Prompting Children's Curiosity Through Questions: An Experimental Test of Framing in Science Learning

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Abstract

Promoting curiosity may support learning, but there is little research assessing effective methods of promoting curiosity in children. Framing a lesson using questions to make uncertainty salient may be one such method. This study examined whether question framing led to higher self-reported and demonstrated curiosity compared to a statement-framing. Children (age 7-8, *N* = 110 after exclusions) were randomly assigned to hear a science activity introduced using either statements or a question about what they could learn, or they generated their own question about what could be learned. Children then engaged in exploration to learn. Curiosity was assessed using self-report before and after the exploration activity, and time exploring and number of explorations during the task. There were no differences across conditions, but children's self-reported curiosity before exploration predicted their behavioral curiosity, supporting the use of children's self-reported curiosity in future research. Possible explanations for the results are discussed.

Keywords: curiosity; question-framing; uncertainty; science learning

Instructional Framing and Children's Curiosity

Curiosity arises when there is something one doesn't know—a knowledge gap—that then motivates information seeking to resolve (Lowenstein, 1994). While uncertainty can motivate exploratory behavior to resolve it (Grossnickle, 2016; Shin & Kim, 2019), awareness of a knowledge gap, or uncertainty more generally, does not always lead to curiosity (Gruber & Ranganath, 2019). This study explored whether introducing something unknown using a question leads to higher curiosity than introducing it as a statement. Children's curiosity informs their developing understanding of the world and how they make sense of it (Jirout et al., 2024), and several studies show associations between curiosity and learning and academic achievement (Shah et al., 2018; Kang & Kim, 2024). Thus, understanding how to foster children's curiosity could support educational practice, and using questions to introduce uncertainty may be a way to do so.

Curiosity

The current study focuses on children's in-the-moment (state) curiosity, operationalized as information-seeking behaviors that are intrinsically motivated with the goal to resolve uncertainty (Jirout et al., 2024). People explore when there is something unknown, or uncertain, such as after a surprising or ambiguous outcome (Lowenstein, 1994), a pattern observed across ages and contexts. For example, infants increase exploration and hypothesis-testing behaviors and learn more about the objects after viewing events inconsistent with their expectations (Stahl and Feigenson, 2015). In adults, reading stories with contradictory or "uncertain" outcomes relates to a stronger curiosity to know more when compared to expected story outcomes (Campion et al., 2009). Experiencing unresolved uncertainty prompts readers to seek explanations to provide understanding.

Several studies suggest a non-linear effect of uncertainty and curiosity, a "Goldilocks effect", where some uncertainty is more likely to lead to curiosity than too much or too little (Lowenstein, 1994; Kidd et al., 2012). For example, when children are introduced to a toy with a causal mechanism and then given a chance to play with the same toy or a new toy, they choose the same toy if the demonstration they saw did not clearly show how the toy worked, even though they had less knowledge about how the new toy worked; if they saw unambiguous demonstrations of how the toy worked, they chose the new toy (Schulz & Bonawitz, 2007). Adults similarly show this effect, such as when experiencing a "tip-of-tongue" (TOT) feeling of knowing, rather than confidently knowing or not knowing something, with TOT related to higher curiosity ratings and exploratory behavior (Markey & Loewenstein, 2014; Litman et al., 2005).

The patterns between uncertainty and curiosity can also generalize into educational contexts. For example, in a study of middle-school-age children, experiencing levels of uncertainty during a science lesson led to higher levels of curiosity, as well as higher transfer of learning compared to students who did not experience uncertainty (Lamnina & Chase, 2019). These and similar studies highlight that when an information gap is made salient, curious exploration increases both in lab-based and educational contexts.

