Educational dialogue and teacher occupational stress in relation to student math performance

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Abstract

This study examined the amount and quality of educational dialogue in relation to student math performance in Grade 2. Domains of teacher occupational stress were considered as predicting variables for dialogue and math performance. Video-recorded lessons (n = 151) of 50 teachers were analysed in terms of dialogic episodes to determine the amount (length and number of episodes) and quality (four patterns) of dialogue. Multilevel modelling showed that the amount of educational dialogue associated positively with student math performance. In addition, teacher cynicism was related to math performance via the amount of educational dialogue. Regarding the dialogue quality, moderate quality dialogues linked positively with student math performance, but no indirect associations were found when considering teacher cynicism. The findings provide important new knowledge by investigating the effect of educational dialogue on young students' achievement and by mapping indirect associations between teacher occupational stress, dialogue and student math performance.

Keywords: educational dialogue; student math performance; teacher occupational stress; patterns of dialogic teaching; primary school.

1. Introduction

Current views on student learning highlight the importance of interaction and reciprocal knowledge building between the teacher and students (Howe & Abedin, 2013). Educational dialogue can be considered as one of the most ideal forms of effective teacher-student interaction, in which the teacher and students aim to build and explore shared knowledge together through extended, reciprocal and cumulative classroom talk (Alexander, 2006). Therefore, it is hardly surprising that educational dialogue is widely believed to support student learning and development in diverse ways (Howe et al., 2019).

Prior research has predominantly investigated the associations between educational dialogue and student academic performance through interventions and has revealed positive effects, for instance, on the development of students' mathematics, science or literacy skills (e.g. Alexander, 2018; Mercer, 2008; Reznitskaya et al., 2001). In addition, some recent studies have shown the benefits of educational dialogue to student learning among Grade 6 and Grade 9 students without an interventional study approach (Howe et al., 2019; Muhonen et al., 2018; Sedova et al., 2019). Despite the encouraging findings on the effectiveness of educational dialogue, research conducted in an authentic classroom setting (without intervention) is still scant and limited to older students. There are hardly any studies concerning the associations between educational dialogue and student academic performance among younger students who are only at the beginning of their school career. Consequently, experts of dialogue research call for studies that map the relationship between educational dialogue and student learning (Howe, 2017; Howe & Abedin, 2013).

In addition, prior research on educational dialogue has scantly considered any factors of the complex classroom environment that may have an impact on how often and how the educational dialogue may occur, and therefore, also have an impact on student learning. An important teacher-related factor is teacher occupational stress, that has been found to link

negatively with a general classroom interaction (e.g. Braun et al., 2018; Penttinen et al., 2020) and with student academic achievement (Arens & Morin, 2016). However, there are no prior studies regarding how teacher occupational stress may predict the occurrence of educational dialogue and further indirectly associate with student performance. The present study aims to address these research gaps by investigating educational dialogue in Finnish Grade 2 classrooms. The study examines the amount and quality of educational dialogue and their associations to student math performance. In addition, teacher occupational stress is considered as a predicting variable for dialogue and student math performance.

1.1. Educational dialogue and associations to student performance

According to theories of dialogue, in an ideal dialogue that supports student learning, students are treated as active participants who share their knowledge and ideas, elaborate diverse views and therefore build on one another's thoughts (Alexander, 2006; Mercer & Littleton, 2007). However, the student involvement and balance between teacher's and students' participation can vary depending on whether educational dialogue is considered as a whole-class discussion between teacher and students or as a small group discussion. The present study focuses on examining whole-class dialogue in which the teacher's scaffolding and student participation define the quality of the dialogue. Consequently, Alexander's (2006) concept of dialogic teaching is used as a conceptual basis for the present study. The concept of dialogic teaching includes five principles that describe educational dialogue to be (Alexander 2018, p. 566): '1) collective: the classroom is a site of joint learning and enquiry; 2) reciprocal: participants listen to each other, share ideas and consider alternative viewpoints; 3) supportive: participants feel able to express ideas freely, without risk of embarrassment over "wrong" answers; 4) cumulative: participants build on their own and each other's contributions and chain them into coherent lines of thinking and understanding;

and 5) purposeful: classroom talk, though open and dialogic, is structured with specific learning goals in view'.

The teacher plays the key role in scaffolding students' participation and conceptual development through such practises as asking open questions, providing constructive and supportive feedback and encouraging students to share their own thoughts (Rojas-Drummond et al., 2013). Especially in mathematics, which is known for its short and segmented interaction (Hu et al., 2021), teachers have been found to increase the amount of student explaining and sharing details by encouraging students to explain, justify and clarify their problem-solving strategies (Attard et al., 2018; Webb et al., 2019). It is often the practises and active scaffolding that define the quality of the educational dialogue, which has been shown to vary between moderate and high and between teacher- and student-initiated dialogues (Muhonen et al., 2016). Although the quality of educational dialogue and teachers' scaffolding have been widely examined, Howe and Abedin (2013) suggest that educational dialogue rarely occurs in the classrooms of diverse school levels and teachers rarely use scaffolding that supports educational discussion.

