Effects of task structure and group composition on elaboration and metacognitive activities of high-ability students during collaborative learning

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Effects of task structure and group composition on elaboration and metacognitive activities of high-ability students during collaborative learning

J. Schuitema, S. Palha, C. van Boxtel & T. Peetsma

Abstract

Collaborative learning tasks may represent an effective way to stimulate higher-order processes among high-ability students in regular classrooms. This study investigated the effects of task structure and group composition on the elaboration and metacognitive activities of 11th grade pre-university students during a collaborative learning task: 102 students worked in small groups. On an ill-structured or moderately structured task. Differential effects for cognitive ability were investigated using a continuous measure. Likewise, the effects of group composition were examined using a continuous measure of the cognitive heterogeneity of the group. The group dialogues were transcribed and coded. Analysis revealed an interaction effect between task structure and cognitive ability on students' elaboration and metacognitive activities. Task structure had a negative effect on the elaborative contributions of high-ability students. For students with lower abilities, task structure had a positive effect on elaboration and metacognitive activities. No effects were found of the cognitive heterogeneity of the group. Group composition seemed not to be related to group interaction among 11th grade pre-university students. The results indicate that open-ended collaborative tasks with little guidance and directions on how to handle them, can stimulate higher-order processes among high-ability students and may offer them the challenge they need.

Keywords: **Collaborative learning, task structure, group composition, elaboration, metacognitive activities**

1 Introduction

It is important to provide high-ability students with complex tasks that stimulate analytic thinking, reasoning and metacognitive activities (Kanevsky, 2011; Lens & Rand, 2000; Van Tassel-Baska, 2000). This is necessary for two reasons: First, high-ability students must have the opportunity to further develop their higher-order cognitive skills (Reis & Renzulli, 2010); second, a focus on higher-order processes is necessary to offer students the appropriate challenges and to keep them engaged with learning (Preckel, Götz, & Frenzel, 2010; Reis & McCoach, 2000). However, in the regular classroom, there can be large variations in ability levels. This makes it difficult to adapt learning tasks to the students' cognitive level and to provide a challenging learning environment that stimulates higher-order processes for high-ability students (Eysink, Hulsbeek, & Gijlers, 2017).

Collaborative learning tasks may be an effective way to stimulate the higher-order processes of high-ability students in regular classrooms. Collaborative learning is commonly advocated for students with high cognitive abilities (Walker, Shore, & French, 2011). When students work together, they must verbalise their reasoning, and this may in turn lead them to a better elaboration of knowledge and understanding as well as foster the development of higher-order skills (Dekker & Elshout-Mohr, 2004; Lou et al., 1996; Van Boxtel, Van der Linden, & Kanselaar, 2000; Webb, 2009). It is assumed that when working on a collaborative learning task, students can support others and achieve higher levels of reasoning (Cohen, 1994; Webb, 2009). This can make collaborative learning a suitable approach to implement more complex tasks in the regular classroom and to engage students in higher-order processes.

Whether collaborative learning tasks stimulate interactions that include higher-order thinking and reasoning may, however, depend on the task context, such as group composition and task instructions (Esmonde, 2009). To stimulate high-quality interaction between students, it is important that the task is not too structured and leaves room for students to take their own initiative (Cohen, 1994). Another issue that has received a great deal of attention concerns the question of whether students with high cognitive abilities perform better in cognitively homogeneous or heterogeneous groups (e.g., Esmond, 2009; Lou et al., 1996; Murphy et al., 2017; Saleh, Lazonder, & De Jong, 2005; Webb, 2009). The aim of this study was to acquire insight into how collaborative learning tasks can be used to stimulate higher-order processes among high-ability students within the regular classroom. To do so, we examined the effects of task structure and group composition on higher-order processes in interactions among students with different levels of cognitive abilities.

1.1 Elaboration and metacognitive activities

We focused in this study on two higher-order processes in collaborative learning. Our first focus concerned the quality of cognitive activities. Elaborative interactions include explanations or justifications of statements as well as building on the contributions of others with extensions, refinements or counterarguments (Webb, 2009). Especially, explaining oneself to others is believed to help students to restructure their knowledge and understanding of a given problem (Webb, 2009). Research shows that elaboration during collaborative learning promotes learning (e.g., Van Boxtel et al., 2000; Webb, 2009).

The second focus was on the number of metacognitive activities. Students use metacognitive activities to control and monitor their learning and to motivate themselves to engage in learning activities (Meijer, Veenman, & Van Hout-Wolters, 2006; Winne & Nesbit, 2010). When working in small groups, students can apply metacognitive activities, such as orientating towards the learning assignment, planning and monitoring the activities of the group, and evaluating the quality of their work (Hadwin & Oshige, 2011; Molenaar, Sleegers, & Van Boxtel, 2014). Metacognitive activities during collaborative learning have been associated with better learning outcomes (e.g., Azevedo & Cromley, 2004; Van der Stel & Veenman, 2008) and are also considered vital for learning later in life (Dignath & Büttner, 2008; Paris & Paris, 2001). It is therefore important that the collaborative learning task is designed to stimulate the elaboration and regulation of the learning process.

