Methods and key findings in research on conversations in early years mathematics: a review of the literature

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This qualitative systematic review aims to provide insight into applied research methods and key findings in early years mathematical communication research. This literature review focuses on newly published research reporting on young pupils' (age 5 to 10) mathematical communication and reasoning. Reporting on 13 studies published between 2016 and 2020, the review found video-recordings as a favourable method for data collection, given its ability to capture verbal and non-verbal communication. Another finding was that implementing classroom norms or rules for conversation could be useful for children learning to communicate productively. The review also reports on several tools for teachers to improve practice related to conversations and mathematical reasoning.

This study adopts a sociocultural perspective on learning meaning that it considers learning in mathematics to be a social and cultural phenomenon and claims that individuals learn by participating in social and cultural practices of mathematics (Palmér & van Bommel, 2020). In Vygotskian sociocultural theory, language is considered a cultural tool for communicating socially and a cognitive tool to use in thinking individually (Mercer & Littleton, 2007). In sociocultural theory, higher mental functions and human actions, such as communication, are mediated by tools and signs (e.g. language) (Dahl et al., 2017). Tools are defined as the resources – both language-based (and intellectual) and physical – that are available to us and that we use to understand the world around us (Säljö, 2009). Sociocultural theory is relevant to this project because it values language and communication as crucial for learning. There is agreement in the published literature that conversation is an essential tool for learning in early years mathematics. Despite this, in formal education

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settings, such as in mathematics classrooms, conversations are typically dominated by teachers, with little opportunity for pupils to participate actively or interact in a meaningful manner (Howe & Mercer, 2007; Patterson, 2018; Rojas-Drummond & Zapata, 2004). Theoretical and empirical studies have shown that conversations strongly influence young children's everyday experience in school and that it is the primary influence on their knowledge acquisition (Nordin & Boistrup, 2018; Theobald & Kultti, 2012). Conversations in mathematics classrooms play an important part in children's conceptual development in mathematics (Mercer & Littleton, 2007). Previous research has identified and described several types of effective classroom conversations, such as rich talk (Theobald & Kultti, 2012), dialogic teaching (Alexander, 2018; Muhonen et al., 2020), and exploratory talk (Mercer & Littleton, 2007; Wegerif & Mercer, 1997), all of which describe methods of communication that facilitate learning, development, and/or reasoning. According to Bragg et al. (2016), reasoning consists of following a line of enquiry; conjecturing about relationships and generalisations; and developing an argument, justification, or proof using mathematical language. By giving pupils guidance and practice in using language to reason together in mathematics, language can become a functional and efficient tool for solving mathematical problems collaboratively (Mercer & Sams, 2006). As a result of acknowledging the social aspects of teaching and learning, conversations in mathematics classrooms have been studied for some time now, and a substantial amount of research into conversations in mathematics exists. Still, few projects investigate young children's conversations, creating a gap in the current level of understanding (Muhonen et al., 2016; Patterson, 2018).

This literature review is based on publications that use different concepts when discussing communication: conversation, talk, dialogue, and discussion. I will use the concept "conversation", referring to both verbal and non-verbal [1] interaction between two or more participants. To narrow the focus even more, I am interested in a particular type of conversation, that is, the conversations that takes place during mathematical activities.

Conducting reviews on conversation is not new. Howe and Abedin (2013) reviewed forty years of research covering all years of compulsory school and summarising what is known about that period of time. Sidenvall (2019) examined 26 articles published between 2000 and 2016 in top-ranked mathematics education journals, investigating and characterising teaching designs intended to enhance pupils' problem solving and reasoning skills. Although Sidenvall's (2019) review is new, the most recent contributions were published six years ago. We can assume that much has changed in recent years, so it is possible to argue for a new review. In addition, neither Howe and Abedin (2013) nor Sidenvall (2019) focus on

the early years of education, meaning that this review can contribute to filling that gap.