The paucity of educational dialogue in classrooms may be one of the key reasons why previous studies have mapped the effectiveness of educational dialogue predominantly through interventions. Despite the variation in the results and implementation of the interventions, studies have shown positive changes in the use of classroom dialogue and improved results in student outcomes (e.g., Kiemer et al., 2015; Reznitskaya et al., 2001; van der Veen et al., 2017). The well-known intervention studies by Mercer and colleagues (e.g., Mercer, 2008; Mercer & Littleton, 2007) investigated exploratory talk and student achievement in teacher-led sessions and group activities in their Thinking Together programme covering children from 6 to 13 years of age. They showed that students in the intervention programme improved their test scores in math and science and raised their skills

in individual reasoning and collective thinking. Another large-scale interventional study conducted by Alexander (2018) was designed to increase the role of educational dialogue and to enhance Grade 4 students' engagement and learning. The results of the Dialogic Teaching Project showed that at the end of the 20-weeks project, the students in the intervention group were two months ahead of the control group in literacy, mathematic, and science (measured with GL Assessment Progress Tests; GL Assessment, 2016).

Studies without an interventional approach have been rarer and shown diverse results. Some studies have been able to confirm the widely believed assumption that the use of educational dialogue practises is in positive relation with student academic achievement (e.g. Applebee et al., 2003; Muhonen et al., 2018; Sedova et al., 2019). However, there are also studies that have shown contradictory findings, especially in terms of literacy instruction. For example, Michener (2014) suggested that high rates of student explanations and high-quality questions were in fact predictive of students' lower reading outcomes. In addition, Nystrand et al. (1997) showed that some classrooms which seemed to be dialogic were in fact characterised by teacher control of knowledge and linked only little with students' literacy learning. Recently, three observational studies have shown positive associations between educational dialogue and student academic performance without an interventional approach. A recent study by Howe et al. (2019) used the UK's Standard Assessment Tests to measure students' math, literacy and science achievements. The results showed that as long as the students participated extensively to the classroom discussion, dialogue variables of elaboration and querying were found to positively associate with Grade 6 students' mathematics and literacy scores. Another study by Sedova et al. (2019) explored the relationship between participation in dialogue and student achievement among Grade 9 students. They showed that the more students talked in class and engaged in reasoning, the better they performed in a reading literacy test. Finally, the study by Muhonen et al. (2018)

reported positive associations between the quality of education dialogue and students' performance in literacy and physics/chemistry (measured in grades) among Grade 6 students.

1.2. Teacher occupational stress, classroom interaction and student performance

Many teachers experience their work as stressful, and studies have shown teaching to be a highly demanding and stressful profession (e.g., Arens & Morin, 2016; Herman et al., 2020). Teachers' occupational stress has been defined as work-related experience of negative emotions, such as anxiety, frustration or tension, which can cause physiological, psychological and social strain (Klassen & Chiu, 2010; Kyriacou, 2001). In the field of early education, teachers' stress has been predominantly investigated through self-reports measuring their subjective experience of stress (e.g., Arens & Morin, 2016; Friedman-Kraus et al., 2014; Penttinen et al., 2020). In the long run, this persistent stress can lead to burnout, which is defined as type of prolonged occupational stress (Salmela-Aro et al., 2011). It is characterised by domains of emotional *exhaustion* (draining of emotional energy and feelings of chronic fatigue), *cynicism* (a distant and negative attitude towards one's job) and feelings of *inadequacy* (a belief that the person is no longer effective in fulfilling the responsibilities of the job) (Feldt et al., 2014; Jennings & Greenberg, 2009; Salmela-Aro et al., 2011).

Prior studies have shown that the level of teacher occupational stress links with their classroom interaction. Highly stressed teachers have been found to be less supportive of their students and to provide lower-quality teaching practices (Fantuzzo et al., 2012). Teachers who experience high levels of stress are more likely to struggle in building a supportive classroom environment for students' motivation and learning, and they have shown to have a lower quality of interaction with their students (Arens & Morin, 2016; Klusmann et al., 2008; Pakarinen et al., 2010). In terms of classroom interaction, high teacher stress has been found to associate with their lower emotional support and less classroom organisation (Braun et al.,

2018; Li Grining et al., 2010; Penttinen et al., 2020). Yet Friedman-Krauss et al. (2014) showed that a moderate level of teacher occupational stress associated positively with classroom interaction and climate. Although diverse associations between teacher stress and more general classroom interaction have been found, there are no studies that have investigated teacher stress in relation to actual educational dialogue between teacher and students.

In terms of student performance, high levels of teacher stress have been found link to students' lower academic performance (Arens & Morin, 2016; Herman et al., 2017) and to students' lack of effort in completing their school work (Geving, 2007). Additionally, students have been found to demonstrate weaker math performance when their teacher reported more depressive symptoms (stress being one of them) (McLean & McDonald, 2015).

1.3. Aims of the study

The scant prior research calls for evidence regarding the associations between educational dialogue practices and student performance among younger students in authentic classroom settings without an interventional study approach. Student arithmetic skills were chosen for the study due to their high importance in early math education in the Finnish education system (Finnish National Agency for Education, 2014). Students' math skills develop in a hierarchical manner: learning basic arithmetic skills is a vital foundation for mastering more complex skills, which include such aspects as explaining, reasoning and mathematical thinking (Clarke et al., 2012; Entwisle & Alexander, 1990). Researchers have suggested that for the more complex math skills to be developed, rich dialogic interactions in the classroom are required as part of teaching practices (Attard et al., 2018; Hu et al., 2021). However, there is no knowledge on how the teachers' use of educational dialogue in the

classroom links with students' performance, especially in math, when students are still predominantly focused on learning the basic arithmetic skills in Grade 2.

In addition, although some previous studies have investigated direct associations between educational dialogue and student performance, there is also a need to investigate other potential factors that may explain the link between amount and quality of dialogue and further student math performance. Prior research has shown teacher occupational stress to link with both general classroom interaction and with student performance, but the possible link from teacher stress to classroom interaction and further to student learning has remained understudied. The present study aims to investigate this indirect association from teacher occupational stress to educational dialogue and further to student math performance. The research questions of the present study are as follows:

RQ1: To what extent is the amount of educational dialogue in the classroom associated with student math performance, and to what extend does teacher occupational stress predict the amount of dialogue and student math performance?

