# Pedagogical Questions Empower Exploration

**Anishka Jean[1], Emily Daubert[1], Yue Yu[2], Patrick Shafto[1], & Elizabeth Bonawitz[1]**

[1] Rutgers University, Newark NJ 07102
[2] National Institute of Education, Singapore

**Abstract**

Children are motivated to explore and learn about the world, but they vary in their degree of perseverance during exploration. A growing body of literature suggests that is malleable from an early age. Here, we ask whether pedagogical questions empower children to persevere during a difficult problem-solving task with a blicket detector machine. Previous research has shown that when presented with a blicket detector, asking children "pedagogical questions" promotes more exploratory behaviors compared to direct instruction. A pedagogical question is a question asked by a knowledgeable person, whose intention is to teach rather than to seek an answer to that question. The current study examines whether pedagogical questions influence the amount of time children spend problem-solving before seeking help, compared to direct instruction, overheard pedagogical questions, and overheard questions asked by a naive other. We predicted that children who were asked a pedagogical question prior to having the opportunity to play with a machine would persevere longer in trying to make it work, and would be less likely to ask for help. Results suggest that pedagogical questioning encourages children to attempt more hypothesis-test interventions in an effort to make the machine work. Results will be discussed in terms of the role of pedagogical questioning in promoting perseverance during problem-solving.

**Keywords:** pedagogy; pedagogical question; perseverance

## Introduction

Young children are curious and creative problem-solvers. They are motivated to explore and learn about how things work, why they work, and, if necessary, how to fix them. However, there is a great deal of variation in children's perseverance during problem solving, and this characteristic is malleable. Children's perseverance during exploration is likely influenced by a number of factors, including the nature of their interactions with adults. For example, children are more likely to persevere during a difficult task after watching an adult model persevere (Leonard, Lee, & Schulz, 2017). Here, we investigate the particular qualities of adult instruction that may promote children's perseverance during exploration and learning.

Previous research suggests that when children are faced with a difficult task, they rely on their interactions with and observations of adults to guide their exploration and problem solving efforts. For example, preschool-aged children readily detect and utilize pedagogical cues (e.g., the teacher's knowledgeability; the intentionality of the teacher's demonstration; the social context of the learning scenario; etc.) to guide deductive reasoning, exploration, and learning about the world (Bonawitz, Shafto et al., 2011; Buchsbaum, Gopnik, Griffiths, & Shafto, 2011; Butler & Markman, 2014). For example, in Bonawitz, Shafto et al. (2011) children were assigned to one of a few conditions that differed in the social presentation of information. In the Pedagogical condition, a knowledgeable and helpful adult demonstrated one function on a complex-looking toy. After this, children were presented with the toy and allowed to explore. The Pedagogical condition was contrasted with several other conditions including an Accidental condition in which a naive demonstrator accidentally elicited the function, and an Interrupted condition in which the demonstrator was interrupted before it was clear they were completed. Results showed that children in the Pedagogical condition explored less than children in the other conditions, consistent with the explanation that the pedagogical demonstrations lead to high confidence that there was little to be learned beyond the demonstrated function.

Thus, children rely on adults' pedagogical cues to guide learning. What are the particular qualities of these cues that might be most relevant to perseverance during exploration? One pedagogical tool whose efficacy has been of particular interest as of late is *pedagogical questioning*. A pedagogical question is a question asked by a knowledgeable person, whose intention is to teach rather than to seek an answer to that question. Recent research indicates that pedagogical questioning yields effective knowledge transmission, while also promoting exploration (Yu, Landrum, Bonawitz, & Shafto, 2018). This is in contrast to *direct instruction*, another common pedagogical tool. In direct instruction, information is communicated directly from a knowledgeable teacher to a naïve learner. Past research shows that while direct instruction is beneficial for sharing information, this can come at the expense of children's subsequent exploratory learning (Bonawitz & Shafto et al., 2011). This is likely due to the expectation that is often brought into pedagogical learning scenarios that good teachers should provide all the necessary evidence for the learner to be able to solve the problem (Shafto & Goodman, 2008). However, these implications for exploration appear not to be induced by pedagogical questioning. For instance, in Yu et al. (2018), children were shown a novel toy, which had many possible functions, and were told that the experimenter knows all about the toy and how it works. In the direct

instruction (DI) condition, the experimenter told children to push the button on the novel toy; in the pedagogical question (PQ) condition, children were asked to think about "what does this button do?" While children were equally likely to discover the key function (i.e., the button) in both conditions, children also spent longer playing with the toy and discovered more additional functions in the PQ condition (Yu et al., 2018). These results support the claim that pedagogical questions empower children to engage in exploratory behaviors, while direct instruction may constrain exploration.

