Early Childhood Research Quarterly 57 (2021) 121–132

Contents lists available at ScienceDirect

Early Childhood Research Quarterly

journal homepage: www.elsevier.com/locate/ecresq

Questions and explanations in the classroom: Examining variation in early childhood teachers' responses to children's scientific questions

Amanda S. Haber[a,*], Kathryn A. Leech[b], Deon T. Benton[c], Nermeen Dashoush[a], Kathleen H. Corriveau[a]

[a] *Boston University Wheelock College of Education and Human Development, 621 Commonwealth Avenue, Boston, MA, USA*
[b] *The University of North Carolina at Chapel Hill, School of Education, Chapel Hill, NC, USA*
[c] *Swarthmore College, Swarthmore, PA, USA*

ARTICLE INFO

Article history:
Received 8 June 2020
Revised 29 April 2021
Accepted 23 May 2021

Keywords:
Questions
Explanations
Science learning
Personal epistemologies

ABSTRACT

In the current study, we provide a systematic understanding of how early childhood educators ($N = 209$) believe that they would respond to children's scientific questions. We compared 105 inservice preschool and early elementary grade teachers' and 104 preservice teachers' responses on an online survey consisting of 3 parts: (a) responses to children's scientific questions (b) personal epistemologies and (c) demographic information. Results are consistent with naturalistic classroom data demonstrating that inservice and preservice teachers are more likely to answer children's questions with explanations rather than other types of responses when responding to children's science questions. We also explored possible relations between teachers' responses, demographic variables, and personal epistemologies. We discuss implications of these findings for how teachers' responses to children's questions may send a message to children about how to construct and reason about knowledge in the world.

1. Introduction

Consider this scenario: In one classroom, a 4-year-old child is looking out the window and notices that the leaves are changing color. The child turns to his teacher and says, "Why do leaves change color?" The teacher responds to the child by saying, "Leaves change color because it gets cold outside, and the leaves fall to the ground." In a second classroom, a different 4-year-old child asks the same question, but his teacher responds by saying, "Why do you think leaves change color?" The child says, "I don't know. The leaves were green, and now they are red." In a third classroom, a different 4-year-old asks the same question, and his teacher suggests that they find a non-fiction book at the school library and look up the answer together.

In the first classroom, the teacher provided an explanation; in the second classroom, the teacher turned the question back to the child; in the third classroom, the teacher suggested another source for information. Such question-response exchanges are common classroom occurrences for children and teachers, and an important source of information for learning about the world (e.g., Butler, Ronfard, & Corriveau, 2020; Harris et al., 2018; Kurkul et al. (in press)). Although learning is embedded in first-hand experimentation, to fully understand concepts that cannot be learned through firsthand experience, such as scientific phenomena (e.g., electricity, why leaves changes color), children also rely heavily on testimony from others (e.g., Harris & Corriveau, 2014; Harris et al., 2018). However, such information is not always readily provided by others, prompting children to ask questions as a means to acquire knowledge (e.g., Ronfard et al., 2018).

As illustrated in the above example, the responses children receive to their questions vary considerably, and the sources of such variation are not well understood. In the current study, we examine variability in the types of responses that teachers believe they would provide when responding to children's scientific questions. We explore relations between teacher's responses and a variety of demographic variables (i.e., amount of teacher education, classroom experience, age of the children being taught) and teachers' beliefs about how knowledge is constructed (i.e., epistemological stance, Barzilai & Weinstock, 2015). Below, we review research on children's questions and adult explanations before turning to the current study design.

2. Children's use of questions to acquire knowledge

Although sometimes interlocutors spontaneously provide information, children often obtain knowledge from others through asking questions (Chouinard, 2007; Frazier et al., 2009; Hickling &

* Corresponding author.
E-mail address: haber317@bu.edu (A.S. Haber).

https://doi.org/10.1016/j.ecresq.2021.05.008
0885-2006/

Wellman, 2001; Kurkul & Corriveau, 2018; Ronfard et al., 2018; Ruggeri & Lombrozo, 2015). Research indicates that preschool-aged children ask about 76 information-seeking questions *per hour* (Chouinard, 2007) and these questions cover different topics such as natural phenomena (e.g., "why does it rain?") and more physical mechanisms (e.g., "why do we need to press the switch to turn the light on?"; Ronfard, et al., 2018), in addition to more metaphysical questions about for example, religion, death, or the origin of species (Harris, 2000; Isaacs, 1930).

Question-asking supports children's early cognitive development, as children first recognize what they do not know and construct a question in a specific way aimed to obtain information needed to learn new knowledge or solve a problem (Chouinard, 2007; Greif et al., 2006; Legare et al., 2013; Mills et al., 2010; Mills et al., 2011). During the preschool years, the types of questions children ask of others change dramatically. Specifically, in early preschool, children primarily ask fact-based questions ("what is that called?"); by age 4, children begin asking more causal questions ("Why does it snow?"; Chouinard, 2007). This shift is the types of questions children ask is associated with analogous shifts in the quality of interlocutor (or speaking partner's) response. Whereas simple, fact-based questions can often be answered with one-word responses, causal ("why" and "how") questions require a more complex response (e.g., Callanan et al., 1995; Corriveau & Kurkul, 2014). Such explanations in response to causal questions are subsequently associated with greater curiosity and learning of causal mechanisms as compared to other types of explanations (Frazier et al., 2016; Kelemen et al., 2014; Weisman & Markman, 2017; Mills et al., 2017; Crowley et al., 2001; Haden, 2010; Legare et al., 2017). Nevertheless, despite the importance of question-asking as a mechanism for knowledge acquisition, by the time children enter formal schooling, there is a significant decline in the number of questions that they ask, indicating that the preschool years may play a critical role in the question-asking process (Engel, 2011; Tizard & Hughes, 1984).

Question-asking is also a critical part of inquiry-based STEM education, which conceptualizes the child as a scientist who actively constructs knowledge through exploring and evaluating evidence through hands-on investigation (Anderson, 2002; Edson, 2013; Next Generation Science Standards, 2013). Beginning with formal schooling, the *Next Generation Science Standards (NGSS)* calls for all children to engage in the following activities: "asking questions, planning and carrying out investigations, analyzing and interpreting data, designing solutions, engaging in arguments from evidence, and obtaining, evaluating and communicating information" (p. 3). However, less is stated in the NGSS about the role of the teacher's response in scaffolding the process through which knowledge is acquired. In the current study, we explored how teachers think they would respond to children's scientific questions.

We focused on investigating both the patterns and individual differences in teachers' perceptions of how to answer children's science questions. Note that we had no hypotheses about the "best" type of response; rather, we were interested in exploring individual differences in how teachers might respond to children's questions within the STEM context. To understand how teachers would reason about the best way to respond to children's questions, we utilized a survey methodology, where we provided teachers with preschool-aged children's science questions (e.g., "How do fish breathe in water?") in the form of vignettes and invited them to write how they would respond to the child's question. As compared to naturalistic observation, a survey methodology allowed for a more systematic understanding of what teachers think they would be doing in response to specific science questions.

3. Variation in adults' responses to children's questions

Despite the relative paucity of work exploring teacher-student exchanges, a great deal of work exploring how question-explanation exchanges impact children's learning has focused on parent-child interactions at home. For example, previous work has shown that parents' confidence in supporting children to develop literacy and math skills was related to the complexity of questions they posed in interactions with children during a storybook reading session (Uscianowski et al., 2020). Despite the fundamental role of the question-explanation exchange in children's learning, adults vary in their ability to provide high-quality explanations (e.g., Shtulman & Checa, 2012). To date, research has related the complexity of an adult's explanation to the *gender of the child* (e.g., Crowley et al.. 2001), with parents more likely to provide explanations to boys rather than girls (aged 3-8) in science contexts, and *family socioeconomic status (SES)*, with mid-SES parents providing more explanations to children's (4-year-olds) questions than low-SES parents (Kurkul & Corriveau, 2018). Parents' scientific explanations may provide more than just content to children. These explanations may also influence children's behavior including whether children decide to ask additional questions (e.g., Kurkul & Corriveau, 2018; Sak, 2020). For example, the results of the Frazier et al. (2009) study demonstrated that when children's (aged 3-5) first question resulted in a high-quality explanation, they were more likely to ask additional questions to gain more knowledge.

Whereas children at home may have the full attention of their parents as the focus is on collaborating and communicating together to construct knowledge, in the classroom setting, the teacher has multiple goals—meeting the needs of many students at once, ensuring children's safety through monitoring behavior and classroom management and adhering to high academic standards. As a result, the demands of the teacher may impact the quality of the conversations with children. For example, in formal school contexts, the teacher typically controls the classroom discourse and conversation, with research demonstrating that children ask few questions per lesson (Osborne & Reigh, 2020).