1.2 Task structure

Ill-structured tasks are generally recommended to stimulate higher-order reasoning during collaborative learning (Cohen, 1994; Lodewyk, Winne, & Jamieson-Noel, 2009). Ill-structured tasks have multiple solutions and there is no one right way to complete the task (Jonassen, 1997). Solving an ill-structured task requires students to connect information from different sources and thereby gives students opportunities to explore different approaches to the stated problem (Lodewyk et al., 2009; Malmberg, Järvelä, & Kirschner, 2014). Working on these tasks in small groups implies that students must engage in metacognitive interaction, such as discussing the specifics of the solution to the task, determining and planning relevant strategies, and monitoring and evaluating the process while the task proceeds.

In school, most tasks are well-structured: there is a well-defined problem with unambiguous right answers as well as instructions on how to proceed with solving the task (Malmberg et al., 2014; Van Merriënboer, 2013). Well-structured tasks often include sub-goals or in-between steps to guide students to the solution. However, if a task is too well structured, it will not require metacognitive activities from students. This may be frustrating for students with high cognitive abilities, because they will be unable to approach the task as they might wish to. In addition, well-structured tasks may be successfully carried out individually, i.e., they do not require collaboration (Janssen, Kirschner, Erkens, Kirschner, & Paas, 2010). As a result, students may not feel the need to engage in elaborative reasoning, and instead the focus is on following the instructions and completing the task. Research shows that students with high cognitive ability experience ill-structured tasks as more complex and more challenging (Kanevski, 2011; Scager, Akkerman, Pilot, & Wubbels, 2013).

However, for many students with lower cognitive abilities, ill-structured tasks are too complex. Research has shown that metacognitive skills are related to general cognitive ability (Veenman & Spaans, 2005). Many students with lower cognitive ability may therefore not have the required metacognitive skills needed to approach ill-structured tasks (Malmberg et al., 2014). Students with lower cognitive abilities may also have difficulties combining information from different sources. These students may need more structure and guidance in approaching tasks in order to engage in elaborative reasoning. It is therefore important to investigate the influence of task structure on elaboration and metacognitive activities during collaborative learning tasks for students with lower abilities as well. Without support, ill-structured tasks may impede elaboration and metacognitive activities for students with lower cognitive ability and even result in withdrawal (Kirschner, Sweller, & Clark, 2006).

1.3 Group composition

Research on which type of group composition is optimal in terms of cognitive ability has been inconclusive (Murphy et al., 2017; Webb, 2009). Several studies have focused on the effects of group composition on the achievements of students. Most studies found that heterogeneous groups have a positive effect on the achievements of low-ability students (Cohen, 1994; Esmond, 2009; Lou et al., 1996; Saleh et al., 2005; Webb, 2009). Regarding high-ability students, however, findings on the effects of group composition have been inconsistent. Some studies have shown that students with high cognitive ability may profit most from working with other students with high cognitive ability (e.g., Webb, Nemer, Chizhik, & Sugrue, 1998; Webb, Nemer, & Zuniga, 2002), while other studies have either emphasised the beneficial effects of heterogeneous groups (e.g., Carter & Jones, 1994; Webb, 1980) or have found no influence of group composition (e.g., Carter, Jones, & Rua, 2003; Lou et al., 1996; Saleh et al., 2005).

Considerably fewer studies have investigated the influence of group composition on the quality of group interaction. For low-ability students, heterogeneous groups are assumed to be more beneficial, because such students can learn and receive explanations from their high-ability peers through interaction (Webb et al., 1998). Indeed, research has shown that heterogeneous groups produce more elaboration than homogenous groups composed solely of low-ability students (Saleh et al., 2005; Webb et al., 1998). There are two lines of reasoning regarding the effects of group composition on the quality of the participation of high-ability students. On the one hand, it is argued that greater group heterogeneity may enhance the construction of elaborative conceptualizations among high-ability students because they will be stimulated to give explanations to students with lower abilities (Webb, 2009). On the other hand, it is argued that high-ability students can engage in more advanced reasoning when they work with other high-ability students. In more homogeneous groups, participation is more equal among group members, and students can build on each other's arguments, reaching higher levels of reasoning (Webb et al., 1998).

Research on the effects of group composition on the quality of the participation of high-ability students is inconclusive. Some studies have indeed found that high-ability students provide more explanations in heterogeneous groups (Carter & Jones, 1994; Webb, 1980), while other research has found that homogenous groups produce more elaboration (Webb et al., 2002) or no differences between homogeneous groups and heterogeneous groups (Saleh et al., 2005).

In a study among 8th grade students, Webb et al., (2002) found that high-ability students produced less accurate explanations in some heterogeneous groups than in homogenous groups. However, other heterogeneous groups worked equally well as homogeneous groups. Webb and colleagues argued that the nature of the task may have influenced some of the heterogeneous groups. In their study, they used a highly structured task with well-defined procedures and unambiguously correct answers. With Cohen (1994), they argued that ill-structured tasks may prevent domination by one group member in heterogeneous groups and thereby equalise group member participation. Ill-structured tasks may demand the input of multiple students, consequently stimulating equal participation. When there are no clear-cut, correct answers, students are required not only to provide answers but also to substantiate and negotiate different solutions.

