Toddlers Learn with Facilitated Play, Not Free Play

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Abstract

Can children of all age groups engage in self-directed learning? While active learning has been widely advocated in education, it remains unclear whether its benefits apply to children at all developmental levels. In the present study, we demonstrate that 19-month-old toddlers acquire higher-order generalizations in the causal domain only when their play is facilitated by an adult experimenter or a parent, and not when they are provided with full instruction or complete free play. These findings stand in contrast with earlier findings that 36-month-old children can learn effectively from data they generate by themselves under conditions of complete free play. This difference suggests that the ability to engage in self-directed learning may develop over early childhood.

Keywords: free play; facilitated play; self-directed learning

Introduction

In *The origins of intelligence in children*, Piaget (1952) describes his infant son:

> Laurent… grasps in succession a celluloid swan, a box, etc., stretches out his arm and lets them fall. He distinctly varies the position of the fall. When the object falls in a new position (for example, on his pillow), he lets it fall two or three more times on the same place, as though to study the spatial relation (pp. 268-269).

To Piaget, his infant appears to be somewhat of a little scientist, one who carefully varies his behaviors in a bid to construct knowledge about his world. This observation, together with many others like it depicting his own children, led Piaget to theorize that children are constructivists, or active learners, in that much of their development is driven by their own activities and experiences. He believed that like scientists, children generate hypotheses, perform experiments, and make inferences about the world based on their own observations.

While Piaget's theory of cognitive development was not explicitly related to teaching practices, his characterization of children had lasting impacts on education: till today, teachers continue to encourage their students to engage in hypothesis testing and self-directed exploration in order to boost their own learning (Berlyne, 1966; Bransford, Brown, & Cocking, 1999; Bruner, 1961; Papert, 1980).

Recent empirical work have demonstrated the utility of such active learning approaches for adults (e.g. learning through participating in activities or discussion; engaging in problem-solving; emphasizing higher-order thinking related to analysis, synthesis and evaluation; Bonwell & Eison, 1991; Castro et al., 2008; Freeman et al., 2014; Markant & Gureckis, 2013). For example, a recent large-scale meta-analysis revealed that in the context of undergraduate courses, instructors who employed active learning teaching practices were more effective at raising their students' performance, as compared to instructors that used traditional lecturing methods (Freeman et al., 2014).

Advocates of active learning, however, have not been specific about whether this form of learning is suitable at all developmental levels. More specifically, do children of all age groups benefit from such self-directed learning? In the discussion that follows, we take the lead of Gureckis and Markant (2012) and will focus on examining self-directed learning only in contexts that involve allowing learners to make decisions about the information that they experience.

Previous work suggests that 36-month-olds can acquire higher-order generalizations effectively when placed in such active learning contexts (Sim & Xu, 2014). In this study, children were provided with either training, in which an experimenter demonstrated the activations of three different categories of machines (Training condition), or a play opportunity, in which children could freely interact with the machines for five minutes (Free Play condition). Then, children were asked to choose among a novel set of blocks to activate a familiar machine (first-order generalization test) and a novel machine (second-order generalization test). The children's performance in the Free Play condition was remarkable despite having had to generate their own data for learning – they were able to choose accurately in both tests. Their performance also did not differ from that of children in the Training condition, who had received well-calibrated and helpful experimenter-generated data. These results provide evidence that at 36 months, children can learn effectively under conditions of self-directed learning.

We thus examined if these results may be replicated with 19-month-old toddlers. If so, the ability to engage in self-directed learning may be present early on in development. However, in our pilot testing, we found a radically different picture: 11 toddlers trained with experimenter-generated data produced chance performance at test (31.8% accuracy), while another 11 toddlers given the free play opportunity activated the machines far fewer times as compared to the 36-month-olds, and their overall generalization performance was found to be far below chance (13.6% accuracy). These results suggest that 19-month-olds do not learn effectively in such a causal learning task when given direct training, but this remained the case even when they were given the opportunity to make decisions about the information they wanted to experience! Therefore, placing 19-month-old toddlers in self-directed learning contexts may not necessarily be beneficial for their learning.

In that case, which learning contexts would actually boost the learning of 19-month-olds? In the present study, we take the first step towards addressing this question by examining the conditions under which 19-month-old toddlers may be able to succeed in our causal learning task. We hypothesize that one such context may be when children engage in collaborative play with adults, such that their spontaneous exploration is supported by adult facilitation and instruction (Rogoff, 1990; Vygotsky, 1978).

