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Supporting Cooperative Dialogue in Heterogeneous Groups in Elementary Education

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Abstract

Literature agrees that learning in heterogeneous groups could benefit from support that structures the cooperative process, but has been inconclusive as to what this support should look like. This study investigated the effects of a worksheet that structured a heterogeneous cooperative process. The worksheet addressed the elements of social interdependence theory. Fourth to sixth graders (n = 136) worked cooperatively in 34 heterogeneous groups of four, either with or without the worksheet. Results showed that heterogeneous cooperation benefited from the worksheet. Group members with the worksheet participated more equally in the domain-related dialogue, and a larger proportion of the group dialogue was task oriented and spent on exchanging domain-related explanations in comparison with the control group. However, adding the worksheet helped only low-ability children to increase their level of knowledge. Future research should look into possibilities for children's learning outcomes to benefit more from improved heterogeneous group dialogue.

Keywords

cooperation, ability grouping, discourse analysis, elementary education

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Cooperative learning is a popular instructional approach in elementary education (Slavin, 2015). In cooperative learning, children work together to learn from and with each other, being responsible for their own learning process as well as that of their group members (Förrer, Kenter, & Veenman, 2000; Slavin, 1990). For cooperative learning to be effective, children should focus on the task and on sharing explanations (Baker & Lund, 1997), and build upon each other's reasoning (i.e., transactivity; Teasley, 1997). If this occurs, then cooperative learning has been shown to have positive effects on children's achievement (Slavin, 2015). However, children are generally unaware of what is expected from them in a cooperative setting. They are often not focussed on the task and its content, and they regularly fall into uncooperative, competitive dialogue that does not involve sharing information (Mercer, 1996). When working in mixed-ability groups, which is common practice in elementary education (Bosker & Doolaard, 2009), these problems might even be amplified due to differences in knowledge level and pace of learning (Lou et al., 1996; Wang, Kinzie, McGuire, & Pan, 2010). In most situations in which students of different ability levels work together, status differences that are based on ability become activated almost immediately (Cohen & Lotan, 1995). Although working in a heterogeneous setting is generally considered to affect the performance of low- and average-ability children positively (Webb, Nemer, Chizhik, & Sugrue, 1998), it might also lead to situations in which the higher ability children dominate the dialogue and in which the other children accept this without critically reflecting on the contribution of the higher ability children (Webb et al., 1998). As a result, relevant information is often not shared, suspending the expected positive effects on their achievement (see also research on the hidden profile paradigm, e.g., Kirschner, Kirschner, & Janssen, 2016; Stasser & Titus, 1985).

Förrer et al. (2000) stated that heterogeneity could, however, be constructive when differences between children are used positively within the learning process. In this regard, it seems important to enhance the status of the different individuals in a group, so that group members consider each other as resources and potential contributors instead of competitors (Aronson, Blaney, Stephan, Sikes, & Snapp, 1978). A cooperative learning method that implemented this idea is the *jigsaw method*. In this method, each group member possesses a unique piece of information necessary for the group to complete the group task successfully (Walker & Crogan, 1998). The jigsaw method incorporates positive interdependence and individual accountability, which, according to the social interdependence theory (Johnson, Johnson, & Smith, 2007), are considered as prerequisites for a fruitful cooperative process. When working with the jigsaw method, group members should share their information and leave room for others to also share their information to reach the shared learning goal. To lead to knowledge acquisition, this exchange of information needs to include domain-related explanations (Cohen, 1994; Weinberger & Fischer, 2006). To make sure that group members share information, which is essential for learning (van, den, Gijselaers, Segers, & Kirschner, 2006; Webb, 1982a, 1982b, 1984), children should be aware of their group members' different expertise and skills so that they all participate in the group dialogue (Förrer et al., 2000).

Previous research demonstrated that the jigsaw method was more successful than learning in traditional cooperative groups, leading to higher academic achievement (e.g., Aronson & Patnoe, 2011; Colosi & Zales, 1998). The method ensures that group members actively take part in the group process by sharing their knowledge and discussing the content in differently composed groups (Karacop & Doymus, 2013; Oakes, Hegedus, Ollerenshaw, Drury, & Ritchie, 2019). However, these process-related benefits have been demonstrated with an older target group (i.e., university students), and it is not clear yet how the method affects younger children's cooperative processes.

The fact that elementary school children in mixed-ability groups might not spontaneously engage in productive knowledge sharing (Mercer, 1996; Mercer, Wegerif, & Dawes, 1999) suggests that they need additional support when working with the jigsaw method. This study intends to gain insight in whether merely providing the jigsaw method leads to a fruitful cooperative learning process, or whether elementary school children should be given additional support for the jigsaw method to yield its positive effects.

Social Interdependence Theory

In their social interdependence theory, Johnson et al. (2007) distinguished five conditions that should be fulfilled to ensure a fruitful cooperative learning process. First, group members should realize that working together could benefit both their individual and their collective learning goals (i.e., positive social interdependence; Johnson et al., 2007). When positive social interdependence exists, group members work together to optimize the learning process by sharing their resources and providing each other with support resulting in positive learning effects (Lou et al., 1996). A precondition for positive social interdependence to occur is that group members leave room for each other to participate in the group process. However, some children, especially the high-ability ones, believe that they have the expertise and ability to complete the task on their own (Webb, Nemer, & Zuniga, 2002). They tend to dominate the cooperative process by solving problems individually and not leaving room for their lower ability group members or ignoring their suggestions (Mugny &

Doise, 1978). The study by Webb et al. (2002), however, showed that children who generally take the lead in a cooperative process do not have the intention of suppressing their group members. This might suggest that, when creating a situation of positive social interdependence, children should explicitly be made aware of their positive social interdependence and they should be stimulated to act upon this situation.