What makes it difficult to draw conclusions from existing research is that many studies are difficult to compare due to numerous dissimilarities, including differences in participants and in task characteristics. The variable compositions of populations between studies may also affect the distribution of cognitive ability among the participating students. As a result, heterogeneity may have a different meaning in one population than in another. A related problem is the classification of students as high-, medium- or low-ability students. These classifications are relative to the group of students participating in the studies. In addition, not all studies use the same classifications. Most common is categorisation into three groups, but sometimes other categorisations are chosen. The problem with this approach is that such categorisations are typically arbitrary in terms of which cut-off points are chosen. There are no conclusive arguments, theoretically or empirically, for choosing one cut-off percentage over another (Borland, 2005); consequently, studies on high-ability students or gifted students use any number of different cut-off percentages to classify students with high cognitive abilities (Reis & Renzulli, 2010; Subotnik, Olszewski-Kubilius, & Worrell, 2011). A second drawback of categorising students is that high-, medium- or low-ability students are treated as one group, despite differences within these categories. In the same vein, we argue that it is also arbitrary to categorise groups as homogeneous or heterogeneous.

1.4 This study

With this study, we set out to provide more insight into the effects of group composition and task structure on the elaboration and metacognitive activities of 11th grade pre-university students in the Netherlands during collaborative learning. Our research question was *What are the effects of the composition of the group and the amount of task structure on the elaborative and metacognitive contributions during a collaborative learning task among students with different levels of cognitive ability?*

Instead of comparing groups of students with different levels of ability, we used a continuous measure to analyse the differential effects for cognitive ability. Likewise, we used a continuous variable representing the cognitive heterogeneity of the group to investigate the effects of group composition. Our first hypothesis was that there would be an interaction effect between cognitive ability and task structure on elaborative and metacognitive contributions. For students with higher cognitive abilities, we expected that they would demonstrate more elaboration and metacognitive activities in a task with less structure than in a task with more structure. For students with lower cognitive abilities, we hypothesised the opposite effect. We assumed that these students would benefit from more task structure to engage in elaboration and metacognitive activities.

Our second hypothesis concerned the effects of group composition. Again, we hypothesised an interaction effect between heterogeneity and cognitive ability. In line with most studies on the effects of group composition, we expected that students with lower abilities would engage more in elaboration and metacognitive activities when in more heterogeneous groups. For students with high abilities, we expected no effects from group composition. Both the composition of heterogeneous and homogeneous groups seem to have advantages with respect to the quality of the interaction. In the present study, students worked on relatively ill-structured tasks compared to the tasks used in Webb et al.'s (2002) study, and we therefore did not expect negative effects from heterogeneity for students with higher abilities.

2 Method

2.1 Participants

In this study participated 102 pre-university students (11th grade) from 14 history classes in eight schools. Pre-university education is the highest level of secondary education in the Netherlands. About 19 percent of students in the Netherlands follow pre-university education (CBS, 2018). The students in the present study were randomly selected from a sample of 330 students who had participated in a larger project. Data were collected during two lessons, and only students who participated in both lessons were included in the analyses ($n = 90$).

2.2 Procedure

Students in this study participated in a larger project in which they followed a 22-lesson curriculum unit on the development of parliamentary democracy and the constitutional state in the Netherlands during the nineteenth century. In one-half of the lessons, students worked in groups of three on collaborative learning tasks. The groups were randomly assigned to ill-structured or moderately structured collaborative learning tasks. The present study focused on group interaction during one of the collaborative learning tasks of the curriculum unit. Group interactions were video-recorded, transcribed and analysed.

2.3 Collaborative learning task

The collaborative learning task in this study aimed for a better understanding of facts and concepts related to the development of political parties around 1900. Students already had some prior knowledge from their textbook and previous lessons. Students had to apply their knowledge of liberalism, confessionalism, socialism, political parties and their leaders, and issues of debate around 1900 (e.g., social issues, general suffrage and a conflict about the financing of Protestant and Catholic schools). The task was inspired by an activity designed by Richards (2012) in which students had to plan a historians' dinner party in a way that avoided a rumpus. The task had an open-ended character. Students had to decide about (and explain) the seating of five politicians invited for dinner by a Dutch minister in 1900: Who needs to be kept apart to avoid a too heated debate? Who might get along well? They also had to decide which political issues would likely be debated during the dinner and write a part of the (imagined) conversation. The task provided students the freedom to make their own choices in the selection of debate topics, the seating arrangement and an (imagined) conversation. Students were provided with a fact sheet for all five historical persons who were to be seated. The fact sheet included some biographical information as well as information about each politician's main political ideas and how these affected the development of parliamentary democracy. Students could work on the task for about one and a half lessons (75 minutes).

Two versions of the collaborative learning tasks were developed. The first version was ill-structured. Students received a basic description of the end products (the seating arrangements at the dinner party, and a part of the discussion); they received no prompts or hints about in-between steps and no suggestions for planning or collaboration. The second version of the task was structured in steps and included a supplemental answer sheet with prompts and hints about how to work on the task. The task description included a plan of the activities over the two lessons and directions on how to divide the task. The second task, however, was still open-ended and less-structured than most learning tasks in regular history lessons. We therefore refer to this task not as highly structured or well-structured but as moderately structured. All groups were given approximately the same amount of time to finish the task. However,