To test this hypothesis, we designed two causal learning experiments based on a modified procedure of Sim and Xu (2014). In Experiment 1, children's play was guided by an experimenter, such that the 19-month-olds observed both experimenter-generated and self-generated evidence, while in Experiment 2, children's play was guided by their own parents, who were told to play with their child just as they would do at home. We then examined the toddlers' learning in two generalization tests where they were asked to activate a familiar and a novel machine.

Experiment 1

In Experiment 1, we investigated whether 19-month-olds can learn effectively when their play is facilitated by an adult experimenter. Through such collaborative play, the toddlers observed both experimenter-generated and self-generated evidence.

Method

Participants Forty English-speaking toddlers (20 boys) with a mean age of 19.0 months (range = 17.7 to 20.0 months) were tested. All were recruited from Berkeley, California, and its surrounding communities. 6 additional toddlers were tested but excluded due to refusal to make a choice at test (N=2), and parental interference (N=4). Each toddler was assigned to a Shape or a Color condition.

Materials Four categories of toy machines were used in this experiment, with two identical machines in each category. The categories differed in shape and color, i.e. machines in Category 1 were blue and rectangular; machines in Category 2 were red and triangular; machines in Category 3 were green and circular; and machines in Category 4 were orange and L-shaped (each about 30 cm x 10 cm x 5 cm). Each set of machines produced a unique sound when activated.

A variety of small blocks (about 4 cm x 2 cm x 1 cm) with different shapes and colors were used to activate these machines. Some blocks matched the machines in shape but not color (shape-match blocks), some matched the machines in color but not shape (color-match blocks), and others did not match the machines in shape or color (distracter blocks).

The machines were placed in three transparent boxes (covered with an opaque lid), with each box containing one category of machines and its activator block. In the Shape condition, the machines and the block in the same box shared the same shape but differed in color, and in the Color condition, the machines and the block in the same box shared the same color but differed in shape.

Procedure Toddlers were tested in the laboratory, with their parents present in the testing room. Before starting, parents were requested to encourage their toddlers to play during the experiment by giving general instructions without additional descriptors (e.g. "Put the block on the toy!") and only when they appear unresponsive to the experimenter's prompting. Parents were also reminded not to influence their toddlers' responses during the test phase.

During the experiment, toddlers were introduced to the machines and blocks under the pretext of the experimenter showing them her toys. In the Shape condition, children were presented with machines that were activated using a shape rule: a shape-match block had to be used to activate the machine's effect. In the Color condition, children were instead presented with machines that were activated using a color rule: a color-match block had to be used to activate the machine's effect. The procedure consisted of two phases: an interaction phase and a test phase.

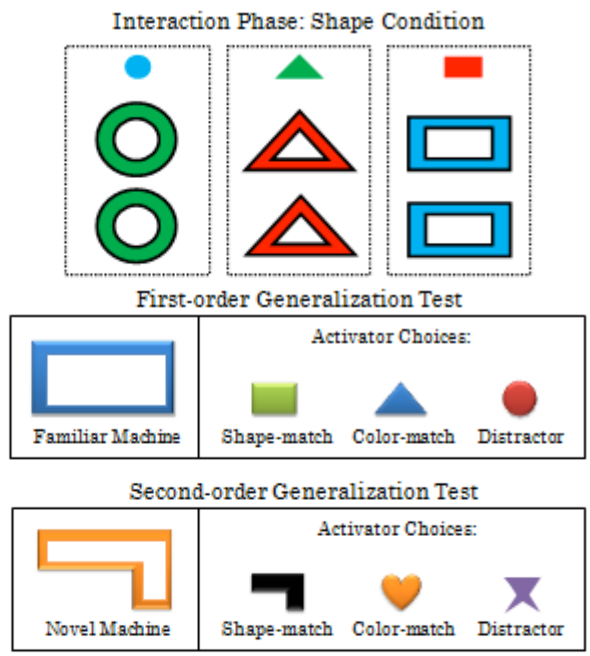

Figure 1: Schematic diagram of materials and procedure for both experiments. Note that only the Shape condition is shown for the interaction phase. Dotted lines indicate that boxes were used only in Experiment 1.