Though research consistently shows uncertainty or information gaps leading to curiosity, the reasons for why this happens can build understanding of how and when to use uncertainty for promoting curiosity for learning. One such explanation comes from the Prediction, Appraisal, Curiosity,

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and Exploration (PACE) framework (Gruber & Ranganath, 2019). This framework proposes that curiosity typically starts with uncertainty related to an error in prediction, or something unexpected. When faced with this uncertainty, the process of appraising one's expectations of attaining the needed information and other relevant contextual information will determine whether the uncertainty will lead to curiosity (Gruber & Ranganath, 2019). If curiosity is elicited, it then supports learning by increasing attention and memory consolidation during exploration and information-seeking. The PACE cycle is complete when uncertainty is resolved, and a closure of an information gap satisfies curiosity.

The way information is presented may influence how learners reason about that information and influence whether it leads to curiosity. Framing of learning goals, such as when introducing a lesson, could impact the appraisal process. Presenting information in ways that activate relevant prior knowledge, supporting learners' sense of efficacy, and increasing their desire to learn more may be most effective in fostering curiosity. The typical practice of telling students what they need to know or learn may or may not get them to activate prior knowledge, as it is involves shallow cognitive engagement (Chi & Wylie, 2014). To promote deeper cognitive engagement, instructional language could present learning goals framed as questions, which might elicit hypothesis generation and planning for information seeking. To further ensure learners activate relevant prior knowledge, learners could generate their own questions to frame learning (Chi & Wylie, 2014). The current study explores these strategies to test if they influence children's self-reported and demonstrated curiosity in an elementary- level science learning task.

Questions to Create Uncertainty

Question generation helps children identify what they already know, which supports sense-making related to curiosity (Jirout, 2020). In other words, question generation allows for cognitive reflection of what the information learned represents, how it interacts with what is already known, and what is left to figure out. Questions can serve as a tool to make information gaps salient to students, which can support engagement and retention of content learned in class (Baranes et al., 2015; Kang et al., 2009; Gruber et al., 2014). This salience of the information gap may be further strengthened by supporting deeper cognitive engagement through the process of reasoning about the question, and further yet by generating a question (Chi & Wylie, 2014). Questions might also highlight uncertainty in way of an unknown answer and, consequently, promote curiosity.

Questions have long been used as a foundation for guiding learning, with the Socratic Method named for this approach more than two millennia ago, and learners' own questions have been suggested to be mechanisms of their learning (Chouinard et al., 2007). Many questions in classrooms are for management or organizational questions, or are closed-ended, which might limit their effectiveness in supporting thinking and promoting curiosity (Svanes & Andersson-Bakken, 2023; Kucuktepe, 2010). Yet, as Socrates demonstrated, questions can shape the way learners think about the goals of their learning and reason beyond looking for simple answers. Pedagogical questioning, when a question is asked by a knowledgeable person with the intent to teach and promote learning, rather than receive an answer, leads to more exploration and better learning, even when a task is an unsolvable problem (Jean et al. 2019). Exploration supported by pedagogical questioning can guide learning (Yu et al., 2018; Jean et al. 2019), possibly by promoting curiosity. This is seen in studies of information seeking and learning. For example, when a novel toy was introduced with questions compared to direct instructions, young children explored the toy more (Yu et al., 2018). In another study, introducing a shape-learning activity with a question ("did you know all shapes have secrets?") led to deeper understanding of shapes than didactic instruction or free play (Fisher et al., 2013).

While pedagogical questions focus on questions asked by a teacher, learner-generated questions may also provide benefits, and they might specifically benefit curiosity. In adolescents, curiosity was significantly higher after learning a question brainstorming technique compared to those who did not learn the technique (Clark et al., 2019). In younger children, those who were encouraged to ask questions placed higher value on new information compared to children in a condition that encouraged them to listen carefully (Park et al., 2025). Unprompted question asking is often viewed as a sign of curiosity, and children's question-asking in classroom learning shows that when learning activities include questions, children are more likely to then ask questions themselves. This suggests that questions in learning can lead to curiosity (Zimmerman & Pike, 1972), perhaps by social cues to support question asking (Lempers & Miletic, 1983).