Aims and research questions

This review focuses solely on early years mathematics (EYM)[2]. The focus on EYM is based on the previously determined gap in knowledge about the youngest children's conversations. The review aims to investigate: (1) what research methods have been used to investigate conversations in EYM over the past five years, and (2) what are the key findings from articles investigating young pupils' conversations in EYM?

Reviewing the methodology can help identify key variables, measures, methods of analysis, and the strengths and weaknesses of various methods. Furthermore, the review aims to present the outcomes of previous research, which could help identify gaps in the current research and determine what areas require additional research (Randolph, 2009).

Method

A qualitative systematic review aims at identifying, evaluating, and interpreting qualitative research to broaden our understanding of a particular phenomenon (Grant & Booth, 2009; Kitchenham, 2004). Although this review is systematic, it is not exhaustive. Given the amount of existing literature on mathematical conversations, strict inclusion criteria were applied. Publications were deemed relevant if they (1) were about communication, (2) had data that were totally or mainly collected in early primary mathematics classrooms; and (3) focused on either reasoning, argumentation, or primary school mathematics. Reasoning and argumentation were included as search terms because conversations that have high learning potential often focus on reasoning or argumentation (Wegerif & Mercer, 1997). Still, articles could also focus on primary school or the early years, so articles not relating conversations to reasoning and/or argumentation were not excluded. Initially, three categories of key terms were decided upon: "Communication", "school subject", and "theme". The following table (table 1) shows the categorisation.

Searches consisted of one term from each category, adding up to sixteen combinations. Based on previous readings, the four terms concerning communication are the four most common words used in describing communication in primary school. The themes were chosen because they could clarify the focal points of the articles. The idea of a multi-term combination is taken from Sidenvall (2019), who applied some of the same inclusion criteria, but because he only searched mathematics

Table 1. *Search terms*

Communication	School subject	Theme
Communication	Mathematics	Primary school
Talk		Reasoning
Conversation		Argumentation
Dialogue		Early years

education journals, he excluded "mathematics" from all searches. Two databases were chosen to reduce biases, as proposed by Howe and Abedin (2013): Scopus and ERIC. All searches included the term "mathematics", combined with one term regarding communication (conversation, talk, dialogue, or communication) and one term regarding either reasoning, argumentation, primary school, or the early years, e.g. "communication AND mathematics AND primary school". The publication date was limited to the past five years (2016–2020)[3].

Scopus search

Scopus is a large source-neutral abstract and citation database for peer-reviewed articles. The search was limited to articles and conference papers. The language was limited to English, and searching within "mathematics", and "social sciences" led to 171 articles, including duplicates. After removing duplications, the total stood at 145 articles. The sample was further examined in a multi-step process. First, papers were evaluated based solely on their abstracts. Because the project investigates EYM, empirical data had to have been collected within the range of first to fourth grade (pupils aged 5 to 10 years old). Publications with data from pupils only over the age of 10 or under the age of 5 and data on only teachers or pre-service teachers were excluded. The same is true regarding studies in other subjects, resulting in 22 articles. Two articles were excluded because they required a paid subscription or were unavailable online. Lastly, one article was excluded because of language, resulting in 19 articles for further evaluation.

ERIC search

The same process was repeated for the *Education resources information centre* (ERIC), an online digital library of education research and information. The education level was set at "elementary education" and limited to "peer-reviewed articles only". The initial search resulted in 113

articles, including duplicates. Excluding duplicates across searches and Scopus reduced the total to 79. The articles were further examined based solely on their abstracts. Of fifteen articles, two that were not accessible online and one that was not published were discarded, resulting in twelve articles from ERIC. Ultimately, 31 articles were read in full for further evaluation.

Data evaluation

Some abstracts did not explicitly state the participants' age or if the researchers collected data from pupils and teachers or only teachers. Several articles were excluded based on the participants' ages (5th to 7th grade) or participants being only teachers. After evaluation, eleven articles were deemed relevant. Table 2 shows the articles in alphabetical order based on the presented process and criteria.

