University of Cincinnati

Date: 10/21/2013

I, Heather R Baker, hereby submit this original work as part of the requirements for the degree of Master of Arts in Psychology.

It is entitled:
Exploring Teaching Regimes to Change Preschoolers' Mistaken Beliefs about Sinking Objects

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Exploring Teaching Regimes to Change Preschoolers’ Mistaken Beliefs about Sinking Objects

A thesis submitted to the Graduate School of the University of Cincinnati in partial fulfillment of the requirements for the degree of Master of Arts in the Department of Psychology of the College of Arts and Sciences by

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B.A. University of Cincinnati 2009

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Abstract

In the last two decades, research on children’s cognitive development has provided valuable insight into barriers that may prohibit children from scientific learning. Two main barriers include identifying an optimal teaching regime to teach young children complex science, and mistaken beliefs that young children hold, which can contend with new factual information. The goal of the current study was to identify a teaching regime which would aide preschoolers in challenging their mistaken beliefs of sinking objects. In an initial experiment three separate teaching regimes were administered between pre-post density assessments. Results indicated that neither teaching regime showed significant differences between pre and post assessment performance. A second experiment was conducted to investigate these unexpected findings. An expanded version of a teaching regime from Experiment I provided an explicit link between training and testing objects. Results indicated a significant difference between assessment performance, however only on certain trial types. A final experiment was conducted to determine whether re-testing could have contributed to the significant findings of the second experiment. A non-density related filler task was administered between assessments. Results showed no significant differences between assessments. Further investigation of Experiment II indicated that the differences in children’s overall performance could have been driven by the substitution of one mistaken belief with another rather than from actual learning. Individual patterns of performance across condition revealed that a majority of children either held an initial mistaken belief at the pretest, or performed at chance. Approximately half of these children changed their pattern of performance from pre to posttest. Most interestingly, the inquiry condition revealed the largest percentage of change from one pattern of belief to another. While most training did not cause change to occur in a positive direction, change still occurred, indicating a certain level of malleability in the mistaken beliefs of preschool aged children.
Acknowledgements

I would like to offer sincere thanks to my mentor, Dr. Heidi Kloos, who has invested countless hours into my educational development. I am also grateful to my thesis committee, Drs. Peter Chiu and Victoria Carr, for their guidance and support throughout this project. This project could not have been completed without the help of Mona Jenkins, Elle Ketterer and Jaymee Heineke in data collection.
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Chapter 1: Introduction

In the last two decades, research on children’s cognitive development has provided valuable insight into barriers that may prohibit young children from scientific learning. One critical barrier is that we have not yet identified optimal teaching regimes to best introduce young children to complex science. In addition, early education teachers face many challenges when incorporating science into their curriculum. A second barrier involves prior mistaken beliefs, or misconceptions, that young children hold, which can contend with new contradictory factual information. Given the nature of these barriers it is possible for them to be addressed concurrently, through an optimal teaching regime that considers classroom feasibility while also aiding young children in challenging their misconceptions. In a best case scenario this approach could lay the foundation for full belief revision, a process known as conceptual change, in later education. Successfully identifying an optimal teaching regime could provide teachers with more feasible approaches to teaching science to young children, by making it more accessible to younger children, which in turn, can have long-term positive effects on their outcomes in both secondary and higher education.

The current study sought to address the barrier of misconception by contrasting three teaching regimes (conceptual-model training, inquiry, and their combination) with each other. A density-related task using sinking objects was chosen for several key reasons; the feasibility of the task being scaled up to classroom group participation, and most importantly, that very little research has been conducted with preschool children on density-related tasks.

One major body of work that has, in the past, dominated the field of cognitive development was Piaget’s four stage model of abstract reasoning (Piaget & Inhelder, 1974). Piaget focused on the limits of children’s abilities to exhibit abstract reasoning. His model
separated the limits of children’s abilities into stages of development as children age. Piaget’s theory posited that children under the age of eleven are not capable of abstract reasoning. Being that learning and comprehending science require a certain amount of abstract reasoning, Piaget’s theories contributed to a conclusion that if young children are incapable of abstract reasoning then they are therefore incapable of learning complex science. Though this theory was not well received, it has nevertheless had far reaching effects on our current educational system. This is demonstrated by the fact that most preschool and elementary curricula do not include any type of complex science that goes beyond basics such as planets, seasons, and/or dinosaurs.

If it were true that abstract reasoning truly is beyond a young child’s capabilities, then the lack of complex science teaching in preschool and elementary schools would be of little concern. However, as will be discussed in detail further along in this paper, more recent findings show that young children are capable of understanding and learning abstract concepts, if presented in ways that they can understand. Therefore the true barrier to learning science may not lie solely in children’s abilities, but it may also result from the attitudes and methodologies that our teachers exhibit towards science.

Currently, children in the U.S. are not assessed on science knowledge until around 5th grade, where beforehand the focus is primarily reading and mathematics. In addition to the lack of national requirement for early science education, some teachers are also reluctant to include science into their everyday curriculum. (e.g., Greenfield, Jirout, Dominguez, Greenberg, Maier, & Fuccillo, 2009). For example, twelve groups of preschool teachers (N=48) participated in a series of twelve, 45-minute focus groups in order for researchers to ascertain the barriers that teachers face in teaching science (Greenfield et al., 2009). Results from these focus groups revealed two main themes that teachers self-identified: 1) low self-efficacy with respect to
teaching science, and 2) insufficient time due to a busy daily routine. Additional studies report similar findings regarding insecurity in teaching science (Wenner, 1993; Jordan 1992).

A study of 167 undergraduate students majoring in early education investigated subjects’ attitudes towards science and their science knowledge (Wenner, 1993). It was found that the average student scored slightly less than 50% on the science knowledge assessment, revealing a low level of science knowledge. Results from the attitude survey revealed that only 15% of participants agreed or strongly agreed that they knew the steps necessary to teach science concepts effectively, while only 29% agreed or strongly agreed that they could effectively monitor science experiments.