RQ2: To what extent is the quality of educational dialogue in the classroom associated with student math performance, and to what extend does teacher occupational stress predict the quality of dialogue and student math performance?

Based on the previous but scant research on educational dialogue and student academic performance (e.g. Alexander 2018; Howe et al., 2019 Muhonen et al., 2018), we expected educational dialogue amount (H1) and educational dialogue quality (H2) to associate positively with student math performance. Based on prior research on teacher occupational stress and classroom interactions at a more general level (e.g. Braun et al., 2018; Herman et al., 2017; Penttinen et al., 2020), we hypothesised teacher stress to negatively predict

educational dialogue amount (H3) and educational dialogue quality (H4) and further student math performance.

2. Method

2.1. *Participants and procedure*

The present study is part of a larger longitudinal research project that focuses on classroom interactions, student performance and the wellbeing of teachers and students (Lerkkanen & Pakarinen, 2016–2022). The participants of this study are 50 Finnish Grade 2 teachers and their students. The teachers (47 female, 3 male) were on average 45.7 years old and holders of a master's degree, which is required for primary school teachers in Finland. There were on average 18.8 students (minimum 5, maximum 26) in the classes of each teacher, which represents a typical class size of Finnish Grade 2 classrooms. The participating students (n = 710) were predominantly eight years old, 50.7% of them being girls and 49.3% boys. The parents of the students (n = 451) reported their educational degree, which varied from no vocational education to a licentiate or doctorate (Mode = vocational school degree). All the participants (teachers and parents of the students) gave their written consent for their own or their child's participation. The recruitment of the participants was conducted on a voluntary basis, and the participants had the possibility to drop out at any point of the study. The research project applied and received ethical approval from the university's ethics committee in 2018 prior to the data collection in 2019.

The data of the present study were collected in three ways. First, the students performed individual pen and paper tests in arithmetic fluency and reasoning. Second, the teachers filled out a questionnaire regarding their occupational stress, and third, the classrooms were video recorded during one school day. The goal of the video-recorded lessons was to observe authentic interaction between the teacher and students and to observe teachers' use of

dialogic practises throughout the school day. Due to the special characteristics of the Finnish school system, the recorded lessons included a variety of subjects, such as math, literacy, science, religion/social studies, art, crafts and English as a foreign language. In Finnish early primary school classrooms, the same class teacher teaches all subjects, and integration across subjects and multidisciplinary learning is highlighted in the National Core Curriculum for Basic Education (Finnish National Agency for Education, 2014). This means that teachers typically use the same kind of practices throughout the school day despite the subject (for example, the same lesson can include literacy, math and art content). In total, 151 lessons (three lessons for 49 teachers and four lessons for one teacher) were recorded, and the lessons typically lasted for 45 minutes. The recordings were done with two video cameras; one was placed to the front corner and the other to the back corner of the classroom.

2.2. *Measures*

2.2.1. *Student math performance*

Arithmetic fluency. Students' basic arithmetic skills were assessed with the Basic Arithmetic Test (Aunola & Räsänen, 2007). The test included 28 tasks in total: 14 tasks of addition (e.g., 22 + 44 =__) and 14 tasks of subtraction (e.g., 15 - 7 =__). The students were given 3 minutes to perform the task, and therefore, the test measured both the accuracy and speed of students' math performance. The test score was determined by calculating the total amount of correct answers (the maximum score was 28). The Cronbach's alpha was 0.91.

Arithmetic reasoning. Students' arithmetic reasoning skills were measured with the Arithmetic Reasoning Test (Koponen & Räsänen, 2003). The test included 30 tasks, which each including a sequence of three numbers (e.g., 30, 45, 60). The students were asked to select from four alternative numbers (e.g., 85, 66, 75, 70) for the number that in their opinion continued the sequence the best. The students were given 10 minutes to perform the test, and

the test score was determined by calculating the total amount of correct answers (the maximum score was 30). The Cronbach's alpha was 0.79.

2.2.2. *Teacher occupational stress*

Teacher occupational stress. The Bergen Burnout Inventory (BBI-9; Salmela-Aro et al., 2011) was used to measure the teachers' self-reported prolonged work stress. The BBI-9 includes nine items that measure three domains of persistent occupational stress: (1) exhaustion at work (three items; e.g., *I often sleep poorly because of the circumstances at work*); (2) cynicism towards the meaning of work (three items; e.g., *I feel that I have gradually less to give.*); and (3) a feeling of inadequacy at work (three items; e.g., *My expectations to my job and to my performance have reduced*). The items focusing on exhaustion measure the fatigue due to increased workload. The items assessing cynicism focus on teachers' loss of interest and feelings of indifference towards their work and people at work. The items of inadequacy cover teachers' reduced efficacy in their professional competence and accomplishments at work. The teachers rated all nine items on a 6-point Likert-type scale ranging from 1 (completely disagree) to 6 (strongly agree). The factorial structure of the BBI-9 has been validated and found to remain the same regardless of sample differences and measurement times (Feldt et al., 2014). The Cronbach's alpha for the whole scale was 0.86 and for the three stress variables was as follows: 0.73 for exhaustion, 0.84 for cynicism and 0.72 for inadequacy.