Table 2. *Relevant articles in alphabetical order*

Article	Author/Year
1	Arias de Sanchez, Gabriel, Anderson & Turnbull (2018)
2	Batista & Chapin (2019)
3	Bragg, Herbert, Loong, Vale & Widajaja (2016)
4	Coppola, Mollo & Pacelli (2019)
5	Dahl, Klemp & Nilssen (2017)
6	Hunter (2017)
7	Klemp (2019)
8	Moffett & Eaton (2018)
9	Nordin & Boistrup (2018)
10	Smith & Mancy (2018)
11	Widajaja, Vale, Herbert, Loong & Bragg (2020)

The references of the sample were reviewed for articles not in the sample but that met the inclusion criteria. Although the sample consisted of relatively new articles, they had few references to articles from the past five years. Two more articles were deemed relevant via this process (table 3). Given that 13 articles were satisfactory, the snowballing was not continued.

Theoretical thematic analysis (Braun & Clarke, 2006) was applied to identify, analyse, and report patterns within the thirteen articles. Braun

Table 3. *Relevant articles found in the references in the sample*

Article	Author / Year
12	Muhonen, Rasku-Puttonen, Pakarinen, Poikkeus & Lerkkanen (2016)
13	Patterson (2018)

and Clarke (2006) state that a theoretical thematic analysis is often driven by a theoretical or analytical interest or research questions. The thematic analysis consisted of six phases in which I (1) read all the articles beforehand; (2) generated the initial codes for analysis; (3) searched for joint themes within the articles, refining the codes; and (4) reviewed the themes to ensure their quality. After ensuring the categories were valid and in line with the data, I (5) defined and named the main themes: methods of data collection and analysis, establishing classroom norms for conversations, and the development of terminology and frameworks. Lastly, the final part (6) was producing the following report. Thematic analysis can occur at two levels: a semantic, or explicit, level or a latent, or interpretative, level (Braun & Clarke, 2006). This review focuses on explicit statements, resulting in a theoretical analysis at a semantic, explicit level.

Results on research methods in the articles reviewed

Methods of data collection in the included articles

Initially, the research strategies and methods applied were addressed. Of the thirteen articles included, twelve applied qualitative research methods, and one applied a mixed-method approach. Reviewing methodology and counting previous approaches can provide an overview of approaches and inform what strategies and methods of collecting data have proven useful. The table below (table 4) shows the applied strategies divided into three categories: experimental, case study, and observational.

As we can see in table 4, five articles reported on findings from experiments or interventions. Experimental studies aim to test the effect or influence of something new, such as a test, a task, a professional development programme, or a particular teaching method (Patterson, 2018). In an educational context, such as the sample reviewed, interventions often focus on authentic, real-world settings, such as a classroom, and have the goal of improving practise (Cohen et al., 2018). An essential feature of experimental research is the deliberate control and manipulation of research conditions (Cohen et al., 2018). One sample study reporting on findings from an intervention project is that of Dahl et al. (2017). Using

Table 4. *Research strategy*

Article	Approach		
	Experimental	Case study	Observational
1		X	
2			X
3	X		
4	X		
5	X		
6	X		
7		X	
8	X	X	
9		X	
10		X	X
11		X	
12			X
13			X

data from the LaUDiM[4] project, they analysed pupils' collaboration in mathematical problem-solving.

Another common research strategy is case studies. A case study can be explained in many ways, but some explain it as a detailed examination of a small sample, in which the examination of a specific instance is used to illustrate a more general principle (Cohen et al., 2018). Arias de Sanchez et al. (2018), Klemp (2019), Moffett and Eaton (2018), Nordin and Boistrup (2018), and Widjaja et al. (2020) all conducted various forms of case studies. Nordin and Boistrup (2018) conducted an interpretative case study to identify argumentation in everyday communication. Case studies can be illustrative and illuminating, but at the same time, they are not replicable and may not be representative, typical, or generalisable (Cohen et al., 2018).