Recent studies have also found that some children and teachers spend very little time in science designated areas during free play (Tu, 2006; Hirschler, 1994; Hanley, Tiger, Ingvarsson, and Cammilleri, 2009; Kontos, 1999). For example, 20 preschool classrooms were analyzed to investigate science areas and materials in the classroom (Tu, 2006). Teachers and children from this study were videotaped during free play time to see how designated science areas were utilized. Results showed that only half of the classrooms had a science area. Also, 86.8% of activities that teachers engaged in were unrelated to science, while only 4.5% related to formal sciencing, and 8.8% of activities related to informal sciencing. Research focused on instructional practices in early childhood education suggested that neither planned nor unplanned science activities are likely to occur in preschool classrooms (Brenneman, Stevenson-Boyd, & Frede, 2009; Greenfield et al., 2009). In a more recent study involving 84 preschoolers across 6 preschool classrooms it was found that the science area of those classrooms was empty 77.6% of the observed time, but intervention greatly increased the use of the science area. (Nayfeld, Brenneman & Gelman, 2011).
Taken together, these findings indicate a possible link between teachers’ attitudes and the lack of science teaching in preschool. Clearly, there are a number of specific barriers that teachers encounter when incorporating science. In addition, children also encounter barriers that can prohibit them from science learning. One of the most critical of these barriers is the permanence of prior misconceptions that can resist the acceptance of new factual information.

But what are misconceptions? For the sake of the current paper, a misconception is broadly defined as any view or opinion that is incorrect based on faulty thinking or understanding which can be adhered to for a brief or extended period of time. Research on mistaken beliefs has been recognized for decades, leading to extensive research into understanding both the nature of the misconceptions across ages and how they can be changed (e.g., see Ohlsson, 2011; Vosniadou, 2008, for an extensive discussion). Children hold misconceptions in many science domains. For example, children believe that heavy stuff sinks fast (e.g., Kloos & Somerville, 2001; Penner & Klahr, 1996), that the sun is alive, but not plants (Venville, 2004), and that the earth is disc-shaped (e.g., Vosniadou & Brewer, 1992).

Without factual explanations of the phenomena experienced in the world around them, young children are left to come up with their own explanations (Carey, 2000). Often, their own explanations are not factual, which leads to the formation of misconceptions. The question is: are misconceptions a strong enough barrier to inhibit learning? The answer is somewhat complicated. In many instances, children prefer their own mistaken ideas over facts, even after extensive training. More surprising is that some still continue to hold on to their mistaken beliefs even after the shortcomings of their mistaken ideas have been revealed explicitly. Take for example findings with 5- to 7-year-olds who participated in an astronomy curriculum on the spherical properties of the earth (Hannust, & Kikas, 2007). A four-week curriculum involving
hands-on mini-lessons was designed to target several apparent contractions, for example why the earth is perceived to be flat, or why people living on the “down-side” of the earth do not fall off the earth. Yet, despite this relatively extensive intervention, childrens’ understanding did not change significantly over the course of the instruction. While their performance on a pretest was below chance (11% correct), it stayed low even after the lessons (15% correct). In fact, results show that children relied more heavily on their phenomenological experience after instruction than before.

Additional research shows that some existing misconceptions appear to be very difficult to change as children age (Hannust, & Kikas, 2007; Kloos & Somerville, 2001, Wandersee, Mintzes, Anderson & Smith, 1987; Gunstone, Champagne, & Klopfer, 1981; Linn & Burbules, 1988; Schneps, 1987). However, research also shows that children exposed to focused instruction seem to harbor fewer misconceptions in later education (Novak & Gowin, 1984; Kenyon, Schwarz, & Hug, 2008; Novak, 2006). These findings in particular give relevance to the current study. While teaching regimes may not succeed in fully replacing misconceptions of young children, the benefits of focused instruction may go well beyond initial interventions. Therefore, the need to identify effective teaching regimes is apparent, not only to aide children in an initial challenging of their misconceptions, but also to lay the foundation for successful science learning in later education.

Recent research has shown that school-aged children are able to challenge their misconceptions using a variety of teaching regimes. Techniques such as science journals (Brenneman & Louro, 2008), concept maps (Akbas & Gencturk, 2011; Novak, 2006), specific prompts (Davis & Linn, 2000), group discussion (Tolmie, Howe, Mackenzie & Greer, 1993), and drawings (Acher, Arca & Sanmarti, 2007) have proven to be successful methods with older
children, even with such complex science concepts as matter conservation and evaporation. These particular concepts are especially difficult for children to comprehend because of a common misconception that once an object is too small to see with the naked eye, or when a material changes form (i.e., liquid to a gas) that it disappears, when in fact matter is ineliminable. To understand these concepts, children have to ignore their phenomenological experience of an object’s presence and therefore engage in abstract reasoning.

A study of 7- to 8-year-olds used a combination of teaching regimes to help children understand the concept of matter conservation (Acher, Arca & Sanmarti, 2007). In particular, these children were asked to change materials (e.g., stone, wood, water, metal) by breaking them down, mixing them in water, or burning them. After each manipulation, children were encouraged to draw the changes they observed in the materials. Figure 1 shows an example of these drawings.

Figure 1. Drawings of the water being broken down by the fire. (In the first drawing the parts of the “liquid water” are reduced as those of “water vapor” increase, and in the second, there is an apparently proportional relationship between the disappearance of “the parts” and the appearance of the “steam.”)
Children also participated in group discussions designed to help them conceptualize their experiences. Findings show that not only were those children able to express opinions and counter arguments, but also that they could understand the abstract concept of matter conservation.

Similarly, children between 6 and 8 years of age underwent a multi-week training on evaporation and condensation, which included observing the evaporation and condensation in a soda bottle, drawing diagrams to capture the system through various moments in time, testing their models through experiments, using tools to measure the amount of water in the air, and revising their models as needed (Kenyon, Schwarz, & Hug, 2008). Findings show that the instructed students significantly outperformed the uninstructed students in their understanding of relevant concepts. Importantly, when students began the formal study of science in Grade 7, instructed students improved in their understanding of concepts much faster than uninstructed students. Clearly, the students who were helped to form basic science concepts in early grades developed an understanding of the domain that continued to facilitate their meaningful learning, further developing their understandings and reducing their misconceptions (for related discussions, see Muthukrishna, Carnine, Grossen, & Miller, 1993).

Another example includes a twelve-year longitudinal study investigating the use of concept maps to trace 1st and 2nd graders conceptual understanding (Novak, 2006). All first-grade classes in the 5 participating schools were given audio-tutorial instruction during the first year, and all second-grade classes in the same 5 schools were given audio-tutorial lessons in the second year. Evidence clearly showed that Instructed children had fewer and fewer misconceptions as they progressed through school, when compared with Uninstructed students. The students who were helped to form basic science concepts in grades 1 and 2 also were shown
in later years to have developed their cognitive structure for energy and molecular kinetics ideas in a way that continued to facilitate their meaningful learning, further developing their understandings and reducing their misconceptions. This data suggests that national curriculum standards for science grossly underestimate the learning capabilities of primary-grade children, who can acquire sufficient understanding of basic, highly abstract science concepts that can serve as a cognitive base for facilitating later learning.