Returning to the appraisal process in the PACE model, questioning and question generation may be effective ways of inducing epistemic uncertainty in educational contexts (Overoye & Storm, 2015). These strategies can support the contextual conditions under which curiosity can emerge, potentially promoting deeper levels of cognitive processing of the activity goals through uncertainty leading to curiosity.

The Current Study

The empirical and theoretical work suggests that uncertainty can initiate curiosity. Thus, it may be possible to intentionally foster curiosity and learning through uncertainty. The current study investigates whether introducing uncertainty through question asking and question generation is more effective in promoting curiosity than framing a learning activity and goals with statements. Our first research question tests whether question framing leads to higher curiosity than introducing uncertainty as a statement alone. We hypothesize that question framing (both formulating a question and being given a question) will report and demonstrate significantly higher curiosity than statement framing (Hypothesis 1).

Our second research question asks whether there is a difference across conditions of learners being given a a question, or generating their own question when compared to a statement. We expected self-generation to lead to higher curiosity (Hypothesis 2). Lastly, our third research question asks whether self-reported curiosity relates to demonstrated curiosity. We predicted that both pre- and post-exploration self-reported (internal) curiosity would relate to children's exploration behavior, which reflects external curiosity (Hypothesis 3). Altogether, this study contributes knowledge of how different question conditions relate to children's curiosity during science learning.

Methods

Participants

Participants were recruited from a lab database and through community partners in two US locations: a large, densely populated Northeastern city and a smaller, university-affiliated Southeastern city. We preregistered 7-8-year-old participants, but our recruitment sites and methods led to data collection including 136 6-to-9-year-old children. Children were excluded based on age and other preregistered criteria as described below. The final sample included 110 7-8-year-old children (M = 7.49 years, SD = 0.50 years) with 59 boys, 50 girls, and one nonbinary child. We did not collect further demographic data.

Exclusion Criteria There were a total of 26 excluded participants; 11 of these were in the statement condition, six in the question-given condition, and nine in the question-generation condition. As we preregistered, children were excluded if outside of our 7-to-8-year old age range (or if age was not reported; n = 12), if technological errors resulted in not being able to code responses (e.g., video cut-offs during critical study measures and lost videos; n = 9), or if children did not complete the tasks or there were protocol errors (e.g., if the condition manipulation did not follow the script, if the child chose not to answer the majority of questions; n = 5). Additionally, two participants were excluded from a specific measure (i.e., only the post-curiosity survey) due to incomplete data (n = 1) or technological errors during the measure (n = 1). Because we had more exclusions than expected, we recruited from an additional site to get closer to our preregistered sample size to have sufficient statistical power (preregistered N = 120, expected attrition = 9, see https://osf.io/nks8j/overview).

Missing Data Children were included in the analytic sample if they completed both the pre-curiosity survey and the behavioral curiosity task. If a child did not complete either of these two primary measures, their data were excluded from all analyses. For the remaining study measures, children were included in each analysis if they had complete data for the specific task and any covariates in that model. When children were missing data for a given measure, they were excluded from analyses involving that measure only.

Measures and Procedures

The study was approved by the University of Virginia Institutional Review Board, and caregiver consent and child assent were collected before study participation. Children participated individually with a researcher in a lab space or at a table at their school or camp. Sessions began with children hearing an overview of what density is. They then heard about how science involves testing things to learn, followed by instructions to learn about what things sink or float in water, with specific instructional language based on their assigned condition. After the instructional manipulation, children completed a pre-knowledge assessment with five materials, reporting whether each would sink or float and why, followed by a pre-exploration curiosity survey. Children then engaged in a sink-or-float exploration activity with ten new materials, followed by a post-knowledge assessment with the original five materials and a post-exploration curiosity survey. The experiment ended with a surprising event demonstration and additional questions. The current study focuses on the condition manipulation, pre- and post-curiosity surveys, and sink or float exploration activity, as other measures are still being coded.