Table 1
Coding Scheme

Codes	Description	Examples
1. Elaboration	Explanations of important concepts; making connections between perspectives, persons and concepts; comparisons between persons, concepts and perspectives; and substantive arguments for the seating plan at the table	*"Schaepman is pro compulsory education and Kuyper is not"* *"The Catholics and the Protestants, they both wanted separate schools"* *"Borgesius can sit here, because he is also a liberal and can get along quite well with this one"*
2. Metacognition	Orienting on the purpose and aim of the task. Activating prior knowledge	*"I think we have to design a seating for each of the three topics"*
	Planning the learning process, setting sub-goals, determining learning strategies, dividing activities between group members	*"let's wait with the explanations until we have read all of it"* *"Everyone should read the information of two persons"*
	Monitoring the learning process	*"Do we still have time to do this?"* *"What are you reading?"*
	Evaluation and reflection on the task and the learning process	*"I think we did quite well"* *"This is very difficult"*
3. Other activities	Processing the content of the task: identifying important concepts and perspectives without explaining or making connections with other concepts or perspectives; making suggestions about the seating without argumentation	*"The topics are child labour, religion, that sort of thing"* *"I think Schaepman should sit next to him"*
	Questions	*"What does Kuiper think of this?"*
	Reading out the assignment text	*"Study the information in your textbook on the 19th century"*
	Short confirmations	*"Yes, that's right"*
	Off task or practical contributions	*"Do you have a pen?"*

students could work at their own pace, and it was up to them to decide when they considered the task to be finished. As a result, the actual on-task time differed, from 32 minutes to 82 minutes (M = 59, SD = 14.9). The amount of time spent on the task did not differ between the ill-structured and moderately structured task (mean difference = 2.09, $t(32) = 0.40$, $p = .69$). There was a small but non-significant correlation between group heterogeneity and time spent on the task ($r = .25$, $p = .16$).

2.4 Cognitive ability

Cognitive ability was measured two months before the start of the curriculum unit using a 23-item version of Raven's Advanced Progressive Matrices (APM: Raven, Raven, & Court, 1998). The possible score range on this version was 0-23. As argued, to analyse the differential effects of cognitive ability, we included the APM score as a continuous variable in our analyses.

2.5 Group composition: Cognitive heterogeneity of the group

To guarantee diversity in the cognitive heterogeneity of the groups, we formed the groups based on cognitive ability. Based on the APM score, we divided the students into three equal groups: 34% of the students scored 15 or higher on the APM and were classified as high cognitive ability students; 33% of the students scored between 11 and 15 and were classified as medium ability students; 33% of the students scored 15 or lower and were classified as low cognitive ability students. It should be noted that the labels high, medium and low cognitive ability are relative qualifications for the group of students in *this* study. Based on the classification of students into high, medium and low cognitive ability, homogeneous and heterogeneous groups were formed.

Because the focus of this study was primarily on high cognitive ability students, we only selected groups that included at least one student with high cognitive abilities. This means that we did not select homogeneous groups with only students with low or medium abilities: 13 groups were homogenous groups containing only students with high cognitive abilities; 21 groups were heterogeneous groups containing one high, one medium and one low cognitive ability student.

We created a continues variable to indicate the degree to which students within the same groups differed from each other. We used the standard deviation of the APM score within each group as a measure for the cognitive heterogeneity of the group. Because not all students were present at both lessons, the heterogeneity differed between the two lessons for 11 of the groups. The differences in heterogeneity between the two lessons were not significant ($t(101) = .718$, $p = .427$) and highly correlated ($r = .89$). For these 11 groups, we used the average heterogeneity between the two lessons.

2.6 Coding of group interaction

The transcriptions of the group interaction were coded based on a coding scheme derived from a taxonomy developed by Meijer et al. (2006). We used the turn shifts of the speakers to delineate the unit of coding. We defined a turn as everything a speaker said until another speaker started talking. Our coding scheme included three codes: 1) elaboration, 2) metacognition and 3) other activities (see Table 1 for descriptions and examples). Five randomly selected dialogues were double-coded (2307 turns) by two independent raters to estimate interrater reliability. The reliability was acceptable, with a Cohen's Kappa of .73 and a interrater agreement of 86% (see Landis & Koch, 1977; McHugh, 2012).

2.7 Analyses

Multilevel analysis was used to investigate whether the cognitive heterogeneity of the group and task structure had an effect on the number of elaborative and metacognitive contributions of the students. Three-level models were estimated for both dependent variables. Students (level 1) were nested in groups (level 2), and groups were nested in classes (level 3). The intraclass correlations for elaboration were .33 on the group level and .13 on the class level. For metacognitive activities, the intraclass correlations were .58 on the group level and .01 on the class level. For each dependent variable, we estimated three models. First, a model was fitted with only main effects for cognitive ability, heterogeneity and task structure (ill-structured = 1, moderately structured = 0). In the second and third models, we investigated the differential effects for cognitive ability. In the second model, we added a term for the interaction between cognitive ability and heterogeneity; and in the third model, we added a term for the interaction between cognitive ability and task structure.

Students who missed one lesson were not included in the analyses. Four students were not present at the first lesson, and eight students were not present at the second lesson. Little's MCAR test showed that the data were missing completely at random ($\chi^2(2) = .540$, $p = .763$). Because some groups were incomplete at lesson 1 or lesson 2, the group size differed between the two lessons. Conceivably, group size may have had an effect on the number of contributions of individual students. We therefore included group size in lesson 1 and lesson 2 as predictors in the multilevel regression models to control for group size. The continuous independent variables, i.e., group size, heterogeneity and cognitive ability, were centred around the grand mean. One of the groups had an extremely high score on elaboration (4.3**SD* above the mean). This group worked with the ill-structured task and its cognitive heterogeneity was 3.73, which is just above average (see Table 3). Outliers may have had a relatively large impact on the outcomes of the analysis. Therefore, the analysis on elaboration was repeated without this particular group.