We also know that children understand that the behavior of objects is affected by their physical properties (Kotovsky & Baillargeon, 1998; Schilling & Clifton, 1998). Davis and Linn (2000) found that using prompts that encouraged reflection significantly increased eighth graders’ conceptual understanding of thermodynamics and light in a computer-supported learning environment. It is also evident that children can connect new events to similar things they have seen before at home (Riojas-Cortez, Huerta, Bustos-Flores, Perez & Riojas, 2008). For example, children can connect the similarities between the flipping on and off of a light switch to the sun rising and setting (Thagard, 2000). In relation to density, there are a number of events that a child can witness in their everyday lives involving the sinking properties of objects. For example, children can experience density through objects in a bathtub or swimming pool, throwing coins into a fountain, or throwing pebbles into a puddle. As demonstrated, there are many examples of teaching regimes that help children challenge their misconceptions. Whether these techniques would also be successful in even younger children, specifically preschoolers, remains to be seen. However, there is an abundance of research that indicates that even preschoolers are able to comprehend some science.

Preschoolers can learn, with little effort, the names of new species, the names of the planets, and even the terms associated with material properties and chemical change (e.g., Fleer
& Hardy, 1993). Similarly, we also know that children can develop a scientific vocabulary through vocal iterations of scientific words (Leung, 2008; Peterson & French 2008). Children also know that the identity of living things is determined internally (Simons & Keil, 1995; Springer, 1995); and they understand the effect of gravity (Vosniadou, 1994). A recent study conducted by Croker and Buchanan (2011) indicates that some 4-year-olds can identify a conclusive experiment from an inconclusive experiment, if the evidence is consistent with their prior knowledge. Considering this body of evidence highlighting young children’s capabilities, there is reason to believe that the lower level concepts of density (sinking and floating) may not be too complex for them to understand and learn. However, in order to find an optimal method to introduce children to these concepts, a clear understanding of their prior misconceptions of sinking and floating objects much first be considered.

When considering the topic of density, we know from previous studies that children and also adults hold a misconception that mass (heaviness) and/or volume (size) are the main casual factors behind an objects sinking behavior (Kloos & Somerville, 2001; Piaget & Inhelder, 1974; Penner & Klar, 1996; Halford, Brown & Thomspn, 1986). The reasoning for this is the amount of salience or prominence of those features. With density, because attention is first drawn to the more salient features of mass and volume, individuals are typically unable to pick up on the hidden feature; that density is actually a ratio of the two features. The inability to detect this ratio results in the misconception that heavier or larger things sink faster. In order to facilitate an introduction to density learning an initial teaching regime must be utilized that draws the focus away from the more salient features of mass and/or volume.

In an attempt to do just this, a study involving a conceptual model of density was developed, also known as a dot-per-box method (e.g., Smith & Unger, 1997; Wiser & Smith,
This method involved a display in which the volume of an object was represented as a certain number of boxes, and mass was represented as the number of dots inside the boxes. Figure 2 shows the dot-per-box representation.

Figure 2. Smith & Unger’s (1997) dot-per-box representation, where the image on the right represents the most dense object of the two due to the crowdedness of dots in each individual box.

Thus, density was represented as the spacing between dots (the more crowded the dots, the more dense the material); irrelevant variation of color, shape, and texture were omitted. Therefore, density of the material now becomes similar in salience to that of mass or volume. Children indeed benefited from these abstract representations of density (for a discussion of these findings, see Wiser & Smith, 2008).

More recently, a pilot study was developed with 4- to 5-year-olds, recruited from Head Start preschools and from preschools serving upper middle class families (Baker, Haussmann, Kloos & Fisher, 2011). This pilot study involved training children with a modified version of the dot-per-box conceptual model. Results from this pilot showed that children who were exposed to conceptual model training significantly outperformed children in a control group that received no training, which subsequently led to the design and rationale of the current study.

However, developing a teaching regime that encourages young children to challenge their misconceptions is highly dependent upon feasibility in the classroom. In order to meet both
requirements, it is necessary to understand the current methodology used to engage preschoolers, which is discussed in turn. A popular regime in current teaching methodology is inquiry, the processes of wondering, questioning, exploring, investigating, discussing, reflecting, and formulating ideas and theories (Kuhn, 2010). Many teachers and educators agree that young children should discover new knowledge through inquiry learning (e.g., Lonka et al. 2000). Inquiry learning in its best form often requires that children conduct experiments and evaluate their outcomes (Piekney, Grube, Mahler, 2012). In addition, discourse between teacher and student also enhances inquiry (Peterson & French, 2008). However, as previously mentioned, the fact that some preschool teachers are hesitant to include science in their classrooms, or may be insecure in their own scientific teaching abilities may result in the likelihood of less student-teacher interactions and more self-exploration scenarios in preschool classrooms. Given this reality, the specific type of inquiry that was focused on in the current study was self-exploration on its own.

Self-exploration is something that happens spontaneously on a daily basis with children as they inquire about the world around them. Indeed, preschool education places strong emphasis on exploration, the idea being that exploration is at the center of what allows children to generate knowledge about the world (e.g., Luken, Carr, & Brown, 2011). In many ways exploration provides incentives that other regimes cannot. For instance, we know that teaching just the facts does not successfully facilitate learning (Bonawitz, Shafto, Gweon, Goodman, Spelke, & Schulz, 2011) being that children need a motivational factor to learn (Mantzicopoulos, Patrick, & Samarapungavan, 2008; Zembylas, 2008). Self-exploration readily supplies this necessary motivational factor. However, given the inconspicuous feature of the mass/volume ratio of density, it is possible that self-exploration alone will not be sufficient in enabling a child to
challenge their misconceptions. Rather, a teaching regime must be utilized that explicitly draws focus away from the more salient features of mass and volume and makes the hidden feature of their ratio (density) more salient.

Considering the complexity of density learning, it is possible that self-exploration alone could end up confirming a misconception rather than challenging it. For instance, if a child believes that heavy things sink faster, when exploring sinking objects, they will most likely deduce that the heavier things seem to sink more frequently than the lighter things, therefore confirming the misconception. This is not to say that self-exploration should be avoided in this domain, but rather that self-exploration should be combined with an additional teaching regime in order to best facilitate belief revision. The question is what teaching regime would be most effective if paired with self-exploration?