Question Framing Manipulation Children were randomly assigned to one of three between-subjects conditions that differed in instructional language framing the activity. In the Control Condition (C; n = 36), children were given learning goals as statements from the experimenter (i.e., "We can test things out to learn about them, which is what we do when we do science. When we test things, it can be a way of exploring. In this activity, you can explore with these materials to try and learn about what kinds of things are more or less dense than water."). In the Question-Given Condition (QGiven; n = 32), learning goals were presented as questions (i.e., "When we do science, we ask questions and try test things out to answer them. Like, I'm curious to know, what kinds of things are more or less dense than water? Can you explore and test things with these materials to figure out what kinds of things are more or less dense than water?"). In the Question-Generation Condition (QGen; n = 42), the researcher scaffolded children in coming up with their own questions (i.e., "When we do science, we ask questions and try test things out to answer them. You can explore and test things with these materials, what do you want to know and what could you figure out?"). If children were unable to generate questions (n = 11) after scaffolding, they were read the question-framing prompt from the Question-Given condition.

Curiosity Surveys Children self-reported their state curiosity before exploration (pre-curiosity survey) and again after the exploration activity (post-curiosity survey). Each scale used a graphical Likert scale (see Figure 1) ranging from 1-5 with descriptions of 1 (not at all like you/how you feel), 3 (some, kind of like you, or you're not sure) and 5 (really, really a lot like you/very very much how you feel).

For the *pre-curiosity survey*, children answered 6 questions about how much they wanted to explore with a set of new materials. The first three items, asked after the seeing the five knowledge-test objects, were: 1) How would you feel if I had a new set of materials you could explore? 2) I would want to figure things out about the materials. 3) I would be excited to explore the materials. Children then saw a set of 10 new materials and answered three additional items: 4) How much do you want to learn about density? 5) How excited are you to do this exploration? 6) How curious are you about these materials? The six items were averaged ($\alpha = .70$), with higher values indicating greater state curiosity prior to exploration.

For the *post-curiosity survey* after exploration, children answered 6 items about their state curiosity, with one additional item dropped due to poor reliability: 1) I want to know more about density and these materials; 2) I feel curious about what I just worked on; 3) Exploring these materials made me feel excited; 4) I feel interested in what I just worked on; 5) I want to explore more questions about what I just worked on; 6) I would like to keep exploring materials like this. The post-curiosity survey used referred to the same 10 materials as the pre-curiosity survey (#s 4-6) and exploration activity. Item scores were averaged ($\alpha = .82$).

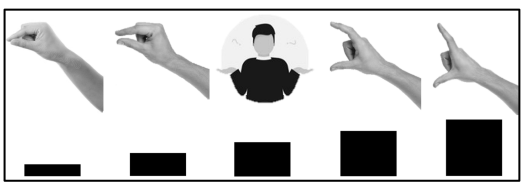

Figure 1. Scale used in pre- and post-curiosity surveys.

Exploration Activity After rating their curiosity to explore the 10 materials presented in the pre-curiosity survey (bowtie pasta, popsicle stick, birthday candle, playdough ball, sponge, magnet, pufferfish bath toy, scrunchie, paper clip, and rubber band), children explored the items with a water-filled tank. Participants were told they could explore and could let the experimenter know when they were finished exploring. If a child did not engage with the materials for approximately 30 seconds, the experimenter asked, "Would you like to keep exploring, or are you all done?" After children indicated they were done or after 10 minutes, the exploration period ended and all materials, except the water tank, were placed out of the child's view. Videos of children's exploration were coded for total exploration time (in seconds) and total number of explorations attempted. Interrater reliability was assessed on a double-coded subset of participants (n = 67) using a two-way random-effects intraclass correlation coefficient with absolute agreement, ICC (A,1). Reliability was excellent for total exploration time, ICC (A,1) = .96, 95% CI [.941, .977], and moderate for total number of explorations, ICC (A,1) = .71, 95% CI [.564, .810] (Shrout & Fleiss, 1979).