A second important element of cooperative learning is individual accountability (Johnson et al., 2007). This means that every group member is individually responsible for his or her own work, as well as contributing his or her fair share of work toward the group goal. However, a recurring issue in cooperative groups is that some group members do not feel the need to participate and, therefore, contribute less than they are capable to (i.e., diffusion of responsibility; Slavin, 1990). Especially, low-ability children working together with high-ability children often feel that contributing has little value for the group product, which leads to low levels of motivation (Shepperd, 1993). Children's individual accountability can be enhanced when there is little overlap in prior knowledge of the group members, so that each group member feels the need to inquire information from the other group members and to contribute to the process by sharing the own information with the other group members (Stasser & Titus, 1985; Wood, Bruner, & Ross, 1976). Collazos, Padilla-Zea, Pozzi, Guerrero, and Gutierrez (2014) add that making children explicitly aware of their individual accountability might encourage them to indeed act on that.

Third, the cooperative learning process benefits from students encouraging and assisting their group members to achieve the group's goals (i.e., promotive interaction; Johnson et al., 2007). In situations of promotive interaction, an atmosphere is created that promotes sharing information and giving and receiving explanations. Research has shown that this has positive effects on learning (Webb, 1982a, 1982b, 1984, 1991), not only in homogeneous groups but also in mixed-ability groups. Lower ability children benefit from explanations they receive from their higher ability group members (Gillies, 2003; Lou et al., 1996) and higher ability children benefit from giving those explanations (Lou et al., 1996), although Webb et al. (2002) showed that help-giving behavior in heterogeneous groups in general leads to better performance. Therefore, children should be able to engage in both of these activities. However, as some children tend to show competitive dialogue instead of demonstrating help-giving behavior (Mercer, 1996; Mercer et al., 1999), merely providing this opportunity might not be enough (Mercer, Dawes, Wegerif, & Sams, 2004). Instead, children should be guided in this process, for instance, by stimulating them explicitly to engage in promotive interactions.

Fourth, evaluation of the group process enacted by the group itself plays an important role in the productiveness of the cooperative process (Johnson et al., 2007). Process evaluation consists of reflecting on the accomplishment of group goals and group members' contribution to this accomplishment and making decisions about whether or not to change aspects of the group process. For process evaluation to occur, groups should be stimulated to reflect on their group process.

As a fifth essential element, Johnson et al. (2007) mention that appropriate use of social skills during the cooperative process is essential for its success. Social skills, such as decision making and conflict management, are considered to be complex and require extensive training. Research into children's social skills during cooperative processes has indicated that younger children in particular need training in these skills (Gijlers, Weinberger, van Dijk, Bollen, & van Joolingen, 2013; van Dijk, Gijlers, & Weinberger, 2014), and that this training should occur outside of the cooperative process itself (see also Saab, van, Joolingen, & van Hout-Wolters, 2007).

A cooperative learning method in which the elements of social interdependence theory are implicitly incorporated is the jigsaw method (Aronson et al., 1978). The jigsaw method creates a learning situation in which each group member possesses a unique piece of information and in which all these pieces are necessary for the group to reach their shared learning goal. Children should share their information and leave room for others to also share their information. Research on the hidden profile paradigm has shown that information that is uniquely divided over group members is not always automatically shared within a group (e.g., Stasser & Titus, 1985). However, making group members dependent on each other for completing a task and sharing relevant information has proven to be successful in this context (Kirschner et al., 2016), which is also the case in the jigsaw method. An additional problem might be, however, that creating this learning situation might not be enough for elementary school children to engage in productive patterns of cooperative interaction (Mercer, 1996). Therefore, the process might benefit from combining this method with additional support that focuses on strengthening and facilitating the elements of social interdependence theory (Johnson et al., 2007).

One way to do so, is through scripting the cooperative process (Dillenbourg & Tchounikine, 2007; Weinberger, Stegmann, & Fischer, 2010). Scripts explicate different steps in the cooperative learning process and can structure the group's interaction in such a way that group members are more likely to engage in content-related interaction, which is often associated with higher learning outcomes (Vuopala, Naÿkki, Isohätälä, & Järvelä, 2019). By specifying and sequencing different activities, a script warrants that activities are carried out by all group members (Weinberger, Ertl, Fischer, & Mandl, 2005). In this way, scripts stimulate that group members not engage in only one delimited activity but instead take turns in performing different responsibilities throughout the cooperative process. Earlier research has shown that scripting the cooperative process in elementary education indeed leads to higher learning outcomes and a cooperative dialogue that is characterized by a greater focus on the to-be-learned domain (e.g., Gijlers et al., 2013; van Dijk et al., 2014). The principles of social interdependence theory (Johnson et al., 2007) could be integrated in a script-like support tool to (a) make children aware of the division of information within the group, (b) provide room for and encourage all group members to contribute and share information, and (c) stimulate them to evaluate the group process. This would lead to a higher quality cooperative process, which is characterized by equal participation in the cooperative dialogue and more information sharing among group members. This process would, in turn, lead to more knowledge acquisition.

Hypotheses

Additional support that focuses on emphasizing positive social interdependence and individual accountability creates a situation in which group members leave room for each other to participate in the group dialogue and feel individually responsible for contributing their part in achieving the group goal (Johnson et al., 2007). This leads to a situation in which each member feels the need to participate and for others to participate, and, therefore, show a higher likelihood of an equal contribution to the group process (Slavin, 1990). Therefore, the following hypothesis was formulated:

> **H1:** Scripting the jigsaw method will create more equivalent participation among children participating in a heterogeneous cooperative dialogue.

Use of a script to support the cooperative jigsaw process creates a situation in which active participation in knowledge-sharing activities is enhanced as group members are made aware of their consecutive responsibilities to share the information of their expertise (Vuopala et al., 2019; Weinberger et al., 2005). A script that focuses on emphasizing positive social interdependence and individual accountability by explicitly instructing group members to take turns in sharing and discussing domain-related information creates a situation in which all group members are expected to provide domain-related elaborations (Gijlers et al., 2013; Johnson et al., 2007; Stasser & Titus, 1985). Therefore, the following hypothesis was formulated:

H2: Scripting the jigsaw method will increase sharing of domain-related information in a heterogeneous cooperative dialogue.