There is a large body of evidence revealing conceptual models to be effective in facilitating belief revision in children (e.g., Gobert & Buckley, 2000; Kenyon, Schwarz & Hug, 2008; Wiser & Smith, 2008; Baker, Haussmann, Kloos, & Fisher, 2011). Conceptual models are abstract representations of a science phenomenon, a kind of diagram that can include central parts of a system. In addition, models represent predictive and explanatory rules of how parts are connected, thus making visible the components of science phenomenon that are difficult to be perceived on the basis of phenomenological experience alone. Conceptual models also allow teachers to have complete control of what content is represented. This makes it possible to highlight only certain features or relations while downplaying others. Given the adaptability of this type of teaching tool, it is possible to design a conceptual model that highlights the hidden feature of density.

For the current study a conceptual model was developed to specifically make visible the
hidden feature of density that is difficult to be perceived by exploration alone, in a way that is easy for a young child to understand. Rather than attempting to teach young children the more complex fractional relation of density, this model highlighted the empty space inside an object as the salient feature. In order for a child to correctly select the densest item out of a pair they would have to correctly judge the amount of empty space versus filled space. While this process does not incorporate the exact mathematics related to density, it does require a child to make distinctions between relations of inequality, for example, between more than or less than, which requires a mental calculation much like a ratio. It was theorized that combining training using the model with inquiry through self-exploration, could facilitate a learning platform that would confirm the learned facts while challenging mistaken beliefs. Study design, methods, results and conclusions are discussed.

Overview

The goal of the current research was to empirically test the degree to which various training regimes would encourage belief revision through the challenging of prior mistaken beliefs of density in preschoolers. Experiment I compared the effect of three different trainings, referred to as: Conceptual Model, Inquiry and Combined (inquiry + conceptual model). Children were randomly assigned to one of three conditions that differed only in training method. The conceptual model condition utilized a conceptual model of density, one in which density was related to the amount of empty space inside an object. The inquiry condition utilized self-exploration of sinking objects, and the combined condition was a combination of the two. The central hypothesis was that the combination of inquiry and conceptual-model regimes would lead to more successful belief revision than either training regime on its own. To test this hypothesis,
a pre-post density assessment was administered to determine differences between patterns of performance. Experiments II & III were conducted to explore surprising results of Experiment I.

Chapter II: Experiment I

Three training methods were developed to encourage belief revision of preschooler’s density misconceptions. These training methods were divided into three conditions: Conceptual Model, Inquiry and Combined (inquiry + conceptual model). All conditions included identical pre-post density assessments which were administered directly before and after the specified training of that condition. The conceptual-model condition included training that involved placing sinking/floating wooden cubes (all painted the same color) one at a time inside of a so-called plastic x-ray machine that displayed a conceptual model (image) of the ‘insides’ of the cube on a laptop screen. Children were instructed to focus their attention on the amount of ‘empty space’ inside the cube image. Children were provided with a rule about the relation of empty space to sinking speed. The inquiry condition training involved free play with three set pairs of sinking containers in a clear tank of water. Each of the three pairs consisted of one high-density (sinking) container and one low-density (floating) container. The experimenter first demonstrated the pairs, one at a time, in the water themselves, and then allowed the children set time for free play. The combined condition included a combination of both the inquiry and the conceptual model trainings. Children first watched as the experimenter demonstrated the three set pairs of containers in the tank of water. They were then given the conceptual model training, followed by a free-play phase with the same three pairs of containers as the inquiry condition.
Method

Participants

Participants were 4- to 5-year-old preschoolers (n = 60; mean age = 4.9 years; SD = 6.3 months; 23 boys and 37 girls). They were recruited through local daycare and preschool centers in the greater Cincinnati and northern Kentucky regions. Participants were randomly assigned to one of three conditions (n = 20 per condition).

Materials

Materials consisted of wooden cubes used for training, a so-called x-ray machine to demonstrate the inside of the cubes, sinking objects for the density assessment, and a small 30.48 cm deep water tank for children to explore the sinking behavior of objects.

Cubes were made of wood (4 total; 2 that would sink, 2 that would float, measuring between 4.76 cm to 5.55 cm), hollowed out and filled with lead to achieve a desired density. In particular, cubes could either sink in water (density $\approx 2.0$ g/cm$^3$), or float (density $\approx 0.5$ g/cm$^3$). All cubes were painted the same color, such that no single cube could be differentiated from another.

The x-ray machine was made out of a plastic trapezoidal box (24.5 cm high; 17 cm wide on the top; 21.5 cm wide on the bottom). The right side of Figure 3 shows a schematic of the box. A blue light was placed at the bottom of the box which was controlled by a switch outside of the box and connected to an electrical cord. A horizontal see-through platform was mounted above the light such that cubes could be placed on top of it, and the light from below would illuminate the cube. Above the platform, the front and right side of the box was made out of clear plastic in order to provide visual access to the cube inside the box. The left side had a flap-like door for the cubes to be placed through. A USB cord was threaded through the box and was
plugged into the laptop computer during training to give the impression that box was actually transmitting scans to the laptop.

Figure 3. Schematic of setup used during the conceptual-model condition.

Sinking objects were clear-glass containers with black lids that came in three sizes. Ten of the containers were 8 cm high and 6.3 cm wide (large); five containers were 6.9 cm high and 5.8 cm wide (medium), and three containers were 5 cm high and 5.3 cm wide (small). Round aluminum discs (1 cm high, 4 cm in diameter, 43g) were placed inside the containers to obtain a desired mass. Large containers could hold between one and five discs (ranging in density between 0.81 and 1.54g/cm³); medium containers could hold between one and four discs ranging in density between 0.94 and 1.68 g/cm³); and small containers could hold between one and three discs (ranging in density between 1.21 and 2.06 g/cm³). Sinking objects were combined into pairs that differed in how mass and volume varied within a pair. Figure 4 shows examples of each type of pair in schematic form. For Type A pairs, the denser (winning) container was heavier and larger (Figure 4A), For Type B pairs, the denser (winning) container was heavier and smaller (Figure 4B), and for Type C pairs, the denser (winning) container was lighter and smaller (Figure 4C).
Figure 4. Schematic of one example of each trial type. Relative to the losing container, the denser container (marked with a vertical line underneath) could be heavy and large (Type A), heavy and small (Type B), or light and small (Type C).

