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Depth of Breadth? How do elementary school children explore information actively?

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Depth or Breadth: How do children explore?

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Abstract

From an early age on, children possess an intrinsic curiosity toward their environment, they explore and search for information to make sense of the world. This exploration is often driven by their curiosity toward new information. Even though they are naturally active learners and explorers, research shows that they express it less and less as they start with formal education. To understand school-age children's exploration behavior driven by their curiosity, we assessed them in a self-directed learning environment and examined their learning patterns in terms of in-depth and in-breadth. Eight to twelve-year-olds (N = 75) explored questions and explanations in a three-day workshop on Qualtrics. On each day, a new main topic with 5 subtopics was added to the workshop. Children explored this learning environment freely for 10 minutes and then answered questions about the information they gathered. The assessment of the relationship between their learning patterns, individual differences and outcome variables showed that children's learning patterns, together with age and socioeconomic status, were related to the amount of information they gathered, but did not have an effect on the accuracy of the information recalled later. Importantly, younger children from the higher SES group were more likely to explore new information rather than repeat the older ones. The findings suggest new directions for future research and new implications for formal education.

Keywords: Exploration, Curiosity, Learning, In-depth learning, In-breadth learning

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1 Introduction

Why is the sky blue? Why do people get old? Is there another planet like Earth? Children are natural question askers. From an early age on, they search for information to learn and make sense of the world. They spontaneously explore the world around them and develop new knowledge. This exploration is often not driven by externally imposed rewards but is motivated by their insatiable curiosity. Research examining young children's questions in everyday parent-child conversations found that starting from the age of 2 until 5 children ask around 95 questions an hour, in other words, 3 questions every 2 minutes when accompanied by parents older (Chouinard et al., 2007). The vast majority of these questions were information-seeking with an increasing percentage as children get older. Moreover, the questions shifted from fact-seeking to explanation-seeking questions that build on fact, signifying their will to understand the world.

We all have met that kid sometime in our life who can't seem to get enough information about dinosaurs, about their names, eras, habits and so on. This almost universal phenomenon is an obvious indicator that while children ask lots of questions about everything around them, some children can become deeply occupied with one topic of their interest and can concentrate their questions and exploration on it. In other words, they can learn about anything in general while they can also follow their curiosity and interest to deeply engage with a specific topic. These two different styles of learning can be traced to the well-known dichotomy of "jack of all trades" and "master of one". "Jack of all trades" refers to someone who tends to learn in breadth and have a general knowledge about all sorts of things, while "master of one" refers to someone who has an in-depth knowledge of a topic and so, tends to learn in depth. These two styles do not need to exclude each other as someone can have in-depth knowledge about a certain topic and at the same time be eager to learn anything that grabs her attention. Yet, from the moment children start primary school, the question "how do they learn?" transforms to "how to teach them?" and learning patterns become a subject of teaching and curriculum design

(Beittel et al., 1961; Gallagher and Stepien, 1996; Hirsch, E. D., Jr., 2001; Schwartz et al., 2009). Interestingly, following their transition to school, children have significantly less intense interest aka interest in in-depth learning (Alexander et al., 2008), less intrinsic motivation (Anderman and Maehr, 1994; Lepper et al., 2005; Sansone and Morgan, 1992) and less curiosity (Tizard and Hughes, 1984; Engel, 2011). This erosion in interest, intrinsic motivation, and curiosity, which are all associated with better learning outcomes, raises questions about the relationship between schooling and children's learning.

In the light of prior research, this study aims to explore the difference in school-aged children's learning styles of in-depth and in-breadth learning and investigate its relationship with their age, active learning capabilities, intrinsic motivation and learning outcomes. In the following, we review the prior research on children's in-depth/in-breadth learning, curiosity, interest, and exploration and, their relation to each other. Considering that the studies in the literature have been conducted mostly in Western culture while our study was conducted in a non-Western culture, the educational context in Egypt is also reviewed with the reasons why children's learning behaviors may differ across diverse cultures and SES groups.

1.1 In-Depth vs In-Breadth Learning

1.1.1 Preschool children

Some young children express an intense interest in various objects or concepts and, become captivated by them. In a study conducted with 117 parents, DeLoache et al. (2007) revealed that nearly one-third of young children display extremely intense interest which refers to an intense, occasionally very close to obsessive, affinity to things in their interest group e.g. vehicles, trains, or dinosaurs. Interestingly, almost 30 years ago, Chi et al. (1989) realized the kids who were particularly interested in dinosaurs and started a research project to understand how domain-specific knowledge (e.g. knowledge about dinosaurs) is structured and how it is used. They divided children based on their prior knowledge of dinosaurs as either experts or novices and

gave them both general and domain-specific tasks such as sorting dinosaurs, and answering questions about their family, diet, habitat, defense mechanisms, etc. They made sure that some dinosaurs were novel to both experts and novices by constructing dinosaurs by transposing the features of the existing ones to ensure that they would speculate based on their own knowledge. The results indicated that expert children's knowledge about dinosaurs is more coherent and hierarchically structured to include taxonomic categories. Even though expert and novice children did not differ in their general use of learning strategies when dinosaurs were not involved, expert children outperformed novice children in using domain knowledge to infer and back their causal reasoning about the dinosaurs which was novel to both of the groups. Though the study wasn't longitudinal and the sample size was relatively small, results suggest that conceptual interests lead to deep, often taxonomically organized, hierarchical knowledge in that particular domain which can serve as a base to enhance learning and retrieval of information in that domain.

A more recent study that investigated the factors that are associated with intense interest, with a relatively large sample of 4-year-olds found that children's cognitive abilities (verbal intelligence, impulsivity, and working memory) together with their home environment e.g. the spared time for free play, consistency, and communication are important determinants of the sustainment of the conceptual interest (Johnson et al., 2004). Considering that preschoolers access conceptual knowledge through their parents e.g. asking them questions, reading related books, buying related toys, playing, etc. (Leibham et al., 2005; DeLoache et al., 2007), the role committed parents play is not surprising. They provide preschoolers the opportunity to ask curiosity questions and feed their knowledge with informative answers (Chouinard et al., 2007). In fact, a more recent study examined the relationship between the characteristics of parental explanations to biology-related questions and preschool children's knowledge, revealing that the frequency of correct parental responses predicts verbal intelligence and biology knowledge of children (Mills et al., 2022)

Unlike early childhood years, a primary school might not provide the opportunity to explore one's intense interests and curiosity. A latent growth curve analysis revealed that the probability of having a conceptual interest declined as children transitioned to formal schooling. One can explain this as a coincidence in the developmental trajectory. Children might be learning how to distribute their interests evenly as they age which can intersect with their schooling. However, a closer look at the traditional education system and its relation to children's curiosity and interest may tell a different story. Research showed that children exhibit less conceptual interest as formal education began(Alexander et al., 2008; Helmke, 1993; Krapp, 1999a). Moreover, an abundance of prior research indicates that intrinsic motivation in learning gradually decreases as children move through the educational system (Anderman and Maehr, 1994; Lepper et al., 2005). Similarly, the curiosity children express seems to be diminishing once they transition to school. Tizard and Hughes (1984) revealed that toddlers who asked many questions to their parents asked almost no questions during their time at preschool. In another study, Engel (2009, 2011) unintentionally revealed that the same is valid for school kids when she wanted to study individual differences among curiosity questions but failed to do so due to the lack of curiosity expressed in the classroom. Conceptual interests have an opportunity to flourish especially during preschool years, however, things seem to reverse. Possible reasons include in the school there are more children, less time for individual questions, a curriculum to catch, and most importantly a will to shape the children.

1.1.2 School children

As children transition to formal schooling, the focus of the research transition from how children learn to how to teach them. Thus, "depth" and "breadth" are considered instruction methods rather than learning styles. An earlier study compared the effectiveness of a "depth" and "breadth" method with a control group in art instruction in the 9th grade (Beittel et al., 1961). While in the depth program they

allowed students to focus on one specific area of study e.g. painting via different activities and materials, they allowed the same but on a variety of subjects that were chosen in a way to accommodate the different preferences in students' interest. Results suggested that the breadth method was more popular both among the students and in high schools in general, even though the depth method led to a greater knowledge gain that was sustained longer. The study concluded that research results should be opted for student preferences at determining the kind of teaching they need. Similarly, though not that strict, other studies conducted in different fields (Gallagher and Stepien, 1996; Schwartz et al., 2009) concluded that schools should pursue an in-depth method of teaching for greater learning outcomes.

The two lines of research explored above are interestingly in-line with the well-known parenting metaphor of "the gardener and the carpenter". In her book, Gopnik (2016) describes this metaphor as, "the gardener" creates an environment for the child to flourish and helps her to become who she is while "the carpenter" shapes the child like a raw material into the final product in his head like a chair or a door. She also states that preschool children and childcare workers tend to have an approach similar to the "gardener" model which is similar to the pattern of a gardener-like approach in preschool research and more carpenter-like patterns in the research about school-aged children. In response to the carpenter approach dominating school education literature, there are also researchers that call education practitioners and other researchers to stimulate children's epistemic curiosity (Engel, 2011; Pluck, G. and Johnson, H. L., 2011) and interest (Hidi and Renninger, 2020; Schraw et al., 2001) to provide them a space they would like to explore and so that learning in the classroom. Before moving further, we need to clarify the concepts of epistemic curiosity and situational interest used in this study. Epistemic curiosity refers to a desire for knowledge in response to experiencing a feeling of missing information or a novel stimulus that violates expectations (Berlyne, 1962; Grossnickle, 2016; Loewenstein, 1994) and while situational interest refers to an affective reaction to novel stimuli and requires no lack of information to be triggered. Recent research

asserts conflicting results about whether these are in fact two distinct constructs or not. A review of Shin and Kim (2019) points out that they differ in many dimensions e.g. their theory, neurological underpinnings, arousing factors and related emotions, while a more recent experimental study indicates that both epistemic curiosity and situational interest refer to the same underlying psychological mechanism (Schmidt and Rotgans, 2021). Considering the scope and the method of the current study, we will adopt the latter finding in the rest of the study.

1.2 Curiosity – What makes children explore?

A study by Engel and Hackmann (2002) revealed that in a survey, over 70% of the teachers choose curiosity as one of the five characteristics they aim to assure which implies a consensus about the positive relationship between curiosity and learning. The pioneering work of Piaget (1954) and contemporary psychologists following his lead have underlined the importance of curiosity as a driving force for exploration and showed that children learn by actively exploring their environments and engaging with it and asking questions to construct their own knowledge (Chouinard et al., 2007; Harris, 2012a), and school-aged children are no exception of that (Cook et al., 2011; Liquin and Gopnik, 2022; Meder et al., 2021).

1.2.1 Deprivation Theory of Curiosity

At this point, for the sake of curiosity-friendly education, we ask ourselves: "What makes children curious? What makes them want to learn more about something?" The desire for knowledge According to the information-gap theory of curiosity of Loewenstein (1994) individuals become curious and eager to learn when they become aware of the existence of an information gap in their knowledge. The theory is also called the deprivation theory of curiosity as encountering missing information aka an information gap in their knowledge produces a feeling of deprivation they want to avoid, which leads them to attempt to obtain the missing information and engage in learning. This desire to acquire new knowledge and eliminate information

gaps is also called epistemic curiosity (Berlyne, 1954; Loewenstein, 1994). According to Loewenstein (1994), one of the situational factors that induce the effect of deprivation and perhaps the most straightforward curiosity inducer is posing a question, since a question directly challenges the individual's lack of information. The work of Jirout and Klahr (2012) showed that the deprivation theory of curiosity provides a solid framework to study children's curiosity too.