Active participation in knowledge-sharing activities is known to lead to higher learning outcomes (Vuopala et al., 2019). To reach active participation, it is important that domain-related knowledge is shared within the group (Webb, 1982a, 1982b, 1984), that this knowledge is elaborated upon (van den Bossche, Gijselaers, Segers, & Kirschner, 2006; Webb, 1991), and that group members equally participate in the dialogue (Weinberger & Fischer, 2006). Therefore, additional support that stimulates active participation in knowledge-sharing activities creates a situation in which learning is more likely to occur. Therefore, the following hypothesis was formulated:

H3: Scripting the jigsaw method will facilitate domain knowledge gain.

Method

Participants

Originally, 347 fourth, fifth, and sixth graders from six different elementary schools located in a midsized city in the Netherlands participated in the lesson series. Children were categorized as low ability, average ability, or high ability by means of the Dutch students' monitoring system (Centraal Instituut voor Toetsontwikkeling, 2012). This standardized scoring system is used in Dutch elementary education to determine children's relative position within their age group on various subjects. Scores on each subject vary from I (*children scoring in the top 20%*) to V (*children scoring in the bottom 20%*). For this study, four academic subjects were selected to define children's learning skills: technical reading skills, mathematics, spelling, and reading comprehension. Children were categorized as low ability when they scored V on two out of the four subjects (n = 51, 15%). The group of high-ability children (n = 53, 15%) included children who scored I on three out of the four subjects as well as children who were identified on the basis of the Dutch Digital Protocol for Measuring Giftedness (i.e., Digitaal Handelingsprotocol Hoogbegaafdheid; van Gerwen & Drent, 2011). The latter protocol combines teachers' and parents' impression of the children's abilities, as well as data on children's cognitive performance, to include underachieving children within the high-ability group. The remaining children who were not categorized as either low ability or high ability were categorized as average-ability children (n = 243, 70%).

Within classes, heterogeneous cooperative groups of four were randomly assembled, made up of one high-ability child, two average-ability children, and one low-ability child. Data for 211 children who were part of a group that did not fit the grouping criteria for the heterogeneous grouping during the design phase (one high-ability child, two average-ability children, and one low-ability child) were excluded from the final sample.

Consequently, the final sample consisted of 136 children (60 boys, 76 girls; M_{age} = 10.95 years, SD = 0.86 years, ranging from 8-12 years). After the grouping procedure, groups were randomly assigned to the supported or unsupported condition. The supported condition consisted of 19 groups (33 boys, 43 girls; M_{age} = 10.95 years), and the unsupported condition included 15 groups (27 boys, 33 girls; M_{age} = 10.96 years). However, due to recording equipment failure, video recordings for eight groups (32 children) was of poor quality (i.e., inaudible). Process data for these groups were left out of the analyses. Data based on the knowledge tests for these groups were included in the analyses.

Prior to the study, children's parents were informed about their child's participation in the study, which included video recordings of the cooperative process, and they gave active consent for their child's participation.

Design and Context

A pretest–posttest design was used to test the hypotheses, comparing two conditions in which groups were either provided with a worksheet to structure their heterogeneous cooperative dialogue (i.e., supported condition) or were set to work without this worksheet (i.e., unsupported condition). We investigated how the worksheet affected the cooperative dialogue of the groups and the development of domain knowledge by the children in the groups.

Data were collected in the context of a 7-week lesson series. The overarching assignment for the children was to design a house on the moon that could be inhabited by a family of four (two adults, two children), and that included all that would be necessary for living on the moon. During the 7 weeks, children worked according to the jigsaw method (Aronson et al., 1978). The jigsaw process entailed that prior to the lesson involving heterogeneous cooperation, every child became an expert on a subtopic that was essential for completion of the shared assignment goal. Allocation of topics was ability related, based on the complexity of the topics: High-ability children studied light or heat, average-ability children examined the topic of either oxygen or water, and low-ability children were concerned with nutrition (van Dijk, 2017).

Materials

Worksheet. To structure the heterogeneous design phase, a script-like support tool was developed (i.e., worksheet; see Figure 1). The designed worksheet

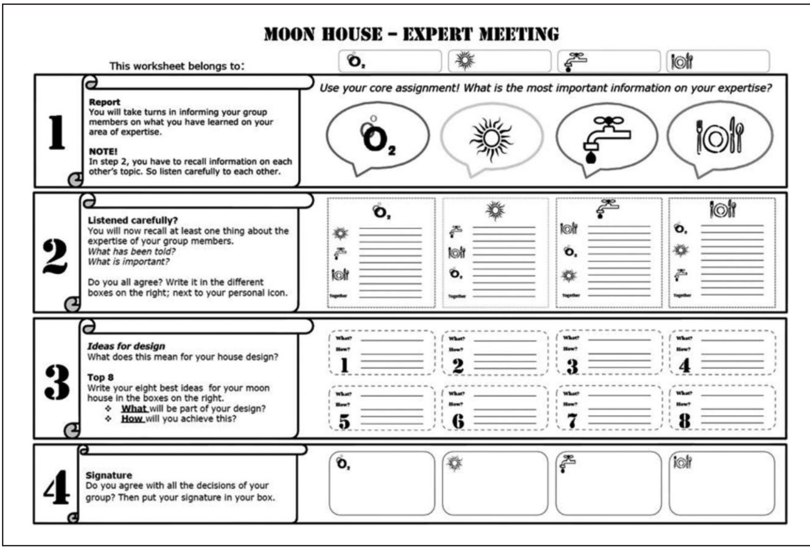

Figure 1. Worksheet that structured the heterogeneous design phase (translated from Dutch).

intended to increase (positive) social interdependence, individual accountability, promotive interaction, and evaluation of the group process. The worksheet presented four steps that guided the group members through the cooperative process of information sharing based on the conditions for successful cooperation specified by Johnson et al. (2007). The main aim was to make sure that all children shared the information they had gathered on their topic and that all group members were actively and equally participating in the cooperative process, thus strengthening the division of roles that is enhanced by the jigsaw method. First, children were to inform their group members about their assigned topic, one by one. This first step should contribute to children's feelings of responsibility for the group's success by sharing the information on their topic (i.e., positive social interdependence and individual accountability).