**Design and Procedure**

A pre-post design was used to assess the degree of belief revision due to training method. Table 1 shows the study design. In all conditions, children first participated in the density assessment, after which they were presented with the respective training, followed by the same density assessment, repeated.

*Table 1. Study Design includes identical pre and posttest density assessments with three separate training methods, depending on condition, implemented between assessments.*

<table>
<thead>
<tr>
<th>Density Assessment</th>
<th>Training Conditions</th>
<th>Density Assessment</th>
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<tbody>
<tr>
<td><strong>Pre-Test (5 mins)</strong></td>
<td><strong>Conceptual Model Condition</strong> (5 mins)</td>
<td><strong>Post-Test (5 mins)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Inquiry Condition</strong> (5 mins)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Combined Condition</strong> (10 mins)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Inquiry</strong> (2 mins) + <strong>Conceptual Model</strong> (5 mins) + <strong>Inquiry</strong> (3 mins)</td>
<td></td>
</tr>
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</table>

Participants were tested in a quiet location, outside of their classroom, at their school. For all conditions the child sat down at a table directly beside the experimenter. A DELL laptop computer was used for data collection, using Superlab (2.0), as well as to display the conceptual model of density. In what follows, details of the density assessment and each of the trainings are described.
Density Assessment. The experimenter began by relating a brief story involving a scientist that likes to know what things sink the fastest in water. Children were told that the scientist brought some containers with them that day and that they needed the child’s help to figure out which containers would sink the fastest in water. Children were presented with a total of 12 pairs of sinking containers, one at a time, four of each trial type. Pairs were presented in random order. For each trial, the experimenter first placed one pair of sinking containers on the table in front of the participant. Children were instructed to pick up the containers, feel them, and look at them to help them decide which container they thought would sink the fastest in water out of the pair. Children were instructed to hand the experimenter the container they chose in order to ensure that the experimenter was clear on their selection.

Conceptual-Model Training. During conceptual-model training, the experimenter began by relating a brief story involving a scientist that invented an x-ray machine to see the insides of things. The child was told that the scientist brought the actual machine with them today so that they could use the machine to look at the insides of some things. The experimenter took out the x-ray machine that was hidden under the table, plugged it into the laptop computer and turned on the light in the back. The laptop computer then showed a screen that read, “Ready to Scan”. The experimenter started by placing one wooden cube inside of the machine and then hit a button on the computer that made the conceptual model of the inside of the cube appear on the laptop screen. The experimenter pointed out the ‘empty’ space around the molecules (dots) inside the cube and explained that a lot of empty space inside meant that cube would sink very slowly, while very little empty space inside meant that cube would sink very fast. Four total cubes (2 with a lot of empty space, 2 with very little empty space) where demonstrated randomly, one at a time, in the machine.
Following this training, the child was told that the scientist thought they were ready to try it without the x-ray machine. The x-ray machine was turned off, unplugged and placed back under the table, out of sight. An image appeared on the laptop screen with the two possible insides of the cubes (a lot of empty space, or very little empty space). Eight empty-space testing trials were administered where children were asked the following questions in random order: 1) Which would sink the fastest? 2) Which would sink very slowly? 3) Which has a lot of empty space inside? 4) Which has just a little empty space inside? Children were asked to point to the image that they thought corresponded to each question. Questions were randomized such that each was asked twice. These trials were used to determine the child’s understanding of the empty space concept. Afterwards another image appeared on the computer screen that depicted a conceptual model of two sinking containers (one with very little empty space, one with much more empty space) on the screen. The experimenter then said, “Now we’re back to the containers, and the containers have empty space inside”. The experimenter pointed out the empty space in both containers on the screen and then verbalized the rule that ‘things with just a little empty space inside sink the fastest’.

*Inquiry Training.* The experimenter began by relating a brief story involving a scientist who brought a small tank of water and three pairs of containers for them to put in the water to see what happens. The experimenter placed the small tank of water on the table along with the three unique pairs of sinking containers, one from each of the trial types displayed in Figure 2. Each pair was comprised of one sinking and one floating container in order to best emphasize the density differences. Children first observed for 2 minutes as the experimenter placed each of the pairs of containers, one at a time, in the water. Children were instructed to watch through the side of the tank and not from above. Instructions were given that the containers would be put in the
water to see what happened. No feedback was given from the experimenter as to the sinking behavior of the containers. After the experimenter demonstrated each pair twice, children were then instructed to play with one pair of containers at a time in the tank of water themselves for an additional 3 minutes. This session was timed and no verbal feedback was given from the experimenter. After 3 minutes the three pairs of sinking containers and the water tank were removed from sight.

**Combined Training.** During the combined training, the same storyline involving the scientist was used. Children were exposed to 2 minutes of observing the experimenter place the three pairs of containers, one at a time, in the water tank. Afterwards the tank and three container pairs were removed from sight and were followed by 5 minutes of the identical conceptual model training. After the conceptual-model training, the small water tank and three container pairs were placed back on the table. The child was told that it was now their turn to put the containers in the water to see what happened. The experimenter then timed the child’s 3 minutes of free play with the containers in the water tank.

**Results and Discussion**

Scores of the pretest and the posttest were used to calculate two averages, one representing the proportion of correct answers in the pretest (out of 12 trials), and one representing the proportion of correct answer in the posttest (also out of 12 trials). Figure 5 shows these averages, separated by condition.
The initial analysis began with determining if there were any significant differences in the pretest scores across condition. A one-factor ANOVA (with condition as between-group factor) revealed no effect of condition, $F(2, 57) = .22, p = .81$, suggesting that children had similar competences across conditions. To test for equality of variances, a Levene’s test showed no statistical differences between the variances of the conditions, $p > .05$. In fact, children, as a group, did not perform differently than what would be expected by chance alone, ($M = .50$), single-sample $t$-tests against chance, $t < .53$. This finding was expected in that children’s misconceptions typically cause them to make their selection based off of a single feature (i.e. mass or volume), leading them to consistently make incorrect selections; in opposing trial types. To better make this point, scores from individual children were examined. Only one child (from the conceptual-model condition) performed above chance (binominal probability $p < 0.02$) on the pretest.