1.2.2 Actively exploring and learning

Several studies examined this theory's relevance to children's learning process across their development. Building on the notion that recognizing that there is an information gap between what one knows and what one ought to know is a crucial part of learning, studies examined whether children could differentiate an ignorant or inaccurate informant from a knowledgeable informant and adjust their inquiries accordingly (Mills and Landrum, 2016) and whether they can distinguish a weak explanation from a strong explanation and engage with additional learning to fill the gap caused by the weak explanation (Mills et al., 2017, 2019). Legare (2014) suggested that there is a link between explanation and exploration as explaining something prompts one to reflect on what one knows and does not know which leads to exploration. Extending this work, Danovitch and Mills (2018) asserted that children use the explanations they receive to reflect on what they know and don't know and engage in exploration and thus, additional learning to address the lack of knowledge they perceived. Additionally, they suggested that this additional exploration depends on their perception of if i) there is more to be learned, ii) there is a gap in their knowledge, and iii) further exploration is encouraged by one's environment. A study conducted by Ruggeri et al. (2016a) on active learning and exploration behavior showed that, unlike adults, children continue to explore and learn even after they eliminate the information gap, suggesting that it may not only a feeling of deprivation but also a desire to maximize acquired information that leads exploration in children. In fact, considering the scope of the things they want

to learn about and retaining the idea that they are active learners, children's exploration includes a good amount of asking questions in it as they grow older (Harris, 2012b; Harris and Koenig, 2006). Therefore, the ability to actively ask questions to other people to gather information and merge it with what they learn through other means such as observation and trial and error is a very strong learning mechanism in children's learning (Ronfard et al., 2018). Another important aspect of exploration and active learning is its widely accepted enhancement effect on learning (Markant et al., 2016; Bruner et al., 1976; Gureckis and Markant, 2012; Montessori, 1964; Piaget and Valsinen, 2017). A few recent studies have revealed that active control over the information to be gathered (Sim et al., 2015) and, the order and pace of the stimuli presented (Ruggeri et al., 2016b) enhance memory when compared to the yoked condition in elementary school children. A more recent study conducted with 5-11-year-old children by Ruggeri et al. (2019) revealed that the advantage of active learning over memory is relatively low among 5-year-olds, however, it becomes comparable to adults' performance by the age of 8. Even though the idea of learning is enhanced when the learning process is actively controlled by the learner is old and widely accepted in the literature there is also some research that takes a rather critical perspective on the issue and challenges the link between curiosity, self-directed learning and better learning outcomes (Kirschner and van Merriënboer, 2013; Wade and Kidd, 2019). For that very reason, in this study, we included an active learning task and a recall memory task in the main procedure which is a self-directed learning paradigm.

1.3 Education in Egypt

While doing research, reading the literature, and interpreting the results, we should always keep in the back of our minds that most of the time these studies are conducted in Western countries. Thus, the participants were usually children growing up in Western cultural contexts which resulted in very limited knowledge about whether children's ways of exploring and question-asking vary in different socio-

cultural contexts. In a cross-cultural study conducted with children from Belize, Kenya, Nepal, and American Samoa, Gauvain et al. (2013) stated that even though the number of questions children asked is comparable to their western peers, the proportion of explanation-seeking questions was significantly lower. Ünlütabak et al. (2019) have shown the same difference in the proportion of explanation-seeking questions in a study conducted with Turkish children. However, besides the effect of the culture, they also showed samples from different cultures do also vary in terms of their socioeconomic status (SES) as children from low SES were more in number in the Turkish sample. The cultural difference might stem from what these cultures prioritize as children's independence and self-confidence are emphasized in Western cultures while being quiet, showing respect, and not questioning the knowledgeable adults around them are reinforced in some non-Western cultures. Besides the macro culture, a micro-culture within the family that either encourages children's autonomy and exploration or nurtures children's obedience can affect children's learning behavior. Since SES consists of multiple facets such as parental education, income levels, and the social environment nourished by it, it can explain some of the individual differences children have (Kurkul and Corriveau, 2018). Even though it can be expected that culture and SES may influence children's exploratory behaviors, research in different cultures and SES groups are quite limited. With the hope of contributing to this line of research, the current study examined the learning patterns of children from low to middle-low SES in Egypt. According to Langsten and Hassan (2018) study that reviewed data from 1988 to 2014, Egypt is a developing country that pursues Universal Primary Education that is encouraged by the United Nation's educational millennium development (United Nations, 2005). The aim of this program is to ensure that all girls and boys complete free, equitable, and primary education. Langsten and Hassan (2018) study showed that even though Egypt showed improvement toward the goal of universal equal education, only high SES children achieved that level. Fostering preschool education, bridging the gap between children from low SES families in rural areas and children from urban areas

and equal opportunities for girls are some of the future goals of the country [for a detailed background see (Egypt Ministry of Education. National Center for Educational Research and Development and UNESCO Office Cairo and Regional Bureau for Science in the Arab States, 2014).

1.4 The current study

In light of the literature reviewed above, the current study addresses the in-depth and in-breadth learning pattern in children and their relationship to SES, active learning abilities, motivation and age by conducting an experimental study via a self-directed learning environment. As a similar design to Mills (2019), we created a self-directed learning environment on Qualtrics to be explored on a tablet to allow children to direct their own information gathering and exploration in a three-day workshop. We called this self-directed learning environment TRIVIA, since it included "Did you know that..?" type of interesting pieces of information that are not necessarily treated as valuable in the schools. In TRIVIA, children tap on a weird animal of their choice and the question they want to learn about. After learning about that piece of information they return to the main menu to choose again either the same animal or a different one. On the second and third days, other main topics were added to the main menu in addition to animals, to assess the effect of novelty and have a comparable learning environment in terms of ecological validity since they don't always learn about the same topic in the schools. Since TRIVIA allowed children to guide their own learning experience rather than answering to stimuli chosen by an experimenter, it made it more likely that children would indicate interest in exploring the environment out of self-interest rather than out of a need to fit in with their peers (Mills et al., 2019). To our knowledge, there is no prior research conducted about school-aged children's learning patterns with a self-directed learning tool. In this study, we expected to find a positive relationship between the amount of exploration and children's active learning abilities and motivation. We hypothesized that even though younger children cannot catch up on the amount of information explored

by their older peers, in proportion wise they would perform comparably. Since this is the first use of a self-directed learning environment to assess in-depth and in-breadth learning, our approach is exploratory and aims to understand whether children adopt different patterns of exploring and if yes, how is it related to other individual factors and outcome variables.

2 Method

2.1 Participants

Participants: Participants were seventy-two 8- to 12-year-olds (M= 9.9,SD= 1.43, 40 females) from an Educational foundation, Amena Bent Wahb, which is based in Giza, Egypt. All participants were students in primary school, able to read, comprehend and speak fluent Arabic. Children were tested in a quiet environment by one experimenter and each session took around 30 minutes. An additional 3 children took part in the study but were dropped, due to having the same anonymized ID (2 of the children had by chance names and surnames that started with the same letter and were born on the same day and month. We found out about it since they have the same ID but different genders and age) and due to dropping off after the first day (1 child).

2.2 Materials and design

This study was conducted as a 3-day workshop that consists of a self-directed learning environment called TRIVIA. On the first day, TRIVIA included one main category, which is "animals" and 5 subcategories which were "pangolin, pink fairy armadillo, narwhal, naked mole rat, and platypus". Each of these uncommon animals had 5 pieces of fun-fact questions such as "Why do pink fairy armadillos have a pink shell?". On the second day, another main topic joined the scene which was the "universe". Similarly, the main topic of the "universe" consisted of 5 subcategories which were "Earth, Sun, galaxies, moons, and Venus" each including 5 fun-fact questions.

On the third day, the last topic of "food" was added to the main topics. The food category included "fruits, vegetables, junk food, cuisines, and poisonous foods". In total first day had 25 questions, the second day had 50 questions, and the third day had 75 questions to explore. See Figure 1 and Table 1). The appearance of main topics, subtopics and questions were counterbalanced on each day. Both questions and answers were prepared as 1920x1080 visuals via Canva which is a free graphic design platform. Questions and answers were translated to Arabic by a colleague from Egypt whose mother tongue is Arabic. Three separate Qualtrics surveys were created for three successive days. The surveys allowed children to explore in a loop of "choosing a topic from main topics – choosing a subtopic – choosing a question – learning the answer – choosing the main topic" until their 10-minute time was up. We didn't restrict the number of pieces of information they can explore, since a recent finding stated that restrictions led to less selective information seeking (Mills et al., 2019) At the end of the exploration, children were given a recall task that consisted of a maximum of 5 multiple-choice questions about the pieces of information they explored.

2.3 Individual measures

Individual differences were assessed through three different measures: an SES scale presented to the parents, a 13-question motivation questionnaire that measures intrinsic and extrinsic motivation for learning at school, and an active learning task. While motivation and SES questionnaires were filled on the first day of the study before introducing TRIVIA, the active learning task was presented at the end of the third day within the same Qualtrics survey. Children's motivation was measured with the Motivational Regulation Scale of **?** which is a 13 items scale based on the Self Determination Theory of **?**. The socioeconomic status of the children was assessed with the SES scale of El-Gilany et al. (2012). The scale consisted of seven domains that are education and cultural domain, occupation domain, family possessions domain, family domain, home sanitation domain, economic domain and

health care domain. The scale is adapted to Egypt and has a Cronbach's alpha of .66. The active learning task consisted of a total of 8 videos half of which introduced the tasks, and the other half asked the questions. The videos were adapted from two different active learning studies and vocalized in Arabic by a native speaker. First, children were introduced to how to play a spatial search task, a maze-exploration game by 80 seconds long. Then they were presented with three 20-second long videos in which they had to find out the better move among two options to find out the one path that goes through the maze (Swaboda et al., 2022). In the second part of the task, children watched 3 introductory videos, 29, 38, and 40 seconds long respectively, about two different agents aka monsters that solve a 20-question game to discover a target object by asking yes/no questions. In the 48-second long final video, children were reminded how each agent played the 20-questions game and asked to choose the one who played the game better than the other (Swaboda and Ruggeri, 2022). In each question, children were provided two options and asked to choose the better one. See Figure 2.

2.4 Procedure

2.4.1 Day 1

Prior to the study, recruited participants were reached, informed about the study, and asked to bring their tablets with them to participate. On the first day, parents were informed again and signed an informed consent sheet to allow the participation of their children. Children were taken to another room and informed about the purpose of the study. They were told that the aim of this study was to find out how children at their age learn information about different topics and how they solve puzzles. In addition, they were informed that they can quit whenever they wanted, they will play a learning game and will receive a participation certificate and goodie bags once the games were over.