Results

Descriptives

Data for the curiosity measures were available for 110 children for pre-exploration curiosity and exploration, and 108 children for post-exploration curiosity (see Methods for exclusion information). On average, there were no ceiling effects though children's self-reported curiosity was skewed. Children generally rated their curiosity as slightly below four on the five-point scale, explored on average for about 4.7 minutes of the 10 minutes possible (only 20 children explored the full 10 minutes), and conducted about 27 explorations on average. See Table 1 for descriptive statistics for all curiosity measures.

Table 1: Descriptive statistics of curiosity measures

Curiosity measures	*n*	*M*	*SD*	Range
Pre-curiosity	110	3.90	.66	1.5 - 5
Total explorations	110	27.40	17.89	9 - 104
Exploration time	110	281.13	205.16	35 - 600
Post-curiosity	108	3.81	.88	1.17 - 5

Analytic Overview

All analyses used ordinary least squares regression models. For condition analysis, age in months[1] and gender[2] were included as covariates. Condition was first treated as assigned, following an intention-to-treat (ITT) analysis, and then the condition was treated as implemented, testing for a treatment-on-the-treated (TOT) effect. The TOT analysis excluded participants who were unable to generate questions, resulting in new group sizes of: C (n = 36), QGiven (n = 32), QGen (n = 31). We do not report these analyses, as the results showed the same patterns as the ITT models. Sensitivity analysis excluding outliers, defined as values exceeding ±2 SD on pre-exploration curiosity (n = 4), exploration time (n = 0), total number of exploration (n = 3), and post-exploration curiosity (n = 2) variables were conducted.

RQ1: Does Question Framing Increase Children's Curiosity in a Science Activity?

Controlling for age and gender, separate linear regressions were conducted predicting each curiosity measure (pre-curiosity, exploration time, number of explorations, and post-curiosity) from question framing, using a planned contrast comparing the Control condition (coded 0) to a combined

[1] Two participants did not provide their age in months; consequently, they were only included in the descriptive statistics.

[2] Gender was binary coded (0=male and 1 =female); one nonbinary participant was included in the descriptive statistics but excluded from regression analysis due to limited cell size.

Question condition (Question-Given & Question-Generation; coded 1). Question framing was not significantly associated with Pre-curiosity (b = −0.12, SE = 0.13, 95% CI [−0.38, 0.15], t(103) = −0.88, p = .38), Exploration Time (b = −40.65, SE = 41.75, 95% CI [−123.45, 42.14], t(103) = −0.97, p= .33), Number of Explorations (b = 0.32, SE = 3.40, 95% CI [−6.42, 7.05], t(103) = .09, p = 0.93), or Post-curiosity (b = 0.20, SE = 0.18, 95% CI [−0.17, 0.56], t(101) = 1.07, p = .29). For sensitive analysis, we ran all models without outliers, and there was no significant change in the pattern of results.

RQ2: Are There Differences in Children's Curiosity Across Control, Question-Given, and Question-Generation Conditions?

To examine whether curiosity differed across all three ITT conditions (Control, Question-Given, and Question-Generation), we ran separate linear regressions for each outcome (pre-curiosity, exploration time, number of explorations, and post-curiosity), including condition as a categorical predictor and controlling for age and gender. There was no significant difference across conditions for any outcome measures (see Table 2 for estimated means and statistical results).

Table 2: Estimated marginal means (SE) across ITT conditions and omnibus tests

Curiosity measures	C	QGiven	QGen	Omnibus condition test
Pre-curiosity	3.96 (.11)	3.78 (.12)	3.89 (.10)	*F*(2, *102) = 0.64, p = .53*
Total explorations	26.6 (2.76)	30.2 (3.05)	24.4 (2.59)	F(2, 102) = 1.03, p = .36
Exploration time	305 (33.9)	302 (37.5)	236 (31.9)	F(2, 102) = 1.36, p = .26
Post-curiosity	3.67 (.15)	3.87 (.17)	3.86 (.14)	F(2, 100) = 0.57, p = .57

Note. Values are estimated marginal means (SE), adjusted for age in months and gender. Omnibus tests compare models with and without condition (controlling for covariates).