Once it was determined that a majority of children were starting at the same performance level, the next step was to test whether the training had an effect on children’s learning. In order to do this, a 2 x 3 mixed-design ANOVA was conducted, with score type (pre, post) as the within-group factor, and condition (conceptual model, inquiry, combined) as the between-group

![Figure 5. Mean proportion correct comparing pre and posttest performance of all conditions in Experiment I.](image-url)
factor. There was no significant effect of score type, no effect of condition, and no interaction $p > .25$. This finding was surprising in that it was expected that clear differences would show between training methods. To further investigate this finding, a one-factor ANOVA of posttest scores yielded no effect of condition, $F(2, 57) = .85, p = .43$, with children performing largely at chance overall, single-sample $t < 1.56$. These findings were also unexpected being that each particular training method provided children with knowledge directly opposed to the most common misconceptions. For example, the pairs of inquiry containers were selected in such a way that the density differences were extreme (one sinker, one floater). Taking this into consideration, the scores were removed from the single child who performed above chance in the pretest, however, the results remained essentially unchanged.

Interestingly however, when looking more closely at individual children’s scores, we find that they differed in whether performance in the post test was at chance or not. While a large majority of children performed at chance (84%; out of 60 children total), eight children (13%) performed above chance (i.e., performance correctly on more than 9 trials, one-tailed binomial probability $p < .02$), and two children (3%) performed below chance (i.e., performing correctly on fewer than 3 trials, one-tailed binominal probability $p < .02$). This indicates a high variability in responses, which reduces the power of overall ANOVAs.

Though no differences were detected when trial type was collapsed across condition, a more closer look at separated trial types was necessary. Scores of the pre and post tests were calculated for each trial type separately. Figure 6 shows the averages of these scores, separated by condition, for Trial Types A, B, and C (Fig. 6A, 6B, and 6C respectively).
To test whether pretest performance on these individual types of trials differed as a function of trial type, a 3x3 mixed-design ANOVA was conducted with trial type (A, B or C) as the within-group factor and condition (conceptual model, inquiry and combined) as the between-group factor across conditions. There was no effect of trial type, $F(2, 57) = .55, p = .58$, nor condition, $F(2, 57) = .22, p = .81$, and there was no significant interaction, $F(2, 57) = .18, p = .95$. These results confirm the findings of the overall ANOVA with pretest scores, showing that children did not differ as a function of condition ($M_{Type A} = .55, M_{Type B} = .48, M_{Type B} = .47$). As before, it was expected that pre-training scores would show no differences.

Once this was determined, the focus was again drawn towards how the training affected children’s performance differently, this time as a function of trial type. A 3x3 mixed-design ANOVA was conducted for the posttest, with trial type (A, B or C) as the within-group factor and condition (conceptual model, inquiry and combined) as the between-group factor. This analysis showed no effect of condition, $F(2,57) = .83, p = .44$ and no significant interaction, $F(2, 57) = .25, p = .91$, however a marginally significant effect of trial type was indicated, $F(2, 57) = .

Figure 6. Mean proportion correct of trial Types A, B and C comparing pre and posttest performance of all conditions in Experiment I.
2.74, \( p = .07 \). To further investigate this marginal effect, comparisons between the means of posttest performance between trial types were made using a series of post hoc paired sample t-tests. A significant difference was found between Type B and Type C, \( t(59) = 2.13, p = .04 \), however no significant differences were found between Type A and Type C \( t(59) = 1.62, p = .11 \) as well as between Type A and Type B, \( t(59) = .17, p = .87 \). Unfortunately, this significant difference only remains when posttest trials are combined across condition, showing no clear benefit of any single type of training condition.

To illustrate this, two additional 1 x 3 one-way ANOVAs were conducted for the posttests of trial Types B and C within condition. Results for Type B showed no significant effect of condition, \( F(2,57) = .31, p = .73 \). Results for Type C showed no significant effect of condition, \( F(2,57) = .06, p = .95 \), with children participating largely at chance in all trial types, single-sample t-tests against chance, \( t < 1.83 \). Review of the surprising findings of this experiment lead to the development of Experiment II, which attempted to better support knowledge transfer between training and testing objects.

**Chapter III: Experiment II**

Due to unexpected results in Experiment I, an additional experiment was conducted that more closely replicated the pilot study of this experiment. In particular, the pilot study included a condition where a more direct link was made between the training cubes and the sinking containers of the density assessment. Experiment II included the identical training as the conceptual-model condition in Experiment I, with one key difference: an additional sentence was added to the training; “just like the cubes, there is empty space inside the containers as well”. Experiment II utilized the exact pre-post density assessments as Experiment I.
Method

Participants

Participants were 4- to 5-year old preschoolers (n = 20; mean age = 4.8 years; SD = 6.5 months; 14 boys and 6 girls) recruited through local daycare and preschool centers in the greater Cincinnati and northern Kentucky regions.

Materials

The exact materials used in Experiment I were used for Experiment II.

Procedure

The identical procedure and pre-posttest design used in Experiment I was also used in Experiment II.

Density Assessment. The identical pre-post density assessment used in Experiment I was also used in Experiment II.

Training. There was one type of training, conceptual-model plus, which is explained in turn.

During this new expanded training, the exact procedure used in the conceptual-model condition of Experiment I was repeated, with one small change in the script of the training. As a reminder, the participant was shown 4 cubes using the x-ray machine, then given 8 empty space testing trials. After this, just like the previous experiment, a screen appeared with an image of two containers, one with very little empty space and one with much more empty space. This time, the script was modified so that experimenter said, “Now we’re back to the containers. Guess what? Just like the cubes, there is empty space inside the containers as well”. The experimenter then pointed to the empty space inside of the container with more empty space and verbally acknowledged that there was a lot of empty space inside that container. Then the
experimenter pointed out the empty space of the container with less empty space and verbally acknowledged that there was very little empty space inside that container. Finally, the experimenter verbalized the rule “remember, things with just a little empty space inside sink the fastest”.

Results and Discussion

Scores of the pretest and the posttest were also calculated using averages representing the proportion of correct answers in the pretest (out of 12 trials), and in the posttest (also out of 12 trials). Figure 7 shows these averages. To initially test for significant differences between the pre and posttest scores a paired sample t-test was conducted indicating a significant difference, $t(19) = 2.42, p = .03, (M_{pretest} = .54, M_{posttest} = .65)$.

As in Experiment I, performance of pretest scores across trial type was compared using a one-factor ANOVA (with trial type as between-group factor) revealed no significant effect of trial type, $F(2, 57) = .48, p = .62$, again confirming that children had similar competences across trial type in the pretest. In fact, children also did not perform differently than what would be expected by chance alone, $(M = .54)$, single-sample t-tests against chance, $t < .52$. However, looking at individual children, two of them performed above chance (binominal probability $p < 0.02$) on the pretest.

