Capturing Curiosity: Task-Based Differences in Children's Exploratory Behavior

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Abstract

This study explored differences in children's information seeking in the two exploration tasks aligned with proposed curiosity frameworks. One task provided an open-ended unlimited information seeking design assessing the frequency of exploration attempts across similar options; the second was a constrained information seeking design with limits on how much could be explored, focusing instead on what children chose among varying levels of uncertainty. Children's information seeking did not relate between the two tasks, and children give different explanations for their motivation for seeking information that aligned with the different designs; in the open-ended task children's exploration was motivated by more superficial and perceptual features, while in the constrained task they described desiring information and mentioned uncertainty and mystery. Potential implications of the results are discussed.

Keywords: curiosity; uncertainty, exploration, information seeking, children, measurement

Curiosity and Information Seeking

Evidence suggests that curiosity promotes a range of positive outcomes from exploration and persistence in information seeking to academic performance and longer-term well-being (Kashdan & Silvia, 2009; Kashdan & Steger, 2007; von Stumm et al., 2011). It is widely believed that learning and innovative thinking are driven by curiosity (Livio, 2017, Kashdan et al., 2013). In adults, curiosity relates to engagement and persistence when facing obstacles and setting goals (Kashdan & Steger, 2007). In children, it supports academic performance, even when controlling for students' effort and ability (von Stumm et al., 2011). Curiosity can help to develop sustained interests, and, in turn, promote self-regulation, information seeking, and motivation (Renninger, 2000; Hidi & Renninger, 2006). Despite these positive findings, and the belief that children are naturally curious (e.g., Dewey, 1910), some evidence suggests that curiosity dissipates over time (Engelhard & Monsaas, 1988), perhaps due to formal schooling (Engel, 2015).

While this research highlights potential benefits of curiosity, synthesizing across these studies is limited by the variability in ways the construct was conceptualized and measured (Jirout & Klahr, 2012). In children, many measures of curiosity are indirect, such as using teacher or parent ratings (e.g., Shah et al., 2018; Alberti & Vitriol, 1994). Sometimes children are asked to indicate their curiosity on survey measures, similar to methods commonly used with adults, but there is little evidence for these measures predicting children's actual curiosity behaviors.

When observations of behavior are used, measures vary in what is observed. Some researchers use the frequency of questions asked or other information seeking behavior as indication of curiosity, without considering why children sought information (Jirout et al., 2024). This is potentially problematic, as curiosity is assumed to be intrinsically motivated but observed behavior is often linked to specific external goals or rewards. Other research has assessed the type of information children sought, such as preferring to explore when there were higher or lower levels of information to be learned (e.g., Jirout & Klahr, 2020; van Schijndel et al., 2018; Ruggeri et al., 2019), though this would still be limited if the information was sought for specific goals, like solving a given problem, rather than seeking non-instrumental information.

There is no "right" measure to use or idea of what should be measured; the lack of a universally accepted conceptualization of curiosity or measure in children is likely because curiosity is multidimensional and complex (Jirout & Klahr, 2012). In parent-report measures, children's tendencies to think and act in curious ways are reported, such as items like "My child has fun learning about new topics or subjects" and "When presented with a tough problem, my child focuses all his/her attention on how to solve it," and these measures relate to expected parent-reported constructs like sensation seeking (Piotrowski et al., 2014). While measures comparing parent-reported curiosity haven't been tested to relate to observed curiosity behaviors in children, some parent-reported curiosity items relate to kindergarten academic achievement (Shah et al, 2018).

Behavioral measures of children's curiosity may provide a more meaningful measure of children's information seeking behavior. Studies vary in how curiosity is assessed across studies, often based on different conceptualizations of curiosity, limiting generalization. For example, some researchers suggest that higher curiosity is related to an optimal level of cognitive conflict, such as from prediction

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error or a gap in information (e.g., Information-Gap Theory and Prediction, Appraisal, Curiosity, Exploration Framework (PACE); Loewenstein, 1994; Gruber & Ranganath, 2019) while other researchers suggest that curiosity is related to higher frequency of information seeking using a reward-learning framework (Murayama et al., 2022). It could be that measures based on these conceptualizations would relate, or they may describe different types or orientations of curiosity. The current study explores these possibilities by assessing relations between children's information seeking patterns on tasks providing children with non-instrumental information seeking aligned with these two frameworks.