Table 2
Correlation for the Study Variables (N = 90)

	1	2	3	4	5
1. Elaboration					
2. Metacognition	.59**				
3. Cognitive ability	.15	.12			
4. Heterogeneity	-.08	-.08	-.42**		
5. Group size lesson1	-.10	-.05	-.01	.06	
6. Group size lesson2	-.17	-.06	-.06	.10	.18

* $p < .05$, ** $p < .01$

Table 3
Mean and Standard Deviations for the Moderately Structured and Ill-structured Tasks

	Moderately structured (n = 44)		**Ill-structured (n = 46)**		**Total (n = 90)**	
	M	*SD*	*M*	*SD*	*M*	*SD*
Total contributions	171.48	70.48	171.57	93.04	171.52	82.32
Elaboration	31.70	15.23	33.00	22.12	32.37	18.97
Metacognition	20.98	9.86	20.48	13.18	20.72	11.62
Cognitive ability	14.23	4.25	14.41	3.66	14.32	3.94
Heterogeneity	3.60	2.20	3.40	1.86	3.50	2.03
Group size lesson1	2.95	.21	2.89	.32	2.92	.27
Group size lesson2	2.86	.35	2.83	.53	2.84	.45

* $p < .05$, ** $p < .01$

3 Results

3.1 Descriptives

Table 2 presents correlations between the continuous variables in the study. It shows that elaboration was correlated with metacognition (r = .57). Students who made more metacognitive contributions also engaged more in elaboration. There was a negative correlation between cognitive ability and heterogeneity (r = -.42). This was of course due to the way we selected the groups. We selected only groups with at least one student with high cognitive ability and did not select groups with only low or medium cognitive ability students. As a result, students with lower cognitive abilities were part of more heterogeneous groups.

The means and standard deviations of all the variables for the moderately structured and the ill-structured task in the study are presented in Table 3. The results show only small differences between the two types of tasks. On average, 20% of students' on-task contributions were elaborative contributions; 13% of all contributions were categorised as metacognitive contributions.

3.2 Multilevel analyses: Elaboration

The hypotheses were tested separately for respectively elaboration and metacognitive activities. The results of the multilevel regression analyses for elaboration are presented in Table 4. Model 1 included only the main effects for cognitive ability, heterogeneity and task structure. The results showed no main effects on students' elaborative contributions during group interaction. In model 2 we added a term for the interaction between cognitive ability and heterogeneity. However, no interaction was found between the heterogeneity of the group and individual cognitive ability. In model 3 a interaction term was added (relative to model 1) for the interaction effect between cognitive ability and task structure. The interaction between cognitive

Table 4
Results of the Multilevel Analyses on Elaboration

	model1		model2		model3	
	B	*SE*	*B*	*SE*	*B*	*SE*
Intercept	31.57**	3.87	29.78**	3.98	31.58**	3.55
Group size lesson1	-3.44	8.48	-3.06	8.36	-6.07	7.74
Group size lesson2	-5.65	5.26	-6.42	5.21	-4.55	4.79
Cognitive ability	.37	.44	1.17	.64	-1.11*	.54
Heterogeneity	-.14	1.30	.52	1.34	-.29	1.19
Task structure (ill-structured)	.95	4.84	1.45	4.79	.58	4.40
Heterogeneity x cognitive ability			-.46	.27		
Task structure x cognitive ability					3.30**	.79
Random effects						
Variance student-level	200.25	39.99	192.50	38.30	167.70	33.95
Variance group-level	99.41	62.96	97.27	61.22	80.18	52.41
Variance class-level	49.91	48.04	50.91	48.34	45.20	39.51
Deviance (-2logliklihood)	767.85		764.92		751.74	

* *p* < .05, ***p* < .01

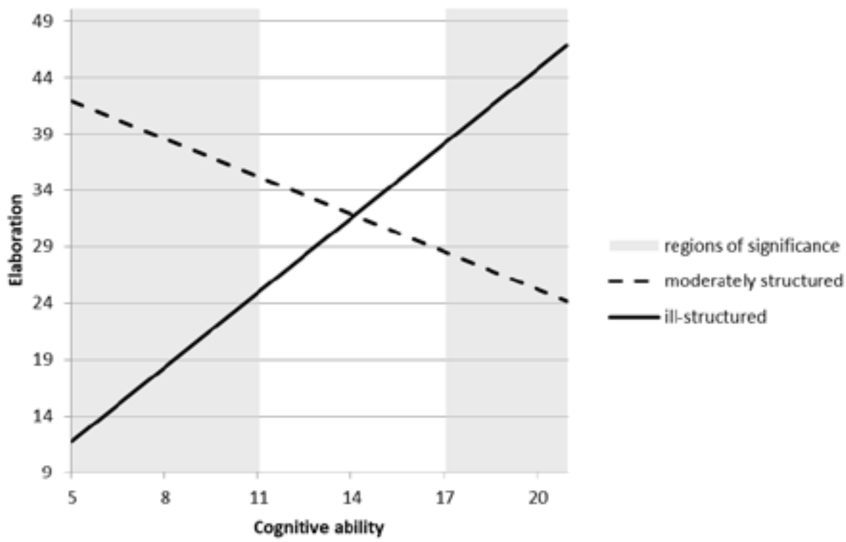

Figure 1. Simple regression lines for the ill-structured task and the moderately structured task and regions of significance for the effect of task structure on elaboration.

