and supported the epistemic dimension explicitly, the script over-scripted the cooperative process (Dillenbourg, 2002; Weinberger, Fischer & Mandl, 2001). This could decrease the need to seek for information and diminish the necessity to engage in transactive communication (Weinberger & Fischer, 2006; Mäkitalo et al., 2005). In fact, this could have prevented transactive communication from occurring (Weinberger et al., 2001). Therefore, a script with less structure or guidance on interaction (i.e., sharing information) seems needed to increase the transactive communication used by learners. Hence, future research should investigate the effect of less structured scripts on the extent of transactive communication learners use.

Another possible explanation for the little time spent on transactive communication could be the lack of learners' ability to engage in transactivity. Previous research states learners to not easily engage in transactivity (e.g. Jurkowski & Hänze, 2015; Cohen, 1994; Chinn & Brewer, 2013; Baker et al., 1999). Engagement in transactive communication requires learners to have a certain level of thinking and social skills (Azmitia & Montgomery, 1993; Johnson et al., 2007). Learners need the skills to reason upon information, and therefore need to be able to order information given, analyze and compare information, generate ideas on their own, distinguish facts from opinions, find relations within the information and communicate their findings and believe (McGuinness, 1999; Johnson et al., 2007). These skills, however, develop as age increases (Koerber, Osterhaus, Schwippert & Sodian, 2015). For this reason, especially young learners, do not have the skills themselves and need extensive support how to engage in transactive communication (Koerber et al., 2015; Saab et al., 2007; Jurkowski & Hänze, 2015). Learners that received training on transactive communication showed to increase their individual learning gain (Jurkowski & Hänze, 2015). This suggests that

offering implicit support in a script on the spot as done by van Dijk et al. (2019) might not be enough to elicit transactive communication. Moreover, this suggests that training prior to the cooperation is needed before implicit support via a script can enhance transactive communication.

It was also expected that learners from different ability levels (based on intelligence) would engage in transactive communication differently. However, in contrast to the expectations, no differences were found. Again, a possible explanation could be the small amount of transactive communication demonstrated by learners. The lack of learners overall usage in transactive communication could have caused the absence of potential differences between learners with different ability levels. Nevertheless, more explanations are possible. A feasible explanation could be found in the effect of the support offered through the script. Possibly, the script enhanced learners shared task focus, making communication easier for all learners regardless of their ability level (Gijlers et al., 2013). As a consequence, it could have led to a more equal use of transactivity between learners regardless their ability level (Gijlers et al., 2013). Similarly, the script's aim to enhance learners' equal participation to the group dialogue could have indirectly affected learners' usage of transactive communication more than expected.

Additionally, it could be that learners from this target group were too young to engage in transactivity differently. As the impact of age suggests transactive communication to be related to cognitive skills, differences between ability levels should have appeared. However, as stressed prior, these skills need to be learned (Koerber et al., 2015). Therefore, it could be that none of the learners yet mastered the skills enough to show differences in their use of transactive communication (Koerber et al., 2015). Hence, future research should provide clarity on the relation between learners' cognitive skills and use of transactive communication. Furthermore, it seems interesting to investigate from which age learners' use of transactive communication can differ per ability level.

Conclusion

The present study explored whether the extent of transactive communication learners engaged in during cooperative learning affected learners' individual learning gain while being supported to share information and provide explanations to each other (Van Dijk et al., 2019). Against expectations, the results showed that neither the amount of transactive communication nor the different forms of transactivity affect learners' individual learning gain. Additionally, the present study indicates that learners' ability levels don't affect learners' use of transactive communication. And examination of learners' groups' dialogues revealed that learners spent only a small amount of time on transactive communication in general. Moreover, it was found that the higher the forms of transactivity, the fewer learners engaged in it. This reveals that young learners do not engage in transactive

communication themselves easily. Therefore, they might benefit from explicit support to learn how to engage in transactive communication. Future research is needed to establish effective support for young learners to engage in transactive communication during cooperative learning.

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