While we know that training significantly improved performance, a comparison of trial types was necessary to accurately pinpoint where changes might have occurred. Performance of posttest scores across trial type was compared using a one-factor ANOVA (with trial type as between-group factor) revealed a significant effect of trial type, $F(2, 57) = 9.32, p < .001$, in that children performed above chance in Type A, $t(19) = 4.6, p < .001$, and Type B, $t(19) = 3.9, p = .001$, whereas there was no difference from chance in Type C, $t(19) = 1.2, p > .05$. Finally, when
the scores were removed of the two children who performed above chance in the pretest, significance slightly increased from, $t(19) = 2.4, p < .05$, to $t(19) = 2.7, p = .01$. These findings indicate that children struggled most frequently with Type C trials. This was not surprising given that a majority of children attribute heaviness or largeness to increased sinking speeds. Given that the densest container in trial Type C is neither the heavier nor larger of the two, it was expected that children would struggle most with that type. While this modified training did improve performance for Type A & B, fully replacing a mistaken belief would have resulted in significant differences in all trial types. It is also important to note, that while scores did improve no child got all correct (12/12) on the posttest. Before making more concrete conclusions a third experiment was added to ensure that the increase in performance could be correctly attributed to the effect of the training alone.

![Figure 7](image)

*Figure 7.* Mean proportion correct of trial Types A, B and C comparing pre and posttest performance of Experiment II, trial type separated and collapsed.
Chapter IV: Experiment III

To rule out the possibility that re-testing contributed to the difference found in Experiment II, a final experiment was conducted in which no training was presented. Children participated in the pretest, a filler task, and the posttest.

Method

Participants

Participants were 4- to 5- year old preschoolers (n = 20; mean age = 4.9 years; SD = 8.3 months; 13 boys and 7 girls) recruited through local daycare and preschool centers in the greater Cincinnati and northern Kentucky regions.

Materials

The exact materials used in the previous two experiments were used in Experiment III.

Procedure

The procedure was identical to that of previous experiments, with the exception of the training phase, which was replaced by a filler activity. The filler activity began with a screen appearing on the laptop computer stating that it was time for a story. For 5 minutes a non-density related story about two shapes being friends was read aloud to the participant by the experimenter. The story pictures and text appeared on the laptop computer screen.

Results and Discussion

Once again, scores of the pretest and the posttest were used to calculate two averages, the proportion of correct answers in the pretest (out of 12 trials), and the posttest (also out of 12 trials). Figure 8 shows these averages. In order to initially test for significant differences between
the pre and posttest scores a paired sample t-test was conducted. Results indicated no significant difference between pre and posttests, \( t(19) = .85, p = .41, (M_{\text{Pretest}} = .51, M_{\text{Posttest}} = .48) \).

As in Experiment II, analysis was conducted on the performance of pretest scores across trial type was compared using a one-factor ANOVA (with trial type as between-group factor) revealed no significant effect of trial type, \( F(2, 57) = .42, p = .66 \). As with all previous experiments, this too confirms that children had similar competences across trial type in the pretest. In fact, also similar to all previous experiments, children did not perform differently than what would be expected by chance alone, \( (M = .51) \), single-sample t-tests against chance, \( t < .52 \). However, looking at individual children, none performed above chance (binominal probability \( p < 0.02 \)) on the pretest.

Performance of posttest scores across trial type was also compared using a one-factor ANOVA (with trial type as between-group factor) revealed no significant effect of trial type, \( F(2, 57) = .34, p = .71 \). These findings indicate that replication of the density assessment would not have contributed to the significant difference found in Experiment II.

![Figure 8](image-url)

*Figure 8.* Mean proportion correct of trial Types A, B and C comparing pre and posttest performance of Experiment III, trial type separated and collapsed.
Given that the significant findings of Experiment II could not be attributed to replication of the density assessment, it might have been reasonable to conclude that the training did in fact induce learning. However, children only showed improvement on certain trial types. This lack of improvement in all trial types indicated that children may not have truly learned the empty space concept, but rather, the differences in their performance averages could have been driven by the substitution of one mistaken belief with another. In order to further investigate this possibility, individual patterns of performance were examined.

A binomial test was used to determine that a child would need to score 10 or more correct out of 12 trials to be categorized into a pattern of performance. Five individual patterns of mistaken beliefs were identified: heavy, big, small, or light sinks the fastest, as well as all incorrect. For example, if a child has a mistaken belief that heaviness is the main causal factor to an items sinking behavior then their pattern of performance would be a 4/4 correct in Type A, a 4/4 Correct in Type B and a 0/4 correct in Type C. This would indicate a perfect pattern of performance. Results offered surprising findings. While average group differences between all conditions, except one, were not significant, changes in patterns of performance did, in fact, occur in every condition. These changes occurred through five different variations: change from one mistaken belief to a different mistaken belief, from one mistaken belief to chance, from one mistaken belief to all correct, from chance to a mistaken belief or lastly from chance to all correct. Changes in patterns of performance from pre to posttest are shown in Table 2.
Table 2. Number of children in each cross-tabulated pattern of performance (pre vs. post), as a function of condition.

<table>
<thead>
<tr>
<th>Pre:</th>
<th>Conceptual Model</th>
<th>Inquiry</th>
<th>Combined</th>
<th>Experiment II:</th>
<th>Filler</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>W</td>
<td>C</td>
<td>R</td>
<td>W</td>
<td>C</td>
</tr>
<tr>
<td>Post:</td>
<td>sW</td>
<td>6</td>
<td>2</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>nW</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>2</td>
<td>1</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

*Note.* Children’s performance in the pretest (shown horizontally) was classified to represent a ‘wrong belief’ (W), ‘chance’ (C), or a ‘right belief’ (R). Children’s performance in the posttest (shown vertically) was classified to represent the ‘same wrong belief as in the pretest’ (sW), a ‘new wrong belief’ (nW), ‘chance’ (C), or a ‘right belief’ (R). Shaded areas show number of children with no change in their performance. One child from the combined condition had a pattern of performance that could not be classified, and is excluded from the table.

Individual pretest scores revealed that a majority of children (70%) held a consistent pattern of mistaken beliefs, while some children performed at chance (28%) and two children scored correctly on 11 or more trials out of 12. Out of the 98 children who began with a pattern of mistaken belief or performed at chance, 51% changed their pattern of performance after training, across condition. Most interestingly, while all trainings brought about some change from the original patterns of performance, the inquiry condition revealed the largest percentage (75%) of change from one pattern of belief to another, though never to a correct belief pattern. While most training did not cause change to occur in a positive direction, changes in patterns of performance still occurred throughout all conditions.