ability and task structure appeared to be significant ($b = 3.30$, $SE = .79$, $p < .001$). To obtain more insight into the meaning of this interaction, simple slopes and regions of significance were calculated using an online tool described by Preacher Curran and Bauer (2006). Figure 1 presents simple regression lines for the ill-structured task and moderately structured task. The simple slopes of both regression lines within conditions were significantly different from zero (for the ill-structured task: $b = 2.19$, $SE = .59$, $p < .001$; for the moderately structured task: $b = -1.11$, $SE = .54$, $p = .047$). This means that cognitive ability was negatively related with elaboration in the moderately structured task and positively related with elaboration in the ill-structured task. In addition, regions of signi-

Table 5
Results of the Multilevel Analyses on Metacognitive Activities

	model1		model2		model3	
	B	*SE*	*B*	*SE*	*B*	*SE*
Intercept	20.67**	2.50	19.95	2.54**	20.65**	2.42
Group size lesson1	-1.57	5.73	-1.72	5.62	-2.61	5.48
Group size lesson2	-.67	3.65	-.95	3.59	-.33	3.49
Cognitive ability	-.07	.23	.27	.36	-.66*	.30
Heterogeneity	-.50	.88	-.23	.89	-.53	.84
Task structure (ill-structured)	-.24	3.45	-.04	3.38	-.35	3.29
Heterogeneity x cognitive ability			-.19	.15		
Task structure x cognitive ability					1.30**	.44
Random effects						
Variance student-level	54.17	10.28	53.83	10.23	48.95	9.32
Variance group-level	75.82	33.81	70.66	32.36	67.26	29.73
Variance class-level	2.76	23.81	4.82	23.60	5.93	21.56
Deviance (-2logliklihood)	667.77		666.25		659.37	

* $p < .05$, ** $p < .01$

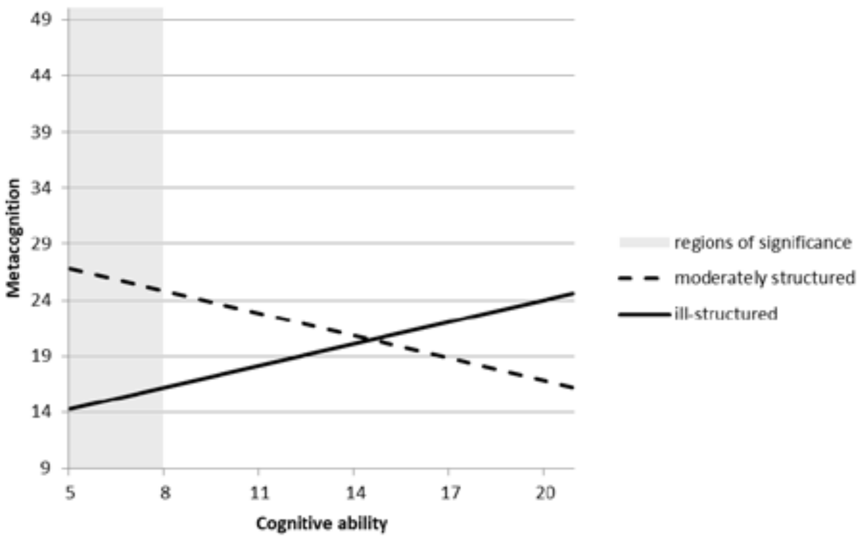

Figure 2. Simple regression lines for the ill-structured task and the moderately structured task and regions of significance for the effect of task structure on metacognition.

ficance are marked in Figure 1 for the effects of task structure. The boundary of the lower region of significance was estimated at an APM score of 11.03. However, 11.03 is not a possible APM score. In our study, this implies that for students with an APM score of 11 or lower, there was a significant effect of task structure. This corresponds to 20% of the students. For these students, a moderate task structure resulted in more elaboration. This trend was reversed when cognitive ability increased. The boundary of the higher region of significance was estimated at 17.09. This means that for students with an APM score of 18 or higher, the effect of task structure was significant (11% of the students). For these students, less task structure resulted in more elaboration.

The analysis was repeated without one group that had produced an extremely high score on elaboration. Again, the analysis revealed an interaction effect between task structure and cognitive ability (b = 2.64, SE = .71, p < .001). The regions of significance were slightly different (estimated AMP score at the lower bound was 13.18, and 18.52 at the higher bound). This means that the effect of task structure was significant for students with a cognitive ability lower than 13 (32% of the students) and higher than 19 (5% of the students). Compared to the analysis that included the outlier group, a larger group of students had more elaboration in the moderate structure task, and a smaller, more extreme group of high-ability students contributed most elaboration in the ill-structured task.