In our *"Themed Exploration" (TE)* task, children seek information about countries, with a limited number of choice options varying in the amount of uncertainty presented and limited exploration opportunities. This task was based off the underwater exploration game that assessed children's preference for uncertainty as a measure of curiosity, with validity support in prior research showing associations to teacher reports of children's learning behaviors (Jirout & Klahr, 2012), learning during exploration tasks (van Schijndel et al., 2018), and question asking behaviors (Jirout & Klahr, 2020). This task aligns with the uncertainty or information-gap perspectives of curiosity.

In our *"Explore and Learn"* task (E&L), children seek information about nine different topics in an open-ended platform with the perception of unlimited numbers of information available to explore about those topics, relating to the frequency accounts or reward-learning framework of curiosity. Importantly, both tasks are designed for the information sought to be non-instrumental; there is no externally provided goal or reward that aligns with specific patterns of information seeking. Both tasks were iteratively developed across several rounds of pilot testing to deter superficial choice preferences (e.g., shape) and ceiling effects. In addition to exploring children's patterns of information seeking on these two tasks, we also compare reasons children give for their motivation to explore.

Research Questions

RQ1: Does children's information seeking differ between the explore and learn and themed exploration tasks?
RQ2: Do children's explanations of motivation for their information seeking differ between the explore and learn and themed exploration tasks?

We designed the two tasks with the hypothesis that children would explore differently on them, based on both the amount of exploration and the motivations given for their exploration. Because *TE* aligned more with the information gap theory and PACE Framework, we expected children's explanations to mention uncertainty-related and information-related responses more than *E&L*, as they would need to be more strategic and thoughtful given the constraints. We expected more non-information related motivations in *E&L*, the task aligning with the reward-learning framework, because any exploration would result in information, so there was less need to be strategic. We did not have predetermined hypotheses about how the performance would differ on them in terms of amount of exploration.

Methods

Participants

Participants included 532 6–10-year-olds (*M*= 8.19, *SD*= 1.16, 47% Female, 46% Male, 7% Other or Unknown; 68% with a parent educated with a 4-year degree or higher). Recruitment was conducted using social media and a participant database for online participants (N=212; *Mage*= 8.31, *SD*= 1.37, 50% Female, 49% Male, <1% Gender Non-Binary) or through their schools for in-person participants (N=320; *Mage* at start of study= 8.10, *SD*= 0.97, 45% Female, 45% Male, 10% Unknown).

Measures and Procedures

All children participated in data collection either in their schools or online over Zoom. Prior to participating, parental informed consent was collected via Qualtrics. These data were collected as part of a larger project aimed at developing new measures of children's curiosity, creativity, and creative problem solving, and to assess curiosity promotion and development in schools. We used children's responses on two tasks in the following order: *Explore & Learn (E&L)* and *Themed Exploration (TE).*

Explore & Learn: Open-ended Information Seeking

This task was designed to measure children's free exploration to learn about different topics (see Figure 1). Children had the opportunity to explore and hear up to 63 facts total, seven facts for each of the nine shapes. Exploration was capped at 5 minutes, but children were not told this, so they perceived an unlimited amount of time during exploration, and it was rare for the researcher to end the task.

In *E&L (Open-ended)*, children heard recorded instructions explaining that they will play a game where they explore to learn new things about different topics. They were then shown the home screen with nine shapes and were told they can click the same shape to hear more about the same topic and click different shapes to learn about different topics. They were told they could click the "I'm done" button when they were finished exploring. When a shape was clicked, the screen showed a full-screen image related to the audio fact that was given, and then the program returned to the home screen. When they clicked "I'm done" the researcher confirmed that children meant to click it and wanted to stop, and ended the game if confirmed. The mean length of recorded facts was 5.5 seconds (SD=2.19).