In the second step, children had to write down two concepts for each topic other group members had presented. To make sure that every group member listened to their fellow group members during the first step, they were told in the explanation of the first step that they would have to be able to recall concepts about their group members' topics during the following activity (i.e., individual accountability). This second step should contribute to children's notion of the benefits of working together and what they could learn from one another (i.e., positive social interdependence). If the group felt an important concept had not been mentioned, additional concepts could be added under the heading *together* (i.e., evaluating the group process).

In the third step, group members were asked to cooperatively construct a list of the top eight elements that should definitely be considered in their moon house design. For every element, they had to write down how they would achieve the inclusion of this element in their design. In the fourth and final steps, every group member had to evaluate the cooperative process by determining whether or not he or she agreed with the decisions made by the group, and whether their topic was sufficiently considered in the process (i.e., evaluating the group process).

The clear references in the worksheet to the different topics, by using corresponding symbols and colors, were intended to make children aware of the content that needed to be discussed. This facilitated promotive interaction between group members, as children could easily refer to the information about the topics that still had to be shared and discussed (and thus call upon the group member who represented this topic to share the information).

The fifth element specified by Johnson et al. (2007), appropriate use of social skills, was not integrated into the worksheet, as research has shown that training children in social skills should be done prior to the cooperative process (cf. Saab et al., 2007). Such training was not part of the support offered in this study, as it would require more extensive preparation of the teacher's lessons and would, therefore, not apply as a support tool that could be offered *just in time*. In the current study, the focus was on developing this worksheet so that it could be applied by teachers just in time, when heterogeneous groups are sharing information in the context of the jigsaw method.

Domain knowledge–assigned topic test. Eight knowledge tests were developed: a parallel pretest and posttest for each topic (i.e., light and heat, oxygen, water, and nutrition) to assess what knowledge children gained about their assigned topic from working cooperatively in the heterogeneous design groups. Each test included eight open-ended questions. For each topic, four main subtopics were selected that children learned about in the context of their assigned topic. Two questions were asked for each subtopic: (a) a question that tested children's ability to name and describe a main concept in their area of expertise (e.g., "What do plants need to create oxygen?") and (b) a question that tested children's ability to apply their knowledge (e.g., "Explain what role plants play in decreasing the amount of carbon oxide and increasing the amount of oxygen in the air."). The separate domain knowledge–assigned topic had varying reliabilities (Cronbach's αs between .18 and .70). Considering that the tests assessed children's knowledge of varying subtopics, it could not be expected that children would necessarily develop equal levels of knowledge about these different subtopics. Therefore, the relatively low reliability scores for some of these tests are not a major concern.

Open recall other topics test. To assess children's conceptual knowledge of the three remaining topics (i.e., topics that were investigated and represented by their group members), an open recall test was administered. Children were instructed to write down everything they knew about these topics in single words or short sentences, without requiring a set minimum or maximum. In the pretest, children were asked to write down everything they knew about the topics (i.e., prior knowledge), and in the posttest children were instructed to write down what they had learned (additionally) about the topics during the cooperative dialogue.

Video recordings. To gain insight into the group's cooperative dialogues, the information-sharing lesson from the heterogeneous design phase was videotaped. Each group was taped using an individual video camera with a Bluetooth-connected microphone to record the audio. Video recordings started after groups received an explanation of the cooperative task. To determine the exact beginning of the cooperative dialogue, group members were instructed to say their names into the microphone. Video recordings ended when all four group members confirmed to the researcher that they had completed the cooperative assignment.

Procedure

Children's participation spanned seven lessons. In the first 4 weeks, children were subsequently assigned to their topic, were provided with assignments that activated their prior knowledge, and were given three lessons of 2 hr each in which they completed a set of assignments covering various subareas of their assigned topic. Children worked in homogeneous expert groups on these assignments, which were provided in a digital learning environment.

In the fifth week and start of the data collection, children individually completed the domain knowledge–assigned topic pretest on the topic they had studied in the previous weeks, and the open recall other topics pretest on their knowledge related to the other three topics. They were given 30 min to complete the tests. Children were then grouped in their heterogeneous design groups and continued the assignment in a face-to-face cooperative setting, with the main purpose of sharing their knowledge about the different topics. Groups were told that they had to inform their fellow group members about their own assigned topic so that every group member could participate in making design decisions in the upcoming lessons. Groups in the experimental condition received the worksheet to support this process and were given additional instructions on how to complete the four steps in the worksheet. Groups in the control condition did not receive the worksheet to support their cooperative process. Groups' cooperative processes were video recorded.

At the end of the lesson, children were told that in the upcoming two lessons, they were to visualize their design by creating an annotated drawing. The main requirement for their design was that every group member had to agree on the design decisions. In the week following the final design lesson, children individually completed the domain knowledge–assigned topic posttest and the open recall other topics posttest. They were given 30 min to complete the tests.

Data Analysis

Domain knowledge–assigned topic test. A coding scheme was developed to analyze children's answers for each of the eight domain knowledge–assigned topic tests. The answers were scored for the presence of required concepts and the explanations of required process(es). Depending on the presence of required concepts and processes, answers were awarded 0 to 3 points. Each test had eight questions, so the maximum score per test was 24 points. A second coder scored 20% of the domain knowledge–assigned topic tests. Coders scored the answers blind to children's condition. The interrater reliability coefficient (i.e., Cohen's κ) was calculated separately for each pretest and posttest. Cohen's kappas showed good interrater reliabilities, varying between .73 and .84.

Open recall other topics test. For each topic, eight key concepts were identified that were the basis of a coding scheme that was used to score the open recall other topics tests. Given that there were different directions for the pretest and the posttest (i.e., in the pretest, children had to write down everything they knew about the topics, and in the posttest, children had to write down what they had learned about the topics during the cooperative dialogue), normalized learning gain was calculated. First, the number of correct key concepts mentioned on the pretest was assessed using the coding scheme. Every concept was awarded 1 point, with a maximum score of 24, eight concepts for each of the three topics that were investigated by their group members. Second, the presence of new key concepts in the posttest as compared with the pretest was assessed. Every new key concept was awarded 1 point. Third, normalized learning gain was calculated by dividing the number of new concepts by the total learning gain that was possible for that child (i.e., maximum score minus score on the pretest). A second coder scored 27 combinations of tests (i.e., 20%). Interrater reliability was calculated for scoring the key concepts on the tests, and for identifying the new key concepts in the posttest as compared with the pretest. Cohen's kappa showed acceptable interrater reliabilities, reaching .87 and .69, respectively.