After making sure that each child has an internet connection on their tablet, children were introduced to the game of Day 1 on Qualtrics and were asked to

create their anonymized IDs by putting the initials of their first and last name, their birthday, and their birth month, respectively. For example, assuming that she was born on the 14th of September, the ID of the author of this work would have been "HA1409". Each child started with the testing by putting their IDs in. As a first step, they filled out a 5-point Likert scale to assess the motivation they have for learning at the school. In the next step, TRIVIA was introduced. On Day 1, TRIVIA had one main topic which was "Animals" and 5 uncommon animals as subtopics that includes 5 fun-fact questions in it. Children were told that they have 10 minutes of time to explore this game to learn about different animals of their choice and they can choose the same animal or a different one. Each time they explored a piece of information, they were sent to the main menu to choose the next animal they wanted to learn about. The experimenter was present in the room during this phase to answer children's questions about the game when they had any, such as "Can I open the same question? Yes, you can." or when they had a problem with the internet connection. As the internet connection was not stable in the area, some kids were disconnected from the game and had to log in again. While children were playing in this self-directed learning environment, parents were asked to fill out the SES questionnaire on paper. When the time was up they were asked to tap on the "quit" button to start the quiz about the information they had gathered. Due to the technical error, we realized later, that rather than a maximum of 5 recall questions, children were asked as many recall questions as the number of information they gathered, meaning that children who explored more had to answer more questions.

2.4.2 Day 2

On Day 2, the procedure was almost the same as on Day 1. Children logged in on the second day's link with the IDs they used on the first day. They directly started with TRIVIA which had a new main topic, "universe" besides the old one, animals. Children were informed that today they have 2 main topics and 5 subcategories

each but similar to yesterday, they had 10 minutes to explore. After gathering information for 10 days, children were asked to quit and answer the recall questions. The error of an unlimited number of recall questions was still unfixed as we realized it at the end of the second day.

2.4.3 Day 3

Similar to Day 2, on Day 3 children were asked to log in with their IDs and start exploring TRIVIA. They got introduced to the third main topic, "food" and its 5 subtopics. Children had again 10 minutes time to explore and gather information. The error with the number of recall questions was solved, meaning that regardless of how many pieces of information they visited, they received a maximum of five questions to answer to assess the accuracy of their recall memory. After completing the exploration and recall phase, they were presented with the active learning task. The active learning task was composed of two different games: a maze-exploration game and a 20-questions game. With these games, children's ability to distinguish the question that leads faster to the correct answer was assessed. With the completion of the active learning task, the 3-day workshop of TRIVIA was finished. Children and their parents were thanked for their participation and received their participation certificates and goodie bags.

3 Results

3.1 Overview

The statistical analyses were conducted using RStudio software. We first report analyses investigating whether Day 1, Day 2, and Day 3 differed from each other in terms of children's performances by assessing the effect of new topics on the amount of exploration. (Section 3.2). This part consists of within-subject statistical analyses since the same children participated on the three subsequent days. Next, we assess whether individual differences can explain the differences in children's performances.

Finally, we report analyses that assess children's in-depth and in-breadth exploration in relation to their performance on these three days and their individual differences.

3.2 Investigating how children performed on Day 1, Day 2, and Day 3

To assess how children's exploration differ when the number of topics increased from Day 1 to Day 3, we compared their performances on these three days.

1) Does the number of questions explored differ from each other on different days?

First, we checked whether the total number of questions children explored differed from each other on Day 1, Day 2, and Day 3 as the number of main topics and subtopics, thus the number of questions had increased from the first to the last day. After checking for the assumptions for parametric analysis, we conducted an ANOVA test to compare the total number of questions explored on Day 1, Day 2, and Day 3. The result showed that the number of questions explored was statistically significantly different on different days, $F(1.72, 122.3)= 88797$, $p < .001$, $\eta = .332$. Post-hoc comparisons using the Bonferroni correction indicated that the mean of the number of questions explored on Day 3 ($M = 17.21$, $SD = 8.16$) was significantly more than Day 2 ($M = 7.99$, $SD = 5.95$) and Day 1 ($M = 7.68$, $SD = 4.24$), $p < .001$. However, Day 1 and Day 2 did not significantly differ from each other, $p > .05$. See Figure 3a

Since the design of the learning environment did not restrict children's exploration in any way except a time constraint of 10 minutes, children were also allowed to explore the same questions more than one time. This feature of the study resulted in some repeated questions. Descriptive statistics showed that on average 19% percent of the total questions were repeated questions. Therefore, we conducted an additional ANOVA to see whether the total number of unique questions, meaning the questions explored only once, differ on different days. The analysis showed that the number of the unique questions explored was also statistically significantly different on different days, $F(1.4, 96.9) = 96973$, $p < .001$, $\eta = 0.406$.

Post hoc comparisons using the Bonferroni correction indicated that the number of unique questions explored on Day 3 ($M = 13.42$, $SD = 6.29$) was significantly more than on Day 2 ($M = 5.83$, $SD = 3.1$) and Day 1 ($M = 5.92$, $SD = 2.68$), $p < .001$. However, Day 1 and Day 2 did not significantly differ from each other, $p > .05$. See Figure 3b. Finally, we wanted to see besides the number of unique pieces of questions, whether the ratio of them to the total number of questions, i.e. the rate of uniqueness varies on Day 1, 2, and 3. Since the rate of uniqueness did not meet the normality assumption, a non-parametric Friedman test was conducted. The Friedman test stated that the rate of the uniqueness of the questions did not significantly differ from each other on Day 1, Day 2, and Day 3, ($\chi^2 = 3.08$, $p > .05$.)

2) How did novelty affect exploration?

To explain the difference among the number of questions, we conducted a set of analyses that explores the effect of novelty on exploration. There are two ways to examine how novelty affected children's exploration in the self-directed learning environment (Mills and Landrum, 2016). We can look at the number of unique pieces of questions children explored in the newer and older main topic of that day. However, focusing on the number of question pieces explored would heavily weigh the data from Day 3, since there were significantly more pieces of questions explored. In addition, this approach might give more weight to the data from children who explored a large number of questions. Another way to tackle this issue is by examining the percentages of the questions explored in newer and older topics. This method allows us to consider children who could not explore that many due to several individual differences yet explore heavily newer questions than the older ones. However, it would underestimate the children who are more into exploration and outperform their peers. Therefore, in the following analyses, we performed both of these approaches.

2.1. Does the number/percentage of unique pieces of questions explored about "the universe" (the new topic of Day 2) differ from "animals" (the old topic) on Day 2?

In addition to the main topic "animals" on Day 1, another main topic was introduced on Day 2, which was the "universe". This means that on Day 2 children first made a choice between two main topics, the old topic vs a new topic. Since the normality assumption was rejected, we conducted non-parametric analyses to examine the difference between the two. A paired sample Wilcoxon test showed that the number of unique questions explored in the old topic -animals- on day 2, ($M = .6$, $SD = 1.04$) are significantly less than the new topic -the universe- on the same day, $M = 5.25$, $SD = 2.84$. Similarly, a paired sample Wilcoxon test on the percentages showed that the rate of uniqueness of the questions explored in the old topic -animals- on day 2 is significantly less than in the new topic -the universe- on the same day, suggesting that a big majority of children avoided the older topic and explored the new one.

2.2. Does the number/percentage of unique questions explored about "food" (the new topic of Day 3) differ from the number/percentage of unique questions explored about animals or the universe (old topics) on Day 3?

The three-day workshop design of TRIVIA gave us the opportunity to confirm the effect of novelty by reassessing it with a comparison of the third day and the first two days. A one-way repeated subjects ANOVA showed that the number of unique questions explored on Day 3 about "food", the novel main topic, was statistically significantly different than about animals and the universe, which were the topics of the previous day, $F(1.23, 87.32) = 121.45$, $p < .001$, $\eta^2 = .54$. See Figure 4a. Post-hoc comparisons using the Bonferroni correction indicated that the number of unique questions explored about food ($M = 10.31$, $SD = 5.55$) was significantly more

than the ones about the topics of the main topic of universe ($M = 1.92$, $SD = 3.14$) and animals ($M = 1.42$, $SD = 1.72$), $p < .0001$. However, the number of questions explored in older topics, animals, and the universe, did not significantly differ from each other, p 0.05. Similarly, the percentage of unique questions explored about food was also statistically significantly more than animals and universe, F(1.31, 92.87) = 228.62, p $< .0001$, $\eta^2 = .76$. See Figure 4b.

2.3. Does the presence of other topics impact one's exploration of one topic? Is the number of unique questions explored about animals on Day 1 significantly more than on Day 2 and Day 3?

The main topic of animals was constant over all three days, which allowed us to examine how the exploration of one topic changed once new topics had joined the scene. A one-way repeated subjects ANOVA revealed that the number of unique questions explored about animals was statistically significantly different across these three days, $F(1.33, 94.08) = 157.264$, p<0.001, $\eta^2 = 0.58$. Post-hoc comparisons using the Bonferroni correction indicated that the number of questions explored about animals on Day 1 ($M = 5.99$, $SD = 2.72$) was significantly higher than on Day 2 ($M = .67$, $SD = 1.27$) and on Day 3 ($M = 1.42$, $SD = 1.71$), p $< .0001$. Interestingly, on Day 2 it was significantly less than on Day 3, p $< .001$. This can be interpreted as even though a newly introduced topic attracts children's interest disproportionately at first, they regulate it when other newer topics are added to the scene.

2.4. Was the effect of novelty on the amount of exploration the same for different topics?

On both Day 2 and Day 3, we introduced a new main topic to the participating children. On Day 2 the new main topic was the "universe" and on Day 3, it

was "food". Since we could not counterbalance the order of the main topic across different days, we needed to check whether the number/percentage of the unique questions explored about the universe on Day 2 significantly differ from the number/percentage of unique questions explored about food on Day 3. A paired sample t-test showed that the number of unique questions explored about the universe (M = 5.42, SD = 3.14) on Day 2 was significantly less than the number of unique questions explored about the universe on Day 3. See Figure 5a. On the contrary, a paired sample Wilcoxon test examining the percentages of the questions showed that the percentage of unique questions explored about the universe on Day 2, (M = .92, SD = .14) was significantly more than the percentage of unique questions explored about food on Day 2, M = .79, SD = .23, p < .000. See Figure 5b.

3.3 In-depth vs In-breadth learning: How do children explore questions

Before analyzing further, we prepared the data using mainly the "tidyverse" package in the RStudio. Independent variables of this study included age, SES score, motivation score, and active learning score. The age variable wasn't continuous due to the fact that it was collected numerically as opposed to birth date. Therefore, and also for the sake of sample sizes, a new variable named "age group" was created by splitting the age into two, 8 to 10-year-olds as younger children and 11-12-year-olds as older children. Similarly, the active learning score (ALS), whose range is 0 to 4 was split into as higher ALS and lower ALS to create an additional variable as the "active learning group". Higher ALS included scores of 3 and 4, which are above the chance level, and lower ALS consisted of scores that are at the chance level and below. See Table 2 for descriptive statistics.