Chapter V: Discussion

The goal of the current research was to empirically test the degree to which various training regimes would encourage belief revision through the challenging of prior mistaken beliefs of density in preschoolers. The study began by contrasting three separate regimes,
conceptual model teaching, inquiry through self-exploration, and their combination. Several important results were found, which led to a modification of one of the learning regimes. First, neither of the two initial training methods was successful in helping children replace their mistaken beliefs. Their combination was also not successful. However, in a supplementary experiment it was found that by creating a direct link between training and assessment objects, significant differences were found between pre and post assessments. However, given that children only improved on certain trial types, it was not possible to deduce that the training was successful with regard to the density-related task.

So, what does this say about density? There are several possibilities. First, it might be plausible that density is too complex for preschoolers to learn, and in an attempt to teach them, we may only cause them to either change their mistaken belief from one pattern to a different faulty pattern, or cause them to adhere more strongly to their original mistaken belief. However, it is possible that correct belief revision can be increased through training that is more in depth and more frequent than what was provided in the current study. In fact, many of the conceptual change studies previously referenced took place over extended periods of time with daily or weekly interventions. However, the current study design took into account teacher’s claims of insufficient time to devote to science learning (Greenfield et al., 2009) by attempting to develop a maximally effective training that requires the least amount of time to administer. Given the brief amount of training that children were exposed to in the current study, evidence of belief revision was still found. Thus indicating that teachers who have minimal free time in their students’ daily schedules are able to provide impactful science teaching in a short amount of time.

As mentioned before, it was expected that a combination of teaching regimes would best
support belief revision. The results confirmed that, indeed, out of all the training regimes, the combined training produced the largest number of children (4/20) moving from an incorrect pattern or chance, to a correct belief pattern. Similarly, the conceptual model and conceptual model plus conditions also showed children moving from incorrect patterns or chance to a correct belief pattern (3/20 in both). However, in terms of the total number of children changing patterns of belief, regardless of correct or incorrect change, the combined condition did not show the highest number. Surprisingly, inquiry alone showed the highest number of children moving from one category to another (15/20). However, the inquiry condition showed zero children moving from an incorrect pattern or chance to a correct pattern.

With regard to learning on the density-related task it is clear that the majority of children did not grasp the empty space concept, in spite of exposure to various training regimes. This is especially true of inquiry where all children either moved from one incorrect pattern to another or their pattern remained the same. The majority of children were unable to pick up on the hidden feature of density, even in a best case scenario where all the connections were made for them. For instance, in Experiment II children were explicitly told that the concept of empty space transfers between training and testing objects. Regardless of this clue, only a handful of children correctly changed their pattern of performance. Also, in the inquiry condition, in spite of the fact that children were provided with a container pair that demonstrated that the smallest and lightest jar (Type C) sank while the bigger and heavier floated, this evidence was still not sufficient enough for them to replace or modify their mistaken beliefs.

Given that the inquiry and combined conditions showed the highest percentage of changes in patterns of performance, it is possible that by extending the inquiry training, belief revision may occur in a more positive direction. For instance, a child may benefit from their
teacher immediately verbally addressing the sinking properties of the objects and giving the child the opportunity to ask questions, after placing the containers in the water. In fact, research does indeed support the notion that inquiry is a multi-step process involving more than just experimentation (Klahr, 2000, Klahr, 2005; Klahr & Dunbar, 1988) but also including components of hypothesis generation and evidence evaluation.

This multi-step inquiry approach could have been included in the current study, however it was intentionally excluded. Considering the research previously reviewed involving preschool teachers typically exhibiting negative attitudes towards science, insecurities in teaching science and avoidance of science areas in the classroom, the current study was designed to best replicate real-world classroom scenarios. These would most likely include a water table and various objects to sink or float, with possibly little to no relevant instruction, feedback, or training from teachers. Taking this into account, the best-case learning scenario was provided to children for self-exploration. This included pairs of containers of opposite densities in order to best emphasize sinking/floating differences. However, even when provided with this best-case scenario, children still were not able to pick up on the hidden feature. It is clear that experiencing the sinking differences in person was not enough to correctly replace their mistaken beliefs. Considering the current findings, it is unlikely that children would correctly pick up on the hidden feature of density during an undirected free-play session in preschool. It is more likely that their free-play would confirm their mistaken beliefs rather than challenge them without teacher intervention.

Taking these results into account, it is also possible that the level of belief revision attained through conceptual model training could be maximized if it were paired with more complete inquiry training. However, it was important to consider that in a real-world scenario
children are unlikely to experience training in this one-on-one fashion in the classroom. As previously discussed, children have been shown to benefit from a variety of learning regimes, combined. For instance, we know that children benefit from hands-on exploration, paired with drawings and group discussion (Acher, Arca & Sanmarti, 2007), all of which are relatively feasible in a classroom setting. Therefore a next step would be to scale this training to a classroom setting in order to assess how group interaction might have an effect. Given that a preschool environment has a daily schedule that is not as rigorous as in K-5, this could be an ideal time to introduce complex sciences. With generally small classroom sizes, and relatively more free time, it is quite feasible for this type of training to be done in the classroom.

The goal of the current research was to empirically test the degree to which various training regimes would encourage belief revision through challenging prior mistaken beliefs of density in preschoolers. Valuable information was discovered about teaching regimes that worked best and those that had surprising effects. These barriers to childrens’ science learning are two-fold and yet coincide in such a manner that they cannot successfully operate without the other. On one hand we have teacher’s apprehensions and low self-efficacy with regard to their capabilities to teach science. On the other hand is the barrier of children’s mistaken beliefs. While a teacher may have the necessary desire to expose their preschoolers to science, without teaching regimes that successfully challenge mistaken beliefs, efforts are likely to be impeded. Likewise, identifying learning regimes that are successful in promoting belief revision are not valuable without a large-scale mechanism through which to impact children. Therefore these barriers are contingent upon each other for success.

The present study offered two teaching regimes, a conceptual model and inquiry in an attempt to aide young children in belief revision. It is feasible for them to be implemented in the
classroom, by requiring a minimum amount of time commitment, and also requiring very little complex science knowledge from teachers. As indicated through the findings of changes in patterns of performance, young children’s mistaken beliefs on this density-related task were quite malleable. Although this training only touched on the basic aspects of density (sinking and floating) it nevertheless has the potential to set the stage for more complex learning later on.
References