One limitation of this study however, is that children in both the PQ and DI conditions were at ceiling in their ability to discover the target function of the toy, so it is difficult to assess the extent to which pedagogical questions might differentially influence the pursuit of learning about queried information. In other words, when children are tasked with a simple problem, which was readily solvable (the button immediately generated the effect), it was not possible to explore the potentially different influence of PQs and DI on persistence for learning *targeted information.* Of course, once the goal was complete (in this case discovering the buttons function), it remained important to ask what next steps children would take with the toy. In Yu's paper, children in the PQ condition then went on to discover significantly more functions of the toy as compared to the DI condition, providing important insights into the power of PQs in supporting longer term exploration. Nonetheless, it remains unclear if pedagogical questions also empower children to persevere and engage in exploratory behaviors in service of the queried information. The current study addressed this question by presenting children with a more challenging problem (i.e., an unsolvable problem). Children were tasked with discovering how to make a (deactivated) blicket detector machine work, a procedure inspired by past literature (Gweon & Schulz, 2011).

We hypothesized that that pedagogical questions might promote persistence in problem-solving during a difficult task for a few reasons. First, pedagogical questions that are directed to the child may empower them to feel as though the expectation is that they can figure the machine out on their own, rather than having to seek help from an adult. That is, by asking "what do you think?" a Pedagogical Question could imply that the questioner believes the child can discover the answer. Second, pedagogical questions may encourage children to engage in exploratory behaviors during a difficult problem-solving task because questions do not limit the number or nature of potential solutions to the problem at hand. In contrast, direct instruction may hinder children's creative exploration of potential solutions by "over focusing" children in on the directed content.

One alternative to the claim that pedagogy is the driving factor behind pedagogical questions, is the possibility that *any* kind of question might lead to greater perseverance. In order to control for this possibility, we included a condition in which children overheard a *naive* confederate asking a question to an experimenter (Overheard Naive Question condition; ONQ). In this way, the exact language of the question is matched, but the crucial difference is that in the ONQ condition, the question-asker was not knowledgeable (i.e., was known by the child to have no knowledge of how to make the machine work), where as in the PQ condition, the question-asker was knowledgeable. A person who does not know the answer is not naturally thought of as a having the goal of teaching the outcome because they do not know the outcome. Thus, in the current study, any potential effects could be attributed to the pedagogical nature of the question, and not just the question itself.

Another alternative to the claim that pedagogy is the driving factor behind pedagogical questions, is the idea that any pedagogical question, no matter who it is being directed to, might promote greater perseverance. In order to control for this possibility, we included another condition in which children overheard an experimenter asking a pedagogical question to a confederate (Overheard Pedagogical Question; OPQ). In this way, the exact language of the pedagogical question is matched, but the pedagogical question is not child-directed This condition allows us to isolate the influence of the child-directed nature of the pedagogical question asked in the PQ condition form the mere influence of overhearing a pedagogical question as in the OPQ condition. . Although pedagogical questions have been found to promote exploratory behaviors in children, these questions may only influence exploration if they are child-directed.

Thus, we hypothesized that pedagogical questions, compared to direct instruction and overheard naive questions, would encourage children to persevere and play with the machine longer before seeking help than children in the DI, OPQ, and ONQ conditions, although we expect no condition differences in the amount of time it takes children to recognize that there is something wrong with the machine. We might expect that pedagogical questions promote perseverance in problem-solving during a difficult task for a few reasons. First, pedagogical questions may empower children to feel as though the expectation is that they can figure the machine out on their own, rather than having to seek help from an adult (i.e., the experimenter). The amount of time the child spends engaging with the machine before reaching out for help and the number of hypothesis tests the child performs during exploration could make this claim evident. Second, pedagogical questions may encourage children to engage in meaningful exploratory behaviors during a difficult problem-solving task because questions do not limit the number or nature of potential solutions to the problem at hand. The number of unique actions and the variability in the nature of hypothesis tests performed on the toy could make this claim evident. In contrast, DI may hinder children's creative exploration of potential solutions. We also predicted that children in all conditions would be equally quick to notice that something was wrong with the machine. The time to first look could make this claim evident.