Unsurprisingly, given teachers' goals in the classroom, prior work has found mixed results in how teachers respond to scientific questions (e.g., Dean Jr. & Kuhn, 2007; Golinkoff & Hirsh-Pasek, 2016; Klahr & Nigam, 2004). For example, in a qualitative study examining Turkish preschoolers' difficult classroom questions (Sak, 2020), many of the responses to children's questions did not support children's learning (included no response, wrong explanation or irrelevant). In addition, teachers have been found to turn the question back to the child rather than providing a direct answer. On one hand, turning the question back to the child might be a more developmentally appropriate way of responding to children's questions (*pedagogical move*) for early childhood educators, which would encourage children to reflect upon their own knowledge and how they might answer it. On the other hand, it is not clear if the child will be able to answer their own questions without guidance from their teacher, especially when questions concern unobservable or abstract scientific concepts. Some research from classroom observations has found that when children ask a question, teachers' most frequent response is to provide an explanation e.g., Kurkul et al. (2021). In the current research, we focus not on teachers' real-time behavior in response to a question, but on how they think they would respond. We asked whether teachers would also be more likely to provide an explanation under those hypothetical situations.

3.1. Teacher-level factors

Given that much of the research focuses on parent-child question-asking exchanges at home and there are mixed findings about the classroom setting, an open question is what accounts for the differences in teachers' responses to children's questions. We explored teacher-level factors that might act as another source of variation in how teachers respond to children's scientific questions. Our sample included both preservice and inservice teachers to examine the role of teaching experience in teachers' responses and hypothesized that teachers' experience may impact how they would respond to children's questions. Previous research indicates that teachers' knowledge of language and literacy predicted preschoolers' vocabulary acquisition (Cash, Cabell, Hamre, DeCoster, & Pianta, 2015). Additionally, prior work (e.g., Kurkul & Corriveau, 2018) examining factors that influence parent-child conversations has focused on socioeconomic status and epistemological stance (Kuhn, 2001). We divide teacher factors into those associated with demographics and personal epistemologies, and describe each in more detail below.

3.1.1. Demographics

We explore 3 demographic variables that may relate to teachers' approach to responding to their students' queries. First, Tenenbaum and Callanan (2008) found that parents' *education level* mediated the quality of the explanation that parents provided to children's (aged 2-8) questions. It is argued that formal schooling provides individuals with more experience with discourse patterns that include causal reasoning and pedagogical moves such as question-answer exchanges (Cazden, 1988; LeVine, LeVine, Schnell-Anzola, Rowe, & Dexter, 2011; Rogoff, 2003). Thus, we explored whether teachers with more education were more likely to employ a certain pedagogical move when responding to children's questions. Second, for inservice teachers only, we examined whether total years of teaching experience predicted their responses to children's questions. Two recent reviews focusing on the relation between teaching experience and student achievement since 2003 indicates that teacher experience is positively associated with students' achievement in school and teachers with more experience are more supportive of students' learning (Kini & Podolsky, 2016; Podolsky, Kini, & Darling-Hammond, 2019). An open question is whether teachers' experience may also be related to differences in how they respond to children's questions. Third, we were interested in potential differences in responses by classroom grade level. Some research has indicated that when guiding preschoolers' play, teachers adopt different roles depending on the age of the child (Jones & Reynolds, 2011), and research on parent-child interactions suggests that parents ask more questions to younger (aged 3-6) than older children (aged 7-11; Callanan et al., 2017). On one hand, teachers might provide more scaffolding to preschoolers as opposed to older children's questions, by providing an explanation. On the other hand, teachers might provide less scaffolding to younger children, which would promote child-level exploration. Because preschool classrooms do not have to answer to the same academic standards as elementary formal schooling, there might be more time for self-directed learning.

3.1.2. Personal epistemologies

In addition to demographic factors, variation in teachers' responses to children's questions may also be reflected in their "personal epistemologies," or beliefs about the construction of knowledge (Kuhn et al., 2000). Kuhn (2001) identified 3 stances (absolutist, multiplist, evaluativist) that individuals adopt as they reason about the construction of knowledge. According to Kuhn (2001), an *absolutist* stance views claims as right or wrong (Luce et al., 2013), with knowledge originating from an external, definite source. A *multiplist* stance assumes that knowledge is derived from subjective humans. Thus, beliefs here are uncertain and do not necessarily apply to others. Finally, in the *evaluativist* stance, knowledge is derived from human minds and is uncertain. As a result, judgments are based on evidence that has the most merit. For the current study, we examined teachers' personal epistemologies through the use of a validated survey, the *Epistemic Thinking Assessment (ETA)* (Barzilai & Weinstock, 2015). The ETA probes teachers' epistemic thinking within the science domain: individuals are presented with 2 accounts from researchers for why frogs may have physical deformities and then invited to respond to an 11-item multiple choice questionnaire (each question had 3 response options). This survey can reliably identify individual differences in epistemic stance among adult populations. For example, one question on the ETA states "What should the knowledge about deformed frogs be based on?" For this question, teachers chose 1 of 3 multiple-choice responses: an *absolutist* response "only the facts," a *multiplist* response "mainly personal points of view", and an *evaluativist* response "mainly on interpretations of the data." Given beliefs about the construction of knowledge, we reasoned that teachers' personal epistemologies may guide their response patterns to children's questions. For example, an adult who holds an *absolutist* perspective may respond to children's questions in ways that convey that knowledge is fixed, static, and there is an absolute truth, whereas an adult who holds an multiplist stance may suggest that people can hold different opinions about an issue. By contrast, an adult who holds an *evaluativist* stance may encourage the child to find evidence to support the answer to the question.

In prior research exploring the relation between parents' epistemological stance and children's evidence talk (Luce et al., 2013), parents who endorsed a non-absolutist stance were more likely to use evidence to support their claims when deciding on a strategy to solve a problem. Luce et al. (2013) explored the association between the parent's epistemological stance and their child's (aged 4-8) evidence talk through a book reading activity about a scientific concept (i.e., planets). Parents' evaluativist epistemic stance was related to an increase in their evaluativist talk demonstrating that adult epistemic beliefs are transmitted to children through conversations. More specifically, parents of 4- to 5-year-olds were more likely to assume an absolutist stance as compared to parents of 6- to 8-year-olds. Thus, the age of the children in the parents' personal epistemologies influenced children's ability to utilize evidence talk.

4. Current study

In the current study, we aim to develop a more systematic understanding of early childhood educators' perceptions of how they would respond to children's scientific questions.

We had 2 main research questions. Our first research question examined the pedagogical moves teachers (e.g., providing an explanation) use when responding to children's scientific questions. Given prior research exploring teachers' responses to children's questions in the classroom Kurkul et al. (in press), we hypothesized that *providing an explanation* would by the most common response on the vignettes. However, because prior research also suggests individual differences in adults' response patterns, our second research question explored factors that might predict teachers' responses to questions. We asked whether teachers' response patterns were predicted by the *level of experience* (preservice vs inservice teachers), *demographic factors* (e.g., grade taught) or *personal epistemologies* (beliefs about knowledge).

We had 3 predictions. First, prior research suggests that parent education level impacts the explanations that they provide to children's questions (e.g., Tenenbaum & Callanan, 2008). Additionally, teacher experience mediated the quality of the explanation provided to questions, which impacted student achievement (e.g., Cazden, 1988; Podolsky, Kini, & Darling-Hammond, 2019). As a result, we expected to see greater variation in how inservice teachers responded to children's questions compared to preservice teachers. Second, for grade level taught we considered 2 possibilities. On one hand, we might expect teachers to provide more scaffolding when responding to preschoolers as opposed to older children's questions and thus, would provide an explanation. On the other hand, we might expect them to provide less scaffolding, encouraging them to explore, given the fact that there might be more time at this age to engage in this self-directed learning. Third, we explored if teachers' epistemic beliefs of how to respond to children's questions suggests that there is only one answer (*absolutist*), or if they underscore the importance of evaluating available evidence (*evaluativist*). Note that we also considered a third epistemic stance, *multiplist*, but as we discuss below, did not expect teachers to endorse this stance when reasoning about scientific phenomena. For epistemic beliefs, we reasoned that teachers' personal epistemologies may guide their response patterns to children's scientific questions. Moreover, an adult who holds an absolutist perspective may respond to children's questions in ways that convey that knowledge is fixed, and there is an absolute truth and thus, would be more likely to provide an explanation in response to children's questions.