The observational approaches in the table include publications that did not implement something new but, instead, focused on what is being done (without interference), also referred to as the observation of "authentic" learning situations (Patterson, 2018) or ethnographic research (Cohen et al., 2018). Unlike case studies, these projects focus on either a larger number of pupils or several learning situations, maintaining a "holistic" focus on the learning situation and context. An ethnography is a descriptive, analytical, and explanatory study that seeks to create a vivid and analytical reconstruction of the culture or groups studied (Cohen et

Table 5. *Methods for data collection*

Article	Methods of data collection in the sample						
	Video recording	Audio recording	Interview	Observation	Demonstration lessons and debrief discussion	Collection of pupil work	Other
1	X		X	X			X
2						X	X
3			X		X		
4	X	X	X			X	
5	X					X	
6	X	X	X	X			
7		X					
8	X		X				X
9	X					X	
10	X			X			
11				X	X		
12	X	X		X			
13		X		X			
Total	8	5	5	5	2	4	3

al., 2018). One example from the sample is Patterson (2018), who, through observation and audio-recordings, analysed collaborative group work in authentic classroom settings.

Moving on to methods of data collection, table 5 presents an overview of the six most common methods of collecting data.

As shown in table 5, the most common methods of data collection were video recordings, audio recordings, interviews, and observations. Out of the thirteen articles, eight used video recordings either independently or in combination with other methods. Several articles highlight the importance of non-verbal interaction in communication in early years education (Muhonen et al., 2016; Patterson, 2018), which can only be captured using video or very detailed observation.

Methods for data analysis

The sample shows that several studies analyse transcriptions of either audio or video recordings and pupils' written work. Some researchers (Coppola et al., 2019; Muhonen et al., 2016) utilised content analysis, a method for analysis that defines the process of summarising and reporting written data (Cohen et al., 2018). Coppola et al. (2019) utilised content analysis that included the segmentation of the corpus data into semantic units, in which categories were created based on lexical units relating to the same theme or topic or units that had identical or similar

meanings. Others used variations of discourse analysis or sociocultural discourse analysis (Arias de Sanchez et al., 2018; Klemp, 2019), a form of analysis that highlights text as a product in a context. In general, discourse analysis examines language in terms of use and linguistic features, forms, patterns, and units and focuses on texts as parts of a social context. For example, Klemp (2019) analysed transcriptions of audiotapes using a pre-determined framework for analysing mathematical discourses on a turn-to-turn basis, focusing on teachers' utterances (p.5). Others (Dahl et al., 2017; Patterson, 2018; Smith & Mancy, 2018) used conversation analysis, which, according to Cohen et al. (2018), is a type of discourse analysis. Conversation analysis examines conversations between two or more people, specifically the interactions' what, why, and how. For example, Patterson (2018) used conversation analysis to identify exploratory talk in transcriptions before performing an in-depth analysis of the context of the situations. The sample shows examples of constant comparative analysis (Widjaja et al., 2020) and thematic analysis (Bragg et al., 2016; Moffett & Eaton, 2018).

Results regarding the key findings in the articles reviewed

The reviewed articles suggest a range of different routines and tools for improving classroom conversations. In addition, several articles also highlight the importance of developing terminology and framework for teachers and researchers. These two themes are addressed separately in this section.

