EVALUATING A MEASURE OF CHILDREN'S ATTITUDES TOWARDS SCIENCE IN PRESCHOOL

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By

Kelsey S. Inouye

Thesis Committee:

Lois Yamauchi
Seongah Im
Carol Brennan

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Evaluating a Measure of Children’s Attitudes Towards Science In Preschool

In recent years, researchers have investigated the integration of science education programs in preschool, kindergarten, first and second-grade classrooms as a means of further developing literacy and inquiry skills, demonstrating the potential for science education in young children’s classrooms (Best, Dockrell, & Braisby, 2006). Although science is often thought of as a subject learned in secondary and upper elementary school, science can be understood as using evidence such as observation and new information to modify or construct new patterns of understanding—a system of learning that young children seem to innately acquire (Kuhn, 1989). This study developed an instrument to assess children’s attitudes toward science and evaluated its utility with children in preschool. In the following sections, I describe the literature on early childhood science curricula and young children’s attitudes towards science.

A central question when thinking about children’s attitudes towards science is whether or not children have a concept of science with which to begin. As the field of education has focused more on teaching science early on, the empirical research in this area has grown. Koerber, Sodian, Thoermer, and Nett (2011) recently conducted two sets of experiments with five- and six-year-olds in Germany to evaluate preschoolers’ abilities to understand relationships between two variables. Results suggested that young children could form interpretations of non-covariate data patterns and understand how relationships between variables emerged from the evidence (Koerber et al., 2011). Similarly, other studies that have centered on children’s speech as evidence of understanding find that young children’s explanations of simple scientific concepts like how bees collect pollen from flowers (Danish & Phelps, 2011), and changing seasons (Kumpulainen, Vasama, & Kangassalo, 2003), have found that children are able to reference past experiences and class discussion and activities when explaining phenomena after an instructional period (Kumpulainen et al., 2003). The quality of their discussions increased, moving from "what" to "how" and "why" (Danish & Phelps, 2011), implying a higher level of thinking. These empirical studies offer evidence for young children's understanding of science, and the importance of teaching science skills during early childhood.

Research on children's ability to reason and modify their preconceived beliefs indicates that children as young as three-years-old are able to use evidence to update causal beliefs (Koerber et al., 2005). Other studies have suggested that scientific thinking—defined as forming relationships between theory and evidence—may be difficult for young children, as the task of distinguishing between two entities is sometimes problematic. Young children are less able than older children to resolve conflicts between their beliefs and contradicting evidence (Kuhn, 1989). But while the extent to which young children are cognitively prepared for science education is tenuous, even the most critical research concedes that young children are able to somewhat modify their thinking based on observation, though the extent to which they can differentiate between belief and evidence remains questionable (Kuhn, 1989). In short, science education in early childhood does appear to be beneficial.

Yet, in addition to curricular efforts to engage young children in scientific thinking, children's attitudes towards science may also play a critical role in the extent to which they respond positively to science activities. Studies focusing on people who have pursued careers in science-related fields have found that positive attitudes toward science that begins as early as in elementary school may influence future interest in science and science as a career choice (Maltese & Tai, 2010; Bartley, 2009; Gibson & Chase, 2002). From a theoretical perspective, Doob (1947), defined attitude as an "implicit, drive-producing response considered socially significant in the individual's society" (P. 136). Essentially, attitudes are learned responses, many of them shaped during early childhood when children are exposed to cultural values. Thus, children form attitudes and beliefs about science based on their experiences, perhaps through cartoon depictions of scientists (Buldu, 2006) or through conversations with their parents. In preschool, for the most part, children still possess the natural inquisitiveness and sense of wonder that might influence their attitudes toward science learning, making the experience a more positive one (Eshach & Fried, 2005; Howitt, Morris & Colvill, 2007).

In conducting research for this literature review, I perused the following databases: ERIC, Academic Search Premier, Web of Science, and Google Scholar. I used a combination of keywords: science learning, attitudes, preschool, early childhood education, science attitudes, science assessment, and young children. Based on these searches, I found that while ample empirical research exists in science education from the educator's perspective, there are few studies that specifically address student attitudes toward science, particularly for the early elementary school population. Even fewer studies evaluate children's attitudes at the preschool level. Thus, I extended the range of this literature review to encompass trends in science learning and attitudes for early childhood, specifically preschool through third grade, or children aged 3-9.