5. Method

5.1. Participants and procedure

The final sample included 209 early childhood and elementary school teachers (M_{age} = 29.37 years, age range: 19-75 years; 197 female, 12 male) recruited through local schools in the Northeast area of the United States (consent was obtained through approval from [the Boston University] Institutional Review Board). These teachers were fairly representative of the larger teacher population in the United States, with most being female and receiving at least a 4-year college degree (National Center for Education Statistics, 2017). One hundred and five participants were inservice teachers (M_{age} = 37.02 years, age range: 22-75 years; 99 female, 6 male). One hundred and 4 participants were preservice teachers (M_{age} = 21.63 years, age range: 19-48 years; 98 female, 6 male). In our sample, preservice teachers were defined as individuals who currently enrolled in a teacher preparation program at an institution of higher education. Of the preservice teachers, 75 participants were in their third year of college at the time the study was conducted (72.11% of the sample).

To investigate whether teachers respond differently depending on the grade they teach, we recruited a wide range of inservice teachers. Our final sample included 54 inservice teachers (51.4% of the inservice teacher sample; M_{age} = 36.11 years, SD_{age} = 13.01 years) currently teaching children of kindergarten or younger (preschool teacher group), with the remaining 50 teachers (47.6% of the inservice teacher sample; M_{age} = 37.4 years, SD_{age} = 11.9 years) teaching children of first grade age through third grade (early elementary group). The average years of teaching experience for the inservice teachers in the survey was 9.17 years (SD = 7.37). Note that this question about years of teaching experience was only asked to the half of the inservice teachers (question was added to the survey after data collection had begun). In addition, 61.9% of the sample included inservice teachers who had at least a master's degree or higher level of education (see Table 1).

Teachers were eligible to participate if they were at least 18 years of age and were currently teaching children between the ages of 3 and 9 years old. As survey compensation, teachers received a $10 gift card. Data were collected between January 2018 and March 2019.

5.2. Measures

Participants completed 3 survey blocks in a fixed order: (i) *responses to children's questions*, (ii) *personal epistemologies*, and (iii) *demographic information*. Each block is described in more detail below.

5.3. Responses to children's questions

Teachers were presented with 6 vignettes consisting of hypothetical situations about science. The vignettes focused on biological, physical, and natural scientific phenomena, which reflects children's curiosity to inquire about things beyond individuals' beliefs or desires (e.g., Ronfard et al., 2018). Our study design, primarily the use of vignettes, is in line with other work (Mills et al., in press) examining parents' responses to older children's (aged 7-10) causal (why and how) questions.

5.3.1. Vignette development

Questions were chosen through gathering questions children have asked their teachers. Ten early childhood educators were invited to record the scientific questions that children (aged 3-7) asked in their class over the course of several days. After collecting questions from teachers, we chose 6 open-ended, causal scientific questions that were frequently asked (multiple teachers reported children asking about a similar topic) and targeted different scientific domains. In our final sample (see Table 2), we aimed to have 2 vignettes that focused on the following 3 scientific domains: biological, physical and natural science. Finally, in order to ensure the participants knew they should answer the question as if they were interacting with one child (and not the whole class), we added some context to the questions.

To begin the survey, teachers were presented with the following prompt: "Here are some questions from children. Pretend that the question was asked by a child in your class. Let's also pretend you have an opportunity to interact one-on-one with this child. Use the shaded box below to type what you would say to this child." For example, "One of the classroom jobs is to feed the fish in the morning. One day after completing the morning job, one child asks you, "How do fish breathe in water?". Vignettes were presented individually. Immediately after reading the vignette, teachers were invited to respond to the question, "What would you say to this child?" Table 2 displays the full list of vignettes and children's questions.

5.4. Personal epistemologies

To measure teachers' personal epistemologies, participants completed the science domain of the *Epistemic Thinking Assessment (ETA*; Barzilai & Weinstock, 2015), which is a valid and reliable measure of adults' beliefs about the construction of knowledge. Barzilai & Weinstock, 2015). Barzilai and Weinstock (2015) conducted exploratory factory analyses to examine the development and validation of the ETA (specifically the *deformed frogs scenario* used in our study) and the model fit was confirmed through confirmatory factor analysis. More specifically, Barzilai and Weinstock (2015) "a one-level structural equation model with absolutism, multiplism, and evaluativism as latent variables was constructed based on the exploratory factor analysis solution. All 33 items relating to the 11 questions identified in the EFA were loaded on their respective factors, [and] the resulting model had acceptable fit with all items [and] most loadings were above .50" (CFI = 0.91, SRMR = 0.07, RMSEA = 0.05; p. 150). Thus, both exploratory and confirmatory factory analyses from Barzilai and We-

Table 1
Highest level of teacher education achieved and school type for inservice teachers.

Teacher grade level	Demographic characteristics		Number of teachers (percent of total sample)
	Education level		
		High School	1 (.96%)
		Associates degree	4 (3.8%)
Preschool/kindergarten group($n = 54$)		Bachelors	21 (20.2%)
		Bachelors + 1	2 (1.9%)
		Masters	19 (18.3%)
		Masters + 1	6 (5.8%)
		Doctorate	0
	School type		
		Public	23 (22.1%)
		Private	30 (28.8%)
		Other	1 (0.96%)
	Education level	High school	0
		Associates degree	0
Early elementary group($n = 50$)		Bachelors	6 (5.8%)
		Bachelors + 1	4 (3.8%)
		Masters	30 (28.8%)
		Masters + 1	9 (8.7%)
		Doctorate	1 (.96%)
	School type		
		Public	39 (37.5%)
		Private	7 (6.7%)
		Other	1 (3.8%)

Table 2
Vignettes of children's questions about science. All teachers are asked to respond to the question, "*What would you say to this child*?"

Vignette context	Child's question
1. Yesterday it rained and afterward, you and your class saw a rainbow.	Today one child asks you, "How are rainbows made?"
2. One day a child in your class tells you a story about playing with toys in the bathtub. This child is wondering why some of the toys float in the water.	The child asks you, "Why do some objects sink and some objects float when you put them in water?"
3. In your classroom, you have a fish tank. One of the classroom jobs is to feed the fish in the morning.	One day after completing the morning job, one child asks you, "How do fish breathe in water?"
4. Children have been playing outside at recess and commenting on all the leaves falling off the trees.	After recess 1 day, a child in your class asks you, "Why do leaves change color?
5. Your class recently took a field trip to a nature reserve. You and your students saw different animals, including a few types of birds.	A couple days later, a child asks you, "Why do birds have different beaks?"
6. After recess 1 day, a child in your class is wondering about how plants grow outside.	The child asks you, "How do plants grow?"

Table 3
Example epistemic thinking assessment items (Barzilai & Weinstock, 2015).

ETA item	Absolutist response	Multiplist response	Evaluativist response
Can there be certainty about the deformed frogs?	Eventually one could know for certain.	One could never know for certain because it is impossible to find out what happened.	There is never full certainty, but it is possible to improve the degree of certainty.
What should the knowledge about deformed frogs be based on?	Only on facts.	Mainly people's opinions about the topic.	Mainly on interpretations of data.
What is the best way to judge different accounts about this topic?	The best way is to check if the account is based only on the facts.	The best way is to check which account is most reasonable according to the reader's worldview.	The best way is to check which interpretation best explains the available data.

instock (2015) indicate that the ETA provides a valid scenario-based assessment of individuals' personal epistemologies (absolutist, multiplist, evaluativist).

In our study, teachers were presented with 2 accounts from researchers for why frogs may have physical deformities and then invited to respond to an 11-item multiple choice questionnaire. For example, for the question, "What should the knowledge about the deformed frogs include?" Teachers chose from the following 3 multiple choice responses: (i) only detailed data about the topic) (ii) mainly people's opinions about the topic and (iii) mainly theories that explain the topic. See Table 3 for example questions from the ETA.

5.5. Classroom demographic information

Teachers were asked to report level of education, current grade level (teaching) and the amount of time that they spend on science instruction every week (less than once a week, 1-2 times per week,

Table 4
Sample teacher responses for the child's question, "why do birds have different beaks?"

Category code	Description	Example teacher response
Explanation	The teacher offers an explanation when responding to the child's question	Different beaks do different jobs, depending on what the bird eats.
Asks questions	The teacher asks a question related to the child's questions	What do birds use beaks to do?
Turns question back	The teacher restates the child's question back to the child	Why do you think birds have different beaks?
Look up	The teacher suggests that the child go look up the answer in a book or video.	Let's see if we can find a book on birds' beaks.
Ask a person	The teacher suggests that the child ask another person.	Let's ask our third-grade friends. They studied birds this year.
Inquiry	The teacher suggests an inquiry to find out the answer. Typically, this involved an experiment.	Let's compare some different bird beaks we see at recess and think about the types of food that birds eat.
Don't know	The teacher indicates that he or she is unaware of the answer.	I have no idea!

3-4 times per week, daily) and day (1-30 minutes, 31-60 minutes, 61-90 minutes, more than 90 minutes per day).