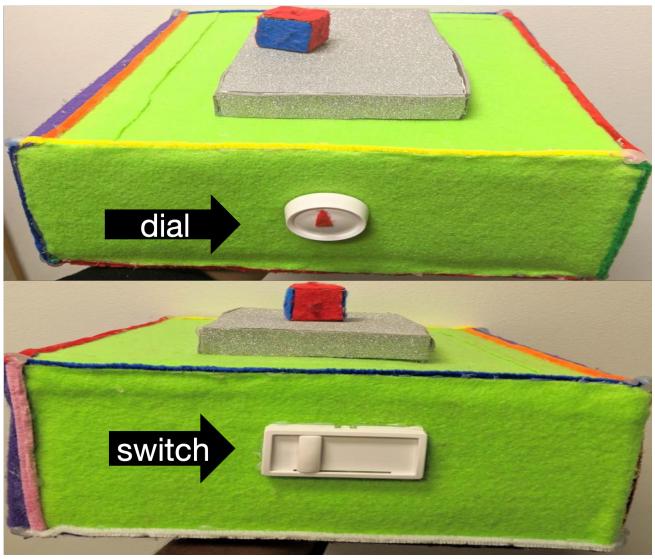


*Figure 1*. Blicket detector machine used by children in the experiment. The switch and dial "sliders" are highlighted. Another feature of the machine is the platform on the top of the machine. The multicolored block is the accessory that appears to activate the machine when placed on the platform, even though it's the remote control transmitter that's actually activating the machine.

## Method

### Participants

Participants were 100 4- to 6-year-old children ($M_{age}$ = 57.91 months, *SD* = 6.62 months; Range = 48.26 - 78.77 months, 53% female) recruited from preschools and public sites located in Essex County, New Jersey, one of the most racially and socioeconomically diverse counties in the United States. Prior to the study, consent from the sites, participating families, and the Rutgers University - Newark internal review board were obtained. Based on a power analysis, and as preregistered[1], we recruited 25 children per condition. Children were only included in the final sample if they met the following criteria: 1) English was their primary language, and 2) there was no outside interference during the testing session. Participants were randomly assigned to one of four conditions: Pedagogical Question (PQ); Overheard Pedagogical Question (OPQ), and Overheard Naïve Question (ONQ), and Direct Instruction (DI). Age was matched across conditions.

### Materials

A novel "blicket detector" machine that was approximately 13.25'' X 10.5'' X 5'' with a switch on one side and a dial on the other was created (Figure 1). A wireless doorbell receiver hidden inside the machine produced a C major arpeggio when the experimenter surreptitiously pressed the button on the remote control transmitter which connected to the wireless doorbell. The switch and dial "sliders" on either side of the machine were inert. There was also a multi-colored block whose sole purpose was to "activate" the machine when placed on a shiny platform on top.

### Procedure

Children were introduced to the machine by the experimenter and told that "the way the toys works is, the way the toy works is, when the block is on the platform and the toy is all set up right, the toy goes". In all conditions, a confederate was seated next to the child during the introduction to the machine and the demonstration of its use. In the PQ and DI conditions, the experimenter first demonstrated directly to the child how the block can activate the machine (but did not show whether, and which of, the switch and the dial should be positioned for it to work.) The experimenter then showed the machine separately to the confederate in another location in the room, so that the child could not see what was being changed on the machine. In the OPQ and ONQ conditions, the child also observed the block activating the machine (but was not shown the role of the switch or dial like in the PQ and DI conditions), however in the OPQ and ONQ conditions, the confederate did not observe the role of the switch and dial. Specifically, the experimenter walked away from the child and confederate to a corner of the room to activate the machine while verifying with the confederate that they cannot see what the experimenter was doing with the machine. Thus, in the OPQ and ONQ conditions, the confederate was never shown how the machine worked with respect to the switch and dial. In all four conditions, the experimenter explained that something about the machine had been changed so that now the block would not activate the machine.

Critically, the prompt given to the child prior to the free play period varied by condition. In the PQ condition, the experimenter asked the child, "what happens if you change *these sliders?*" while moving the sliders (the switch and dial) on either side of the machine. In the DI condition, the experimenter instructed the child by telling them to "change *these sliders* to see what happens" while moving the sliders. In the OPQ condition, the experimenter asked the confederate, "what happens if you change *these sliders?*" while moving the sliders, controlling for the pedagogical nature of the question. In the ONQ condition, the confederate picked up the machine and asked the experimenter, "what happens if you change *these sliders?*" while moving the sliders, controlling for children's awareness of a knowledgeable other by having the confederate ignorant to how the machine works. Immediately, following these prompts, children engaged in a free play period described below.