To our knowledge, there is no study that explores children's exploration and learning patterns in terms of depth and breadth. Therefore, we had to operationally define in-depth and in-breadth learning or in-depth and in-breadth exploration which are used interchangeably in this context. Since each subtopic included 5 questions to

explore, we suggested that if a child explored a subtopic above chance level, meaning that at least 3 of the 5 questions of that subtopic were explored, it indicated in-depth learning. Similarly, each main topic included 5 subtopics to explore, thus, we suggested that exploring at least 3 subtopics of the main topic would define in-breadth learning. Naturally, in-depth learning and in-breadth learning are not mutually exclusive. One can explore all the questions about one animal and also explore a question about the rest of the animals in the given time. Indeed, when we applied these operational definitions, we ended up with 4 different levels of learning patterns: in-depth learning only, in-breadth learning only, both, and no interest. "No interest" was the label given when the child explored equal to or less than the chance level in none of the sub and main categories, thus when their exploration wasn't enough to label as such. First, we focused on each of the three days separately. Our within-subjects design allowed us to confirm our result as if different days serve as a repetition study of each other. We checked whether children used different learning patterns and how, if there is any, their learning patterns are related to their age, SES, active learning score, motivation, and also with the indicators of their exploration in TRIVIA which were stated as the number of questions explored, the number of unique questions explored, the rate of uniqueness, the number of recall questions, and the rate of their accuracy. Preliminary analyses showed that children indeed adopt different exploration patterns in terms of depth and breadth of the topic. On Day 1, 55% of the children explored in-breadth only, 8% of the children explored in-depth only, while 17% of the children used both patterns, and 9% of them did not explore enough to label either of them thus, called a no-interest group. Similar to Day 1, on Day 2 and Day 3 children mostly explored either in both directions or in-breadth only. We, therefore, defined the difference between the learning patterns in terms of the presence of in-depth learning (see Table). Children either learned and explored in a way that involved in-depth learning or they explored in-breadth only (in-depth not involved), or they had no categorizable interest. See Table 3. Preliminary analysis showed that older and younger children explored

similarly in terms of depth and breadth, while SES played a different role. 86% of the higher SES children engaged with in-depth learning while this ratio dropped to 62% in the lower SES children. Similarly, while 87% of the children with higher active learning engaged in in-depth learning, children with lower active learning scores had a lesser ratio of 67%. Results suggested that motivation also did not make a difference in learning patterns.

Day 1: The aim of this analysis was to see whether there is a difference between learning patterns (in-depth involved – in-depth not involved), age (younger-older), SES (higher – lower), and active learning score (ALS) (higher – lower) on i) the rate of uniqueness, i.e. the ratio of the number of unique questions to the total number of questions and ii) the rate of the number correct answers to recall questions, i.e. the rate of accuracy. To avoid making a tautology, we did not analyze the number of all, and unique questions explored as dependent variables, since, by definition, the "in-depth learning involved" pattern includes more questions. Further, we excluded 9 participants that were from the "no interest" group, because the main purpose of the analysis was to see the effect, if any, of the different learning patterns. First, we checked the assumptions of normality and homogeneity of variances. While the results of Levene's tests suggested that the homogeneity assumption of the variance was met for both the rate of accuracy and the rate of uniqueness, the distribution of the latter failed to reject the assumption of normality, $p < .01$. A factorial ANOVA was conducted on the influence of the age, SES, learning pattern and active learning score on the rate of accuracy. Since children were allowed to leave the study anytime they wanted and there were problems with the internet connection, not all of the participating children were able to answer all the questions, which resulted in data from 49 children which is a lesser sample than the total number of participants. The analysis revealed that there wasn't any significant main effect of the independent variables on the accuracy rate. However, there were two significant interaction effects of the learning pattern, SES and age, $F(1, 34) = 12.01$, $p < .01$, $\eta^2 = .26$ and, the learning pattern, age and active learning, $F(1, 34) = 16.64$, $p < .001$, $\eta^2 =$

.33. Even though no main effect was found, the interaction effects were considered while working on possible models in the following section of the results. Lastly, to compare the difference between children who explore in-depth and in-breadth on the rate of uniqueness a Mann-Whitney U test was conducted which resulted in no significant difference, $p < .05$.

Day 2: The assumption of normality and homogeneity of variances assumptions were met, p> .05 for the rate of uniqueness. A factorial ANOVA showed that there was a main effect of SES on the rate of the uniqueness of the questions explored, $F(1,\ 42) = 4.35,\ p = .04,\ \eta^2 = 0.09$, suggesting that higher SES children's rate of repeating the same questions were lower, thus the rate of uniqueness in their exploration was higher ($M = .85$, $SD = .16$) than their lower-SES peers ($M = .78$, $SD = .18$). Moreover, there was also a statistically significant interaction effect between SES and age, indicating that younger-higher SES children had the highest rate of uniqueness while older-lower SES children have the lowest. See Figure 6a. Since the rate of accuracy was not normally distributed, a Mann-Whitney U test was conducted to see if there is an effect of the learning pattern on the accuracy rate, which yielded no significant results. However, the same test conducted to see the effect of SES showed that higher SES children ($M = .94$, $SD = .12$) performed significantly better than their lower SES peers ($M = .67$, $SD = .28$), $p < .001$, with an effect size of $r = .57$. See Figure 6b.

Day 3: On Day 3, neither the rate of accuracy nor the rate of uniqueness was distributed normally. Several Mann-Whitney U tests were conducted to investigate the differences between the groups of SES, age, active learning score, and learning pattern. Besides the significant difference between older and younger children in their accuracy, no significant difference was found, $p < .05$.

3.4 Exploring possible models to explain how children perform differently

In this section, we used the R package "AICcmodavg" (Mazerolle, 2020) to distinguish among a set of possible models describing the relationship between the outcome variables of TRIVIA and dependent variables. This R package uses Akaike's Information Criteria (AIC) which is a mathematical method to estimate the relative quality of a model compared to the other models by resolving the trade-off between model fit and complexity. Before moving on, we excluded one child from the data since she explored less than three questions in all three days and, ended up with 71 participants for further analysis. We focused on the four outcome variables of TRIVIA, which were the total number of questions explored, the total number of unique questions explored, the rate of uniqueness, and the average rate of accuracy. Dependent variables included age, motivation, SES score, active learning score, and learning pattern. Consistent with the former analyses, the learning pattern was examined on two levels according to the presence of in-depth learning. The variable was treated as an indicator variable coded as [1] when in-depth learning was present and [0] when in-depth learning wasn't present. Based on the previous findings of the study, we stated 9 candidate models that include these variables: i) age, ii) SES, iii) learning pattern, iv) age and SES, v) motivation, vi) age and learning pattern, vii) age, learning patterns and SES, viii) age, learning pattern, and active learning, and lastly a model that includes all variables, ix) age, SES, active learning, and learning pattern. With the help of AIC, we compared these models and presented the model that fits the data the best. Previous analysis showed that children adopted different learning patterns on different days, which allowed us to assume a counterbalance across three days. Therefore, unlike the analyses of a single day, we could add the learning pattern variable to the models that predict the number of information explored without the danger of tautology. The model comparison revealed that the best-fit model, carrying 35% of the cumulative model weight consisted of the learning pattern variable. The model explained a statistically moderately significant

amount of variance in the total number of information explored by children, $F(1, 69) = 6.87$, $p = .011$, $R^2 = .09$ adjusted $R^2 = .07$. The learning pattern was a significant predictor of the number of pieces of information explored, $t(69) = 2.62$, $p = .011$. Children who didn't explore in-depth in any of the three days also explored the least amount of information. This relationship was the most visible in the younger children. The number of unique information explored was best predicted by the model of age and learning pattern that carried 38% of the cumulative weight, $F(2,68) = 6.46$, $p = .003$, $R^2 = 0.16$, adjusted $R^2 = 0.14$. The learning pattern was a statistically significant predictor of the number of unique information explored, $t(68) = 3.04$, $p = .003$, while age did not significantly predict it, $t(68) = 1.65$, $p = .10$. See Figure 7a and 7b.

The AIC model selection showed that the model that fits the best to describe the rate of uniqueness consisted of the motivation parameter and carried 63% of the cumulative weight. The investigation of the model revealed that, as children's intrinsic motivation score increased, the rate of uniqueness of the questions they explored decreased, $F(1,69) = 4.73$, $p = .03$, $R^2 = .06$, adjusted $R^2 = .05$. See Figure 8a. Finally, the regression model that describes the rate of accuracy best was calculated. Before that, children who answered less than 3 questions were dropped and the sample size became 69 participants. The best model had a cumulative weight of 48% and consisted of age, SES, and learning pattern. The multiple regression model explained a statistically significant amount of variance in the rate of accuracy, $F(3, 65) = 5.84$, $p = .001$, $R^2 = .21$, and adjusted $R^2 = .18$. See Figure 8b. An analysis of the model revealed that SES was a significant predictor of the accuracy rate, $t(65) = 3.55$, $p = .0007$. Moreover, age had a relative significance, $t(65) = 2.39$, $p = .02$ while learning pattern wasn't a significant predictor, $p > .05$. See Table 4.

4 Discussion

The purpose of this study was to investigate whether children adopt different learning patterns such as in-depth and in-breadth learning and whether these learn-

ing patterns are related to factors such as active learning ability, motivation, age and SES. In addition, the study also examined how children's performance can be predicted by these factors The results are based on an Egyptian sample of children recruited via an educational foundation. The study found that children indeed adopt different learning and exploring patterns and some of the learning outcomes and individual differences are associated with these patterns. Consistent with the literature (Berlyne, 1962; Loewenstein, 1994; Jirout and Klahr, 2012) results confirmed that novel information attracts children's willingness to engage with and learn. Both on Day 2 and Day 3, children explored significantly the novel topic more than the old topic.

4.1 Investigating how children performed on Day 1, Day 2, and Day 3

Children had one main topic to explore on Day 1, two main topics to explore on Day 2, and three main topics to explore on Day 3. When the three days of the TRIVIA were examined separately, it was found that the new topic was explored more than the old topics. Interestingly, the effect of novelty wasn't the same for Day 2 and Day 3. Children's exploration of the novel topic on Day 3 was significantly more than their exploration of the novel topic on Day 2 in terms of its quantity. However, when the distribution of the questions was checked as percentages, it was found that children explored significantly more on the new topic on Day 2 than on Day 3. This can be interpreted as while the amount of exploration peaked on the last day of the workshop, interest in the novel topic peaked on the second day as 92% of the explored questions belonged to the newer topic. This might be due to the fact that Day 2 was the first day of TRIVIA on which a new topic was introduced. It might be that by the third-day children were not that surprised when a newer topic came up. Secondly, the number of topics on Day 3 was three which means 15 subtopics and a total of 75 pieces of questions to explore, while on Day 2 it was two, which provided 10 subtopics and 50 pieces of questions. Thus, children's interest was split

among three different topics and 15 different subtopics on Day 3, which may explain the relatively small percentage of the exploration of the new topic on Day 3. This approach was supported by the finding that even though the main topic "Animals" was the oldest topic and present on all three days, children explored it more on Day 3 than on Day 2. It would have been expected of the interest for the first introduced topic to follow a linear decrease, which wasn't the case here. This suggests that children adapt their learning and exploration behavior according to the presence of the other topics. Another factor influencing this adaptation might be the time, since Day 3 was the last day of the TRIVIA, children might have wanted to take the most out of it and distribute their interest accordingly. This also explains the finding that children explore significantly more unique questions than on Day 1 and Day 2 even though they had the same amount of time to explore. The explanation that getting familiar with the design helped them to explore the most on Day 3 doesn't seem like a fit here, since the amount of exploration on Day 1 and Day 2 is the same. Since the order of the main topics wasn't pseudorandomized across the three days, another factor affecting this finding might be that children found one topic more interesting than the other, which is a limitation that we will address in the limitations section.