6. Coding

6.1. Responses to children's questions

Our coding scheme sought to categorize teachers' responses into several pedagogical moves. This coding scheme was mutually exclusive and exhaustive. The 7 codes included: (i) *providing an explanation:* the teacher offers an explanation to the child's question, (ii) *asks a question*: the teachers asks a question related to the child's question, (iii) *turns the question back:* the teacher restates the child's question back to the child, (iv) *look up*: the teacher suggests that the child go look up the answer in a book or online video, (v) *ask a person*: the teacher suggests that the child ask another person, (vi) *inquiry*: the teacher suggests an inquiry to find out the answer (typically an experiment), and (v) *don't know*: the teacher indicates that he or she is unaware of the answer. Table 4 displays the example teacher responses for each code.

6.2. Personal epistemologies

Recall that after reading 2 accounts regarding why frogs may have physical deformities, teachers were asked to respond to the *Epistemological Thinking Assessment (ETA)* (Barzilai & Weinstock, 2015), an 11-item questionnaire, which tapped into the different dimensions of epistemology. Epistemic Stance was determined based on the number of multiple-choice items that fell into the 3 different stances (Barzilai & Weinstock, 2015). For example, a teacher was considered to have a predominantly *absolutist* epistemic stance if they provided more absolutist responses than either evaluativist or multiplist responses on the assessment. Likewise, a teacher who provided more "evaluativist" responses was considered to hold an *evaluativist* stance. We tallied teachers' responses across all 11 items to create 3 sub-scores: (i) the number of absolutist responses (ii) the number of multiplist responses and (iii) the number of evaluativist responses. Teachers were categorized as holding no predominant stance if their responses to the 11-item questionnaire did not favor a particular epistemic stance (e.g., gave responses across all 3 epistemic stances).

6.3. Reliability

Inter-rater reliability was established by using a randomly selected sample of 8% of the data. The 2 raters independently coded this data and overall agreement was 92% (Cohen's kappa = 0.88). All discrepancies in coding were resolved through discussions between coders.

7. Results

7.1. Overview

The results section is organized as follows. First, we focus on our first research question, where we evaluated teachers' responses to the 6 vignettes and examined differences between inservice and preservice teachers (e.g., providing an explanation, turning the question back, asking a person). Second, we examine relations between teacher *demographics* (age, education level) and *personal epistemologies (epistemic stance)* and teachers' choices of a pedagogical move. We ran separate multilevel logistic regression models with Teacher Response Type (the likelihood of responding with a particular question type vs the other 5 question types) as the binary outcome variable, with Age, Epistemic Stance, Teaching Grade Level, and Teacher Education Level as fixed effects and with teacher random effects on the intercept. All analyses were performed using R Statistical Software.

7.2. Teachers' responses to children's questions

We first explore the ways in which teachers approach answering children's questions across the 6 vignettes. We calculated the percentage of the 1254 total responses that fell into each of the 6 coding categories. After removing non-responses, this yielded a sample of yields a sample of 1248 responses. Because *asks person, looks up* and *don't know* were represented by less than 3.5% of the data, these codes were collapsed into an "other" category and not represented in the final analysis. All subsequent analyses focused on the 4 remaining codes: *explanation, turns question back, asks a question*, and *suggests an inquiry.* The most frequently utilized pedagogical move across all 6 vignettes types was *providing an explanation* (67.1%), followed by *turning the question back* (11.2%), *asks a question* (*10.6%*), *suggests an inquiry* (4.4%), and *other* (6.1%).

To examine whether the type of pedagogical moves differed between inservice and preservice teachers, we conducted a 2 (teacher status: preservice vs inservice) × 5 (pedagogical moves: asks question, inquiry, explanation, turns question back, and other) chi-square test. As demonstrated in Fig. 1, this analysis indicated that the distribution of moves between the preservice and inservice teachers differed significantly, $\chi^2(4) = 232.58$, $P < 0.001$. Follow-up Bonferroni-corrected ($\alpha = 0.05/3$) binomial tests indicated that although inservice teachers ($N = 51$; 4%) provided more inquiry-based responses than preservice teachers ($N = 5$; 0.4%), $P < 0.001$, preservice teachers ($N = 545$; 43.7%) provided more explanation-based responses than inservice teachers ($N = 296$; 23.7%), $P < 0.001$. Inservice teachers ($N = 116$; 9.2%) also chose to turn the

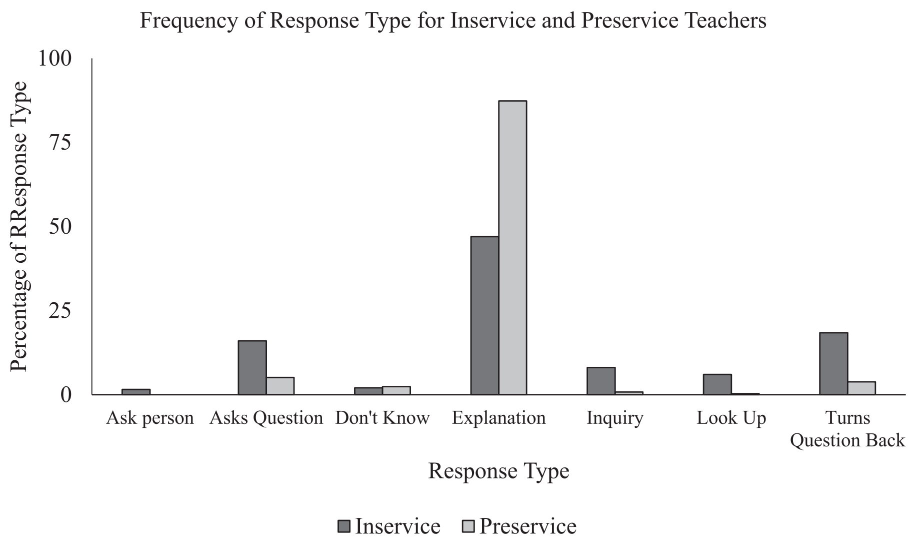

Fig. 1. Inservice and preservice teacher responses to children's questions across 6 vignettes.

question back at a higher rate than preservice teachers ($N = 24$; 2%), $P < 0.001$.

Taken together, teachers primarily chose to *provide explanations* over other pedagogical moves such as *turning the question back, suggesting an inquiry* across all vignette types. When comparing inservice to preservice teachers, preservice teachers primarily utilized explanations whereas inservice teachers showed more variation in response patterns.

7.3. Teacher-level factors as a source of variation

Our second research question investigated relations between teacher *demographics* (age, education level) and *personal epistemologies (epistemic stance)* and teachers' choices of a pedagogical move.

7.4. Demographics and epistemic stance

We ran separate multilevel logistic regression models with Teacher Response Type (the likelihood of responding with a particular question type vs the other 5 question types) as the binary outcome variable, with Age, Epistemic Stance, Teaching Grade Level, and Teacher Education Level as fixed effects and with teacher random effects on the intercept. Although the ideal analysis strategy would have been to fit a single multilevel multinomial logistic-regression models, currently there exists no open-source, non-proprietary technique for fitting multilevel models that simultaneously allow for random effects. The approach taken of fitting separate multilevel logistic regression models for each response category used here represents a better approach than either univariate ANOVA or ordinary least-squares regression because multilevel models account for unexplained variance at multiple levels of analyses, address unbalanced and non-independent designs, and account for correlated errors among observation units. Note that the 6 vignettes are nested within 209 teachers, and thus, the model includes random effects at 2 levels: (i) *vignette type*, which involved looking at the data by each vignette (e.g., did teachers respond differently to the question about bird beaks than objects sinking or floating?) and (ii) *teachers' individual differences* in responses across 6 vignettes. As illustrated in Fig. 2, most teachers held either an *absolutist* or *evaluativist* stance, with very few holding a multiplist stance. Therefore, the analyses for Epistemic Stance excluded the 4 teachers with a *multiplist* stance. Separate multilevel regressions were run for inservice teachers and for preservice teachers given that the distribution of pedagogical moves differed between both groups, yielding a total of 12 separate models.

7.5. Explanations vs all other pedagogical moves

7.5.1. Inservice teachers

For the first analyses, we focused on our subset of inservice teachers and the dichotomous outcome was the extent to which inservice teachers provided an explanation vs all other pedagogical moves (see Table 5 for the full model). Although none of the main effects reach statistical significance, which was confirmed by the fact that teachers who held an absolutist stance were no more likely to provide an explanation than any other pedagogical move than those who held an evaluativist stance, $b = 0.57$, $P = 0.26$, OR = 1.76, 95% CI [1.43, 2.09], overall inservice teachers with evaluativist stances were marginally *less* likely to provide an explanation than any of the other pedagogical moves, $b = -0.48$, $P = 0.15$, OR = 0.62, 95% CI [0.40, 0.84]. However, this result was not significant after correcting for multiple comparisons (i.e., .05/3). In contrast, teachers with absolutist stances did not differ in their likelihood of providing an explanation vs other pedagogical-move choice, $b = 0.09$, $P = 0.81$, OR = 1.09, 95% CI [0.85, 1.33].