Interaction Phase Upon entering the testing room, toddlers saw three covered boxes containing the machines laid out on the ground (Figure 1). They were given about 1 minute to familiarize themselves with the testing room.

The experiment began when the toddler reached towards one of the boxes and attempted to open it. At that point, the experimenter encouraged the toddler to return to his/her parent's lap, and opened the box revealing a set of toy machines and its activator block. One of the machines was then taken out of the box, and the experimenter activated this machine by placing the available block on top of the machine. The experimenter drew attention to the activation event by saying, "Look! The block made the machine go; it made it go!" She then offered the block to the toddler, encouraging him/her to make the machine go. The toddler was now free to activate the machine as many times as he/she wants, but the experimenter ensured that the toddler saw each machine being activated at least twice, either by the experimenter or the toddler him/herself.

When the toddler lost interest in the first machine, the experimenter pointed to the other identical machine and said, "I have another one over here! Let's see what this one does." The second machine was then retrieved from the box, and the toddler was again free to play with this machine for as long as he/she wants. The experimenter only activated the second machine if the toddler did not initiate play with it.

When the toddler lost interest in the second machine, the experimenter then drew his/her attention to the remaining boxes, and said, "Let's see what I have in those boxes over there!" The first set of machines and block were returned to their box, and put away. This procedure was repeated with the other two sets of machines, activating them with the shape-match or color-match block available in each box. After the toddler had played with all three categories of machine, the experimenter put all the items away.

Test Phase The test phase followed, and it consisted of a first-order *or* a second-order generalization test. In other words, half of the toddlers received a first-order test, while the other half received a second-order test. This step was taken because pilot testing revealed that most toddlers were unable to complete a second test trial, i.e. they were not willing to hand the experimenter a second block, regardless of whether it was a first- or second-order generalization test.

In the first-order test, each toddler was presented with 3 novel choice blocks: a shape-match block, which is similar to the test machine in shape but not color, a color-match block, which is similar to the test machine in color but not shape, and a distracter block, which differed from the test machine in both color and shape. The blocks were spatially separated, and the toddlers were given about 1 minute to familiarize themselves with them. The experimenter then presented a *familiar* test machine, which is a machine that was previously presented in the interaction phase. The toddler was asked to make the test machine go.

In the second-order test, each toddler was also presented with 3 novel choice blocks: a shape-match block, a color-match block, and a distracter block. After approximately 1 minute of exploration with the test blocks, the toddler was then asked to choose among these blocks to activate a *novel* test machine, which is a machine that was not previously presented in the interaction phase (See Sim & Xu, 2014).

Coding The toddlers' responses in the test trials were scored for accuracy according to the condition they were assigned to. For the children who were exposed to the shape rule, choosing a shape-match block was scored as 1 point. Correspondingly, for children exposed to the color rule, choosing a color-match block was scored as 1 point. The toddlers' scores were converted into percentage of accuracy. A second coder recoded all of the children's responses, and the level of agreement between the coders was 100%.

Two coders also coded all videos for the number of activations for each machine by the child, the parent and the experimenter, and the duration of each interaction phase.

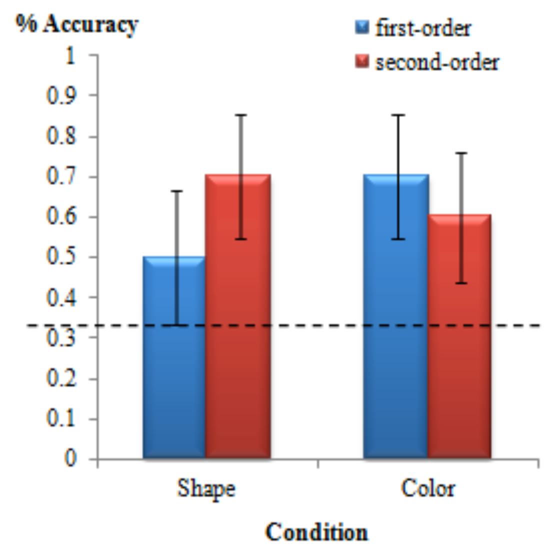

Figure 2: Percentage accuracy for two generalization trials in Experiment 1. Dashed line represents chance performance. Error bars represent standard error.