3.3 Multilevel analyses: Metacognition

The results for metacognition were comparable with the results for elaboration (see Table 5). The same procedure was followed as with elaboration. No main effects were found for cognitive ability, heterogeneity or task structure on students' metacognitive contributions during group interaction (model 1), and there was no interaction between the heterogeneity of the group and individual cognitive ability (model 2). Likewise with elaboration, we found a significant interaction in model 3 between cognitive ability and task structure for metacognitive contributions (b = 1.30, SE = .44, p = .004). Figure 2 presents simple regression lines for the ill-structured task and moderately structured task. Only for the moderately structured task did the simple slope differ significantly from zero. The relationship was negative: Higher cognitive ability was related to fewer metacognitive contributions in the moderate task (b = -.66, SE = .30, p = .031). In the ill-structured task, this trend was reversed; however, the simple slope was not significant (b = .65, SE = .33, p = .054). Again, regions of significance were marked for the effect of task structure. The boundaries were estimated at 7.94 and 21.54. The effect of task structure was significant for students with an APM score of 7 or lower (8% of the students). For these students, a moderate task structure led to more metacognitive contributions. For students with a score of 22 or higher, a reverse effect of task structure was found. However, a score of 22 is rather extreme and did not occur in our data. This means that ill-structured tasks may lead to more metacognition, but only for students with exceptionally high cognitive abilities.

4 Discussion and Conclusions

4.1 Discussion

In this study, we investigated the effects of task structure and group composition on students' elaborative and metacognitive contributions during a collaborative learning task in history class. The results were partly in line with our expectations. Our first hypothesis, which concerned an interaction between task structure and cognitive ability, was confirmed. It seems that the effects of task structure on elaboration and metacognitive activities depend on students' cognitive ability level. Task structure had a negative effect on the elaboration of students with relatively high cognitive abilities, whereas, for students with relatively low cognitive abilities, task structure had a positive effect on elaboration. We found a similar pattern for metacognition – to a certain extent. Students with high abilities engaged more in metacognitive activities when working on ill-structured tasks, although this effect was only significant for students with exceptionally high cognitive abilities. Again the relationship was reversed for students with lower levels of cognitive ability. Task structure seemed to enhance the participation in metacognitive activities among low-ability students.

What is remarkable is that on average there were no differences in elaboration and metacognitive activities between ill-structured and moderately structured tasks. Neither were there differences between high- and low-ability students. This means that within the group of students who worked with the moderately structured task the high-ability students were outperformed by students with lower abilities regarding elaboration and metacognitive activities. These results indicate that support in the form of hints and directions to handle the task may indeed impede students with higher cognitive abilities from engaging in higher-order reasoning. The moderately structured task may also not have been demanding enough to necessitate the need among high-ability students to engage in higher-order collaborative reasoning (Janssen et al., 2010; Malmberg, et al., 2014). The results also confirm that when a task is too open, students with lower abilities may have trouble to decide how to handle the task and refrain from participation in higher-order processes (Malmberg, et al., 2014). The support that was provided in the moderately structured task may have helped these students to engage in higher-order processes.

The results of our study did not confirm our hypothesis regarding the interaction effect of group composition and cognitive ability. The results supported our assumption that heterogeneity would not have an effect on the contributions of high-ability students. However, unexpectedly, heterogeneity did also not have an effect on the elaboration and metacognitive activities of students with lower cognitive abilities. Regarding high-ability students, the results are in line with other studies that have found no differences between homogenous and heterogeneous groups in the participation of high-ability students (e.g., Webb et al., 1998). The results support our assumption that both heterogeneous as well as a more homogeneous group compositions can be beneficial for high-ability students. An important difference from other studies that investigated the effects of group composition (e.g. Saleh et al., 2005; Webb et al., 2002) is that the tasks used in this study were less structured. Even the moderately structured task in our study was still relatively open and less structured than most other school tasks. Although students received directions and hints about how to handle the task, there were still different possible solutions, and students still had to explain and negotiate choices. These elements of ill-structured tasks may have stimulated equal participation among group members and suppressed negative disruptive behaviours (Cohen, 1994; Webb et al., 2002).

An unexpected result of this study was that low-ability students did not seem to profit from collaboration with students with higher abilities. A possible explanation is that the spread in heterogeneity in this study was not large enough. For this study we selected only groups with at least one high-ability student. As a result there were no groups with only low-ability students. So although there was still variance in cognitive heterogeneity in groups with low-ability students, this may not have been large enough to make a difference for their participation in the group interaction.

Our approach in this study differed from those taken in most other studies that have investigated the differential effects of cognitive ability or group composition. We did not categorise students as high, low or medium in cognitive ability. Instead, we used continuous measures for cognitive ability and group composition. The benefit of this approach is that the results do not depend on the choice of a certain cut-off point. Probing the interactions provide information on simple slopes and regions of significance that help to interpret the results (Preacher et al., 2006). The evaluation of the regions of significance still provides an indication about the effect of the amount of structure for specific groups of students. This may be a useful approach to follow in further research on as well the differential effects for cognitive ability of task characteristics as on the effects of group composition. A continuous variable better represents the variation between students than a categorical variable.

4.2 Limitations and further research

As argued above, the results of different studies are hard to compare. The participants in our study were all in the 11th grade of pre-university education and among the upper 19 percent of the student population in the Netherlands. Accordingly, they may have been more similar to each other than the participating students in other studies. The spread in cognitive ability in the more heterogeneous groups in our study may not have been large enough to cause problems such as those described in Webb et al.'s (2002) study.