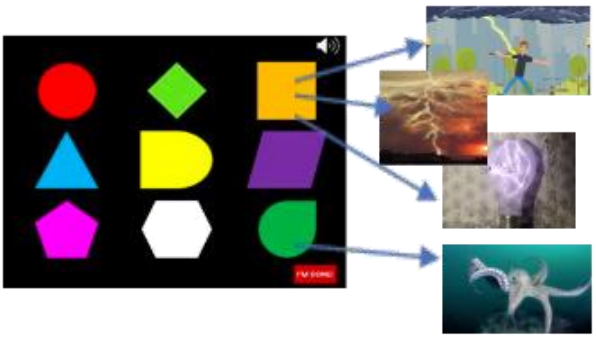

Figure 1. Screenshots from the *E&L (Open-ended)* game. Left: Screenshot of the 9 shapes children could click on to learn about different facts and the "I'm done" button at the bottom to end the game. Right: Examples of screens children saw after clicking a shape.

The nine topics ranged from lightning, the human body, octopuses, video games, to whipped cream. Each click provided an independent fact to avoid introducing new information gaps generated by incomplete or continuing (building) information (Mills et al., 2019). Example facts given about chocolate included: "White chocolate is not real chocolate" and "Chocolate was once used as currency"

After children completed the game by having explored all 63 exploration opportunities, clicked "I'm done", or reached the 5-minute limit, they were asked what else they were curious to know, and then were prompted to explain their motivation with the prompt: "How did you decide to click on shapes? How did you decide which one to click and how did you decide you were done?". Their responses were transcribed and coded to assess their reasons for their information seeking behavior, and the total number of facts explored was used as indication of information seeking.

Themed Exploration: Constrained Information Seeking

This task was designed to measure children's preference to explore across different levels of uncertainty. Children began by listening to audio instructions explaining that they would get to pick three (out of the 10) countries to learn about (see Figure 2). They were shown an example with a single country and question icons below the country and heard an explanation that the question icons indicated how many facts they would learn about the country. The country was then clicked to show children an example of what they would learn and how the number of facts given corresponded to the number of question mark icons.

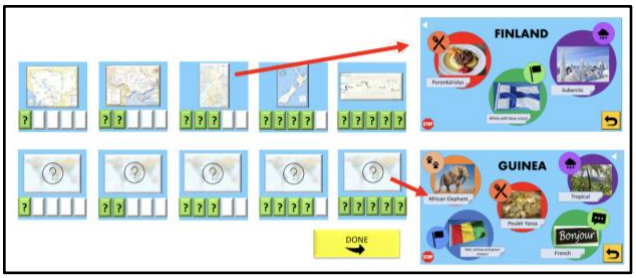

Figure 2. Screenshots from the *TE (Constrained)* game. Left: Screenshot of home screen where children heard instructions and saw a brief demonstration; Right: Examples of screens children saw after choosing a country; while children saw the images, audio with the information about the country played, and the screen returned to the home screen when it was done.

Children then saw an array of ten countries, with five in the top row showing a country section of a map and five in the bottom row showing a blurred world map, indicating nothing about which country the item would give facts about. Along each row, the country options varied from indicating one to five facts that could be learned if that the country was selected. Once the child selected a country, they heard audio about the country containing the number of facts they selected and saw corresponding images. Each country could only be selected once and children could only choose three total to explore, so the minimum number of facts children could learn was four (both options with one fact and one with two) and the maximum number of facts children could explore was fourteen (both options with five facts and one with four). Children could choose all three known (top row) or unknown (bottom row) countries. Once the child picked three countries, they were asked to explain how they chose the countries to explore. We coded both the number of facts selected to learn and the total number of 'unknown' (bottom) countries selected as separate indicators of information seeking.

Explanation Coding

Children's full explanations were coded such that each utterance or statement was coded into one of two categories, information seeking or non-information seeking, and then were further coded into corresponding sub-categories within each. A response could include multiple utterances describing motivations to explore, and each utterance was coded separately. Thus, children could have given multiple types of explanations for their exploration for each task. We coded both the overall number of each type given for each task, as well as the proportion of children who gave each type. Each child utterance was coded by two trained coders (κ = .683). If coders disagreed, an expert coder (e.g., project administrator) would review the utterance and codes and decide. Coding categories are further described below.