Results

An alpha level of 0.05 was used in all statistical analyses. Preliminary analyses found no effects of gender or median age-split on children's accuracy at test. Subsequent analyses were collapsed over these variables.

Due to the free play nature of the interaction phase, several parameters of the experiment varied across toddlers: the number of activations for each machine (M = 6.49, SD = 2.80), the number of times the child activated each machine (M = 3.92, SD = 2.60), the number of times the parent modeled the activation of each machine (M = 0.18, SD = .53), and the duration of the interaction phase (M = 8.22 minutes, SD = 2.57 minutes). Regression analyses did not reveal any effects on test trials related to these parameters.

As Figure 2 indicates, most of the toddlers performed accurately during the test trials, selecting the correct activator block according to the condition they were assigned to. A logistic regression model is used to estimate the factors which influence children's accuracy at test, revealing no effects of Condition (Shape vs. Color), p = .37, or Generalization (first-order generalization vs. second-order generalization), p = .37. There was also no interaction between the two factors, p = .33.

Critically, we were interested in the effect of the collaborative play on toddler's accuracy on the test trials. A binomial test indicated that the toddlers were significantly more likely to choose the correct activator block in the first-order generalization test (proportion = .60) than chance (0.33), p = .012. Their performance in the second-order generalization test (proportion = .65) was also significantly greater than chance by a binomial test, p = .0034.

Discussion

When their play was facilitated by an adult experimenter, 19-month-old toddlers successfully acquired higher-order generalizations about the causal structure of the novel toy machines. This finding stands in contrast to the results obtained from our pilot testing, in which under conditions of *both* training and complete free play, the toddlers performed at chance levels in the same generalization tests.

Experiment 2

In Experiment 2, we examined whether the 19-month-olds' successful learning could be replicated when their parents were the ones who were facilitating their play instead.

Method

Participants Twenty-four English-speaking toddlers (15 boys) with a mean age of 19.0 months (range = 18.3 to 20.0 months) were tested. All were recruited from Berkeley, California, and its surrounding communities. 5 additional toddlers were tested but excluded due to refusal to make a choice at test (N=2), and experimenter error (N=3). Each toddler was assigned to a Shape or a Color condition.

Materials The toy machines and blocks in Experiment 1 were reused in Experiment 2. An additional cross-shaped yellow machine was used in this experiment; it was activated by a cross-shaped yellow block.

Procedure The toddlers were tested in the laboratory, with their parents present in the testing room. Before starting, the experimenter asked that during the experiment, the parents play with their toddlers in a natural way, just as they would play with them at home. The toddlers began the experiment while seated on the lap of their parent.

As in Experiment 1, half of the toddlers were presented with machines that were activated by a shape-rule (Shape condition), while the other half were presented with machines activated by a color-rule (Color condition). The procedure in Experiment 2 consisted of three phases: a familiarization phase, an interaction phase, and a test phase.

Familiarization Phase To begin this phase, the experimenter presented the child with a cross-shaped yellow machine, together with its activator block. This block matched the machine both in shape and color. The familiarization phase served to introduce the child and the parent to the sound-making function of these new machines. This phase was not necessary in Experiment 1 since the experimenter was directly introducing the machines' function during the interaction phase. The experimenter activated the cross-shaped yellow machine, drawing attention to the event by saying, "Look! The block made the machine go; it made it go!" Either the child or the parent was then given the activator block, and they were allowed to activate the machine freely, for as long as they wanted to. The experimenter ensured that each child saw *at least* six activations of this familiarization machine: two by the child, two by the parent, and two by the experimenter.

When the toddler lost interest in the familiarization machine, the experimenter put the machine and activator block away. She then presented the toddler with three new activator blocks that differed in shape and color. The toddler was free to play with these blocks for 1 minute. After this exploration, the blocks were removed. The experimenter then exclaimed, "Oh no! I just remembered that I have some work to do. While I'm doing my work, you can play with some of my toys together with mommy/daddy!"

Interaction Phase The experimenter then requested that the parent holds on to the toddler while she laid out the three activator blocks from before, as well as the three sets of toy machines. These items were laid out such that each activator block was placed directly in front of its corresponding category of machines (Figure 1).

After the blocks and toys had been laid, the experimenter moved to a chair at the corner of the room and pretended to work. She then told the parents and toddler, "You can go ahead and play!" Each parent-child pair was given 10 minutes to play freely with the machines and blocks. After 10 minutes, the experimenter announced that she was done with her work and it was time to put the toys away.