Video files. The video files were coded by means of ELAN software ("ELAN Multimedia Annotation Tool," 2013; Sloetjes & Wittenburg, 2008). To distinguish the individual contributions of the group members, segments were created by pulling out the different speaking turns of the four children in the group. A speaking turn started when a child began to speak and ended when another group member began his or her contribution to the dialogue, when the speaker was interrupted by a third party (e.g., researcher, teacher, or a student from another cooperative group), or a silence occurred for more than 2 s. Segments were given two types of codes: *topic content of the segment* (i.e., light and heat, oxygen, water, nutrition, or other) and *conversational mode.* When children spoke about more than one topic during a segment, multiple codes were assigned to the segment, leading to subsegments.

For the conversational mode, a distinction was made between on-task and off-task input (see Table 1 for an overview of the conversational mode codes). Within *the on-task coding*, three different codes were distinguished. The first code referred to children's topic-related input regarding the four topics in the context of the moon house (i.e., light and heat, oxygen, water, nutrition). Different topics were distinguished by means of the list of key concepts per assigned topic, based on the content of the assignments in the homogeneous expert phase. Two subcodes were distinguished to gain more insight into the type of information children provided when discussing the content of the four topics: *theoretical explanations* of concepts within these topics and *concrete design ideas* within the context of one of these topics. Second, two codes were distinguished to indicate children's contributions that were related to the task, but were not about one of the four major topics: talk concerning the *coordination* of the task, and *other* task-oriented talk that did not refer to one of the four topics (e.g., concrete design ideas beyond the four topics, and talk referring to gravity). A final code was used to indicate children's contributions that dealt with *off-task* topics. A second coder coded 21% of the video recordings (i.e., 1,521 segments). Cohen's kappa was calculated for content and conversational mode separately, .74 and .72, respectively.

Dialogues were analyzed at the level of both the group and the individual. For each code, the total number of segments was calculated. To account for

Table 1. Descriptions and Examples of the Different Conversational Modes.

Code	Description	Example
On task		
Domain related	Input regarding one of the four topics	
Theoretical explanations	Explanation in the context of one of the topics	"The moon has no atmosphere."
Concrete design ideas	Concrete design idea for the moon house in the context of one of the topics	"We need solar panels."
Coordination	Coordination of the task	"It is your turn to tell us about your topic."
Other	Other task-oriented talk without referring to one of the topics	"There is little gravity on the moon." "We should add pink roof tiles to our house to make it prettier."
Off task	Off-task talk	"I have soccer practice after school."

differences in the length of a dialogue, measured by means of the total number of segments in the dialogue, sum scores for the different codes were divided by the total number of segments for the group or the individual group member, respectively. These proportional scores were used in the analyses. Based on the segmentation and coding procedure described earlier, three measures were derived from the coding process that would give more insight into the worksheet's effect on the group dialogues. Dialogues were assessed by looking at the difference in children's proportion of contributions within the group (i.e., disparity scores), the content of children's contributions (i.e., domain-related, coordination, other, or off task), and the type of domain-related contributions (i.e., theoretical explanation or concrete design ideas).

Results

Cooperative Dialogue

To test the first two hypotheses regarding the equivalence of participation in the cooperative dialogue and the sharing of knowledge between group members, the cooperative dialogue in the heterogeneous groups was examined from both a group and an individual perspective. In total, 7,141 segments were produced during the cooperative assignment ($M^{\text{supported groups}} = 348.14$, $SD = 119.65$; $M^{\text{unsupported groups}} = 188.92$, $SD = 119.59$). To account for the differences in number of segments between the two conditions, proportional scores were calculated that were used in the analyses.

Equivalence of participation. To test the first hypothesis, the cooperative dialogues were examined from a group perspective. To gain insight into how equally group members participated in the group dialogue, two characteristics of the group dialogues were investigated: (a) differences in the proportion of children's contributions to the domain-related content of the group's dialogue (i.e., inequality domain related) and (b) the differences in the proportion of children's contributions to the group's total dialogue (i.e., total disparity). Disparity scores were calculated based on children's proportional contribution to the dialogue, in which a perfect distribution would mean a distribution of 25% for each of the group members. Basically, the disparity score represents the sum of the deviation from this 25% for each of the four group members, that is, disparity score = $\sqrt{([25-x_1]^2 + (25-x_2)^2 + (25-x_3)^2 + (25-x_4)^2)}$, zero is a perfect score.

Two analyses of variance (ANOVAs) were conducted to identify differences between conditions, with the groups' disparity scores (i.e., domain-related disparity, total disparity) as dependent variables. The ANOVAs revealed that groups working with the worksheet had a more even distribution of domain-related talk ($M^{\text{supported groups}} = 19.38$, $SD = 8.36$) than groups working without the worksheet ($M^{\text{unsupported groups}} = 36.87$, $SD = 17.81$), $F(1, 24) = 10.79$, $p = .003$, $\eta_p^2 = .31$. This was in line with the expectations stated in the hypothesis. However, there were no significant differences between conditions concerning the distribution of contributions to the dialogue in total ($M^{\text{supported groups}} = 21.72$, $SD = 8.09$; $M^{\text{unsupported groups}} = 27.40$, $SD = 9.90$), $F(1, 24) = 2.60$, $p = .120$, $\eta_p^2 = .10$.