2.3. *Classroom analysis*

2.3.1. *Identifying the amount and quality of educational dialogue*

In the first main analysis phase, episodes of educational dialogue were identified from the video recordings. The 151 video-recorded lessons were watched by a researcher

specialised in dialogic interactions. While watching, the researcher made notes of the interaction and identified episodes of educational dialogue. The episodes were watched and evaluated several times to set the boundaries of the episodes as specific as possible and to ensure the dialogic interaction between the teacher and children. On average, the identified episodes of educational dialogue lasted for 169 seconds (minimum 30 seconds, maximum 700 seconds). The identification of the episodes was based on Alexander's (2006) five principles of dialogic teaching. In the video-recorded lessons, continuous verbal exchange between the teacher and children was considered as an episode of educational dialogue when it represented characteristics of all the five principles of 1) collective, 2) reciprocal, 3) supportive, 4) cumulative and 5) purposeful classroom talk. For collectivity, the teacher and students addressed the learning activities together and acted as partners in the discussion. For reciprocity, the teacher and students showed that they listened to each other and reacted by sharing and challenging ideas and providing different viewpoints. For supportiveness, all participants' contributions were valued and respected by the other participants (there was no laughing at others or bullying). For cumulation, the dialogue comprised of ongoing talk, through which the teacher and students built on each other's contributions, linking them into coherent lines of thinking, enquiry, and further exploration. And finally, for purposefulness, the dialogue was structured by the teacher for the students to reach certain learning goals (at the end of the episode, specific learning goals could be summarised by the researcher). This means that, for instance, separate question-answer sequences were not considered as dialogic episodes as such but could be included in an episode with broader exchanges between the teacher and students. Each episode represented dialogue under same broad topic. A change in the discussion topic or a change in the classroom activity was defined to finish an episode. A new topic, initiated by either the teacher or students, was defined to start a new episode. As a result of this analysis phase, the amount of educational dialogue within each lesson was

determined based on the total amount of dialogic episodes and the total duration of the dialogue (total duration of all the episodes of the lesson) per lesson.

Next, the episodes identified as representing educational dialogue were analysed and categorised into four types of dialogic teaching patterns in order to determine the quality of the dialogues. The categorisation was done according to the criteria of Muhonen et al. (2016; 2018), which maps the quality differences between two types of teacher-initiated dialogues and two types of student-initiated dialogues (see Figure 1). Moderate-quality dialogues (both teacher- and student-initiated ones) represent discussions in which the teacher utilises relatively unitary forms of questioning and a limited variety of scaffolding techniques to support shared knowledge building and student participation. In contrast, high quality dialogues (both teacher- and student-initiated ones) represent discussions in which students act as active participants of the dialogue, and the teacher utilises diverse scaffolding strategies that are likely to support students' shared knowledge building, conceptual thinking and synthesis of ideas and information. Each identified episode of educational dialogue was determined to represent one of the four pattern types. As a result of this analysis phase, the quality of educational dialogue within each lesson was determined based on the occurrence of the four patterns. Appendix 1 represents sample extracts of all the four pattern types and description of the key features within each pattern.

Figure 1.

2.3.2. *Associations between educational dialogue, student math performance and teacher occupational stress*

In the second main phase of the analysis, the associations between educational dialogue (amount and quality) and students' math performance were investigated with multilevel modelling, which consider variance at both the classroom level (between-level) and the

individual student level (within-level) (Heck & Thomas, 2009; Muthén & Muthén, 1998–2018). First, intraclass correlation coefficients were calculated to determine how much of the variation in students' arithmetic skills was due to the classroom level (between-classroom variation and classroom differences) and due to the individual level (within-classroom variation and differences between individual students) (Heck & Thomas, 2009). Then, correlations were calculated between educational dialogue (amount and quality) and students' math performance at the classroom level.

Third, separate multilevel path models of the amount and quality of educational dialogue (moderate and high quality dialogue in separate models) were conducted in order to examine the associations between educational dialogue and student math performance. In the fourth step, teacher occupational stress was used to predict educational dialogue amount and quality and between-level variation in math skills. The three domains of teacher occupational stress (exhaustion, cynicism and inadequacy) were added to separate models as predictors of educational dialogue amount and student math performance. Regarding educational dialogue quality, only those stress domains were considered which were already found to predict educational dialogue amount and were indirectly associated with student math performance.

3. Results

In total, 212 episodes of educational dialogue were found in 51 lessons. Considering the amount of educational dialogue, on average, 1.4 dialogic episodes occurred per lesson (min = 0 , max = 12 episodes). In addition, the duration of dialogue per each lesson was determined. On average, 246.6 seconds of educational dialogue occurred per lesson (min = 0, max = 1993 seconds). Considering the quality of the identified dialogic episodes, the teacher-initiated dialogue of high quality occurred the most in the sample (n = 123 episodes). Teacher-initiated dialogue of moderate quality represented 58 episodes, student-initiated

dialogue of moderate quality represented six episodes, and student initiated-dialogue of high quality was found within 27 episodes.

First, we examined the potential differences between classrooms regarding students' performance in arithmetic fluency and reasoning. This was done by calculating the intra-class correlation coefficients (ICCs) and variance estimates at the between- and within-levels. Table 1 shows that statistically significant differences were found between the classrooms. In arithmetic fluency 9.8 % ($p < .001$) and in arithmetic reasoning 5.8 % ($p < .05$) of the variance was due to classroom differences. Therefore, the rest of the variance in students' arithmetic fluency and reasoning was based on within-classroom differences (between individual students). Table 1 also presents the descriptive statistics and the between- and within-level correlations among the study variables. The amount of dialogic episodes correlated positively ($r = .316$, $p < .05$) and the duration of dialogic episodes correlated marginally positively ($r = .320$, $p < .08$) with arithmetic fluency. Regarding the quality of educational dialogue, student-initiated moderate quality dialogue correlated positively ($r = .386$, $p < .001$), and teacher-initiated moderate quality dialogue correlated marginally positively ($r = .323$, $p = p < .08$) with arithmetic fluency.