Information Seeking Explanations

If children's explanations included specific utterances related to learning or controlling information, it was coded as information seeking. These utterances were further categorized using the following codes:

1. **General Information Seeking:** the child wants more information, but does not specify what they want to know more about. (e.g., "I wanted to know more about it, I liked learning a lot")
2. **Specific Information Seeking:** the child specifically says what they want to know more about. It should be related to the topics in the task. (e.g., "I wanted to know more about otters, I liked the one about the octopus")
3. **Mystery/Unknown Information:** the child described wanted to know things that were a "mystery" or a "surprise"
4. **Regulating amount of information:** child selected a certain item because there were **less** facts. (e.g., "I wanted the one with one question mark, I picked that shape so I only had to learn one fact")
5. **Other:** An explanation related to information seeking that does not fit into a sub-category, but it is clear that they are giving some kind of info seeking response
6. **Ambiguous:** It is unclear what the child is referring to

Non-Information Seeking

If children's responses described their exploration being driven by something unrelated to strategies or the desire for gaining information or finding something out, they were coded as non-information seeking. These utterances were further categorized using the following codes:

1. **Likes superficial features:** The child chose a selection due to superficial aspects of it. Could be that they liked the color, the shape itself, etc.
2. **Order/Spatial Pattern**: The child describes an order or spatial pattern guiding their exploration.
3. **Desire for Completion:** The child describes that they wanted to finish the entire task, select all of them, etc.
4. **I don't know**: the child explicitly says that they don't know why they selected the items
5. **Random:** the child explicitly states that they selected randomly
6. **Other:** non-information seeking reasoning that does not fit into the above categories, but it is clear that the child is giving some kind of non-info seeking response
7. **Ambiguous:** the child's response does not make sense. It is unclear what they are referring to

Results

Descriptives

On average, children explored 17.21 total facts on the *E&L (Open-ended)* task, and 9.73 total facts on the *TE (Constrained)* task. When comparing the raw number of facts explored, 305 children explored more facts in the *E&L (Open-ended)* task, 140 explored more in the *TE (Constrained)* task, and 25 explored the same number of facts in both (missing N= 73), though note that the maximum of explorations on *TE* was only 14. For explanations given across the two tasks, we coded 2006 total utterances. These included 616 information-seeking explanations, and 1390 non-information seeking explanations. See Table 1 for frequencies of each of the coding categories.

Table 1. Frequency of children's information seeking and non-information seeking explanations within the *E&L (Open-ended)* and the *TE (Constrained)* tasks.

Type	Code	E&L Open-ended Freq	TE Constrained Freq	Total Freq
Information Seeking	General Information Seeking *	120	245	365
	Specific Information Seeking	52	53	105
	Mystery/Unknown Information *	4	60	64
	Regulating amount of information	12	15	27
	Other	11	10	21
	Ambiguous *	14	21	35
Non-Information Seeking	Likes superficial features *	100	65	165
	Order/Spatial Pattern *	95	49	144
	Desire for Completion *	91	4	95
	I don't know *	71	37	108
	Random *	21	61	82
	Other *	173	77	250
	Ambiguous *	320	234	554

*indicates difference between E&L & TE task is significant at p <0.01

RQ1: Does children's information seeking differ between the *E&L (Open-ended)* and *TE (Constrained)* tasks?

The distributions of exploration on the two tasks are shown in Figure 3. Only 1% of children were at ceiling on the *E&L (Open-ended)* task, while 16.1% of children were at ceiling for the *TE (Constrained)* task. Note that there was a time limit that may have limited children from reaching ceiling (63) on the *E&L (Open-ended)* task, but of 384 participants where we have the data on whether they stopped on their own before the time limit, 84% ended early.