4.2 In-depth vs In-breadth learning: How do children explore questions?

In the second part of the analysis, we again examined Day 1, Day 2, and Day 3 separately to see the effects of learning pattern, age, SES, and active learning on the rate of uniqueness and rate of accuracy. On Day 1 none of the factors had a main effect on the outcome variables. However, we found two significant interactions of learning pattern, age, SES, and learning pattern, age, active learning measure. On Day 2 we found a main effect of SES on both the rate of accuracy and the rate of uniqueness. In line with the previous findings that examined the effect of SES (Gauvain et al., 2013; Ünlütabak et al., 2019) and age (Engel and Randall, 2009;

Engel, 2011; Meder et al., 2021; Tizard and Hughes, 1984), we found an SES and age interaction revealed that while younger children from higher SES explored most of the unique pieces, older children from lower SES groups explored the least of the unique questions. We failed to repeat the results of Day 2 on Day 3. We found a main effect of age on the rate of accuracy but no other effects of SES, learning pattern, or active learning measure and also no interaction effects on the rate of accuracy and uniqueness. However, this finding can be considered as a part of the previous finding that Day 3 differed from Day 1 and Day 2 in terms of children's exploration. In an attempt to understand whether the factors we measured and individual differences can predict the outcome results; we conducted model comparison analyses. The number of total questions explored by children was predicted by the learning pattern. Since to our knowledge, there is no prior study examining the relationship between children's in-depth learning and their exploration behavior, this finding provides a basis for why learning types should be examined further. Together with the age, learning patterns also predicted the number of unique questions explored during the three days. Older children who explored in-depth explored more unique questions than their peers. At first, this finding seems contradictory to the findings that as children progress in school, their curiosity diminishes (Alexander et al., 2008; Engel, 2011; Engel and Randall, 2009; Helmke, 1993; Krapp, 1999b; Tizard and Hughes, 1984). However, it is not surprising that in this design older children explored more in a given time since they are expected to read and process faster than their younger peers. When this finding was challenged with a comparison of older and younger children in the rate of uniqueness, it was seen that younger children's rate of uniqueness was higher than the older children. This finding indicates that older children explored more unique questions because they also explored more in the total number of questions. They are capable of exploring faster than their younger peers. However, their younger peers repeat less information and instead explore newer ones. Thus, our finding is actually compatible with the previous studies showing that younger children's interest and curiosity are higher than their older

peers. Importantly, we need to keep in mind that the capabilities of younger and older children are not the same and thus, their performance should not only be compared on the basis of quantity.

Interestingly, the rate of uniqueness was predicted by intrinsic motivation. As intrinsic motivation increased, the rate of uniqueness decreased. This can be explained as children who wanted to learn the information they explored permanently were higher on their intrinsic motivation. They opened the questions more than one time to have a better memory of them. However, if this relationship would have been found between their extrinsic motivation and the rate of uniqueness, a similarly valid explanation would be also possible such as children higher in extrinsic motivation wanted to score better in the recall test at the end and thus, repeated the items more than once. Therefore, this finding needs further examination before coming to conclusions about the relationship between motivation and exploration. It is also worth noting that children's motivation was measured with a scale developed in Western culture (Thomas 2018) and might have failed to capture Egyptian children's motivation inclusively. The rate of accuracy was predicted by age, SES, and learning patterns. The relationship between age and SES and, learning outcomes is widely stated in the literature and our findings add to them. We contribute to the literature by adding the learning pattern variable to this equation. Even though children who explore in-depth do not differ from their peers in the accuracy of their recalling performance, the model that included learning patterns predicted the accuracy better than the model that involved only age and SES. This finding is consistent with our approach to children learning since we believe that children are good at applying their learning strategies. Their performance does not rely on their learning pattern but on the environment that allows them to explore the way they feel. However, contradicting the previous findings about the positive relationship between active learning and accuracy (Markant et al., 2016; Ruggeri et al., 2016b, 2019) this study didn't find an association between the two. The main difference is that these studies didn't measure an active learning score separately

like we did but examined whether actively learner information is recalled better than observed information. To assess the effect of active learning, further studies can add a yoked group to TRIVIA in which children learn about the questions that are actively explored by another group. This approach would allow the comparison of self-directed learning and yoked learning within the same environment and information pool. Another approach would be assessing the active learning ability in a more elaborated way with a comprehensive and culturally adapted active learning battery, which is, to our knowledge, not developed yet.

4.3 Limitations and Future Research

The main topics of animals, the universe, and food across the three days weren't pseudorandomized. Therefore we cannot solely rely on our experiment when we explain the differences we found between these three days, which is a limitation. It also limits us to treat these separate days as their replications and increases the power of the study. In addition, Day 1 and day 2 also differed in their recall part in which children were asked multiple-choice questions about the information they have learned. While the idea was to present them with a maximum of 5 questions no matter how much they explored, we failed to manage this on Day 1 and Day 2 due to a technical error we missed on Qualtrics. This might have affected how much children explored since children who don't want to answer a lot of questions at the end would keep their exploration limited. It also might have led them to repeat the same information so that they keep exploring in a way that does not increase the number of quiz questions they will encounter at the end. Since this would jeopardize curiosity-driven exploration, it serves as a confounding effect on our study. Since this study was conducted in Egypt in Arabic, we couldn't measure the complexity and length of the information provided in TRIVIA. We also avoided including a verbal intelligence measure unlike similar studies (Mills et al., 2017, 2019) to keep the cognitive load and length of the study reasonable. However, assuming that all the pieces of information were equal in terms of complexity and verbal intelligence

does not affect their exploration would require a ground and thus, worth considering in future studies. Moreover, further studies comparing children's exploration in a self-directed environment with a school environment and, comparing preschool children with school children would allow us to have a broader understanding of the issue, regarding the effect of schooling and age. Finally, as a Qualtrics-based study that requires a stable Internet connection, TRIVIA was caught unprepared for the connection losses that happened during testing. In addition, children sometimes made mistakes while typing their ID after a connection loss, due to the difficulty they had in transforming their names from the Arabic alphabet to the Latin alphabet, which is another aspect worth considering especially in future cross-cultural studies.

5 Conclusion

The present study proposes a first attempt to identify the learning patterns of children in terms of breadth and depth and how they relate to the other factors when children explore in a self-directed learning environment. Even though no strong effects or mechanisms were identified, this study contributed to the literature by adding a new perspective to the research of teaching and learning. Moreover, with a study conducted in a non-Western culture, we contributed to the diversity of the field, which is still largely missing in the literature. Investigating children's learning patterns is a step in the way of providing them with an environment in which their curiosity is encouraged and fed, and the ways that go to the learning are wide open for them to explore. Hopefully, further research following this humble step would shed new light on how to balance the gardener and carpenter approaches toward children and provide the best environment and techniques for them.

References

Alexander, J. M., Johnson, K. E., Leibham, M. E., and Kelley, K. (2008). The development of conceptual interests in young children. *Cognitive Development*, 23(2):324–334.

Anderman, E. M. and Maehr, M. L. (1994). Motivation and schooling in the middle grades. *Review of educational Research*, 64(2):287–309.

Beittel, K. R., Mattil, E. L., Burgart, H. J., Burkhart, R. C., Kincaid, C., and Stewart, R. (1961). The effect of a depth vs. a breadth method of art instruction at the ninth grade level. *Studies in Art Education*, 3(1):75.

Berlyne, D. E. (1954). A theory of human curiosity. *British Journal of Psychology*, 45(3):180.

Berlyne, D. E. (1962). Uncertainty and epistemic curiosity. *British Journal of Psychology*, 53(1):27–34.

Bruner, J., Jolly, A., and Sylva, K. (1976). Play: Its role in evolution and development.

Chi, M. T. H., Hutchinson, J. E., and Robin, A. F. (1989). How inferences about novel domain-related concepts can be constrained by structured knowledge. *Merrill-Palmer Quarterly*, 35(1):27–62.

Chouinard, M. M., Harris, P. L., and Maratsos, M. P. (2007). Children's questions: A mechanism for cognitive development. *Monographs of the Society for Research in Child Development*, 72(1):i–129.

Cook, C., Goodman, N. D., and Schulz, L. E. (2011). Where science starts: Spontaneous experiments in preschoolers' exploratory play. *Cognition*, 120(3):341–349.

Danovitch, J. H. and Mills, C. M. (2018). Understanding when and how explanation promotes exploration. In *Active learning from infancy to childhood*, pages 95–112. Springer.

DeLoache, J. S., Simcock, G., and Macari, S. (2007). Planes, trains, automobiles–and tea sets: extremely intense interests in very young children. *Developmental psychology*, 43(6):1579.

Egypt Ministry of Education. National Center for Educational Research and Development and UNESCO Office Cairo and Regional Bureau for Science in the Arab States (2014). Education for all in egypt 2000-2015: A national assessment.

El-Gilany, A., El-Wehady, A., and El-Wasify, M. (2012). Updating and validation of the socioeconomic status scale for health research in egypt. *Eastern Mediterranean health journal*, 18(9).

Engel, S. (2011). Children's need to know: Curiosity in schools. *Harvard Educational Review*, 81(4):625–645.

Engel, S. and Hackmann, H. (2002). Curiosity in context: The classroom environment examined. In *Society for Research in Child Development, Biennial Meetings, Tampa, FL*.

Engel, S. and Randall, K. (2009). How teachers respond to children's inquiry. *American Educational Research Journal*, 46(1):183–202.

Gallagher, S. A. and Stepien, W. J. (1996). Content acquisition in problem-based learning: Depth versus breadth in american studies. *Journal for the Education of the Gifted*, 19(3):257–275.

Gauvain, M., Munroe, R. L., and Beebe, H. (2013). Children's questions in cross-cultural perspective: A four-culture study. *Journal of Cross-Cultural Psychology*, 44(7):1148–1165.

Gopnik, A. (2016). *The gardener and the carpenter: What the new science of child development tells us about the relationship between parents and children*. Macmillan.

Grossnickle, E. M. (2016). Disentangling curiosity: Dimensionality, definitions, and distinctions from interest in educational contexts. *Educational Psychology Review*, 28(1):23–60.

Gureckis, T. M. and Markant, D. B. (2012). Self-directed learning: A cognitive and computational perspective. *Perspectives on Psychological Science*, 7(5):464–481.

Harris, P. L. (2012a). *Trusting what you're told: How children learn from others*. Harvard University Press.

Harris, P. L. (2012b). *Trusting what you're told: How children learn from others*. Harvard University Press.

Harris, P. L. and Koenig, M. A. (2006). Trust in testimony: How children learn about science and religion. *Child development*, 77(3):505–524.

Helmke, A. (1993). Die entwicklung der lernfreude vom kindergarten bis zur 5. klassenstufe. *Zeitschrift für Pädagogische Psychologie/German Journal of Educational Psychology*.

Hidi, S. E. and Renninger, K. A. (2020). On educating, curiosity, and interest development. *Current Opinion in Behavioral Sciences*, 35:99–103.

Hirsch, E. D., Jr. (2001). Seeking both breadth and depth in the curriculum. *Educational Leadership*, 59(2):22–25.

Jirout, J. and Klahr, D. (2012). Children's scientific curiosity: In search of an operational definition of an elusive concept. *Developmental review*, 32(2):125–160.

Johnson, K. E., Alexander, J. M., Spencer, S., Leibham, M. E., and Neitzel, C. (2004). Factors associated with the early emergence of intense interests within conceptual domains. *Cognitive Development*, 19(3):325–343.

Kirschner, P. A. and van Merriënboer, J. J. (2013). Do learners really know best? urban legends in education. *Educational Psychologist*, 48(3):169–183.