### Free Play

The child was then given five min to play with the machine and was informed that the confederate would be there if they needed anything. Specifically, children in all conditions

[1] Link to preregistration: https://aspredicted.org/j3ah7.pdf

were told, "You can go ahead and play with this. I have to go over there to write something down for a couple minutes, but [confederate's name] will be here if you need anything!" Then,the experimenter sat behind the child (out of sight) and pretended to write, while the confederate sat next to the child and pretended to read a book. During this play period, the machine would not activate at all, regardless of whether the child followed the experimenters' instructions or suggestions. Playtime was ended once one of the following occurred: five minutes elapsed, the child verbally requested help, the child did not interact with the machine for 15 consecutive s twice in a row, or the child asked to stop playing. All sessions were video-recorded.

## Outcome Measures

All videos were coded by a trained coder for three outcome measures: (1) time to first look, (2) time before help-seeking, (3) number of unique actions, (4) number of hypothesis-test interventions and (5) variability of hypothesis-test interventions.

**Time to first look** The time to first look was the amount of time the child spent attempting to activate the machine before looking at the confederate or experimenter for the first time.

**Time Before Help-seeking** The time to help-seeking was the amount of time child spent attempting to activate the toy on their own before verbally requesting help from either the confederate or the experimenter.

**Number of hypothesis tests (Perseverance)** The number of hypothesis tests was the number of times a child performed any other intervention on the machine that may involve the traditional use of the switch or dial "sliders" right before attempting activation with the block on the machine. An intervention required a manipulation of some factor of the toy or block and critically an attempted activation that immediately followed whereby the child placed the block on the machine.

**Number of unique actions** The number of unique actions was the number of unique manipulations to the machine that did not involve the traditional use of the switch or dial "sliders."

**Variability of hypotheses tested** The variability of hypotheses tested was the number of unique hypothesis-tests performed on the machine. For example, if the child tried adjusting the dial and then placed the block on the activator, that would count as a single hypothesis test. However, a second manipulation of the same dial with a following block test would not count as a unique intervention and so would not additionally increase the total variability score beyond the initial attempt.

Table 1
*Unique Actions*

| Unique Actions | | |
|---|---|---|
| Placing the multicolored block on the platform | Placing the block and/or hand inside the toy | Flicking the block on top of the platform |
| Changing the colored side of the block to a different color | Removing the dial "slider" from the toy | Placing another toy/object on top of the platform |
| Placing the block on other parts of the toy | Removing the switch "slider" from the toy | Rolling the block like a dice |
| Moving the block on the platform without lifting up the block | Switching the tune of the toy by pressing the battery inside the toy | Placing the block on 4 corners of the platform |
| Rubbing the block on the shiny platform of the toy | Placing the switch "slider" on the platform of the toy | Lifting up the shiny platform foam paper |
| Lifting the toy up | Placing the dial "slider" on the platform of the toy | Shaking the toy |
| Placing the toy on its side | Playing with the block itself | Shaking the block |
| Putting the toy upside down | Touching the hot glue gun balls on a corner of the toy | |

# Results

Time to first look. Our first question concerned whether children were equally likely to visually "check-in" with the adults during the free play period. The rationale for this measure was that we hypothesized children might initially look to the confederate or experimenter when it became apparent that the machine was no longer activating as expected. Indeed, in all four conditions, on average, children looked to an adult within the first minute of play (PQ: 25 s; DI: 44 s; OPQ: 27 s; ONQ: 26 s), and there were no significant differences in the total amount of time before this first look, $F(3, 96) = 1.12$, $p = .347$, suggesting that children were equally capable of detecting the activation issue across conditions.