Improving classroom communities

Establishing classroom norms for conversations

Batista and Chapin (2019) suggest two routines or tools which could improve classroom communication: the implementation of classroom norms and attention to language. Classroom norms are rules or guidelines concerning what the class values as important in a community. The norms' function is to establish a safe space for the pupils in which they feel comfortable learning. Hunter's (2017) study indicates that pupils learn how to think and act through what is valued in their community, specifically sharing a set of rules or norms that guide action within the classroom. In both Hunter (2017) and Batista and Chapin (2019), the teachers and pupils worked collaboratively on developing group norms for communication. In both cases, the teachers aimed to engage the pupils in reflections on how they were working, helping them understand the benefits of working collaboratively and having a set of rules to guide their

work. Batista and Chapin (2019) claim that sharing a set of rules or norms helps the children learn "ways of thinking and acting" to share ideas, construct arguments, and generate critiques of others' reasoning. According to Batista and Chapin (2019) and Hunter (2017), having pupils engage in developing the rules is important to ensure ownership of the rules.

Of particular importance to EYM, Dahl et al. (2017) state that teachers should broaden pupils' understanding of what mathematics is in the early years, emphasising that mathematics is not just about providing answers but also explaining one's thinking to others and providing arguments for one's claims. Hunter (2017) agrees and states that this can be ensured via teachers facilitating a discourse that encourages reasoning and collaborative work with their pupils, creating a shared understanding of "doing mathematics". Hunter (2017) further elaborates that teachers' facilitation of a reasoning discourse can lead to changes in pupils' participation and perceptions of themselves as learners of mathematics. Hunter (2017) conducted classroom interventions in which the participating pupils were asked what "doing mathematics" meant pre- and post-intervention. Pre-intervention, pupils often provided little reasoning for their verbal statements in the mathematics classroom, and discussions often originated from the teacher, with little engagement on the part of the pupils. In contrast, after the intervention, the pupils now perceived mathe-matics as testing ideas, communicating thinking, and using differing solution strategies, referring to Dahl et al. (2017) and broadening our understanding of what *doing mathematics* is actually about.

Teaching pupils mathematics content and simultaneously developing classroom norms is challenging, and merely introducing students to the rules or norms for classroom communication at the beginning of the year is not sufficient. Pupils require insistent reminders over time, and teachers can benefit from reminding pupils of previously agreed-upon discourse behaviour during lessons (Batista & Chapin, 2019). Batista and Chapin (2019) state that focusing on communication and the development of norms for communication can (1) support pupils' mathematical and academic language; (2) develop their mathematical reasoning; and (3) foster respectful discourse.

Mathematical language and representations

The second routine intended to improve classroom communication, suggested by Batista and Chapin (2019), is mathematical language development. Attention to language includes helping pupils use language to communicate and present their mathematical ideas because "mathematical discussions depend on pupils sharing their reasoning and engaging in others' reasoning" (p. 299–300). Bragg et al. (2016) found that children

struggled to use mathematical language to communicate their reasoning and that teachers viewed the children's limitations in language as a "major barrier to increasing the use of mathematical reasoning in their classrooms" (p. 523). Several researchers mention the development of a shared language as important for facilitating mathematical discourse for mathematical reasoning. In Hunter (2017), the teacher participating in the study realised that facilitating a *productive* mathematical discourse required "constant and deliberate actions" on her part, including applying strategies such as rephrasing, repeating, comparing, and questioning, which was in line with Klemp's (2019) findings. The conscious use of mathematical language is important in facilitating a reasoning discourse (Arias de Sanchez et al., 2018; Bragg et al., 2016; Muhonen et al., 2016).

Coppola et al. (2019) investigated children using language to manipulate and reflect on the development of logical tools in mathematics. In their study, pupils were encouraged to create "commands" for one pupil, who was told to move "like a robot" in certain grid positions in the classroom. Coppola et al. (2019) aimed to encourage the pupils to create a shared language, meaning that the pupils are provided with the opportunity to discuss the functions of mathematical language and the role of mathematical symbols. One particular function the researchers wanted to have the pupils discuss was whether a symbol could have different meanings or shared definitions and understandings were necessary for clear communication and understanding. The children created a language that gradually shifted from everyday language to "symbolic" mathematical language throughout the task.