Because the two tasks differed in the amount of information possible to explore, we calculated the proportion of information explored of the maximum possible on each task (For *E&L (Open-ended)* that is 63, for *TE (Constrained)* it is 14 with a minimum of 4, so we subtracted 4 from amount of information explored and divided it by 10. Using a paired-samples t-test, children explored a smaller proportion of the maximum possible information in the *E&L (Open-ended)* task, (27.3%) compared to the *TE (Constrained)* task (57.3%) (t = -19.82, p < .001.). The proportions of information explored between the two tasks did not relate (R = .051, p = .268; 95% confidence intervals = -0.039 and 0.141). To better interpret this non-significant correlation, we computed a Bayes Factor. The resulting BF_{01} = 5.05 suggests moderate evidence in favor of the null hypothesis, indicating that children's exploration behavior in one task was not predictive of their behavior in the other.

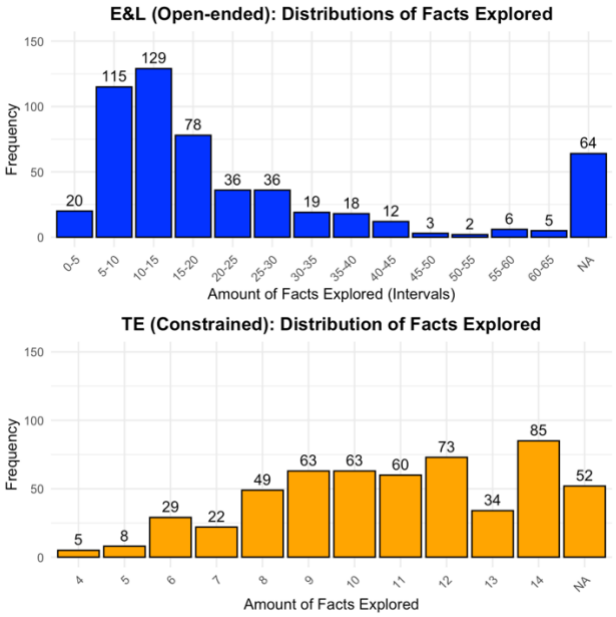

Figure 3. Distributions of exploration frequency in the two tasks; Top: total facts explored across possible range of 0-63 on the *E&L (Open-ended) task*; Bottom: total facts explored across possible range of 4-14 on the *TE (Constrained)* task.

RQ2: Do children's explanations of motivation for their information seeking differ between the *E&L (Open-ended)* and *TE (Constrained*) tasks?

Children's explanations were coded at the utterance level, and many explanations included multiple utterances; thus, children could have given both information seeking and non-information seeking explanations for one or both tasks. See Table 2 for the frequency of children giving one or more information and non-information seeking utterances in their explanations for each task.

On the *E&L (Open-ended)* task, 28.2% of children gave an explanation that included information-seeking motivations, compared to 57.2% on the *TE (Constrained)* task (Chi^2=19.00, p<.001). Across both tasks, 34.4% of children did not give any explanations that were coded as information seeking, and 21.4% gave information seeking explanations for both tasks. Only 7.7% of children did not give any non-information seeking explanations across both tasks, while 54.0% included a non-information seeking explanation in their response on both tasks. At the utterance level, children's explanations for why they chose to explore what they did were less likely to be coded as information seeking on the *E&L (Open-ended)* task compared to / as the *TE (Constrained)* task (t= -10.18, p <0.001).

On the *E&L (Open-ended)* task, 82.3% of children gave a non-information seeking motivation, compared to 64.9% of children on the *TE (Constrained)* task, which was not significantly different (Chi^2=0.862, p=.353). At the utterance level, responses were more likely to be non-information seeking for the *E&L (Open-ended)* task compared to the *TE (Constrained)* task (t= 6.40, p < 0.001). Overall, children were less likely to give an information seeking explanation, and more likely to give a non-information seeking explanation, for their exploration on the *E&L (Open-ended)* task compared to the *TE (Constrained)* task (information seeking t= -10.18, p <0.001; non-information seeking t= 6.40, p < 0.001).

Table 2. Number of children with each response task coded in their explanations between tasks (total N=515; children's responses could include both IS and NIS codes).