Overall time playing. Our second question pertained to whether children would stop playing with the toy earlier in the DI, OPQ and ONQ conditions. We hypothesized that children in the PQ condition might play with the machine longer than children in the DI, OPQ, and ONQ conditions based on previous research (Yu et al., 2018), in which children explored the novel (functioning) machine longer in the Pedagogical Question condition. However, we observed no significant differences between conditions in the amount of time children spent playing with the machine, $F(3, 96) = 2.53$, $p = .062$, indicating that children in all conditions played with the machine for approximately the same amount of time ($M_{PQ} = 240.72$; $SD_{PQ} = 95.78$; $M_{DI} = 188.16$; $SD_{DI} = 106.13$; $M_{OPQ} = 205.56$; $SD_{OPQ} = 112.03$; $M_{ONQ} = 159.52$; $SD_{ONQ} = 112.32$). However, the trend here for children to play longer in the PQ conditions is suggestive.

**Number of hypothesis tests (Perseverance)** Third, we asked whether the number of hypothesis-test interventions during children's play differed significantly between conditions. Specifically, if Pedagogical Questions both empower children to pursue a relevant learning goal (in this case to discern why the machine is failing to activate) in the face of repeated failure then we would expect children in the

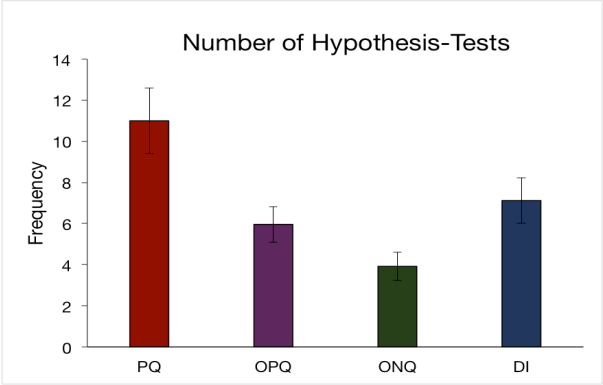


*Figure 2.* Children in the Pedagogical Question condition performed significantly more hypothesis tests during the play period than children in the Overheard Pedagogical Question, the Overheard Naive Question, and the Direct Instruction conditions.

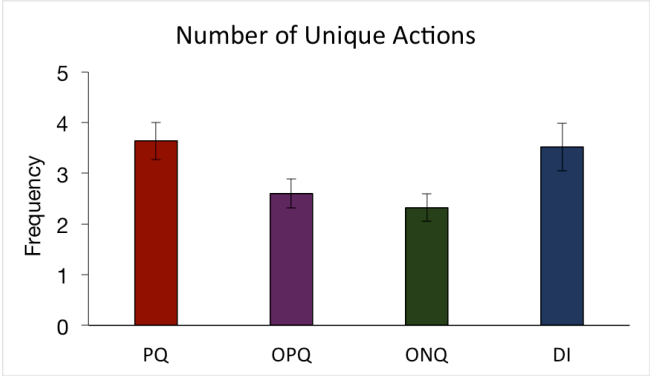


*Figure 3.* Children in the Pedagogical Question and Direct Instruction conditions performed significantly more unique actions during the play period than children in the Overheard Pedagogical Question and the Overheard Naive Question conditions.

PQ condition to perform more interventions on the machine. Indeed, the number of hypotheses tested significantly differed across conditions, $F(3, 96) = 7.03$, $p < .001$. Specifically, planned contrasts1 revealed that children in the PQ condition conducted significantly more hypothesis tests ($M = 11.00$; SD = 8.00) than children in the DI condition ($M = 7.12$; SD = 7.12), OPQ condition ($M = 5.96$; SD = 4.36) and ONQ condition ($M = 3.92$; SD = 3.49). There was no difference in the number of hypothesis tests between the children in the DI condition and children in the OPQ condition, $p = .417$, and there was no difference in the number of hypothesis tests between the children in the OPQ and ONQ conditions, $p = .074$. Thus, even though on average, children in all conditions were equally quick to notice something was wrong with the machine, and played with the machine for approximately the same amount of time, children in the PQ condition engaged in more hypothesis testing during this time, suggesting that PQs might both empower children to persevere in their exploratory causal testing attempts during play.

**Number of unique actions** Next, we asked if children were more likely to explore more different features of the machine overall depending on the type of instruction they were given. By virtue of pedagogical questions being questions, the variability in children's exploratory actions is not limited, leading us to predict children to show more variable exploration in the three question conditions. There were significant differences in the number of unique actions by condition, $F(3, 96) = 3.36$, $p = .022$. Planned contrasts revealed that children in the PQ ($M = 3.64$; $SD = 1.85$) and DI ($M = 3.52$; $SD = 2.37$) conditions performed more unique actions than children in the OPQ ($M = 2.60$; $SD = 1.44$) and ONQ ($M = 2.32$; $SD = 1.35$) conditions, $p = .003$. There were no significant differences in the number of unique actions between the PQ and DI conditions, $p = .842$, and there were no significant differences in the number of unique actions between the OPQ and ONQ conditions, $p = .481$. Contrary to our hypothesis, this suggests that the *child-directed* nature of pedagogical questions (and direct instruction), rather than the inquisitive nature of the input appears to promote variability during play. However, given that there were relatively few actions that might be attempted with the toy (unlike the Yu et al, 2018 novel toy study), this result should be interpreted with caution.