There is agreement that teachers play an essential role in children's acquisition and use of mathematical language, and several researchers point to teachers' role in the development of language to facilitate meaning-making or reasoning (Arias de Sanchez et al., 2018; Batista & Chapin, 2019; Bragg et al., 2016; Moffett & Eaton, 2018; Muhonen et al., 2016). All participating teachers in Arias de Sanchez et al.'s (2018) study thought teacher talk was "absolutely necessary" for learning but, at the same time, agreed that mathematical language could be difficult to explain to children and that communicating the meanings behind concepts could be challenging. Investigating the concept of "code-switching", referring to the change from everyday concepts to formal mathematical language (e.g. same and equal), they found indicators that the choice of language was firmly rooted in the teacher's perceptions of the children's previous experiences with math and the mathematical register. In other words, they found that, sometimes, it was beneficial to switch from everyday language to mathematical language, while at other times, it was more beneficial to retain everyday concepts because familiar terms can help

pupils make sense of perceptual and mathematical relationships. Arias de Sanchez et al.'s (2018) find that teachers avoid using mathematical language reveals the existence of a particular "EYM discourse" in which familiar, everyday concepts are favourable to the more complex and formal mathematical terminology.

Moffett and Eaton (2018) state that children can understand abstract ideas when they are presented in meaningful communicative situations and that many teachers feel "pressured" to move from informal everyday contexts to more formal contexts, particularly when using formal mathematical symbols. Some researchers suggest using children's own representations (drawings) as a "springboard" toward formal mathematical representations. Conversations are an important tool for developing knowledge and an understanding of formal representations in mathematics (Moffett & Eaton, 2018). This is further elaborated on in Dahl et al. (2017), who state that pupils should create their own tools and representations and that teachers, through encouragement, can help pupils acquire a variety of representations that are useful for reasoning collaboratively.

Developing terminology and frameworks

Within the concept of "theory building" lies the development of terminology and frameworks for identifying, describing, and analysing reasoning, argumentation, and communication. A decision has been made to divide the section of the findings into (1) developing terminology and frameworks *for researchers* and (2) developing actions or tools *for teachers* and other educational professionals. Still, several of the articles state that they wish to develop frameworks for researchers *and* provide teachers with actions or strategies to encourage pupils' reasoning through communication, e.g. Widjaja et al. (2020) or Nordin and Boistrup (2018).

For researchers

Several researchers highlight the lack of and need for frameworks with which to identify, describe, and analyse children's communication. As part of communication, argumentation and reasoning have received increased attention in research, but little attention has been paid to identifying and reconstructing mathematical arguments in an analytical process. This is where Nordin and Boistrup (2018) contribute with their step-by-step framework for everyday communication. According to Nordin and Boistrup (2018), mathematical argumentation and reasoning must be investigated through various modes, such as drawings, symbols, and written and spoken language. Dahl et al. (2017) agree and state that applying several modalities helps make thinking public, enabling

pupils working together to follow, evaluate, and build on one another's reasoning.

Patterson (2018) also focuses on several modalities and found that the observation of children's interactions cannot focus solely on verbal interaction but must also consider non-verbal aspects. She identified exploratory talk episodes using non-verbal cues and signs. She found that productive mathematical communication was often not identified in children's verbal language but, rather in their non-verbal communication, such as gestures. This does not mean that focusing on language is not important. Bragg et al. (2016) present a framework for noticing reasoning in children's conversations, emphasising children's mathematical language as an important factor in mathematical reasoning. Their framework highlights the fact that some words seem to play particularly important roles in children's mathematical reasoning, such as logical connectives, e.g. "because" and "it seems like".

Furthermore, some articles also present a need to develop conceptual frameworks for describing, identifying, and analysing pupils' conversations, both for teachers wanting to develop their practice and researchers wanting to develop the research field, which relates to this second section: actions and tools for teachers.