Test Phase Before beginning the test phase, the parent was reminded not to influence their toddler's responses. The test phase of Experiment 2 was similar to that of Experiment 1, except that each toddler was presented with *both* the first-order and the second-order generalization test. Unlike Experiment 1, the toddlers in Experiment 2 were able to respond to two test trials. This difference could be due to a variety of reasons related to the parents being the ones who played with their toddlers in the interaction phase: 1) the toddlers may have been more comfortable in a situation that reflected play time in their own homes; 2) the toddlers may have had more experience handing blocks back and forth in this context due to the prior play with parents, etc.

Coding The coding was identical to that of Experiment 1. A second coder recoded all of the children's responses, and the level of agreement between the coders was 100%. Two coders also recoded all videos for the number of activations by the child, the parent and the experimenter, as well as the duration of each interaction phase.

Results

An alpha level of 0.05 was used in all statistical analyses. Preliminary analyses found no effects of gender, median age-split, or the presentation order of generalization tests (e.g. whether the first-order test was performed first or second) on children's accuracy on the test trials. Subsequent analyses were collapsed over these variables.

Once again, several parameters of the interaction phase varied across toddlers: the total number of attempts to activate each machine (M = 7.97, SD = 4.10), the number of times the child attempted to activate each machine (M = 5.86, SD = 3.85), the number of times the parent attempted to activate each machine (M = 2.12, SD = 1.62), the number of times the child successfully activated each machine (M = 3.57, SD = 2.40), the number of times the parent successfully activated each machine (M = 1.78, SD = 1.34), and the duration of the interaction phase (M = 6.89 minutes, SD = 2.04 minutes). As in Experiment 1, regression analyses did not reveal any effects on the test trials related to these parameters.

92% of the children and 70% of the parents activated every category of machines presented during the interaction phase, and the number of times that each toddler activated each machine was not significantly different between the experiments, $t(54) = .515$, $p = .61$, $d = 0.14$.

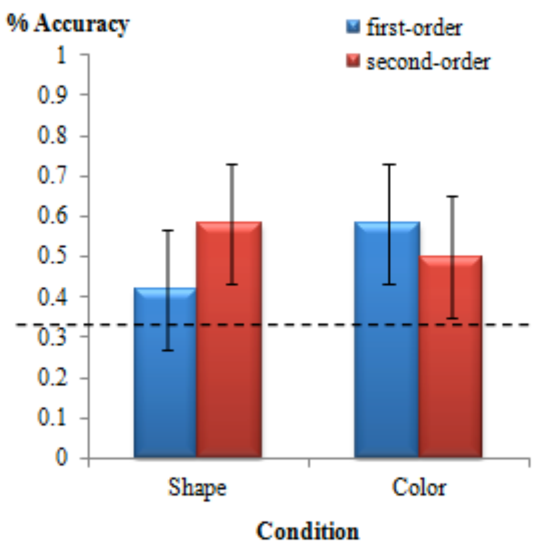

Figure 2: Percentage accuracy for two generalization trials in Experiment 2. Dashed line represents chance performance. Error bars represent standard error.

A 2x2 repeated measures analysis of variance (ANOVA) with Condition (Shape vs. Color) as a between-subjects factor and Type of Generalization (first-order generalization vs. second-order generalization) as a within-subjects factor revealed neither a main effect of Condition, $F(1, 22) = .13$, $p = .72$, $\eta 2 = .006$, nor Type of Generalization, $F(1, 22) = .055$, $p = .82$, $\eta 2 = .003$, and there was also no interaction between the two factors, $F(1, 22) = .50$, $p = .49$, $\eta 2 = .022$.

Planned comparisons were performed to evaluate the effect of collaborative play on the toddlers' accuracy in the generalization tests. The comparisons indicated that the toddlers' overall accuracy across two test trials was significantly greater than chance (0.33), $t(23) = 3.40$, $p = .002$, $d = .69$. A binomial test indicated that the toddlers were marginally more likely to choose the correct activator block in the first-order generalization test (proportion = .50) than chance (0.33), $p = .063$. Their performance in the second-order generalization test (proportion = .54) was significantly greater than chance by a binomial test, $p = .023$.