**Variability of hypotheses tested** Finally, we asked whether the variability of hypotheses tested specifically during children's play differed significantly between conditions. That is, if pedagogical questions both empower the pursuit of a relevant learning goal (in this case to discern why the machine is failing to activate), then we would expect children in the PQ condition to perform more different types of interventions on the machine. Overall, the number of different hypotheses tested significantly differed across conditions, $F(3, 96) = 4.08$, $p = .009$. Specifically, children in the PQ ($M = 2.28$; $SD = 1.21$) and DI ($M = 2.08$; $SD = 1.12$) conditions performed more variable hypothesis-tests than children in the OPQ ($M = 1.52$; $SD = .77$) and ONQ ($M = 1.52$; $SD = .65$) conditions, $p = .001$. There was no difference in the variability of hypothesis tests between the PQ and DI conditions, p = .546, and there was no difference in the variability of hypothesis tests between the OPQ and the ONQ conditions, p = .999 Again, *child-directed* conditions led to more variable exploration during play time.

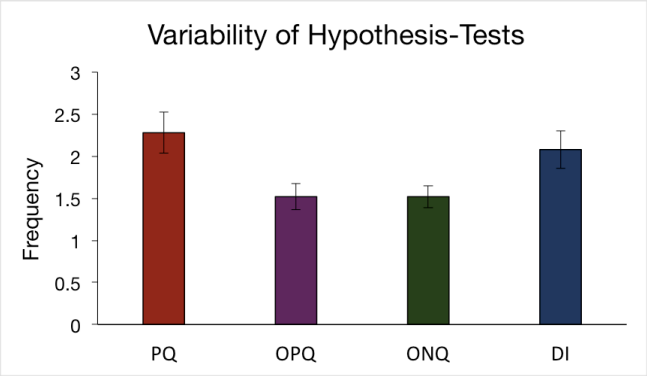


*Figure 4.* Children in the Pedagogical Question and Direct Instruction conditions demonstrated significantly more variability in their hypothesis tests during the play period than children in the Overheard Pedagogical Question and the Overheard Naive Question conditions.

## Discussion

This study examined the effect of Pedagogical Questions on young children's perseverance during a difficult problem-solving task. First, we found that children in all conditions were equally likely to visually check-in with the adults during the free play period, thus children are equally quick to recognize that the machine was not functioning as expected. Second, we found that there were no differences in how long children played with the machine before reaching out for help. Despite recognizing a problem with the machine at equal rates and spending the same amount of time playing with the machine, , children in the PQ condition performed significantly more hypothesis tests, suggesting that prompting children with a Pedagogical Question may lead to their independently persevering through more failed attempts at problem solving before looking to others for help. Our results point to both the pedagogical nature of the question (rather than this effect being about questioning generally) as children in the ONQ condition demonstrated significantly fewer hypothesis tests prior to turning for help, and the child-directed nature of the question as children in the OPQ condition demonstrated significantly fewer hypothesis tests. Additionally, two surprising, but interesting findings indicate that when it came to promoting more variable exploration, as measured by the number of unique actions and the variability in hypothesis tests, the child-directed nature of the pedagogical input was crucial, as children in the two child-directed conditions(PQ and DI) demonstrated more variability during play time.s.

This study extends our understanding of the role of Pedagogical Questions in the preschool years by examining how pedagogical questions affect perseverance and variability during exploration when children are presented with a difficult problem. In the current study, there was a more obvious and specific goal for learners in contrast to Yu et al. (2018), which examined what additional, unbounded exploration children pursued after the initial goal was quickly completed. Classic debates contrast instruction with exploration in terms of their ability to foster learning (Bruner, Jolly, & Sylva, 1976; Csibra & Gergeley, 2009; Piaget, 1929; Singer, Golinkoff, & Hirsh-Pasek, 2008; Tomasello & Barton, 1994; Vygotsky, 1978). However, learning in the real world depends on myriad factors beyond learning content. Often learning comes down to hard work and trying many possible solutions. Whereas these previous debates centered around the material to be learned, at least as important is the effort required. Effective methods of promoting learning in the real world will engage both.