Information-Seeking Motivations

	E&L (Open-ended)	*TE (Constrained)*
0	177	185
1+	43	110

Non-Information-Seeking Motivations

	E&L (Open-ended)	*TE (Constrained)*
0	36	55
1+	146	278

We further compared the more specific coding categories for both the information seeking and non-information seeking explanations between the two tasks. When children's reasoning for their exploration was information seeking, responses on the *TE (Constrained) task* were twice as likely to mention wanting general information and 15 times more likely to mention wanting to explore something that was a mystery or unknown (both p < .001). When children's reasoning for their exploration was coded as non-information seeking, children were more likely to respond that they chose what to explore randomly for the *TE (Constrained)* task, while responses on the *E&L (Open-ended)* task were more likely across the codes related to perceptual information, such as liking visual features (e.g., colors or shapes of options), using a spatial pattern or order, or wanting a sense of completion (all p <.01). When the task was more open-ended (*E&L*) vs. constrained (*TE*) with varying uncertainty/ information levels children were about 30% more likely to give ambiguous responses whether they were coded as information seeking or non-information seeking (p = .001).

Exploratory RQ: How does motivation to explore relate to actual exploration within tasks?

To further probe the link between children's exploratory behavior and their expressed motivations, we compared the total facts explored between children who did versus did not give information-seeking explanations for their behavior. In the *TE (Constrained)* task, children who gave an information-seeking explanation explored significantly more (M = 10.51) than those who did not (M = 9.10), t(466) = -4.62, p < .001.

In contrast, no such difference emerged in the *E&L (Open-ended)* task ($t(282) = -0.59$, $p = .55$).

Discussion

This work aimed to explore differences in children's information seeking related to two conceptualizations of curiosity measured with behavioral exploration tasks. By design, the exploration tasks differed in providing either an open-ended unlimited information seeking design assessing the frequency of exploration attempts across similar options, aligning with a reward-learning framework (Murayama et al., 2022; Jirout, 2020), or a constrained information seeking design with forced choice among varying levels of uncertainty, aligning with the Information-Gap Theory and Prediction, Appraisal, Curiosity, Exploration Framework (Loewenstein, 1994; Gruber & Ranganath, 2019). Children's behavior and motivations differed across the two tasks, suggesting that curiosity was contextually and conceptually multifaceted. While this suggests that the different tasks do seem to be assessing distinct constructs, it does not provide evidence for or against either framework in terms of which is a "better" measure of curiosity.

On the *E&L (Open-ended)* task, children explored more facts overall, but in the *TE (Constrained)* task they explored a greater proportion of the available information. Their self-reported motivations reflected these patterns: children were more likely to provide information-seeking explanations in the constrained *TE* task, and more likely to report non-informational motivations (e.g., liking a shape or following a pattern) in the open-ended *E&L* task.

Related research similarly shows impacts of task design on exploration, such as when there is an external goal or reward provided vs. not (Jach et al., 2022), or when children have different levels of initial information (e.g., Wade & Kidd, 2019). This prior work shows children's ability to discern information gain on tasks to maximize efficient information seeking, though our results show that children do this even when there is not a reward or external goal. Related to conceptualizations of curiosity, the findings here and in past studies suggest that children's information seeking as influenced by reward (both intrinsic for learning and extrinsic) is different from information seeking driven by knowledge gaps – which relates more to the broad and somewhat universal idea of curiosity as a thirst for knowledge. For this reason, the *TE (constrained)* task may be more aligned with what is generally viewed as curiosity. Supporting this, children who gave information-seeking explanations explored more in the TE task, but no such link emerged in the E&L task.

This distinction has implications for understanding and supporting curiosity in educational settings. Open-ended environments, such as those found in project-based or Reggio Emilia-inspired classrooms, may encourage different forms of exploration than more structured, conventional contexts. Designing environments that foster curiosity may thus require different strategies depending on the context and how it supports meaningful engagement with uncertainty.

Limitations & Future Directions

Although the tasks were designed to align with the different frameworks of curiosity conceptualizations, they differed in additional, potentially important ways as discussed above, which could have also influenced exploration in various ways beyond those of interest here (Katz & Assor, 2007; Patall et al., 2008). The data collected here are not able to tease apart these potential influences, but they are important to consider in future research, as is the predictive power of these measures and potential applications of this work to education.

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