For teachers

Patterson (2018) states that little research provides practical advice for teachers wanting to develop or improve their practice because many of the studies conducted are based on interventions performed in close collaboration with researchers, in which the teachers have no or little ownership of what is being implemented. Muhonen et al. (2016) suggest that teachers' scaffolding strategies may differ depending on whether the teacher or the child initiated the conversation. They further state that the *quality* of the teacher's strategies is of particular importance in facilitating shared understanding and conceptual learning through conversation. They particularly highlight factors such as equally distributing participation and teacher "activeness" and timing in conversations.

Batista and Chapin (2019) suggest using "sentence frames" to support pupils' communication in mathematics, which, according to them, encourages pupils to speak, listen, and respond respectfully. Sentence frames can be applied to guide young pupils' speaking and responses. Sentence frames, including the term "because", are suggested by Batista and Chapin (2019) because they encourage children's reasoning. Examples of sentence frames are "I agree with ____ because ___", "I did ____ because____", or "I respectfully disagree with ____ because ___".

Muhonen et al. (2016) state that teachers must support children by facilitating participation in meaningful activities; leading the pupil; and asking questions that build or elaborate on their knowledge. Hunter (2017) suggests some classroom prompts for this purpose: positioning pupils to actively listen to one another's reasoning, asking pupils to add to their and others' explanations, and providing alternative solution strategies to their own or others' answers or statements. Hunter (2017) suggests using re-voicing and questioning to introduce pupils to mathematical language and facilitate reflection regarding their peers' ideas and reasonings.

Hunter (2017) found that teachers actively addressing how collaborative interactions take place can lead to changes in communication in small-group and whole-class conversations. Pupils learn what is considered important and valued by observing the actions and statements of the teacher. The shared notion of how to communicate with others helps the pupils understand what it means to be a member of a specific community, such as a mathematics classroom or a class in general. In her study, Klemp (2019) found that skilled teachers asked questions to clarify the pupils' thoughts and showed genuine interest in interventions with them. This, again, requires deliberate action on the teacher's part over time.

As presented under frameworks for researchers, Nordin and Boistrup's (2018) framework is created for both teachers and researchers. Nordin and Boistrup (2018) claim that teachers can use the framework to identify informal and formal mathematical arguments in day-to-day communication and, therefore, use it to plan further teaching.

Discussion

This review aimed to answer what research methods have been used to investigate conversations in EYM (from 2016 to 2020) and what are the key findings from these articles? The review shows several approaches, both experimental and observational. There are advantages of both approaches to research in EYM; observational studies provide pictures of what is happening in the classroom, and experimental studies help us identify possible solutions to the identified problems.

According to Patterson (2018), observational studies are particularly useful because they provide a picture of the current situation that can be used to create tools or interventions that align with real classroom needs. By examining the findings of both observational and experimental studies, this review extends on to Sidenvall's (2019) review, as he only considered interventional studies.

In comparison to Howe and Abedin (2013), this review focused solely on conversations in mathematics, whilst they reviewed all subjects.

Interestingly, Howe and Abedin (2013) found that whilst quantitative studies were most common previously, qualitative studies have dominated the research field for the latter half of their reviewed period (1972–2001). This is reflected in my study, where all studies used a (mainly) qualitative approach.

In addition, Howe and Abedin (2013) included both qualitative and quantitative studies, whilst I excluded quantitative ones. Interestingly, they found that whilst quantitative studies were most common previously, the qualitative studies have dominated the research field for the latter half of their reviewed period (1972–2011). Therefore, it is natural that reviews focus on qualitative studies – given the increased popularity in the research field.

The review found video recordings as a favourable method for collecting data in EYM because it captures non-verbal communication, which according to Muhonen et al. (2016) and Patterson (2018), is especially essential in the early years. Non-verbal communication can also be captured using very detailed observation. However, in contrast to observations, video recordings are not a "once-and-for-all" type of data collection, making it possible to revisit data at later stages, paying repeated attention to the details, making it easier to interpret data more reliably (Cohen et al., 2018). One argument against the use of video recordings was presented by Patterson (2018), claiming it differs too much from regular teaching, making the data far from what "would normally happen". To deal with this, pupils can be exposed to cameras in the classroom over time, making them used to the cameras and gradually making this a new "normal".