Information sharing. To test the second hypothesis, the different contributions to the dialogue at both the group level and the individual level were explored. The proportion of contributions to the dialogue concerning the domain, coordination, other task-oriented talk (all three being on-task activities), and off-task talk were analyzed on a group level. ANOVAs were conducted to investigate possible differences between conditions. Table 2 shows the mean proportional scores for these four codes. The ANOVAs revealed that groups supported by the worksheet spent more of their dialogue on discussing the content of the four topics, $F(1, 24) = 18.51$, $p < .001$, $\eta_p^2 = .44$, and spent more of their dialogue engaging in coordination of the task, $F(1, 24) = 4.58$, $p = .043$, $\eta_p^2 = .16$, than the unsupported groups. The unsupported groups, in turn, spent a larger proportion of their dialogue on sharing other task-oriented information, $F(1, 24) = 9.25$, $p = .006$, $\eta_p^2 = .28$, and spent a

Table 2. Mean Proportional Contributions (%) to the Group Dialogues, by Condition.

	Supported		Unsupported		Total	
	M	*SD*	*M*	*SD*	*M*	*SD*
On task						
Domain related	47.64	9.88	28.74	12.51	38.92	14.56
Theoretical explanations	31.14	8.10	8.53	4.44	20.70	13.23
Concrete design ideas	16.50	6.45	20.22	10.18	18.22	8.78
Coordination	26.88	4.55	20.63	9.79	24.00	7.94
Other	5.80	5.20	16.90	12.49	10.92	10.70
Off task	19.68	6.89	33.73	19.01	26.16	15.31

larger proportion of their dialogue engaging in off-task talk, $F(1, 24) = 6.66$, $p = .016$, $\eta_p^2 = .22$, than the supported groups.

For the domain-related contributions, dialogues were analyzed from a group and an individual perspective. First, looking at domain-related contributions at a group level (i.e., concerning the four topics that were central to the domain), a distinction was made between theoretical explanations of the topics and providing concrete design ideas for the moon house (see also Table 2). To analyze differences between conditions in how the groups discussed the domain-related content, ANOVAs were conducted with proportion of theoretical explanations and concrete design ideas as dependent variables. The analyses indicated that groups who were supported by the worksheet spent more of their dialogue on exchanging theoretical explanations, $F(1, 24) = 74.24$, $p < .001$, $\eta_p^2 = .76$, than the unsupported groups. However, the difference in providing concrete design ideas was not significant, $F(1, 24) = 1.18$, $p = .289$, $\eta_p^2 = .05$.

Second, the mode of conversation (i.e., either focusing on theoretical issues or suggesting concrete design ideas) that children used to contribute to the topic-related dialogue was examined at an individual level. Table 3 shows the mean proportional scores for the measures concerning children's individual, domain-related contributions as compared with their total contributions, by condition. Four ANOVAs examined differences between conditions concerning the type of contribution (i.e., theoretical explanations or concrete design ideas) children made when discussing their assigned topic and the topics of their fellow group members. The analyses showed that children in the supported groups spent more of their dialogue on providing theoretical explanations of their assigned topic, $F(1, 102) = 42.38$, $p < .001$, $\eta_p^2 = .29$, and the topics of their fellow group members, $F(1, 102) = 201.90$, $p < .001$,

Table 3. Mean Proportional Contributions (%) to Domain-Related Dialogue by Individual Children, by Condition.

	Supported		Unsupported		Total	
	M	*SD*	*M*	*SD*	*M*	*SD*
Own assigned topic	18.94	7.65	15.42	12.58	17.31	10.33
Theoretical explanations	13.93	6.35	5.49	6.86	10.03	7.80
Concrete design ideas	5.02	4.25	9.93	9.71	7.28	7.66
Other topics	29.55	8.89	13.91	10.22	22.33	12.29
Theoretical explanations	17.97	6.83	2.76	3.11	10.95	9.35
Concrete design ideas	11.58	5.91	11.15	9.07	11.38	7.50

$\eta_p^2 = .66$, than the children in the unsupported groups. Children in the unsupported groups spent a larger proportion of their dialogue on providing concrete design ideas for the design of the moon house in the context of their assigned topic, $F(1, 102) = 11.70$, $p = .001$, $\eta_p^2 = .41$, than the children in the supported groups. Providing design ideas for the topics of fellow group members did not differ between conditions, $F(1, 102) = 0.08$, $p = .773$, $\eta_p^2 = .00$.

Finally, children's degree of engagement in discussing their assigned topic as well as the topics of their fellow group members was examined (see also Table 3). The first ANOVA indicated that the discussion of children's assigned topic did not differ significantly between conditions, $F(1, 102) = 3.08$, $p = .082$, $\eta_p^2 = .03$. However, the second ANOVA showed that children in the supported groups spent more of their dialogue on discussing their group members' topics than children in the unsupported cooperative setting, $F(1, 102) = 69.64$, $p < .001$, $\eta_p^2 = .41$.

Knowledge Tests

To test the third hypothesis, children's scores on the tests of individual domain knowledge for their assigned topic and open recall for the other topics were examined. Table 4 shows children's scores on the domain knowledge–assigned topic tests (i.e., pretest and posttest) and their normalized learning gain on the open recall other topics tests (i.e., number of new concepts mentioned in the posttest as compared with the pretest as a percentage of possible new concepts to be mentioned).

Domain knowledge–assigned topic test. Differences between conditions in knowledge gain for children's assigned topic from pretest to posttest were

Table 4. Mean Scores on Domain Knowledge–Assigned Topic Test (Max = 24) and Normalized Gain on Open Recall Other Topics Tests (in %), by Condition.