Krapp, A. (1999a). Interest, motivation and learning: An educational-psychological perspective. *European Journal of Psychology of Education*, 14(1):23–40.

Krapp, A. (1999b). Interest, motivation and learning: An educational-psychological perspective. *European Journal of Psychology of Education*, 14(1):23–40.

Kurkul, K. E. and Corriveau, K. H. (2018). Question, explanation, follow-up: A mechanism for learning from others? *Child Development*, 89(1):280–294.

Langsten, R. and Hassan, T. (2018). Primary education completion in egypt: Trends and determinants. *International Journal of Educational Development*, 59:136–145.

Legare, C. H. (2014). The contributions of explanation and exploration to children's scientific reasoning. *Child Development Perspectives*, 8(2):101–106.

Leibham, M. E., Alexander, J. M., Johnson, K. E., Neitzel, C. L., and Reis-Henrie, F. P. (2005). Parenting behaviors associated with the maintenance of preschoolers' interests: A prospective longitudinal study. *Journal of Applied Developmental Psychology*, 26(4):397–414.

Lepper, M. R., Corpus, J. H., and Iyengar, S. S. (2005). Intrinsic and extrinsic motivational orientations in the classroom: Age differences and academic correlates. *Journal of Educational Psychology*, 97(2):184–196.

Liquin, E. G. and Gopnik, A. (2022). Children are more exploratory and learn more than adults in an approach-avoid task. *Cognition*, 218:104940.

Loewenstein, G. (1994). The psychology of curiosity: A review and reinterpretation. *Psychological bulletin*, 116(1):75.

Markant, D. B., Ruggeri, A., Gureckis, T. M., and Xu, F. (2016). Enhanced memory as a common effect of active learning. *Mind, Brain, and Education*, 10(3):142–152.

Mazerolle, M. J. (2020). *AICcmodavg: Model selection and multimodel inference based on (Q)AIC(c)*. R package version 2.3-1.

Meder, B., Wu, C. M., Schulz, E., and Ruggeri, A. (2021). Development of directed and random exploration in children. *Developmental science*, 24(4):e13095.

Mills, C. M., Danovitch, J. H., Mugambi, V. N., Sands, K. R., and Pattisapu Fox, C. (2022). "why do dogs pant?": Characteristics of parental explanations about science predict children's knowledge. *Child Development*, 93(2):326–340.

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

Mills, C. M. and Landrum, A. R. (2016). Learning who knows what: Children adjust their inquiry to gather information from others. *Frontiers in Psychology*, 7:951.

Mills, C. M., Sands, K. R., Rowles, S. P., and Campbell, I. L. (2019). i want to know more!: Children are sensitive to explanation quality when exploring new information. *Cognitive science*, 43(1).

Montessori, M. (1964). The montessori method (ae george, trans.). *New York: Schocken.(Translation originally published 1912)*.

Piaget, J. and Valsinen, J. (2017). *The child's conception of physical causality*. Routledge.

Pluck, G. and Johnson, H. L. (2011). Stimulating curiosity to enhance learning.

Ronfard, S., Zambrana, I. M., Hermansen, T. K., and Kelemen, D. (2018). Question-asking in childhood: A review of the literature and a framework for understanding its development. *Developmental Review*, 49:101–120.

Ruggeri, A., Lombrozo, T., Griffiths, T. L., and Xu, F. (2016a). Sources of developmental change in the efficiency of information search. *Developmental psychology*, 52(12):2159–2173.

Ruggeri, A., Markant, D. B., Gureckis, T. M., Bretzke, M., and Xu, F. (2019). Memory enhancements from active control of learning emerge across development. *Cognition*, 186:82–94.

Ruggeri, A., Markant, D. B., Gureckis, T. M., and Xu, F. (2016b). *Active control of study leads to improved recognition memory in children.*

Sansone, C. and Morgan, C. (1992). Intrinsic motivation and education: Competence in context. *Motivation and emotion*, 16(3):249–270.

Schmidt, H. G. and Rotgans, J. I. (2021). Epistemic curiosity and situational interest: Distant cousins or identical twins? *Educational Psychology Review*, 33(1):325–352.

Schraw, G., Flowerday, T., and Lehman, S. (2001). Increasing situational interest in the classroom. *Educational Psychology Review*, 13(3):211–224.

Schwartz, M. S., Sadler, P. M., Sonnert, G., and Tai, R. H. (2009). Depth versus breadth: How content coverage in high school science courses relates to later success in college science coursework. *Science Education*, 93(5):798–826.

Shin, D. D. and Kim, S.-i. (2019). Homo curious: Curious or interested? *Educational Psychology Review*, 31(4):853–874.

Sim, Z. L., Tanner, M., Alpert, N. Y., and Xu, F. (2015). *Children Learn Better When They Select Their Own Data.*

Swaboda, N., Meder, B., and Ruggeri, A. (2022). Finding the (most efficient) way out of a maze is easier than asking (good) questions. *Developmental Psychology.*

Swaboda, N. and Ruggeri, A. (2022). *Smart, or just lucky? Inferring question-asking competence from strategies' efficiency versus effectiveness.* Center for Open Science.

Tizard, B. and Hughes, M. (1984). Children learning at home and in school. *London: Fontana.*

United Nations (2005). *The millennium development goals report 2005*. United Nations.

Ünlütabak, B., Nicolopoulou, A., and Aksu-Koç, A. (2019). Questions asked by turkish preschoolers from middle-ses and low-ses families. *Cognitive Development*, 52:100802.

Wade, S. and Kidd, C. (2019). The role of prior knowledge and curiosity in learning. *Psychonomic Bulletin & Review*, 26(4):1377–1387.

A

Appendix A

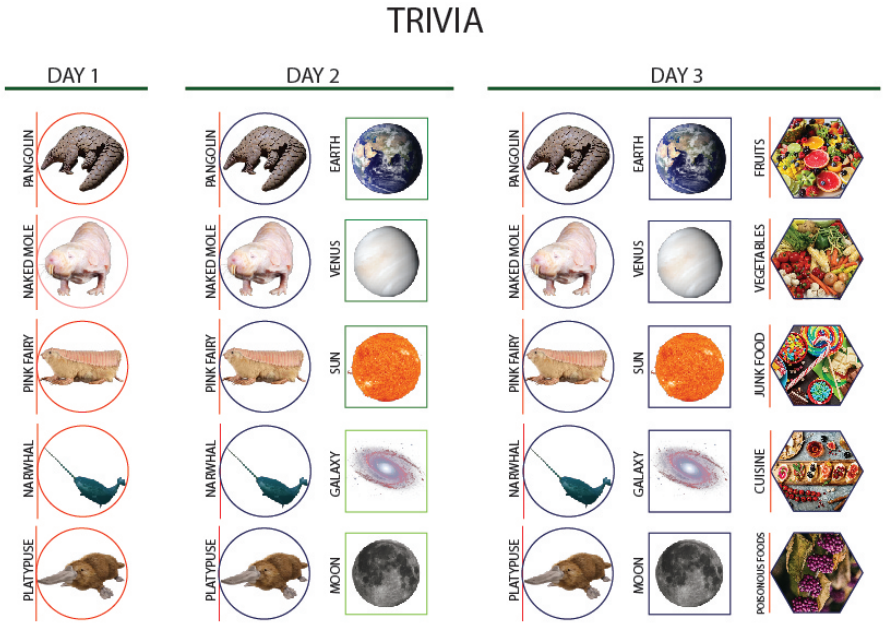


Figure 1: The structure of TRIVIA

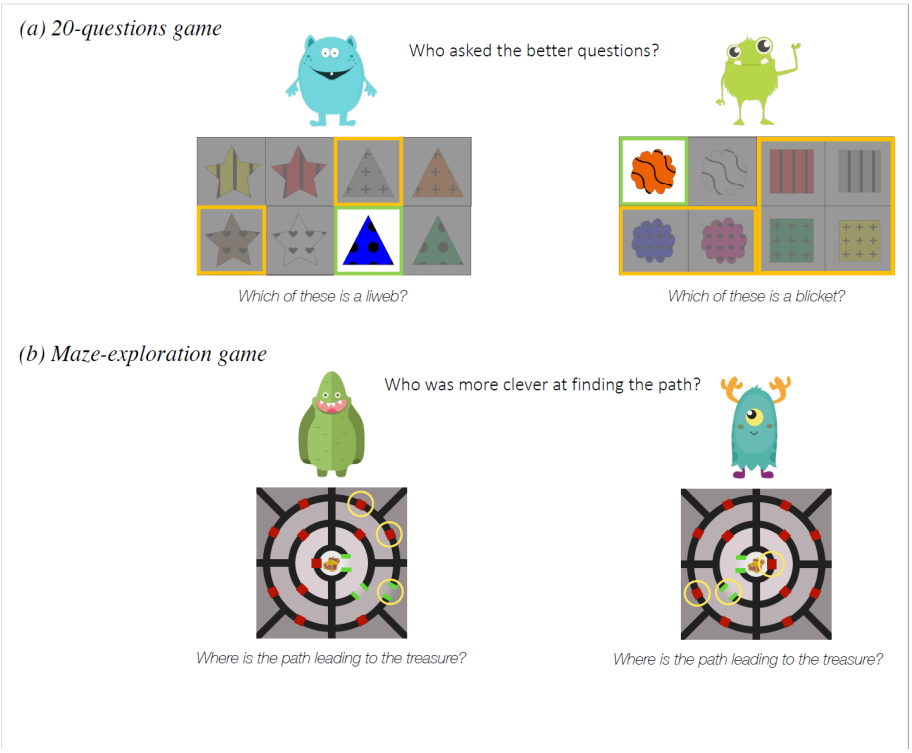
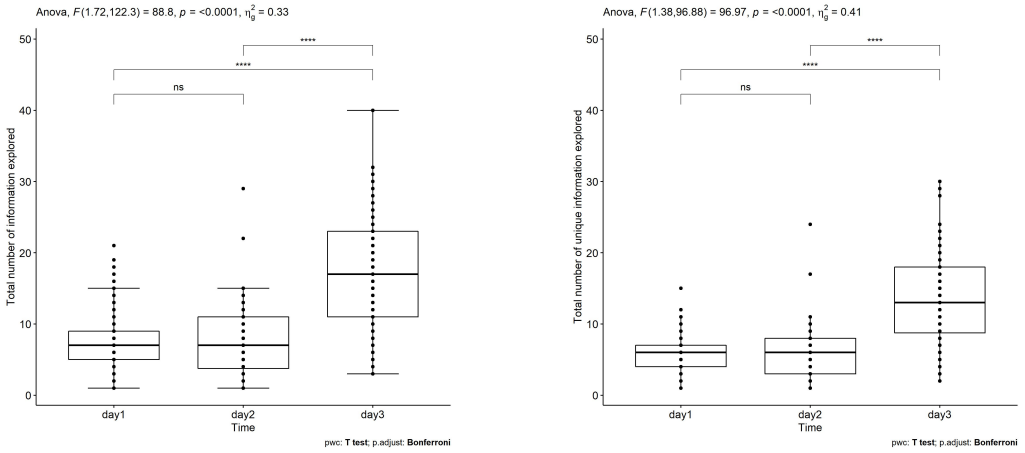
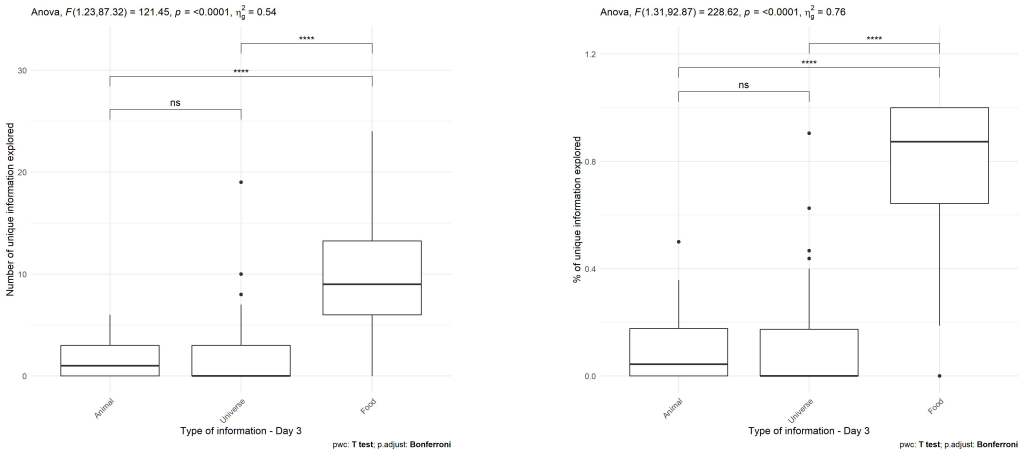


Figure 2: Illustrative examples of the active learning test.