7.5.2. Preservice teachers

Next, we examined our subset of preservice teachers by running a similar model (with all predictors except Teacher Grade Level because this did not apply to preservice teachers). As demonstrated in Table 6, Although the main effect of Epistemic Stance was not significant, $\chi^2(1) = 0.84$, $P = 0.36$, absolutists were more likely to respond with an explanation than with other moves, $b = 5.81$, $P < 0.001$, OR = 332, 95% CI [332.31, 333.11].

7.6. Asks question vs all other pedagogical moves

7.6.1. Inservice teachers

We then focused on our subset of inservice teachers in the (see Table 7) and the dichotomous outcome was the extent to which inservice teachers responded with asks a question vs all other pedagogical moves. Epistemic Stance, Teacher Age, Teaching Grade Level, and Teacher Education Level were included as the fixed-effect predictors with teacher random effects on the intercept. Although the main effect of Teacher Grade Level was not significant, $\chi^2(1) = 1.96$, $P = 0.16$, we nonetheless conducted Bonferroni-

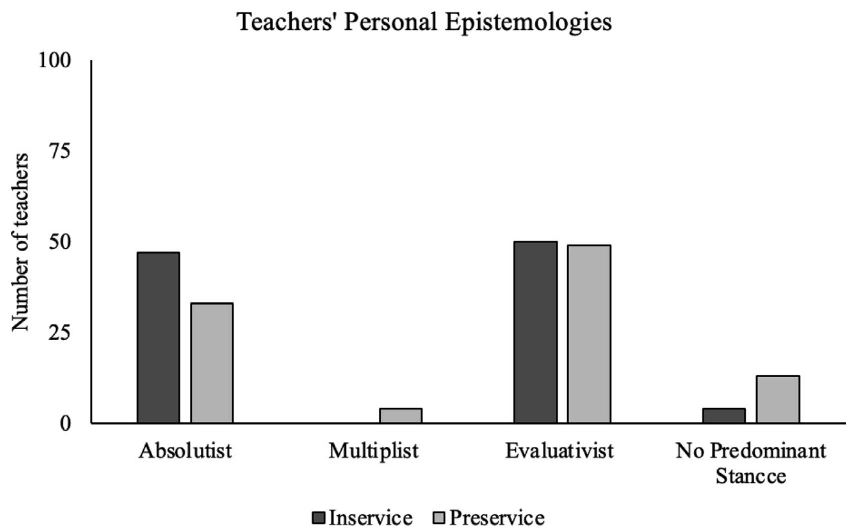

Fig. 2. Number of teachers corresponding to each epistemic stance.

Table 5
Examining variation in inservice teachers' explanation response.

		Inservice teacher explanation model				
Variable†	Unstandardized *B*	(SE)	*z*	Odds ratio	*P*	CI
Intercept (absolutists)	0.08	(0.37)	0.24	1.09	0.81	[0.85, 1.33]
Intercept (evaluativists)	-0.48	(0.33)	-1.43	0.62	0.15	[0.40, 0.84]
Epistemic stance (absolutist)	0.57	(0.49)	1.139	1.76	0.26	[1.43, 2.09]

† $P < 0.10$. *$P < 0.05$. **$P < 0.01$.Note: The 95% confidence intervals are confidence intervals on the odds ratios.

Table 6
Examining variation in preservice teachers' explanation response.

		Preservice teacher explanation model				
Variable	Unstandardized *B*	(SE)	*z*	Odds ratio	*P*	CI
Intercept (absolutists)	5.81	(1.51)	3.84	332.71	<0.001***	[332.29, 333.12]
Intercept (evaluativists)	6.823	(1.23)	5.56	918.78	<0.001***	[918.44, 919.13]
Epistemic stance (absolutist)	-1.016†	(1.106)	-0.919	0.36	0.15	[332.31, 333.11]

† $P < 0.10$. *$P < 0.05$. **$P < 0.01$ ***$P < 0.001$.Note: The 95% confidence intervals are confidence intervals on the odds ratios. +Represents the difference in log(odds) between absolutists and evalustivists.

Table 7
Examining variation in inservice teachers' asks questions response.

		Asks question back model†				
Variable	Unstandardized *B*	(SE)	*z*	Odds ratio	*P*	CI
Intercept (first grade or higher)	-2.12	(0.34)	-6.18	0.12	<0.001***	[-0.18, 0.42]
Intercept (preschool and kindergarten)	-2.77	(0.39)	-7.06	0.06	<0.001***	[-0.27, 0.39]
Teacher grade level (first grade or higher)	0.65	(0.45)	-0.919	1.91	0.16	[1.44, 2.37]

† $P < 0.10$. *$P < 0.05$. **$P < 0.01$ ***$P < 0.001$.Note: The 95% confidence intervals are confidence intervals on the odds ratios.

corrected simple-effects analyses to evaluativists' and absolutists' odds of responding by asking a question compared to responding with other pedagogical moves. Results indicates that inservice teachers who teach at the first grade (or higher) level were marginally more likely to ask a question than to respond with other pedagogical moves than preschool and kindergarten inservice teachers, $b = 0.65$, $P = 0.16$, OR = 1.91, 95% CI [1.44, 2.37]. However, this result was not significant after correcting or multiple comparisons (.05/3). However, overall, both groups were significantly less likely to respond with a question than with other pedagogical moves, both *P's* < 0.001, both OR's < 0.12, and this was true even after applying the above-mentioned Bonferroni correction (i.e., .05/3).

7.6.2. Preservice teachers

We ran a similar model with our subset of preservice teachers and Teaching Grade Level was removed. Although the main effect of Epistemic Stance was not significant, $\chi^2(1) = 0.51$, $P = 0.47$, absolutists were less likely to respond with asks a question than other moves. Given that only one contrast was run here for preservice teachers, we did not correct for multiple contrasts.

7.7. Turns question back vs all other pedagogical moves

7.7.1. Inservice teachers

Next, we focused on inservice teachers' likelihood of turning the question back vs responding with other pedagogical moves (see

Table 8
Examining variation in inservice teachers turns question back response.

Variable	Unstandardized *B*	Turns question back model (SE)	*z*	Odds ratio	*P*	CI
Intercept (first grade or higher)	-2.3	(0.29)	-8.06	0.1	<0.001***	[-0.24, 0.44]
Intercept (preschool and kindergarten)	-1.58	(0.28)	-6.26	0.25	<0.001***	[-0.05, 0.46]
Teacher grade level	-0.72	(0.35)	-1.95	0.50	0.05*	[.05, 0.92]
Epistemic stance (absolutist)	-2.23†	(0.36)	-1.25	0.11	<0.001**	[-0.23, 0.45]

† $P < 0.10$. *$P < 0.05$. **$P < 0.01$ ***$P < 0.001$.Note: The 95% confidence intervals are confidence intervals on the odds ratios. +Represents the difference in log(odds) between absolutists and evalustivists.

Table 9
Examining variation in preservice teachers suggest inquiry response.

Variable	Unstandardized *B*	Turns question back model (SE)	*z*	Odds ratio	*P*	CI
Intercept (absolutists)	-5.28	(1)	-5.27	0.01	<0.001***	[0.001, 0.04]
Intercept (evaluativists)	-4.66+	(0.5)	-9.27	0.01	<0.001***	[0.004, 0.03]
Epistemic stance (absolutist)	-0.63†	(1.12)	-0.56	0.53	<0.001***	[0.06, 4.81]

† $P < 0.10$. *$P < 0.05$. **$P < 0.01$ ***$P < 0.001$.Note: The 95% confidence intervals are confidence intervals on the odds ratios. +Represents the difference in log(odds) between absolutists and evalustivists.

Table 8). Epistemic Stance, Teacher Age, Teaching Grade Level, and Teacher Education Level were included as the fixed-effect predictors with teacher random effects on the intercept. There was no main effect for Teacher Age, Epistemic Stance or Teacher Education Level. However, there was a significant main effect for Teaching Grade Level, $\chi^2(1) = 4.09$, $P < 0.05$, with teachers who teach older children (above first grade) less likely *to turn the question back* than teachers who teach younger children (preschool and kindergarten), b = -0.72, $P < 0.05$, OR = 0.49, 95% CI [0.05, 0.92]. However, this result was not significant after correcting or multiple comparisons (.05/3). In addition, those who taught younger children were significantly less likely to respond by turning the question back than with other moves, b = -1.58, P = 0.001, OR = 0.21, 95% CI [-0.07, 0.48]. Similarly, teachers who taught older children (first grader and older) were significantly less likely to respond by turning the question back compared to other moves, b = -2.30, $P < 0.001$, OR = 0.1, 95% CI [-0.24, 0.44]. In other words, turning the question back is an infrequent move adopted by teachers, and appears to be even rarer among teachers who teach older children.