Table 1

3.1. Associations between the amount of educational dialogue, students' math performance and teacher occupational stress

Next, we ran a multilevel model to determine to what extent is the amount of educational dialogue associated with student math performance (while controlling for the children's gender). The model fit the data well: [χ^2 (4) ($N_{within} = 713$, $N_{between} = 49$) = 6.110, $p = .191$; CFI = .996; TLI = .991; RMSEA = .018; $SRMR_{between} = .064$, $SRMR_{within} = .018$]. The results showed that the amount of educational dialogue had a positive association with students'

math performance (β = .350, p = .041).

Next, in order to examine to what extent teacher occupational stress may predict the amount of educational dialogue, we then ran three models that each included one of the three stress domains (exhaustion, cynicism and inadequacy) as a predicting variable. The model including teacher cynicism fit the data well: [χ^2 (6) (N_{within} = 688, $N_{between}$ = 48) = 6.877, p =.333; CFI = .998; TLI = .996; RMSEA = .015; $SRMR_{between}$ = .062, $SRMR_{within}$ = .020]. The results showed that teacher cynicism was found to negatively predict the amount of educational dialogue, which was positively associated with student math performance (see Figure 2). The indirect effect of cynicism on math performance via the amount of educational dialogue was marginally significant (standardised estimate = -.098, p = .069).

Figure 2

In the model including teacher exhaustion, no statistically significant association was found between teacher exhaustion and the amount of educational dialogue (β = .005, p = .964). However, the association between the amount of dialogue and student math performance was marginally significant (β = .337, p = .050). In addition, in the model including teacher inadequacy, a marginally significant association was found between teacher inadequacy and the amount of educational dialogue (β = -.249, p = .078). The association between the amount of dialogue and student math performance was statistically significant, (β = .360, p = .029).

3.2. Associations between quality of educational dialogue, students' math performance and teacher occupational stress

Based on the second research question, we ran multilevel models for moderate and high quality dialogues to determine the extent to which the quality of educational dialogue is associated with student math performance (while controlling for the children's gender). The

model fit the data well: [χ^2 (3) (N_{within} = 713, $N_{between}$ = 49) = 2.328, p =.507; CFI = 1.000; TLI = 1.000; RMSEA = .000; $SRMR_{between}$ = .035, $SRMR_{within}$ = .018]. The results showed that the moderate quality educational dialogue (including both teacher- and student-initiated dialogues) had a positive association with student math performance, (β = .604, p = .000). However, in the model of high quality dialogue (including both teacher- and student-initiated dialogues), no statistically significant association to student math performance was found, (β= .253, p = .475). The model fit indices were as follows: [χ^2 (3) (N_{within} = 713, $N_{between}$ = 49) = 4.098, p = .251; CFI = .996; TLI = .988; RMSEA = .023; $SRMR_{between}$ = .058, $SRMR_{within}$ = .018].

Next, since teacher cynicism was already found to predict the amount of educational dialogue, we aimed to examine to what extent teacher cynicism may predict the quality of educational dialogue. Separate models for moderate quality dialogue and high quality dialogue were run. The model of moderate quality dialogue fit the data well: [χ^2 (5) (N_{within} = 688, $N_{between}$ = 48) = 3.684, p = .5958; CFI = 1.000; TLI = 1.000; RMSEA = .000; $SRMR_{between}$ = .039, $SRMR_{within}$ = .020]. Teacher cynicism did not predict moderate quality dialogue, which was, however, positively associated with student math performance (see Figure 3).

Figure 3

In the model of high quality dialogue, teacher cynicism negatively predicted high quality dialogue (β = -.556, p = .001). However, there was no statistically significant association between high quality dialogue and student math performance (see Figure 4). The model fit indices were as follows: [χ^2 (5) (N_{within} = 688, $N_{between}$ = 48) = 4.359, p = .4990; CFI = 1.000; TLI = 1.000; RMSEA = .000; $SRMR_{between}$ = .058, $SRMR_{within}$ = .020].

Figure 4

4. Discussion

The present study aimed to examine the amount and quality of educational dialogue in the classroom and their associations to student math performance in Grade 2. In addition, indirect associations to student math performance were investigated by considering three domains of teacher occupational stress (exhaustion, cynicism and inadequacy) as predicting variables for educational dialogue and student math performance. The results of the multilevel modelling showed that the amount of educational dialogue had a positive association to student math performance. In addition, teacher cynicism predicted math performance negatively via the amount of educational dialogue. Regarding the quality of dialogue, moderate quality dialogues (both teacher- and student-initiated ones) associated positively with student math performance, but no indirect associations were found when considering the teacher cynicism. However, teacher cynicism was found to link negatively with high quality dialogue.

First, we focused on the amount of educational dialogue. In line with our hypothesis (H1), the results showed that the more teachers utilised educational dialogue in their classrooms, the better students performed in arithmetic fluency and reasoning. Perhaps due to the low amount of dialogue, positive associations between dialogue and student math performance have been shown predominantly through interventions (Alexander, 2018; 2000; Mercer, 2008). To our knowledge, only the study by Howe et al. (2019) among older Grade 6 students has been able to show at least some links between certain dialogic variables (e.g., elaboration and querying) and student math performance without an interventional approach. The present study, conducted in an authentic classroom setting, adds to this scant existing literature by suggesting that even among younger students, who are still learning the more basic of arithmetic skills, the teachers' use of educational dialogue has a beneficial impact on student math performance.