Another limitation of this study is that our approach assumed a linear relationship. However, the relationships we investigated did not necessarily have to be linear. It is possible that a certain amount of task structure is particularly effective for medium-ability students but less effective for students with higher or lower abilities. This may also be the case for the effects of group composition. It might be that a particular heterogeneity in cognitive ability is most effective, whereas more homogenous or more heterogeneous groups are less effective. An extension of this approach would be to investigate non-linear relationships (Montgomery, Peck, & Vining, 2012).

In this study, we focused on the individual contributions of students to group interaction. We assumed that contributing to interaction is important because students may learn better when they are themselves engaged in higher-order processes (Cohen, 1994; Webb, 2009). However, this focus does not take processes of co-construction into consideration. During processes of co-construction, students co-construct meanings and understanding of the topics at hand that no individual group member could have developed on their own (Van Boxtel et al., 2000; Webb, 2009). In their study, Saleh et al. (2005) found that group composition influenced processes of co-construction. High-ability students in homogenous groups engaged more in collaborative elaboration, while high-ability students in heterogeneous groups engaged more in individual elaboration. It is also possible that, in our study, task structure and group composition had an effect on co-constructive processes. In future research, it would be interesting to consider individual contributions of students as well as processes of co-construction.

Future research may also take into account other student characteristics that are important for collaborative learning. In this study we examined differential effects for cognitive ability. However, it could be interesting to examine also differential effects for metacognitive skills. As argued, metacognitive skills are related to cognitive ability (Veenman & Spaans, 2005). However, metacognitive skills of individual group members may still have a unique contribution to the quality of the interaction. Likewise, it could be worthwhile to include motivational aspects in collaborative learning (see, e.g., Järvelä, Volet, Järvenoja, 2010).

Another approach would be to further investigate the quality of elaboration and metacognitive activities during collaborative learning tasks. In our study, the focus was mainly on the quantity of elaboration and metacognitive activities. Elaboration was operationalised as any contribution, including arguments or explanations. However, it might be interesting to make further distinctions between, for example, correct or incorrect explanations, or between valid arguments and less valid arguments (see, for example, Webb et al., 2002). Similarly, we could further investigate the quality of metacognitive activities. Some of the approaches suggested by students may be less productive than others. For example, some groups in our study took a long time to orient towards the task. Although metacognitive activities may be important for effective collaboration, too much or unproductive regulation may have a negative effect on collaboration and the learning processes of individual group members (Janssen et al., 2010).

4.3 Conclusions and practical implications

Altogether, this study confirms the importance of providing high-ability students with ill-structured collaborative learning tasks. Open-ended collaborative tasks with little guidance and directions on how to handle them, can stimulate elaborative reasoning among high-ability students and may offer them appropriate challenge in regular classrooms. More structure may hinder these students from engaging in elaboration. For students with lower ability, on the other hand, it seems more beneficial to provide more support. For these students, structure can help them to engage in elaboration and also stimulates metacognitive activities. To provide challenges for high-ability students while also considering students with lower ability, it may be advisable to permit students to work on collaborative learning tasks more frequently and to vary the amount of structure. It may also be that low-ability students need more practice. If so, then working more often on collaborative learning tasks with a decreasing amount of structure may aid these students while gradually providing more challenges for *all* students. Alternatively, another approach would be to differentiate in the preparation of students for collaborative learning. Group composition seemed not to be related to the quality of the group interaction among students in 11th grade pre-university education. However, more research is necessary to investigate the quality of elaborative and metacognitive contributions of high-ability students and processes of co-construction.

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Samenvatting

Effecten van taakstructuur en groepssamenstelling op elaboratie en metacognitieve activiteiten van leerlingen met hoge cognitieve vermogens tijdens samenwerkend leren

Samenwerkend leren kan een effectieve manier zijn om hogere-orde-processen te stimuleren bij leerlingen met hoge cognitieve vermogens in reguliere klassen. In dit onderzoek is nagegaan wat de effecten zijn van taakstructuur en groepssamenstelling op elaboratie en metacognitieve activiteiten van vwo-5 leerlingen tijdens een groepsopdracht. 102 leerlingen werkten in kleine groepjes aan een laaggestructureerde of matig gestructureerde opdracht. Cognitief vermogen werd meegenomen als continue variabelen om gedifferentieerde effecten te onderzoeken. Het effect van de groepssamenstelling werd onderzocht met eveneens een continue variabele voor de cognitieve heterogeniteit van de groep. De groepsdialogen werden getranscribeerd en gecodeerd. De analyses lieten interactie-effecten zien tussen taakstructuur en cognitief vermogen op elaboratie en metacognitieve activiteiten. De taakstructuur had een negatief effect op de elaboratie van leerlingen met hoge cognitieve vermogens. Voor leerlingen met een lagere cognitieve vermogens had de taakstructuur een positief effect op elaboratie en metacognitieve activiteiten. Er werden geen effecten gevonden van de cognitieve heterogeniteit van de groep. Groepssamenstelling leek niet van invloed te zijn op de groepsinteractie van vwo-5 leerlingen. De resultaten bevestigen dat open groepsopdrachten met weinig begeleiding en aanwijzingen hogere-orde-processen kunnen stimuleren bij leerlingen met hoge cognitieve vermogens en hen de uitdaging kunnen bieden die ze nodig hebben.

Kernwoorden: Samenwerkend leren, taakstructuur, groepssamenstelling, elaboratie, metacognitieve activiteiten