7.7.2. Preservice teachers

Next, we examined our subset of preservice teachers, which yielded a non-significant model and main effects and thus, there is no table for preservice teachers.

7.8. Suggests an inquiry

7.8.1. Inservice teachers

We first focused on our subset of inservice teachers and included whether or not participants responded with *suggests an inquiry* as the binary outcome (suggests inquiry vs all other pedagogical moves) variable with Epistemic Stance, Teacher Age, Teaching Grade Level, and Teacher Education Level as fixed effects and Teacher Individual Differences' (Level 2) as a random factor. Given that the overall model was not significant, there is no corresponding table with results.

7.8.2. Preservice teachers

Finally, we examined our subset of preservice teachers and ran a similar model to the previous one with Teacher Grade Level removed (see Table 9). Although the overall model was not significant, we also found that evaluativists and absolutists were less likely to respond by suggesting an inquiry than with other pedagogical moves, b = -4.66, $P < 0.001$, OR = 0.01, 95% CI [0.004, 0.03], and b = -5.28, $P < 0.001$, OR = 0.01, 95% CI [0.001, 0.03], respectively.

8. Discussion

Taken together, a tacit assumption in education is that adult (e.g., teachers, parents) explanations in response to children's scientific questions play a fundamental role in enhancing children's early learning (e.g., Callanan, Oakes, 1992; Kurkul & Corriveau, 2018; Legare & Lombrozo, 2014; Lombrozo et al., 2018; Willard et al., 2019). However, this assumption does not take into account the fact that adults respond to children's questions in a variety of ways. Our results indicate that when presented with a scientific question from a child, a teacher may provide an *explanation, turn the question back to the child, ask a question* or *suggest an inquiry or experiment*. Thus, the goal of this study was to develop a systematic understanding of how early childhood educators would respond children's scientific questions. To the best of our knowledge, little research has explored if teachers' beliefs about the nature of knowledge, grade level taught and own level of education is reflected in how they would respond to children's questions. Below, we focus on findings from our 2 main research questions.

8.1. How do teachers believe they would respond to children's scientific questions?

Our first research question concerned the ways in which teachers would respond to children's scientific questions. Given prior research exploring teachers' responses to children's questions in the classroom (e.g., Kurkul et al., in press), we predicted that the most common response to children's questions would be to provide *an explanation*. Teachers' responses could be reliably categorized into 1 of only 7 categories, with 4 categories representing more than 95 percent of responses. Across 6 vignettes, both inservice and preservice teachers were more likely to *provide an explanation* when responding to children's questions compared with other pedagogical moves such as *suggesting an inquiry* or *turning the question back* to the child. On one hand, this finding supports and aligns with naturalistic classroom data (Kurkul et al., in press) demonstrating that teachers often respond to children's scientific questions with explanations, rather than utilizing other pedagogical moves. Thus, teachers' beliefs of how they think they should respond to children's questions seems to reflect what occurs in the classroom.

By contrast, our results differ from naturalistic research with parent-child dyads, which indicates that when parents do have the chance to provide explanations to foster children's scientific learning, the majority of their responses are not explanations (e.g., Gutwill & Allen, 2010; Shtulman & Checa, 2012). Although providing explanations has been positively associated with gains in children's learning, especially in informal learning environments (e.g., Haden, 2010) such as the museum setting, prior work suggests that parents do not always utilize all opportunities to provide an explanation when interacting with their children (e.g., Tabors et al., 2001). For example, Kurkul et al. (2021) found that when parents and children engaged in a scientific circuit task activity, parents rarely provided explanations to 4-year-olds spontaneously. In contrast to parents, teachers seem to recognize that explanations are the "language of formal schooling," even though there are other ways to respond to children's scientific questions, which may all contribute to children's learning—and even though many of these teachers attended programs and/or taught in classrooms that promoted inquiry learning (Uccelli et al., 2019). Future research should explore the relations between teachers' responses to these hypothetical questions and their actual classroom responses.

Although providing an explanation was the most common response for all teachers, their responses also varied based on their experience. Inservice teachers provided more inquiry-based responses and turned the question back at a higher rate than preservice teachers, whereas preservice teachers provided more explanations than inservice teachers. Thus, the results support our hypothesis that we would find greater variation in how inservice teachers responded to children's questions as compared to preservice teachers. Given this variation, our second research question explored teacher-level factors that would explain sources of variation in inservice and preservice teachers' perceptions their responses to children's questions.

8.2. What accounts for individual variability in explanatory response strategy?

Prior research exploring learning in informal environments has found that parents are more likely to provide explanations to boys than girls (aged 3-8; Crowley et al., 2001) and parents with higher levels of education and socioeconomic status are more likely to provide causal explanations to children's (age 4) questions than low-SES parents (Kurkul & Corriveau, 2018; Tenenbaum & Callanan, 2008). In formal learning settings such as schooling, research has also found variability in how teachers respond to children's questions (e.g., Dean Jr. & Kuhn, 2007; Golinkoff & Hirsh-Pasek, 2016; Klahr & Nigam, 2004). Indeed, even when teachers do provide explanations, it may be at the cost of preschoolers' experimentation and exploration (Bonawitz et al., 2011). One limitation of these studies is that because questions and explanations were spontaneous, not all teachers or parents provided responses to the same question, making it challenging to determine the mechanisms associated with individual variability in explanatory response strategy. Thus, in the current study, we presented teachers with hypothetical questions and asked what teacher-level factors might explain sources of variation in inservice and preservice teachers' perceptions their responses to children's questions.

We first investigated demographic factors, including the teachers' education level, age and the grade that they currently teach. We found that there was no relation between inservice teachers' education level or age and how they responded to children's questions. One possibility for this result is that there was not much variance in the level of education, as it is a requirement of inservice teachers to hold at least a college degree.

Next, we explored how the grade level that inservice teachers teach might explain variation in their responses to children's questions. Recall that we introduced 2 possibilities for the expected relation between teachers' pedagogical moves and the age of the children they taught. On one hand, we might expect inservice teachers to provide more scaffolding when responding to preschoolers as opposed to older children's questions and thus, would provide an explanation. On the other hand, we might expect them to provide less scaffolding, encouraging them to explore, given the fact that there might be more time at this age to engage in this self-directed learning. Although it was not significant after correcting for multiple tests, it seems more inservice teachers who teach older grades (first grade and older) are less likely to turn the question back than teachers who teach younger grades (preschool and kindergarten). This is consistent with the possibility that early childhood educators may believe that this pedagogical move of turning the question back to the child is more appropriate when responding to younger children. One reason is that turning the question back might provide younger children with the opportunity to explore and experiment without constraining their inferences (Yu et al., 2018).

In addition to exploring variability based on teacher demographic factors, we also explored how inservice and preservice teachers' understanding of how knowledge is represented (epistemological stance) is reflected in their responses to children's questions. Although our study did not directly examine the relation between teachers' epistemological beliefs and children's learning in the classroom, to the best of our knowledge, this is one of the first studies to explore teachers' beliefs about knowledge construction. The results suggest that most preservice and inservice teachers (regardless of experience), hold an absolutist or evaluativist stance when reasoning about scientific phenomena. It is plausible that teachers' epistemological stance might also guide their response patterns to children's scientific questions. Indeed, prior work (e.g., Luce et al., 2013; Valle, 2009) has explored the relation between parents' epistemic stance and their use of evidence when talking to their children about science, finding that interactions with adults who integrate evidence from several sources may have implications for children's ability to use evidence when problem solving or making an argument.

We predicted that preservice and inservice teachers who hold an absolutist perspective may respond to children's questions in ways that convey that knowledge is fixed, static, and there is an absolute truth. Therefore, we anticipated that they would be more likely to provide an explanation in response to children's questions. By contrast, we predicted that teachers who hold an evaluativist perspective might want to engage with the child to determine their reasoning for asking the question, and would therefore be less likely to provide fixed explanations. Our results were somewhat consistent with these hypotheses: preservice teachers who were categorized as absolutists were more likely to provide an explanation than teachers categorized as evaluativists when responding to children's questions. However, given that teachers who were classified as evaluativists should be interested in the search for evidence, we would have anticipated that they would be most likely to suggest an inquiry. Our data did not support this finding, perhaps because there are different ways that evaluativism may be embedded in classroom interactions (e.g., classroom routines, material selections, methods and whole class discussions), which cannot be measured using survey data. Future research should further probe the ways in which teacher's personal epistemologies play into their everyday interactions with children.