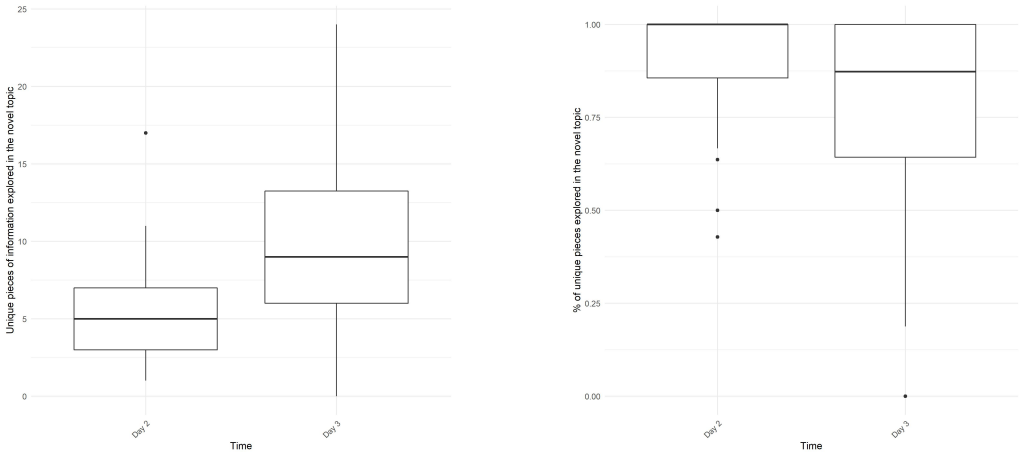
(a) (b)

Figure 3: Total number of questions (a) and total number of questions unique questions (b) explored across the three days



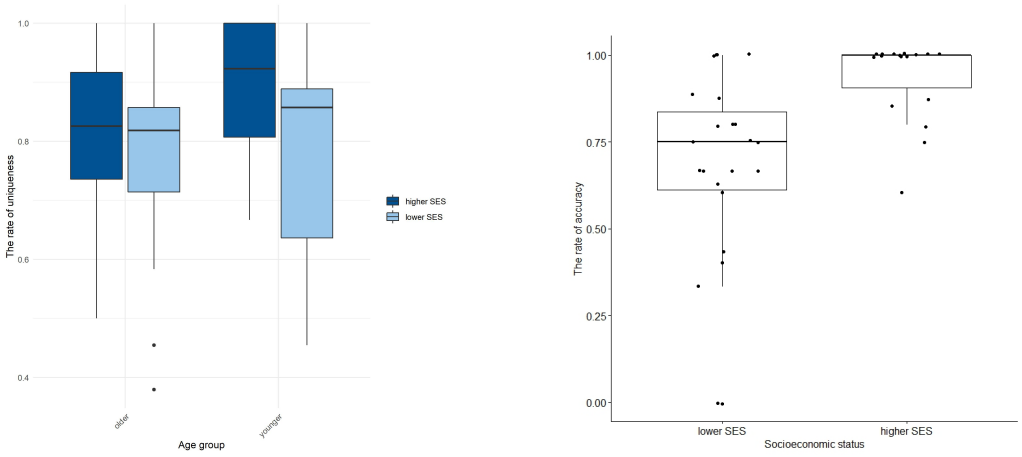
(a) (b)

Figure 4: Total number (a) and percentage (b) of unique questions explored on Day 3



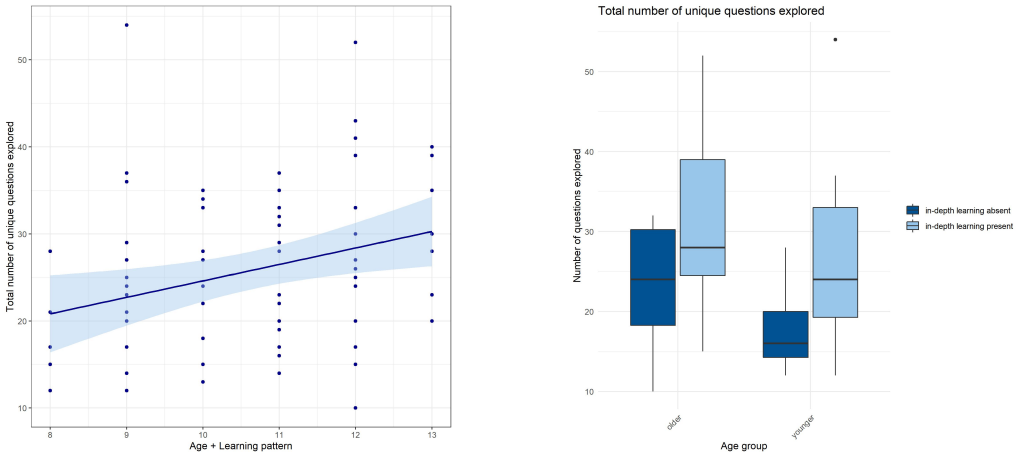
(a) (b)

Figure 5: Total number (a) and percentage (b) of unique questions explored in the novel topics of Day 2 and Day 3



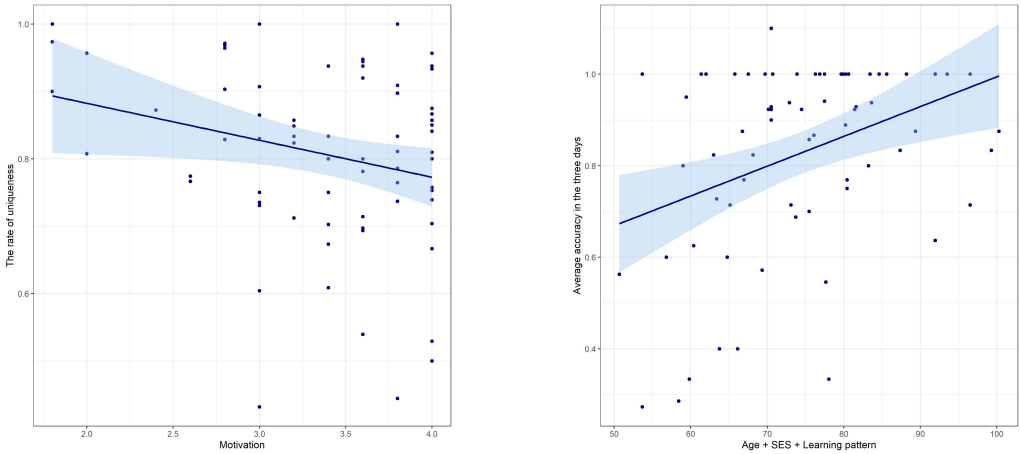
(a) (b)

Figure 6: Box plots of the rate of uniqueness (a) and the rate of accuracy (b) on Day 2



(a) (b)

Figure 7: A scatter plot (a) and a box plot (b) of age and learning pattern predicting the total number of unique informations explored



(a) (b)

Figure 8: Scatterplots of motivation predicting the rate of uniqueness (a) and age, SES and learning pattern predicting the rate of accuracy (b)

TRIVIA items	
English Note: (A) is the right answer	**Arabic**
Animals	عالم الحيوان
1- Pangolin	**حيوان البنغول**
What does the Pangolin eat?	ماذا يأكل البنغول؟
a- Using its very long tongue, it eats up to 20,000 ants a day.	أ- باستخدام لسانه الطويل جدًا ، يأكل ما يصل إلى 20000 نملة يوميًا.
b- Using its very long tongue, it eats up to 20,000 frogs a day	ب- باستخدام لسانه الطويل جدًا يأكل ما يصل إلى 20000 ضفدع يوميًا
c- Its very short tongue doesn't help it to eat anything but 1 ant a day	ج- لسانه القصير جداً لا يساعده على أكل أي شيء إلا نملة واحدة في اليوم
d- I don't know	ج- لا اعرف
Do the Pangolins have teeth?	هل حيوان البنغول له أسنان؟
a- No, they don't! They swallow stones to grind up the food.	أ- لا ، لا يملك اسنان! يبتلع الحجارة لطحن الطعام.
b- Yes they have 23 teeth	ب- نعم لديهم 23 سنًا.
c- Yes they have one long tooth	ج- نعم لديهم سن واحد طويل.
d- I don't know	ج- لا اعرف
What are the pangolin's strongest senses?	ما هي أقوى حواس حيوان البنغول؟
a-Hearing and Smelling	أ- السمع والشم لمساعدتهم على اصطياد النمل
b- Hearning only	ب- السمع فقط
c-Smelling only	ج- الشم فقط
d- I don't know	ج- لا اعرف
What are the Pangolins' weakest sense?	ما هي أضعف حاسة البنغول؟
a- Sight	أ- حاسة البصر
b- Touch	ب- اللمس
c- Hearing and smelling	ج- السمع والشم
d- I don't know	ج- لا اعرف
How does the Pangolin defend himself against predators?	كيف يدافع البنغول عن نفسه ضد الحيوانات المفترسة؟
a-They curl up into a tight ball and tuck their heads under their arms and tails.	أ- يلتفون على شكل كرة ضيقة ويضعون رؤوسهم تحت أذرعهم وذيولهم.
b- They change their color	ب- يغيرون لونهم
c- They run away	ج- يهربون عن طريق الجري
d- I don't know	ج- لا اعرف
2- Sand Puppy	**جرو الرمال**
How long does the sand puppy live?	ما هو عمر جرو الرمال؟
a- 30 years.	أ- 30 سنه.
b- 30 months	ب- 30 شهرًا
c- 2 years	ج- سنتان
d- I don't know	ج- لا اعرف
Where do the sand puppy Live?	أين يعيش جرو الرمل؟
a- In the underground tunnels.	أ- في الأنفاق تحت الأرض.
b- On the mountains	ب- على الجبال
c- On the trees	ج- على الشجر
d- I don't know	ج- لا اعرف
How does the sand puppy find its way in the dark?	كيف يجد جرو الرمل طريقه في الظلام؟
a- It uses its little hairs as sensory organs to move around in the dark underground tunnels.	أ- يستخدم شعيرات صغيرة كأعضاء حساسة للتنقل في الأنفاق المظلمة تحت الأرض.
b- Its body lighten up in the dark	ب- يضيء جسمه في الظلام
c- It moves following the sound	ج- يتحرك باتباع الصوت
d- I don't know	ج- لا اعرف
What happens to the sand puppy when there is not enough oxygen in the tunnels?	ماذا يحدث لجرو الرمل عندما لا يوجد أكسجين كافٍ في الأنفاق؟
a- They can survive five hours with little oxygen, that's why they are resistant to Cancer as well.	أ- يمكنهم البقاء على قيد الحياة لمدة خمس ساعات مع القليل من الأكسجين ، وهذا هو سبب مقاومتهم للسرطان أيضًا.
b- They die	ب- يموتون
c- They faint	ج- يغمى عليهم
d- I don't know	ج- لا اعرف
Why do sand puppies have incisors outside their mouth?	لماذا الجراء الرملية لها قواطع خارج أفواههم؟