This study also investigated if the three domains of teacher occupational stress predicted the amount of educational dialogue and further the level of student math performance. Prior research on the effectiveness on educational dialogue has focused on studying the direct associations between dialogue and student performance without considering other possible factors, which may prevent or advance the occurrence of dialogue and thereby further affect students' performance. Hence, the findings of the present study are of a high importance since they showed an undiscovered indirect association between teacher cynicism and student math performance via the amount of dialogue. The more teachers experienced cynicism, the less they utilised educational dialogue in their teaching and the lower the students' math skills were. This finding was in line with our hypothesis (H3), which was set based on prior research on teacher occupational stress and classroom interactions at a more general level (due to the lack of research focused on educational dialogue). The prior research has shown that teachers who experience high levels of stress tend to have a lower quality of interaction with their students (Braun et al., 2018; Penttinen et al., 2020) and provide their students with lower quality teaching practices in math (Fantuzzo et al., 2012). Since conducting educational dialogue is acknowledged as demanding and effort-requiring task for the teacher (Muhonen et al., 2016), feelings of cynicism may prevent the teacher for making an effort to scaffold student learning through shared knowledge building, which again is reflected in the students' lower math performance.

Second, we investigated the associations between the quality of educational dialogue and student math performance. Partly in line with our hypothesis (H2), the results showed interestingly that moderate quality dialogues associated positively with student math performance, but there were no significant associations for the high quality dialogues. One explanation for this finding might be that students' math performance was measured in terms of basic arithmetic skills focusing on the fluency of additions and subtractions and on

arithmetic reasoning. Basic arithmetic skills may allow less shared reflection, since they are expected to be mastered more mechanically to form a mathematical foundation before the young students learn more complex math skills (Clarke et al., 2012; Entwisle & Alexander, 1990). Therefore, the basic arithmetic skills may be best reached through moderate quality dialogue, which includes fewer broad reflections and mainly aims towards certain specific answers and outcomes. In high quality dialogues, in turn, teachers are more focussed on scaffolding students' shared knowledge building, conceptual thinking and synthesis of diverse ideas and information (Muhonen et al., 2016, 2018). Therefore, high quality dialogues may support students' more complex math skills (such as explaining, conceptual understanding and mathematical thinking) (Clarke et al., 2012; Entwisle & Alexander, 1990), which were not measured in this study but should be investigated in further research. It is also possible that since educational dialogue of high quality occurred the most (and most evenly) in the sample classrooms, variation between the classrooms remained somewhat low. Nevertheless, the fact that no significant association between high quality educational dialogue and student math performance was found, suggests that further research on this topic is needed. Different analysis methods should be utilised to examine the dialogue quality even more rigorously. In addition, different student achievement measures of both math and other subjects should be considered to examine if the associations between dialogue quality and student performance vary depending on the type/content to be achieved.

This study also investigated whether teacher stress, especially cynicism, predicted the quality of educational dialogue and indirectly student math performance. Against our hypothesis (H4), no indirect associations were found. Moderate quality dialogues were found to associate positively with student math performance, but no indirect association was found when teacher occupational stress was considered as a predicting variable for moderate quality. Yet teacher occupational stress was found to negatively predict high quality dialogue,

although no indirect association to student math performance was found. As we suggested earlier, feelings of cynicism may prevent the teachers from making an effort to scaffold shared knowledge building in the classroom. These findings may indicate that it is especially high quality dialogues that require a large amount of effort from teachers due to their more active role in utilising diverse scaffolding strategies in supporting students' knowledge building and participation (Muhonen et al., 2016). In the case that teachers have lost interest towards their work (Salmela-Aro et al., 2011), they are probably also more prone to lose their interest in effective scaffolding through dialogue. It has also been suggested that many teachers in fact have relatively weak basic skills in conducting dialogic teaching and that they are not familiar with effective scaffolding strategies (Mercer et al., 2009). Conducting moderate quality dialogue may not be as demanding for teachers, since the scaffolding and participation process is not as versatile, and therefore it may not be affected by the level of teacher cynicism.

4.1. Implications, future directions and limitations

The present study has both theoretical and practical implications. The present study is one of the very first attempts to show positive associations between educational dialogue and student math performance in Grade 2 without an interventional approach. In addition, the study provided undiscovered evidence regarding the indirect associations between teacher occupational stress, amount of educational dialogue and student outcomes. In the future, more research is needed regarding early school educational dialogue and student achievement in different subjects. In addition, diverse teacher-related variables should be considered to investigate factors that may prevent or advance educational dialogue in the classroom.

Since the results showed that the amount of educational dialogue had a positive association to student performance, it is important to increase the amount of dialogue in the

early school years. In addition, attention should be paid to the quality of the dialogue in teacher training. Moderate quality dialogues were found to support student math performance in basic arithmetic skills, but it is suggested that rich dialogue is needed to support the development of more complex math skills, such as explaining, reasoning and mathematical thinking (Attard et al., 2018; Hu et al., 2021). It is important that teachers receive knowledge, practical training and tools about how to scaffold dialogue that supports the development of students' both basic and more complex math skills. Attention to the teachers' dialogue skills should be paid already in teacher education and continue with in-service training. In addition, it is important that teachers become aware of their level of stress and how it can negatively affect their teaching and thereby student learning. Supporting teacher wellbeing to avoid high occupational stress can enhance the quality of classroom dialogue and further student learning.