8.3. Limitations and future directions

Taken together, the results of this study demonstrate that teachers approach answering scientific questions by primarily providing an explanation to children. One limitation of these findings is that we focused on how teachers would respond to children's scientific questions through the use of hypothetical questions (vignettes), not their actual behavior in the classroom.

Additionally, there was also variation within the vignettes, for example, if the child was asking a question about a previous activity vs a question about something in the moment. However, we argue that these vignettes reflect the variety of questions that teachers are likely presented with in the classroom setting. Also, we focused only on teachers' beliefs about knowledge in the scientific domain, and so our findings may not generalize to other domains (Buehl & Alexander, 2001; Kuhn et al., 2000). Thus, future work should examine teachers' epistemic stance across multiple domains as well as further exploring the relation between teachers' actual behavior in the classroom, epistemic stance and children's subsequent learning in formal schooling. Additionally, it is plausible that a teacher's knowledge of the topic or comfort level about a specific science domain might impact the type of response they would provide to answer a child's question. Although our study did not ask about teachers' knowledge or comfort level with different scientific topics, we think that future work might explore this question. Also, although our study compared inservice vs preservice teachers, with a larger, more diverse sample, future work might focus more on exploring variability within the inservice teachers for example, with regard to years of experience or education level. Finally, it is also plausible that there might be variability in teachers' beliefs about what constitutes a developmentally appropriate, and accurate explanation. Thus, in future research we aim to further examine the quality of teachers' explanations. Despite these limitations, we argue that our approach to focusing on teachers' perceptions allows us to acquire a more systematic understanding of the variation in how early childhood educators' approach answering the many questions that children ask at school.

9. Conclusion

To conclude, although we are agnostic about the relative utility of the varying pedagogical moves in response to children's questions, we find that teachers' experiences and beliefs about knowledge appear to relate to the ways in which they think they would interact with children. Through utilizing this methodology, we also found that teachers' responses to children's questions can transfer more than just content being learned. The relation between teachers' epistemic stance and responses to children's questions demonstrates that these responses might send messages to children about how to construct and reason about knowledge in the world. Given the new emphasis on inquiry-based learning (focused on children asking questions, experimenting, evaluating evidence for arguments) as part of the *Next Generation Science Standards* (NGSS, 2013), it is important for teachers to provide high quality responses to children's questions that highlight the process of evaluating multiple sources of evidence. Thus, understanding sources of variation in teachers' approaches to responding to children's scientific questions can be used to shape professional development programs and curricula.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Authors' contributions

Amanda S. Haber: Conceptualization, Methodology, Formal analysis, Writing - Original Draft, Writing - Review & Editing, Project administration. Kathryn A. Leech: Conceptualization, Methodology, Formal analysis, Writing - Original Draft, Writing - Review & Editing. Deon T. Benton: Formal analysis, Writing - Review & Editing. Nermeen Dashoush: Investigation, Writing - Review & Editing. Kathleen H. Corriveau: Conceptualization, Methodology, Writing - Original Draft, Writing - Review & Editing, Project administration, Supervision, Funding acquisition.

Acknowledgments

The work was supported by the National Science Foundation to KHC [grant #1652224].

References

Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry. *Journal of Science Teacher Education, 13*(1), 1–12. https://doi.org/10.1023/A:1015171124982.

Barzilai, S., & Weinstock, M. (2015). Measuring epistemic thinking within and across topics: A scenario-based approach. *Contemporary Educational Psychology, 42*, 141–158. https://doi.org/10.1016/j.cedpsych.2015.06.006.

Bonawitz, E., Shafto, P., Gweon, H., Goodman, N. D., Spelke, E., & Schulz, L. (2011). The double-edged sword of pedagogy: Instruction limits spontaneous exploration and discovery. *Cognition, 120*(3), 322–330. https://doi.org/10.1016/j.cognition.2010.10.001.

Buehl, M. M., & Alexander, P. A. (2001). Beliefs about academic knowledge. *Educational Psychology Review, 13*(4), 385–418 https://doi.org.ezproxy.bu.edu/10.1023/A:1011917914756.

Callanan, M. A., Castañeda, C. L., Luce, M. R., & Martin, J. L. (2017). Family science talk in museums: Predicting children's engagement from variations in talk and activity. *Child Development, 88*(5), 1492–1504. https://doi.org/10.1111/cdev.12886.

Callanan, M. A., & Oakes, L. M. (1992). Preschoolers questions and parents' explanations: Causal thinking in everyday activity. *Cognitive Development, 7*(2), 213–233.

Butler, L. P., Ronfard, S., & Corriveau, K. H. (2020). The questioning child: Insights from psychology and education. *The questioning child: Insights from psychology and education*. United Kingdom: Cambridge University Press. https://doi.org/10.1017/9781108553803.

Callanan, M., Shrager, J., & Moore, J. L. (1995). Parent-child collaborative explanations: Methods of identification and analysis. *The Journal of the Learning Sciences, 4*(1), 105–129 www.jstor.org/stable/1466850.

Cash, A. H., Cabell, S. Q., Hamre, B. K., DeCoster, J., & Pianta, R. C. (2015). Relating prekindergarten teacher beliefs and knowledge to children's language and literacy development. *Teaching and Teacher Education, 48*, 97–105. https://doi.org/10.1016/j.tate.2015.02.003.

Cazden, C. B. (1988). *Classroom discourse: The language of teaching and learning*. United Kingdom: Pearson Education Canada. In press.

Chouinard, M. M. (2007). Children's questions: A mechanism for cognitive development. *Monographs of the Society for Research in Child Development, 72*(1), 129. https://doi.org/10.1111/j.1540-5834.2007.00412.x.

Corriveau, K. H., & Kurkul, K. E. (2014). Why does rain fall?": Children prefer to learn from an informant who uses noncircular explanations. *Child Development, 85*(5), 1827–1835. https://doi.org/10.1111/cdev.12240.

Crowley, K., Callanan, M., Jipson, J. L., Galco, J., Topping, K., & Shrager, J. (2001). Shared scientific thinking in everyday parent—Child activity. *Science Education, 85*(6), 712–732. https://doi.org/10.1002/sce.1035.

Crowley, K., Callanan, M. A., Tenenbaum, H. R., & Allen, E. (2001). Parents explain more often to boys than to girls during shared scientific thinking. *Psychological Science, 12*(3), 258–261. https://doi.org/10.1111/1467-9280.00347.

Dean Jr. , D., & Kuhn, D. (2007). Direct instruction vs. discovery: The long view. *Science Education, 91*(3), 384–397. https://doi.org/10.1002/sce.20194.

Edson, M. T. (2013). *Starting with science: Strategies for introducing young children to inquiry*. Portland, ME: Stenhouse. In press.

Engel, S. (2011). Children's need to know: Curiosity in schools. *Harvard educational review, 81*(4), 625–645. https://doi.org/10.17763/haer.81.4.h054131316473115.

Frazier, B. N., Gelman, S. A., & Wellman, H. M. (2009). Preschoolers' search for explanatory information within adult–child conversation. *Child Development, 80*(6), 1592–1611. https://doi.org/10.1080/15248372.2015.1098649.

Golinkoff, R. M., & Hirsh-Pasek, K. (2016). *Becoming brilliant: What science tells us about raising successful children*. Washington, D.C: American Psychological Association Press.

Greif, M. L., Kemler Nelson, D. G., Keil, F. C., & Gutierrez, F. (2006). What do children want to know about animals and artifacts? *Psychological Science, 17*(6), 455–459. https://doi.org/10.1111/j.1467-9280.2006.01727.x.

Gutwill, J. P., & Allen, S. (2010). Group inquiry at science museum exhibits: Getting visitors to ask juicy questions. *Group inquiry at science museum exhibits: Getting visitors to ask juicy questions*. California: Exploratorium.

Haden, C. A. (2010). Talking about science in museums. *Child Development, 4*(1), 62–67. https://doi.org/10.1111/j.1750-8606.2009.00119.x.

Harris, P. L. (2000). On not falling down to earth: Children's metaphysical questions. In K. Rosengren, C. Johnson, & P. Harris (Eds.), *Imagining the Impossible: Magical, Scientific, and Religious Thinking in Children* (pp. 157–178). Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511571381.007.

Harris, P. L., & Corriveau, K. H. (2014). Learning from testimony about religion and science. In E. J. Robinson, S. Einav, & P. Harris (Eds.), *Current issues in developmental psychology. Trust and skepticism: Children's selective learning from testimony* (pp. 36–49). Psychology Press. https://doi.org/10.1177/1948550618806057.