RQ3: Does Self-reported Curiosity (Internal) Relate to Demonstrated Curiosity (External)?

We examined associations among children's pre-exploration self-reported curiosity, post-exploration self-reported curiosity, total exploration time, and total number of explorations using linear regression analyses. We also ran all models with and without outliers.

Linear regression analyses indicated that pre-exploration curiosity was a significant predictor of exploration time (b = 83.83, SE = 29.08, 95% CI [26.18, 141.49], t(105) = 2.88, p = .005). Pre-exploration curiosity was also a significant predictor of the total number of explorations (b = 4.96, SE = 2.39, 95% CI [0.23, 9.68], t(105) = 2.08, p = .04). Pre- and post-exploration curiosity were highly related; pre-exploration curiosity significantly predicted post-exploration curiosity (b = 0.75, SE = 0.11, 95% CI [0.53, 0.97], t(103) = 6.80, p < .001). Demonstrated curiosity was not significantly associated with post-exploration curiosity. Neither exploration time (b = 0.0005, SE = 0.0004, 95% CI [−0.0004, 0.0013], t(103) = 1.06, p = .29) nor total of explorations (b = 0.01, SE = 0.01, 95% CI [−0.0033, 0.0175], t(103) = 1.35, p =.18) predicted post-curiosity. Age in months was a non-significant predictor in all of the linear models.

Excluding outliers did not change the overall pattern of results. Outliers included children with explorations about more than triple the average: 79, 83, 104, with self-reported curiosity of 3.66-4.5; four children had very low self-reported curiosity: 1.5-2.5, with average explorations: 10, 13, 27, 34. These values slightly changed the regression coefficient of pre-curiosity predicting exploration (b = 4.96, 95% CI [0.23, 9.68], p = .04 to b = 5.06, 95% CI [−0.07, 10.19], p = .053).

Discussion

This study investigated how framing a learning activity within a question influences 7- to 8-year-olds' curiosity, whether being given vs. generating questions mattered, and whether self-reported curiosity related to demonstrated curiosity during a science learning activity. No differences were observed between either of the question-framing conditions and the non-question-framing condition. Children's self-reported pre-exploration curiosity did predict children's exploratory behavior and post-exploration curiosity.

Explanations for the lack of differences observed for question-framing on curiosity may be related to the activity structure, by providing a specific learning goal (understand density), or it might be that the manipulation was unclear, with language about exploration also included in the control condition. Related to the activity structure, much of the past work considers curiosity to be related to non-instrumental information seeking, but the focus on science learning in a realistic context, as used here, creates a goal-driven context that might be misaligned with prior work (e.g., Jirout et al., 2024; van Lieshout et al., 2020). Specific goals given to children, not goals related to their own curiosity, might lead to the desire for efficiency or effectiveness, creating competition between the explore/exploit tradeoff. Children may best achieve the given goal by focusing on what will provide the best information about density, rather than explorations of what they may want to know, such as their own hypotheses about materials unrelated to thinking about density. Thus, children across all three conditions may have been similarly exploring based on the learning goals, rather than curiosity. Although children tend to be more explorative than adults, they are still influenced by the task contexts and goals, and the information gained during exploration (Liquin & Gopnik, 2022; Lapidow & Bonawitz, 2023).

Children's trait curiosity may also have impacted their state curiosity (Whatley et al. 2025), which was not measured or controlled for due to the length of the study. It could be that controlling for trait curiosity may have shown differences by condition by reducing the variability of that individual difference, such as in a recent study of autonomy support (Natalie et al., in prep). Finally, it is also possible that stronger instructional manipulation was needed to have an impact, such as more frequent question framing strategies and additional prompting. These are all possibilities that can be explored in future studies.