	Supported		Unsupported		Total	
	M	*SD*	*M*	*SD*	*M*	*SD*
Total						
Assigned topic pretest	9.28	3.93	9.89	4.42	9.54	4.14
Assigned topic posttest	10.16	4.00	9.20	4.40	9.74	4.19
Other topics (% of possible new concepts mentioned)	13.56	9.16	10.85	8.06	12.36	8.76
High ability						
Assigned topic pretest	9.24	4.68	10.43	4.36	9.77	4.51
Assigned topic posttest	9.59	3.08	9.00	3.92	9.32	3.44
Other topics (% of possible new concepts mentioned)	13.06	11.07	10.97	10.76	12.12	10.80
Average ability						
Assigned topic pretest	9.57	3.77	10.14	4.93	9.83	4.29
Assigned topic posttest	10.17	4.48	9.07	4.97	9.68	4.69
Other topics (% of possible new concepts mentioned)	13.84	8.57	10.18	6.99	12.18	8.04
Low ability						
Assigned topic pretest	8.71	3.58	8.67	3.14	8.69	3.35
Assigned topic posttest	10.71	3.90	9.75	3.77	10.31	3.90
Other topics (% of possible new concepts mentioned)	13.46	8.80	12.35	7.37	13.00	8.11

Note. The pretest in this study occurred after children spent time in their homogeneous groups developing their expert knowledge on their assigned topic.

assessed with repeated measures analyses. Using Wilks's statistic, the main effect for the within-subject factor Time was not significant, $\Lambda = .99$, $F(1, 121) = 0.09$, $p = .766$, $\eta_p^2 = .00$). The interaction (Time × Condition) showed a significant result, $\Lambda = .96$, $F(1, 121) = 5.56$, $p = .020$, $\eta_p^2 = .04$.

The latter result supports the stated hypothesis. However, the main effect is not significant. Therefore, it seemed interesting to explore possible differences for the different ability levels as they completed a domain knowledge–assigned topic test on the topic to which they were assigned on the basis of their ability level. As a result, however, no direct comparisons between ability levels were made. To gain insight into the further development of domain knowledge about their assigned topics by the children of different ability levels, and to determine whether the effect of condition could be attributed to what happened for a specific ability level, the same analysis was conducted for the high-ability, average-ability, and low-ability children separately. Using Wilks's statistic, only the *low-ability children* showed a significant knowledge gain from pretest to posttest on their assigned topic, $\Lambda = .83$, $F(1, 27) = 5.56, p = .026, \eta_p^2 = .17$. The Time × Condition interaction for the low-ability children was not significant, $\Lambda = .98, F(1, 27) = 0.49, p = .489, \eta_p^2 = .02$. *High-ability children* showed no significant knowledge gain from pretest to posttest on their assigned topic, $\Lambda = .98, F(1, 29) = 0.71, p = .408, \eta_p^2 = .02$; neither was there a Time × Condition interaction, $\Lambda = .94$, $F(1, 29) = 1.93, p = .175, \eta_p^2 = .06$. For *average-ability children*, the analysis indicated no significant knowledge gain from pretest to posttest on their assigned topic, $\Lambda = .99$, $F(1, 61) = 0.25, p = .621, \eta_p^2 = .00$; also, there was no significant Time × Condition interaction, $\Lambda = .95$, $F(1, 61) = 3.10$, $p = .084, \eta_p^2 = .05$.

Open recall other topics test. Possible differences in normalized learning gain between conditions were examined with an ANOVA. In contrast to what was hypothesized, differences between conditions were not significant, $F(1, 122) = 2.96, p = .088, \eta_p^2 = .02$. Conducting the same analysis for children of the different ability levels separately showed no significant differences between conditions for the *high-ability,* $F(1, 29) = 0.28, p = .600, \eta_p^2 = .01$, *average-ability,* $F(1, 62) = 3.41, p = .069, \eta_p^2 = .05$, and *low-ability children,* $F(1, 27) = 0.13, p = .723, \eta_p^2 = .00$.

Discussion

The aim of the current study was to investigate to what extent a script-like support tool would influence elementary school children's participation and sharing of information in a heterogeneous cooperative jigsaw setting, and whether this facilitates domain knowledge gain. Children worked according to the jigsaw method that has proven to make group members treat each other as resources to reach a shared learning goal (Aronson et al., 1978). To compensate for the difficulties that elementary school children generally experience during cooperation (Mercer, 1996; Mercer et al., 1999), which is often increased by heterogeneous grouping (e.g., Lou et al., 1996; Wang et al., 2010), a script (i.e., worksheet) was designed that intended to provide elementary school children with additional support for the jigsaw method to lead a beneficial learning process. The worksheet intended to make children more aware of their individual accountability and social interdependence, and tried to emphasize promotive interaction and evaluation of the group process, with a specific focus on providing and receiving domain-related explanations.

The results of this study showed that the support offered in the worksheet assisted the heterogeneous cooperative process, leading to a situation in which children demonstrated learning-enhancing communication. More specifically, the worksheet enhanced the quality of the dialogue, as the supported groups spent a larger proportion of their dialogue on discussing domain-related content, of which a larger proportion consisted of theoretical explanations, and participation in this domain-related dialogue was distributed more equally among group members.

Based on the results related to the dialogue, it could be assumed that children's knowledge gains would also be greater after working with the worksheet. However, the results of this study did not indicate a significant knowledge gain (neither on their assigned topic nor on their group members' topics). The results did, however, indicate an interaction effect between children's knowledge gain for their assigned topic and whether or not they worked with the worksheet. This interaction effect might be partly due to the uncommon result that the unsupported group showed a (slight) decrease in knowledge at the posttest. When analyzing these results for the different ability groups, only the low-ability children showed a significant learning gain, whereas the difference between the two experimental conditions was not significant.

Theoretical Implications

Cooperative learning using a jigsaw setting created a learning situation in which all group members participated in the dialogue. Presumably, the context of the jigsaw method led to a group process that made all group members feel included as they might have felt encouraged to participate in the group process being responsible for their own piece of the puzzle (Aronson et al., 1978; Walker & Crogan, 1998). This finding is in line with one of the main principles of successful cooperation, which is also considered one of the building blocks of jigsaw, that facilitating interdependency by dividing the task over group members positively influences the group's functioning (Wageman, 1995).

An additional effect of the worksheet was visible when analyzing the domain-related part of the dialogue. Groups that worked with the worksheet spent higher proportions of the dialogue on discussing domain-related content in comparison with unsupported groups. In addition, this domain-related dialogue was more equally distributed among group members in the supported groups than in the unsupported groups. Whereas the distribution of unique information in a regular jigsaw setting is known to lead to a possible absence of sharing relevant information (i.e., hidden profile paradigm; Lu, Yuan, &

McLeod, 2012), the findings of this study contribute to the theory by showing that it is possible to increase group members' involvement in sharing domain-related information by cooperation using the jigsaw method. Additional support that explicitly instructs group members to share, discuss, and consider information from different related topics might enhance group members' awareness of the importance of sharing the uniquely divided information.