a- To help them move the dirt while they move without having to eat it.	أ- لتساعدهم على تحريك القاذورات فى الارض أثناء تحركهم دون الحاجة للاضطرار إلى أكلها.
b- To help them eat the big prey	ب- لتساعدهم على أكل الفريسة الكبيرة
c- They don't have incisors outside their mouth.	ج- ليس لها قواطع خارج أفواهها اصلا.
d- I don't know	ج- لا اعرف
3- Pink Fairy Armadillo	**حيوان المدرع الوردي**
What is the length of Pink Fairy Armadillos?	ما هو طول حيوان المدرع الوردي ؟
a- It grows only to 2 inches. That's why it is the smallest armadillos.	أ- ينمو فقط إلى بوصتين. هذا هو السبب في أنها أصغر حيوان من نوعه
b- Its 5 meters long like a giraffe	ب- طولها 5 أمتار كالزرافة
c- Its 3.7 mm like an ant	ج- يبلغ طولها 3.7 مم مثل النملة
d- I don't know	ج- لا اعرف
Why do the Pink Fairy Armadillos have a pink shell?	لماذا يمتلك حيوان المدرع الوردي قشرة وردية اللون؟
a- Because of the underlying blood vessels that regulate the body temperature	أ- بسبب الأوعية الدموية التي تنظم درجة حرارة الجسم
b- Because of the environment it lives in	ب- بسبب البيئة التي تعيش فيها
c- None of the above	ج- غير ما سبق
d- I don't know	ج- لا اعرف
Do Pink Fairy Armadillos lay eggs?	هل حيوان المدرع الوردي يضع البيض؟
a- No, they give birth like other mammals do.	أ- لا ، إنها تلد مثل الثدييات الأخرى
b- Yes they lay eggs	ب- نعم يبيضون
c- They don't give birth or lay eggs	ج- لا تلد ولا تبيض
d- I don't know	ج- لا اعرف
What is the nickname of the Pink Fairy Armadillos?	ما هو لقب حيوان المدرع الوردي؟
a- Sand swimmer	أ- سباح الرمال
b- Ocean swimmer	ب- سباح المحيط
c- Pool swimmer	ج- سباح فى حوض السباحه
d- I don't know	ج- لا اعرف
Why is the Pink Fairy Armadillos nicknamed Sandwimmer?	لماذا يطلق على حيوان المدرع اسم سباح الرمال؟
a- Because it has claws that are used in digging in the sand so fast	أ- لأنه يحتوي على مخالب تستخدم في الحفر في الرمال بسرعة كبيرة
b- because it cannot swim in the sand	ب- لأنه لا يستطيع السباحه في الرمال
c- none of the above	ج- غير ما سبق
d- I don't know	ج- لا اعرف
4- Narwhal	**حوت النروال**
What is the difference between Narwhals and normal whales?	ما هو الفرق بين حوت النروال والحيتان العادية؟
a- Narwhals have one single tooth that extends outside their mouth and it's called a tusk.	أ- حوت النروال له سن واحد يمتد خارج فمه ويسمى بالناب
b- Narwhals have only two teeth that extend outside their mouth	ب- حوت النروال له سنان فقط يمتدان خارج فمه
c- Narwhals don't have teeth	ج- حوت النروال ليس له أسنان
d- I don't know	ج- لا اعرف
Why do the Narwhals have a tusk?	لماذا حوت النروال لديه ناب طويل خارج فمه؟
a- They use it to sting their prey.	أ- يستخدمه لطعن فريسته
b- They use it for directions in the sea.	ب- يستخدمونه في التوجيهات للطريق فى البحر
c- They don't use it at all.	ج- لا يستخدمونها إطلاقاً.
d- I don't know	ج- لا اعرف
What do the Narwhals feed on?	مادا تتغذى حياتن النروال على ؟
a- Fish, Shrimps, and squids.	أ- السمك والجمبري والحبار
b- Frogs	ب- الضفادع
c- Plants	ج- النباتات
d- I don't know	ج- لا اعرف
Can we see the Narwhals in the aquarium exhibits?	هل يمكننا رؤية حيتان النروال فى معارض احواض السمك الكبيرة؟
a- No, because they don't survive captivity.	أ- لا لانهم لا يستطيعون العيش فى حوض سمك
b- Yes because they like captivity	ب- نعم لأنهم يحبون العيش فى حوض السمك
c- None of the above	ج- غير ما سبق
d- I don't know	ج- لا اعرف
In which countries can you find the Narwhals?	فى اى دول يمكنك ان تجد حيتان النروال؟
a-Canada, Russia, and Norway because they prefer very cold water.	أ- كندا وروسيا والنرويج لأنهم يفضلون الماء شديد البرودة.
b- Egypt, Morocco and Algeria because they prefer hot waters	ب- مصر والمغرب والجزائر لأنهم يفضلون المياه الساخنة

c- They can be found everywhere	ج- يمكن العثور عليها في كل مكان
d- I don't know	ج- لا اعرف
5- Platypus	**خلد الماء**
What does the Platypus look like?	كيف يبدو خلد الماء؟
a-They have a mouth and feet like ducks, fur-like otters, and a tail like beavers.	أ- لديهم فم وأقدام مثل البط ، وفرو مثل الثعالب ، وذيل مثل القندس.
b-They have a mouth like a shark, tail like a dinosaur and fur like a cat.	ب- لها فم مثل سمكة القرش وذيل مثل الديناصور وفراء كالقط.
c-They look like a starfish	ج- تبدو مثل نجم البحر
d- I don't know	ج- لا اعرف
Do Platypus lay eggs or give birth?	هل خلد الماء يبيض أم يلد؟
a- They lay eggs.	أ- يبيض
b- They give birth	ب- يلد
c-They don't lay eggs or give birth	ج- لا يضعون البيض ولا يلدون
d- I don't know	ج- لا اعرف
Is the Platypus venomous?	هل خلد الماء سام؟
a- Only the males are venomous, but they can only kill a small animal, not a human.	أ- نوع الذكور فقط هم من سامون ، لكن يمكنهم فقط قتل حيوان صغير ، وليس إنسانًا.
b- Only Females are venomous but they can only kill a small animal, not a human.	ب- نوع الإناث فقط هي السامة لكن يمكنهم فقط قتل حيوان صغير ، وليس إنسانًا.
c- No not at all	ج- غير مما سبق
d- I don't know	ج- لا اعرف
Do Platypus live in water or on land?	هل يعيش خلد الماء في الماء أم على الأرض؟
a- Half of the platypus's day is spent in the water looking for food. The rest of its time is spent in its burrow.	أ- يقضي خلد الماء نصف اليوم في الماء بحثًا عن الطعام ثم يقضي ما تبقى من وقته في جحره.
b- They live only in the water	ب- لا يعيشون إلا في الماء
c- They live only on land	ج- يعيشون على الأرض فقط
d- I don't know	ج- لا اعرف
How do the Platypus swim?	كيف يسبح خلد الماء؟
a-They swim with their ears, nose and eyes.	أ- يسبحون باستخدام آذانهم وأنفهم وعيونهم
b- They swim with their fins	ب- يسبحون بزعانفهم
c- They cannot swim	ج- لا يستطيعون السباحة
d- I don't know	ج- لا اعرف

Table 2: Descriptive Statistics

	Overall (N=72)
Age	
Mean (SD)	9.90 (1.43)
Median [Min, Max]	10.0 [8.00, 12.0]
SES	
Mean (SD)	63.8 (11.2)
Median [Min, Max]	63.1 [41.7, 89.3]
Motivation	
Mean (SD)	3.37 (0.602)
Median [Min, Max]	3.60 [1.80, 4.00]
Gender	
f	40 (55.6%)
m	32 (44.4%)
Active learning score	
Mean (SD)	2.00 (1.11)
Median [Min, Max]	2.00 [0, 4.00]
In-depth or in-breadth exploration	
in-depth learning absent	18 (25.0%)
in-depth learning present	53 (73.6%)
no interest	1 (1.4%)
Total number of information pieces	
Mean (SD)	32.9 (14.7)
Median [Min, Max]	32.0 [6.00, 85.0]
Total number of unique information pieces	
Mean (SD)	25.6 (9.76)
Median [Min, Max]	25.0 [6.00, 54.0]
Average accuracy	
Mean (SD)	0.829 (0.204)
Median [Min, Max]	0.900 [0.273, 1.10]
Missing	3 (4.2%)
The rate of uniqueness	
Mean (SD)	0.810 (0.132)
Median [Min, Max]	0.829 [0.432, 1.00]

Table 3: Distribution of learning patterns across the three days

Frequency of the learning patterns across the three days			
Categorization	Day 1	Day 2	Day 3
In-breadth exploration only	40 (55%)	36 (50%)	22 (31%)
In-depth exploration only	6 (8%)	4 (5%)	1 (1%)
Both patterns present	17 (24%)	15 (21%)	46 (64%)
No interest	9 (13%)	17 (24%)	3 (4%)
2nd categorization			
In-depth exploration absent	40 (55%)	36 (50%)	22 (31%)
In-depth exploration present	23 (32%)	19 (29%)	47 (65%)
No interest	9 (13%)	17 (24%)	3 (4%)

Table 4: Results of models' comparison

	Dependent variable:			
	total questions	total unique questions	rate of uniqueness	rate of accuracy
	(1)	(2)	(3)	(4)
Age		1.236		0.039**
		(0.751)		(0.016)
SES				0.007***
				(0.002)
Learning patterns	9.940**	7.395***		-0.086
	(3.794)	(2.430)		(0.054)
Motivation			-0.055**	
			(0.025)	
Observations	71	71	71	69
R^2	0.090	0.160	0.064	0.212
Adjusted R^2	0.077	0.135	0.051	0.176
Residual Std. Error	13.906 (df = 69)	8.874 (df = 68)	0.127 (df = 69)	0.185 (df = 65)
F Statistic	6.865** (df = 1; 69)	6.462*** (df = 2; 68)	4.726** (df = 1; 69)	5.844*** (df = 3; 65)
Note:	*p<0.1; **p<0.05; ***p<0.01			

Declaration of Authorship

I, Hande Melis Altunay, confirm that this master's thesis is my own work and I have documented all sources and material used. This thesis was not previously presented to another examination board and has not been published.

Berlin, 30.09.2022 _____ _____