Related to the specific language used, explicit question language was used in the two experimental conditions, but exploration may have been unintentionally emphasized in the control condition (mentioned twice, compared to once in the question conditions). Thus, in such an open-ended task, the support for exploration in a more instructional way without specifying what children should do may have been more curiosity-promoting (than intended), making all conditions similarly curiosity-promoting in different ways (i.e., promoting curiosity through questioning vs. encouraging exploration). Further, the non-question-based instruction could scaffold information seeking at a more appropriate level by reducing cognitive load, which may also support curiosity (Jirout et al., 2018).

The effects of cognitive demands across the conditions may also have impacted children's reasoning, especially considering its focus on a novel science topic (i.e., density). The process of generating questions may have created excessive cognitive load for children, reducing their ability to focus on what they could be curious to learn. In addition to requiring greater cognitive resources more generally, generating questions about a topic without much prior knowledge can be challenging (Wade & Kidd, 2019), and when little is known about something, people are less likely to become curious (Lowenstein, 1994). Attempts to avoid this challenge by giving an initial lesson in density may have been insufficient. The information about density may have overwhelmed children, which could impact the appraisal process of the curiosity cycle, during which one might consider uncertainty to be overwhelming (Gruber & Ranganath, 2019).

The observed association between pre- and demonstrated curiosity (self-reported curiosity and behavioral curiosity) aligns with prior research in adults and contributes evidence of this link in children. Importantly, the observed associations show this link in learning-related information seeking designed to be similar to what children would experience in classroom learning, supporting the potential role of using self-reported measures to study curiosity in formal educational contexts and the possibilities of using curiosity in motivation interventions.

The lack of association between post-exploration curiosity and exploration suggests that children's curiosity may have been satisfied by their exploration, because children had already acted on their curiosity, and that new curiosities were not generated. This is consistent with similar research with older children in classroom contexts (Lamnina & Chase, 2021). It is also possible that children's exploration may have been motivated by curiosity that was not addressed in the curiosity questions asked, or that the exploration was not motivated by curiosity at all, in that children were instructed to explore so may have done so even if not curious. The constrained nature of this task may have also reduced uncertainty for children to become curious about (closing the information gap without providing opportunities for new curiosities). Next steps in this work are to explore children's responses to a follow-up surprise variation to the task. As operationalizing and measuring curiosity is an increasingly important topic (Jirout et al., 2024), understanding whether self-reported measures map onto behavior is essential to support their use in large-scale studies of curiosity, such as those conducted in schools.

Limitations and Future Directions

The current study has several limitations that should be considered when interpreting its findings. First, besides age and gender, we were not able to collect other demographic information, such as SES, race, and ethnicity, limiting the generalizability of our findings to a diverse population and to different cultures. It is also important to note that this study was conducted in a laboratory setting, or in spaces outside of classrooms or in learning spaces when children were pulled from class or camp to participate, creating controlled environments with minimized distractions and one-on-one interaction with the "teacher". As we learn more about promoting curiosity, future work must continue to design methods that explore children's curiosity and learning in real classroom environments. Additionally, we had higher than anticipated exclusion rates and some unanticipated failure in our question-generation condition, and insufficient power to explore potential differences between children who were and were not able to successfully generate a question. We will continue to expand on these findings in future publications, including looking at the specific questions children generated and learning assessed before and after exploration.

Conclusion

This study suggests that question-framing instruction, as implemented here, may not have curiosity-promoting impacts beyond exploration-focused instructions of learning goals. The findings suggest the need for further research exploring pedagogical strategies used to promote elementary-aged children's curiosity. Importantly, the results provide support for using children's self-reported curiosity in research, as it predicts curious behaviors in a learning context. This work contributes to the growing body of research seeking to understand how curiosity develops and how it can be intentionally supported through instructional practices.

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