Further, the review shows that teachers should facilitate a discourse in which pupils are enabled to learn mathematics. This can be challenging, but this literature review summarises some (promising) approaches and considerations for facilitating or developing such a discourse: teachers could develop a set of shared classroom norms, ensuring that pupils know how to communicate mathematically. Teachers can and should scaffold pupils' ideas with one another so that the communication is productive (Klemp, 2019). They should also ensure that pupils can work collaboratively (Dahl et al., 2017; Smith & Mancy, 2018). The teacher plays an important role in facilitating and scaffolding pupils learning in mathematics concerning productive collaboration, developing a shared set of norms for conversations, and acquiring mathematical language. Although we cannot be sure, it is assumed that teachers' support is of particular importance for the youngest pupils because their experiences with the use of formal language and representations are limited.

Howe and Abedin (2019) and Sidenvall (2016) report on studies from both primary and secondary years, meaning that their reviews can not tell us whether special considerations need to be made for research in the early years. This review found some considerations regarding the scaffolding of conversations in EYM that may not be needed with older children. One consideration is mathematical language versus informal, everyday language. Whilst children are expected to gain more formal representations and acquire more formal language when they begin school, some teachers find using formal, mathematical language with children difficult (Arias de Sanchez et al., 2018). The use of "sentence frames" was suggested by Batista and Chapin (2019) and Patterson (2018) to support pupil conversations and help them learn mathematical language. As highlighted by Bragg et al. (2016): children's mathematical language is an important factor in mathematical reasoning.

Limitations

The criteria of "participants' age" being mainly between five and ten years old excluded articles that could have been relevant. There could have been fruitful outcomes after including articles focusing on older children, partly because reasoning and mathematical conversations with older children have been investigated to a more considerable extent. The initial result of eleven articles, as well as the final thirteen, could indicate a need for more research into younger children's mathematical conversations, although the review is not exhaustive. Searching additional databases could also have provided other articles than those presented.

Further research

One important aspect of EYM is communication's multimodal aspects (Nordin & Boistrup, 2018). Through applying a multimodal approach, conversations and representations are understood as more than spoken and written language. Nordin and Boistrup (2018) state that, in their framework, "no modes are taken-for-granted as the most meaningful" (p. 19), making it a fruitful starting point for inquiry in EYM, in which pupils are encouraged to communicate through the use of several modalities and representations. More research is needed into how young children communicate in a multimodal manner.

Previous studies show that conversations are happening in classrooms, but because teachers often lack a clear understanding of the nature or purpose of the conversations, the pupils lack insight into what makes conversations meaningful (Patterson, 2018). For children to learn

productive collaboration, they need to be provided with a structure that enables them to benefit from collaborating. This review presents several tools for facilitating productive mathematical conversations in which children are encouraged to reason mathematically. A structure or tool suggested is "ground rules for talk" (GRFT), which are mutual understandings about how to structure verbal exchanges. According to Patterson (2018), GRFT are a form of scaffolding that could help make conversations in primary school more productive. Other studies also claim that consistent use of GRFT in a classroom can be associated with more active participation and increased learning outcomes for pupils (Rojas-Drummond & Zapata, 2004), but these studies have predominantly been conducted in high primary grades. More research into the use of GRFT in EYM is therefore needed.

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Notes

1 E.g. gestures, drawings, signs.

2 I will hereafter refer to early years mathematics as EYM.

3 Data collected in April 2020, articles published after the middle of April 2020 is not included.

4 *Language use and development in the mathematics classroom* is a project aimed at developing deeper knowledge of the significance of the learning environment and developing mathematical thinking and understanding.

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