A further distinction could be made between sharing the basic ideas of a domain and elaborating on these ideas. Providing and receiving explanations about a domain is an important prerequisite for children to have the opportunity to learn about the domains that are communicated within the cooperative group (Baker & Lund, 1997; Teasley, 1997; Webb, 1982a, 1982b, 1984). The outcomes of the current study indicated that the support offered in the worksheet created a situation in which group members provided each other with relatively more theoretical explanations of the domain compared with groups that were not supported by the worksheet. This suggests that scripting the cooperative process makes group members more aware of the fact that the group process profits from sharing and discussing domain-related information by all group members. Along this line, our study shows that it seems possible to influence the cooperative process in heterogeneous groups by emphasizing multiple elements of the social interdependence theory (Johnson et al., 2007).

Previous studies have explored the effects of structuring the group interaction that included a single element from social interdependence theory or that intended to increase the occurrence of one of these elements by means of a tool (Pai, Sears, & Maeda, 2015). These studies, for example, investigated the effect of individual accountability as an individual construct (e.g., Kramarski & Mevarech, 2003; Sears & Pai, 2012). The basic premise of the social interdependence theory, however, is that the interplay of its different elements together determines the quality of the group members' interaction (Johnson et al., 2007). Therefore, the present study contributed by investigating a script-like support tool that incorporated all elements of the social interdependence theory, except for the social skills, which should be trained outside of the cooperative process (e.g., Saab et al., 2007).

The lack of a relationship between the improved cooperative process and children's individual knowledge gain might raise some questions. However, this absence has been found more often in this line of research. For example, Oakes et al. (2019) found that students who participated in a jigsaw lesson did not outperform students who worked in a nonjigsaw setting, even though the jigsaw groups did show high-quality processes, and students considered the jigsaw task as beneficial and enjoyable. Furthermore, Lazonder and Harmsen (2016) stated in their meta-analysis concerning guidance in inquiry learning that guidance that is specifically focused on the process does not necessarily induce acquisition of knowledge.

Practical Implications

The results of this study could imply that teachers who wish to implement heterogeneous cooperative assignments in their elementary classroom should (a) offer support that addresses children's individual responsibilities for sharing knowledge and (b) make children aware of their individual roles in the group's process and group members' mutual interdependence on one another. Within this context, the jigsaw method could serve as an initial frame. However, the effects of the jigsaw method could be strengthened when it is properly supported. More specifically, this means that the cooperative assignment could profit from a script-like structure that distinguishes different steps that stress different activities such as knowledge sharing, discussion of the shared knowledge, and application of this knowledge. At the same time, these activities should make sure that group members are aware of their specific and indispensable role in the cooperative process.

The notion that fruitful heterogeneous cooperation is not merely attained by putting together people with relevant knowledge (van den Bossche et al., 2006) applies not only to the elementary school context but also to team learning. Knowledge creation in teams and organizations also benefits from information sharing between actors in a group; herewith, the division of information over actors is especially considered relevant (e.g., Carlile, 2004; Lin, 2010; Mitchell & Nicholas, 2006). Differences in knowledge require more effort from group members to successfully complete a group process (Carlile, 2004). According to the hidden profile paradigm, information that is uniquely divided over group members is not always shared, as group members tend to focus on discussing common information instead of the uniquely divided information (Lu et al., 2012). Furthermore, sharing personal knowledge such as insights and ideas sometimes leads to resistance (Cabrera & Cabrera, 2005). Similar to cooperation in the school context, social interdependence is considered a relevant phenomenon that influences sharing of knowledge in teams (Courtright, Thurgood, Stewart, & Pierotti, 2015). However, social interdependence is known to vary across teams but can be fostered to lead to higher quality team functioning and knowledge generation (Lu et al., 2012). The outcomes of the current study might provide insight in how to structure cooperation in teams and organizations; the jigsaw method could serve as an initial outline for structuring the cooperative process, and, if necessary, support could be offered that further scripts the cooperative process by focusing on social interdependence.

Limitations and Future Research

The results of the current study showed that support offered through the worksheet did enhance information sharing in the elementary education setting. However, because the results did not show an equally beneficial effect of the support on domain knowledge development, the effect of improved cooperative dialogue on knowledge acquisition should be further investigated.

The lack of an evident relation between first-order effects of our intervention (on the learning process) and second-order effects (on the learning outcomes) invites to think about ways to further improve the potential for learning in a cooperative learning setting. Besides that, it is interesting to investigate whether the heterogeneous cooperation that benefited from the structure offered in the worksheet is equally beneficial for children of different ability levels.

One particular method of investigating the lack of effects related to children's domain knowledge development is to look into the transactivity of the dialogue (Berkowitz, 1980a, 1980b; Teasley, 1997). Transactive dialogue requires children to reflect and act upon each other's reasoning to grasp and process the information. However, research has shown that younger children often experience difficulties with engaging in transactive dialogue and need extensive training to gain these skills (Gijlers et al., 2013; van Dijk et al., 2014). Future research could be done to investigate information processing in heterogeneous cooperative groups, and how training in transactive communication skills could enhance the quality of the group dialogues to further include domain knowledge.

Another issue that might be considered is that the amount and level of knowledge discussed in the different groups was highly dependent on the children responsible for distributing this knowledge. Slavin (2015) corroborates this notion, stating that research on the jigsaw method does not always show positive learning effects, as children have limited exposure to the topics of their group members. Younger children, in particular, experience difficulties with selecting the most important elements from their information base to share with others (Zimmerman, 2007). Making these children rely on their own abilities to gather and select knowledge to share could create a dialogue with less information to be shared and learned than might otherwise be possible. Therefore, it might be interesting to further investigate whether children's learning outcomes would improve when children are provided with guidance about what information to share with their group members.

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