Harris, P. L., Koenig, M., Corriveau, K. H., & Jaswal, V. K. (2018). Cognitive foundations of learning from testimony. *Annual Review of Psychology, 69*, 251–273. https://doi.org/10.1146/annurev-psych-122216-011710.

Hickling, A. K., & Wellman, H. M. (2001). The emergence of children's causal explanations and theories: Evidence from everyday conversation. *Developmental Psychology, 37*(5), 668–683. https://doi.org/10.1037/70012-1649.37.5.668.

Isaacs, S. (1930). *Intellectual growth in young children*. London: Methuen. In press.

Jones, E., & Reynolds, G. (2011). *The play's the thing: Teachers' roles in children's play*. New York, NY: Teachers College Press. In press.

Kelemen, D., Emmons, N. A., Schillaci, R. S., & Ganea, P. (2014). Young children can be taught basic natural selection using a picture-storybook intervention. *Psychological Science, 25*(4), 893–902. https://doi.org/10.1177/0956797613516009.

Kini, T., & Podolsky, A. (2016). Does teaching experience increase teacher effectiveness? *A Review of the Research (Palo Alto: Learning Policy Institute)*, 1–72. In press.

Klahr, D., & Nigam, M. (2004). The equivalence of learning paths in early science instruction: Effects of direct instruction and discovery learning. *Psychological Science, 15*(10), 661–667. https://doi.org/10.1111/j.0956-7976.2004.00737.x.

Kuhn, D. (2001). How do people know? *Psychological Science, 12*(1), 1–8. https://doi.org/10.1111/1467-9280.00302.

Kuhn, D., Cheney, M., & Weinstock, M. (2000). The development of epistemological understanding. *Cognitive Development, 15*(3), 309–328. https://doi.org/10.1016/S0885-2014(00)00030-7.

Kurkul, K., Dwyer, J. & Corriveau, K.H. (in press). 'What do YOU think?': Children's questions, teacher's responses and children's follow-up across diverse preschool settings. Early Childhood Research Quarterly.

Kurkul, K. E., Castine, E., Leech, K., & Corriveau, K. H. (2021). How does a switch work? The relation between adult mechanistic language and children's learning. *Journal of Applied Developmental Psychology, 72*, Article 101221. https://doi.org/10.1016/j.appdev.2020.101221.

Kurkul, K. E., & Corriveau, K. H. (2018). Question, explanation, follow-up: A mechanism for learning from others? *Child Development, 89*(1), 280–294. https://doi.org/10.1111/cdev.12726.

Legare, C. H., & Lombrozo, T. (2014). Selective effects of explanation on learning during early childhood. *Journal of Experimental Child Psychology, 126*, 198–212. https://doi.org/10.1016/j.jecp.2014.03.001.

Legare, C. H., Mills, C. M., Souza, A. L., Plummer, L. E., & Yasskin, R. (2013). The use of questions as problem-solving strategies during early childhood. *Journal of Experimental Child Psychology, 114*(1), 63–76. https://doi.org/10.1016/j.jecp.2012.07.002.

Legare, C. H., Sobel, D. M., & Callanan, M. (2017). Causal learning is collaborative: Examining explanation and exploration in social contexts. *Psychonomic Bulletin and Review, 24*(5), 1548–1554. https://doi.org/10.3758/s13423-017-1351-3.

LeVine, R. A., LeVine, S., Schnell-Anzola, B., Rowe, M. L., & Dexter, E. (2011). *Literacy and mothering: How women's schooling changes the lives of the world's children*. Oxford, England: Oxford University Press.

Lombrozo, T., Bonawitz, E. B., & Scalise, N. R. (2018). Young children's learning and generalization of teleological and mechanistic explanations. *Journal of Cognition and Development, 19*(2), 220–232. https://doi.org/10.1080/15248372.2018.1427099.

Luce, M. R., Callanan, M. A., & Smilovic, S. (2013). Links between parents' epistemological stance and children's evidence talk. *Developmental Psychology, 49*(3), 454–461. https://doi.org/10.1037/a0031249.

Mills, C. M., Danovitch, J. H. Mugambi, V. N., Sands, K. R., & Fox, C. P. (in press). "Why do dogs pant?": Characteristics of parental explanations about science predict children's knowledge. Child Development.

Mills, C. M., Danovitch, J. H., Rowles, S. P., & Campbell, I. L. (2017). Children's success at detecting circular explanations and their interest in future learning. *Psychonomic Bulletin & Review, 24*(5), 1465–1477. https://doi.org/10.3758/s13423-016-1195-2.

Mills, C. M., Legare, C. H., Bills, M., & Mejias, C. (2010). Preschoolers use questions as a tool to acquire knowledge from different sources. *Journal of Cognition and Development, 11*(4), 533–560. https://doi.org/10.1080/15248372.2010.516419.

Mills, C. M., Legare, C. H., Grant, M. G., & Landrum, A. R. (2011). Determining who to question, what to ask, and how much information to ask for: The development of inquiry in young children. *Journal of Experimental Child Psychology, 110*(4), 539–560. https://doi.org/10.1016/j.jecp.2011.06.003.

Next Generation Science Standards: For States, By States. (2013). https://doi.org/10.17226/18290

Osborne, J., & Reigh, E. (2020). What makes a good question? Towards an epistemic classification. In L. P. Butler, S. Ronfard, & K. H. Corriveau (Eds.), *The Questioning Child: Insights from Psychology and Education* (pp. 281–330). United Kingdom: Cambridge University Press.

Podolsky, A., Kini, T., & Darling-Hammond, L. (2019). Does teaching experience increase teacher effectiveness? A review of US research. *Journal of Professional Capital and Community*, 1–8. https://doi.org/10.1108/JPCC-12-2018-0032.

Rogoff, B. (2003). *The cultural nature of human development*. New York, NY: Oxford University Press.

Ronfard, S., Bartz, D. T., Cheng, L., Chen, X., & Harris, P. L. (2018). Children's developing ideas about knowledge and its acquisition. In *Advances in Child Development and Behavior: 54* (pp. 123–151). https://doi.org/10.1016/bs.acdb.2017.10.005.

Ruggeri, A., & Lombrozo, T. (2015). Children adapt their questions to achieve efficient search. *Cognition, 143*, 203–216. https://doi.org/10.1016/j.cognition.2015.07.004.

Sak, R. (2020). Preschoolers' difficult questions and their teachers' responses. *Early Childhood Education Journal, 48*(1), 59–70. https://doi.org/10.1007/s10643-019-00977-x.

Shtulman, A., & Checa, I. (2012). Parent-child conversations about evolution in the context of an interactive museum display. *International Electronic Journal on Elemental Education, 5*, 27–46.

Tabors, P. O., Roach, K. A., & Snow, C. E (2001). Home language and literacy environment: Final results. In D. K. Dickinson, & P. O. Tabors (Eds.), *Beginning literacy with language: Young children learning at home and school* (pp. 111–138). Baltimore, MD: Paul H Brookes Publishing.

Tenenbaum, H. R., & Callanan, M. A. (2008). Parents' science talk to their children in Mexican-descent families residing in the USA. *International Journal of Behavioral Development, 32*(1), 1–12. https://doi.org/10.1177/0165025407084046.

Uccelli, P., Demir-Lira, Ö. E., Rowe, M. L., Levine, S., & Goldin-Meadow, S. (2019). Children's early decontextualized talk predicts academic language proficiency in midadolescence. *Child Development, 90*(5), 1650–1663. https://doi.org/10.1111/cdev.13034.

Uscianowski, C., Almeda, Ma. V., & Ginsburg, H. P. (2020). Differences in the complexity of math and literacy questions parents pose during storybook reading. *Early Childhood Research Quarterly, 50*, 40–50. https://doi.org/10.1016/j.ecresq.2018.07.003.

Valle, A. (2009). Developing habitual ways of reasoning: Epistemological beliefs and formal emphasis in parent-child conversations. *Journal of Developmental Processes, 4*(2), 82–98 DOI: NA.

Weisman, K., & Markman, E. M. (2017). Theory-based explanation as intervention. *Psychonomic Bulletin & Review, 24*(5), 1555–1562. https://doi.org/10.3758/s13423-016-1207-2.

Willard, A. K., Busch, J. T. A., Cullum, K. A., Letourneau, S. M., Sobel, D. M., Callanan, M., & Legare, C. H (2019). Explain this, explore that: A study of parent–child interaction in a children's museum. *Child Development, 90*, 598–617. https://doi.org/10.1111/cdev.13232.

Yu, Y., Shafto, P., Bonawitz, E., Yang, S. C.-H., Golinkoff, R. M., Corriveau, K. H., Hirsh-Pasek, K., & Xu, F. (2018). The theoretical and methodological opportunities afforded by guided play with young children. *Frontiers in Psychology, 9*, 1–8. https://doi.org/10.3389/fpsyg.2018.01152.