Pedagogical questions are particularly promising in this respect. Bonawitz and colleagues (2011) showed that instruction, though powerful for ensuring specific information is learned, has negative consequences for future learning by reducing exploration. Yu et al. (2018) showed that pedagogical questions offer a potentially promising solution by achieving the benefits of direct instruction without restricting exploration following completion of a goal. Here we have shown that pedagogical questions additionally foster learning by increasing the children's persistence in pursuit of solutions.

Pedagogical questions, questions asked by a knowledgeable person for the purpose of teaching, are a surprisingly simple approach. Demonstrations are easily converted into such questions. Given their simplicity, and the relevance to literatures in education and in question asking, it is interesting that they do not appear to have been explored previously. One possible reason is that these literatures tend to focus on behaviors that are easy to see. Pedagogical questions by definition depend on inferences about the questioner's knowledge and intent. For this reason, comparison with overheard questions is an important control and a powerful demonstration of the importance of latent social variables in understanding learning.

Our work on Pedagogical Questions is part of a broader movement beyond simple dichotomies such as direct instruction versus exploration. Recent research has proposed Guided Learning as a framework for considering learning as a dynamic, interactive, social activity (e.g. Hirsh-Pasek et al., 2015). Many aspects of this framework remain to be formalized; however, we believe Pedagogical Questions provide one compelling example of guidance. Pedagogical Questions foster learning not by telling the learner the answer, but by offering the learner strong guidance toward the answer. Many open questions remain regarding when Pedagogical Questions are most effective and how they fit into the broader Guided Learning framework. We leave these to future work.

In sum, this study supports the view that pedagogical questions promote learning. Children who are asked pedagogical questions persevere in service of a specific goal. These findings are particularly relevant for educators who can use pedagogical questions in their classrooms to enhance children's perseverance during challenging problem-solving activities.

## References


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

Buchsbaum, D., Gopnik, A., Griffiths, T.L., & Shafto, P. (2011). Children's imitation of causal action sequences is influenced by statistical and pedagogical evidence. *Cognition, 120*(3):331-40. doi: 10.1016/j.cognition.2010.12.001

Butler, L.P., & Markman, E. M. (2014). Preschoolers use pedagogical cues to guide radical reorganization of category knowledge. *Cognition, 130*(1), 116-127. doi:10.1016/j.cognition.2013.10.002

Leonard, J.A., Lee, Y., & Schulz, L.E. (2017). Infants make more attempts to achieve a goal when they see adults persist. *Science,* 357(6357), 1290-1294. Doi:10.1126/science.aan2317

Shafto, P. & Goodman, N. (2008). Teaching games: Statistical sampling assumptions for learning in pedagogical situations. Proceedings of the 30th annual conference of the Cognitive Science Society.

Yu, Y., Landrum, A.R., Bonawitz, E., & Shafto, P. (2018). Questioning supports effective transmission of knowledge and increased exploratory learning in pre-kindergarten children. *Developmental Science,* 21(6). doi:10.1111/desc.12696

Bruner, J.; Jolly, A.; Sylva, K. (1976). Play-Its role in development and evolution. Basic Books Inc; New York.

Csibra G, Gergely G. (2009). Natural Pedagogy. *Trends in Cognitive Sciences, 13*(4):148–153.

Hirsh-Pasek, K., Zosh, J.M., Golinkoff, R.M., Gray, J.H., Robb, M.B., & Kaufman, J. (2015). Putting Education in "Educational" Apps: Lessons From the Science of Learning. *Psychological Science in the Public Interest, 16*(1) 3–34. doi:
10.1177/1529100615569721

Piaget, J. (1929). *The Child's Conception of the World.* New York: Harcort, Brace.

Singer, DG.; Golinkoff, MR.; Hirsh-Pasek, K. (2008). Play = Learning: How play motivates and enhances children's cognitive and social-emotional growth. New York: Oxford University Press.

Tomasello M, Barton M. (1994). Learning words in nonostensive contexts. *Developmental Psychology, 30*,639–650.

Vygotsky, L. (1978). Mind in Society. Cambridge, MA: Harvard University Press.