Discussion

Overall, the 19-month-old toddlers formed the appropriate higher-order generalizations when they played with the novel toy machines and blocks together with their parents. However, the somewhat weaker performance of toddlers in Experiment 2 may suggest that the evidence that the parents generated for learning was not as effective as that of the experimenter in Experiment 1.

General Discussion

The present study examined whether 19-month-old toddlers can successfully acquire higher-order generalizations when they engage in play that is facilitated by either an adult experimenter or their own parent. Results from two experiments indicate that the toddlers can do so – after a short interaction phase where they either played with the novel toys together with an experimenter or a parent, the 19-month-olds formed first- and second-order generalizations about how the blocks and toy machines interacted with one another, and they extended these generalizations when asked to activate a new machine. The current findings stand in striking contrast to earlier results from our pilot study demonstrating that 19-month-olds fail to form the same generalizations under conditions of training or free play.

There thus appears to be a developmental difference between 19-month-olds and 36-month-olds with regards to their respective ability to engage in self-directed learning. While the 36-month-olds learned effectively and efficiently when they were allowed to independently generate data for their own learning, the 19-month-olds failed to do so in our pilot work. In fact, given the learning success of the 19-month-old toddlers when their play was facilitated by an adult, it appears that their learning was actually impeded when they were placed in conditions of complete free play. Work is currently underway to increase the number of 19-month-old children tested in training and free play conditions. We speculate that situations for optimal learning for children in this age group reside in the middle zone between full instruction and complete free play, where their spontaneous exploration is being supported by parental or experimenter facilitation.

It remains puzzling why the 19-month-olds failed to form the appropriate generalizations under conditions of direct training, despite being provided with the same data set as that provided to 36-month-olds in Sim and Xu (2014). One possibility is that although the data was informative, the number of demonstrations during training was inadequate for the toddlers to learn 1) the causal relationship between the blocks and machines, and 2) the right way to generate data in order to learn about the causal system. This reason may also account for why, despite being shown how to activate the familiarization machine, the 19-month-olds generated far less data in the pilot free play version.

The current results also seem to contradict previous studies showing that even young learners are able to allocate their attention in ways that reflect active learning. For example, researchers found that 8-month-old infants prefer looking at stimuli that provide the greatest information gain (Kidd, Piantadosi, & Aslin, 2010), while others have demonstrated that 17-month-olds devote more attention to aspects of their environment that are learnable, rather than unlearnable (Gerken, Balcomb, & Minton, 2011). Begus, Gliga and Southgate (2014) also found that 16-month-olds were able to point to an object of interest, and that their subsequent learning was superior if a new label was provided for this object as opposed to an alternative object.

But there is a critical difference between these experiments and ours: in these infant studies, the active learning that infants partake in involve *selectively focusing their attention* on a subset of data that is already available in their environment, while in our studies with the 19- and 36-month-olds, children had to *generate the evidence* necessary for their own learning. Although both senses of active learning involve making decisions about the information that one wishes to experience, only the latter requires the child to independently generate data. And to date, there is no evidence that children younger than 36 months are able to learn under such conditions.

These different findings in the developmental literature raise an important question: How do children go from being able to engage in active learning only in the sense of focusing their attention on a subset of available data in early infancy, to being able to engage in active learning that requires them to generate their own data in toddlerhood?

We speculate that conditions where a child's free play is facilitated by adults might hold the key to this puzzle. In the course of such collaborative play, not only is the learning about the task at hand boosted (as our results indicate), children are also provided with an opportunity to observe and pick up on appropriate strategies for generating the evidence necessary to support one's own learning. This knowledge would prepare them well to reap the benefits of self-directed learning later on in development (Bruner, 1961; Castro et al., 2008; Markant & Gureckis, 2013; Sim & Xu, 2014). Future research should closely examine the developmental trajectory of active learning, as well as identify the specific features of such facilitated play that may build up children's ability to engage in self-directed learning.

An emphasis on self-directed learning in education was a consequence of Piaget and Vygotsky's legacy. While it may be effective, it should not be applied indiscriminately, as conditions of self-directed learning may not be beneficial to children at all developmental levels. Just as Piaget and Vygotsky highlighted the importance of assessing children's readiness for the learning of certain concepts, educators should also begin considering the readiness for learning within active learning contexts.

Acknowledgments

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