The present study is not without limitations. First, the number of the participating teachers (n = 50) and their video-recorded lessons (n = 151) was relatively small for complex statistical modelling. In terms of multilevel modelling, small sample size may include a potential for bias of the results. In future research, a larger sample size is needed to confirm the associations between teacher occupational stress, the amount and qualities of educational dialogue, and student math performance. Second, the study did not have a longitudinal design. Therefore, although we did find associations between the study variables, caution is needed before making any direct causal inferences. Third, the subjects of the classroom video-recorded lessons were not controlled for. Since the goal of the study was to capture authentic data considering teachers' use of dialogue throughout the school day, the subjects of the recorded lessons varied following the regular school day of the class. There were necessarily no clear boundaries between the subject fields in the lessons, which is typical and follow the curriculum guidelines (Finnish National Agency for Education, 2014) in Finnish

early primary classrooms. In future, the results should be replicated focusing only on math lessons. Fourth, student math skills were measured only with time-limited tests of arithmetic fluency and reasoning. For future research, more versatile measures of math and achievement in other subjects are needed to investigate the associations between educational dialogue and student performance. Fifth, the qualitative analysis focused only on identifying episodes of educational dialogue, therefore leaving out more shorter and segmented interaction forms such as separate question-answer-feedback sequences. It is important to acknowledge that restricting the analysis only on educational dialogue may have limited the information of the interaction occurring between teacher and students in the participating classrooms. In future research, especially when studying young students, different types of interaction forms should be considered.

5. Conclusions

The present study is among the first to show positive associations between educational dialogue and student math performance among young students in early school years. Based on the findings, we suggest that it is important to develop teachers' knowledge to conduct educational dialogue in order to support student math performance. In terms of dialogue quality, moderate quality dialogue positively links with student basic arithmetic skills that are of high importance in early school years. In the future, research is needed regarding the development of young students' more complex math skills and how they can be supported through dialogue. The results also suggest that feelings of cynicism may prevent teachers from making an effort to scaffold student learning through dialogue. Attention should be given to supporting teachers' wellbeing to avoid high levels of stress in order to enhance their use of educational dialogue and further improve student math skills.

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Appendix 1

Sample extract 1: Teacher-initiated moderate quality dialogue

Context: *The lesson topic is in even and odd numbers. The teacher has written even and odd number lists on the blackboard.*	
Teacher:	Do you notice anything that repeats here? The same count doesn't exist there twice, but what same can you find here if you look at the counts under 10 and above 10. Is there anything similar there? Jenny (student 1).
Student 1:	Well if I look there is 19, and then there is 9.
Teacher:	Yes, we have 9 and 19 here. What else can you find there? Are there any other similar type of links? Molly (student 2).
Student 2:	17 and 7.
Teacher:	Yes, 7 and 17. Danny (student 3)?
Student 3:	5 and 15.
Teacher:	Yes!
Student 4:	11 and 1.
Teacher:	Yes. And what is the last pair that is not mentioned?
Student 5:	3 and 13.
Teacher:	Mmm yes! So, the odd numbers are the ones that are always either 1, 3, 5, 7 or 9. It repeats here like this. But what do you think would be next odd number after 20 then?
Student 1:	21
Teacher:	21 yes, there is that 1 again. And what would be the next pair then? Tom (student 6).
Student 6:	23
Teacher:	Yes. And the next?
Context: *Teacher and students continue exploring odd numbers above 20 and continue then to even numbers.*	

Sample extract 1 represents teacher-initiated moderate quality dialogue in which the teacher actively guides the students towards finding odd numbers. The teacher initiates the dialogue by asking students a semi-closed question "Do you notice anything that repeats here?" to which there is a limited number of possible answers. The children share their observations ("Well if I look there is 19, and then there is 9"; "17 and 7"; "5 and 15"; "11 and 1"; "3 and 13") but they are not encouraged or willing to further elaboration. The teacher

scaffolding comprises of strategies such as asking questions to which there is one or limited number of answers ("Are there any other similar type of links?"; "And what would be the next pair then?"), asking follow-up questions ("But what do you think would be next odd number after 20 then?"), confirming students' responses ("Yes, we have 9 and 19 here"; "21 yes, there is that 1 again") and expanding on them ("So, the odd numbers are the ones that are always either 1, 3, 5, 7 or 9. It repeats here like this").

Sample extract 2: Teacher-initiated high quality dialogue

Context: *Students have been learning to calculate one thousand.*

Teacher:	Last week, we discussed if one thousand is a lot or little. What do think? Andy (student 1).
Student 1:	A little.
Teacher:	A little. How do you justify your opinion?
Student 1:	Well because it's just a little.
Teacher:	One thousand? Are you talking about money, or kilograms or what kind of unit do you mean? Or years?
Student 1:	I don't know.
Teacher:	You don't know.
Student 1:	Perhaps I mean a bit all of them. So I think it's pretty little
Teacher:	Ok. Let's take other opinions also. Alice (student 2).
Student 2:	It's a lot.
Teacher:	A big number. And what unit do you mean? Do you mean money or…?
Student 2:	I mean age.
Teacher:	Age! A thousand years is a pretty long time. Much more than a human lifetime. But what are the oldest animals? Young people usually have better knowledge about these animals things than I do. Dan (student 3), you know about animals. Do you remember an animal that lives really old?
Student 3:	Turtles!
Teacher:	Can they live even several hundred years?
Student 3:	At least 70 years old!
Teacher:	Yes. And I think I heard that the giant turtles can live even hundred years. Simon (student 4).
Student 4:	Was it…. Was it the lobster or some other crustacean that is the oldest animal on earth alive? Lobsters had existed already when there were dinosaurs.

Context: *The discussion continues about animals and then moves into money and a thousand euros.*

Sample extract 2 represents teacher-initiated high quality dialogue in which the teacher actively invites the students to elaborate and share their views. The teacher opens the dialogic space by asking students' take on if one thousand is a lot or a little. The teacher actively invites more students to share their views ("Ok. Let's take other opinions also.") and the discussion cumulates from the number thousand to age ("Age! A thousand years is a pretty long time ") and to long living animals ("Dan, you know about animals. Do you remember an animal that lives really old?"). The teacher's scaffolding comprises a variety of strategies such as encouraging students to justify their opinions ("A little. How do you justify your opinion?"), guiding discussion and questions to authentic topics that allow children to tell their personal knowledge ("Young people usually have better knowledge about these animal things than I do."), showing interest with prompts and follow-up question ("A big number. And what unit do you mean? Do you mean money or…?") and accepting different kinds of views without judgement of their correctness. The students participate actively to the discussion by sharing their opinions ("A little"; It's a lot."), factual knowledge ("At least 70 years old!"), justifying ("Perhaps I mean a bit all of them. So, I think it's pretty little.") and elaborating them further ("Was it the lobster or some other crustacean that is the oldest animal on earth alive? Lobsters had existed already when there were dinosaurs.").

Sample extract 3: Student-initiated moderate quality dialogue

Context: *Teacher is showing an example on the blackboard about how to add hundreds to hundreds.*

Student 1:	Teacher Teacher!
Teacher:	Yes?
Student 1:	You wrote 678.
Teacher:	Did I write it wrong?
Student 1:	No, you didn't write it wrong. But there is 6, 7 and 8.
Teacher:	Well, yes indeed. So what is the thing here with the 6, 7 and 8?
Student 2:	The numbers kind of start from 1 and end in 10.

Teacher:	That's right. They are in the order of magnitude.
Student 3:	Teacher teacher!
Teacher:	Yes Alex (student 3)?
Student 3:	And there in the result is 878
Teacher:	Yes indeed. You wanted to point that out.
Context: *Teacher and students continue solving calculations on the blackboard.*	

Sample extract 3 demonstrates student-initiated moderate quality dialogue which is predominantly based on students' active participation and willingness to share their knowledge. The first student initiates the discussion by sharing his observation that the teacher wrote three numbers in order of magnitude ("You wrote 678."). The teacher allows the dialogic space to open by asking students to elaborate their observation further ("Well, yes indeed. So what is the thing here with the 6, 7 and 8?") and summarising their finding ("That's right. They are in the order of magnitude."). Another student makes a new observation ("And there in the result is 878"), which the teacher acknowledges, but does not encourage for further elaboration ("Yes indeed. You wanted to point that out."), therefore indicating closure for the dialogic space.

Sample extract 4: Student-initiated high quality dialogue

Context: *Students have performed tasks in pairs trying to remember a long number series.*	
Student 1a:	Guess how we remembered those?!
Teacher:	Yes I will ask in a minute. I noticed that some of you had some tricks about how to remember those numbers.
Student 2a:	I came up with a trick, too!
Teacher:	Now I would like to hear what kind of tricks did you discover? Paul (student 2a).
Student 2a:	We did like 86, 35 and 12.
Teacher:	Very clever! You combined two numbers together so that you only had to remember three numbers. Very good!
Student 3a:	I know another one! I did it with a rhythm, like six (claps with herd hands in rhythm). And then I wrote it down and tried with the rhythm if it was correct.
Teacher:	A very good way! Pete (student 4a).

Student 4a:	We did it so that Alice (student 4b) tried to remember the end part, and I remembered the first part.
Student 5a:	We did the same!
Teacher:	Sally (student 5a) and Sophie (student 5b) did the same thing. And you did also. Make a deal with your partner that you remember the beginning, and I will remember the ending. Very good!
Student 5b:	Can we do it one more time?!
Teacher:	Well let's hear Teddy (student 6a) and Emily's (student 6b) trick.
Student 6a:	She came up with the whole thing.
Student 6b:	I did it so that I kept repeating it the whole time.
Student 7a:	I did the same. I repeated it!
Teacher:	Mmm yes. Hey, in this case, did the information go to your brain through your eyes? But you used your ears as well.
Student 6b:	Yes.
Teacher:	So you combined those two ways. Excellent!

Context: *The students keep sharing their tricks about how to remember a number series.*

Note: For identification purposes, the pairs have been numbered from 1 to 7 and the individual students within the pairs with letters a and b.

Sample extract 4 demonstrates student-initiated high quality dialogue in which is the students are eagerly sharing their strategies how to remember long number series. The dialogue is initiated by the students ("Guess how we remembered those?!"; "I came up with a trick, too!"), after which the teacher opens the space for discussion ("Now I would like to hear what kind of tricks you discovered"). The students participate by sharing their own knowledge ("We did it so that Alice tried to remember the end part, and I remembered the first part."; "I did it so that I kept repeating it the whole time.") but also by commenting on other's strategies ("We did the same!"; "I did the same. I repeated it!"; "She came up with the whole thing."), therefore indicating that they were listening to each other's comments. The teaches is asking only few questions since the dialogue is predominantly based on exchanging ideas. However, the teacher is still actively orchestrating the discussion by sharing turns to speak ("Well let's hear Teddy and Emily's trick."), conforming students comments ("Very clever!"; "A very good way!"), and importantly, summarising the main

strategies for the whole class to learn ("You combined two numbers together so that you only had to remember three numbers"; "Hey, in this case, did the information go to your brain through your eyes? But you used your ears as well").

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