This literature review will focus on two emerging trends in science learning in early childhood education, examining empirical studies that explore ways of engaging young children in science and scientific thinking: inquiry-based instruction and a focus on the nature of science. Additionally, I address existing research on young children's attitudes towards science, with the goal of identifying themes in the research to determine how science curricula and child attitudes affect learning. In total, I found 17 empirical studies related to early childhood science education.

In this literature review, I begin by describing trends in children's science education, specifically inquiry-based learning and the nature of science. Next, I focus on the methods of the curricular empirical research, identifying trends in data collection and common limitations of the studies, followed by a section synthesizing patterns in early childhood science assessment. Finally, l explore the current research in children's attitudes toward science.

Science Curricula in Early Childhood Education

Research in science curricula for children reveals two major areas of study: inquiry-based learning and Nature of Science. Although both inquiry-based learning and nature of science are similar in execution, and in the literature there is little distinction between them, I discuss them separately.

Inquiry-Based Learning

A number of recent studies focused on inquiry-based science education in kindergarten and early elementary school classrooms (Howitt, Lewis, & Upson, 2011; Peterson & French, 2008; Kumpulainen, Vasama, & Kangassalo, 2003). Inquiry-based education is a system of teaching that promotes child engagement, focusing on student questions and often allowing children to conduct their own projects and explore material on their own, supplementing instruction with discussion (Keys & Brian, 2001).

Because these studies investigated the effectiveness of a particular instructional method, most of the research on inquiry-based science consists of pilot or case studies, usually involving one or two elementary school classrooms and several teachers that have been trained in inquiry instruction. Teachers often conducted a science unit lasting several weeks, and student learning was measured using mixed-methods, drawing on collected student work, student and teacher interviews, class recordings, or pre- and post-tests. For example, in Zhang, Parker, Eberhardt, and Passalacqua (2011), a kindergarten teacher who participated in a professional development program, designed a unit called "What's so terrible about swallowing an apple seed?" which incorporated experiments (planting apple seeds in soil with light, and planting seeds in a plastic bag with water), books and videos, and a guest speaker who answered student questions regarding what happens upon swallowing an apple seed (Zhang et al., 2011). In this case, the teacher designed her own assessment tool—an interview question—which she used to determine children's understandings of what materials are needed for plants to grow (Zhang et al., 2011).

The general consensus of the empirical research is that inquiry-based science results in improvement in children's understandings of science concepts taught in the inquiry-based unit (Zhang et al., 2011; Best, Dockrell, & Braisby, 2006; Danish & Phelps, 2011). Children perform better on various measures—formal and informal—and exhibit greater vocabulary usage and more thorough oral explanations for various phenomena (Peterson & French, 2008). It is important to note, however, that some of these studies were conducted without a control group, and thus, it is difficult to discern whether or not children's gains in science knowledge can be attributed to the inquiry-style curriculum. Nevertheless, the research compels educators to seriously consider the potential benefits of inquiry-based learning for young children.

Nature of Science

Nature of Science is a second common thread of inquiry found in the literature on early childhood science education. Nature of Science can essentially be understood as scientific thinking, the distinction between what is science and what is not (Lederman, 1992). Although the instructional implementation of Nature of Science closely resembles the inquiry-based learning discussed above, research indicates that inquiry-based instruction alone is not enough to instill the values of Nature of Science, emphasizing the need for explicit Nature of Science education

(Akerson & Abd-El-Khalick, 2005). Nature of Science can be broken down into six aspects, described as being: (a) based on observations and inferences, (b) empirically-based, (c) culturally-based, (d) tentative but reliable, (e) subjective, and (f) a creative endeavor (Quigley, Pongsanon, & Akerson, 2010). The empirical research argues for teaching Nature of Science beginning as early as preschool, as Nature of Science comprises of critical skills that remain important throughout a child's education. Intervention studies focused on Nature of Science demonstrated that young children can acquire and strengthen concepts of Nature of Science following instructional sessions (Quigley, Pongsanon, & Akerson, 2010; Akerson et al., 2011; Murphy, 2011). In other words, through activities, students can better understand the principal concepts underlying Nature of Science thinking. Furthermore, what makes teaching the Nature of Science in early childhood even more critical is that a significant percentage of children still did not have a firm grasp of Nature of Science upon graduation from high school (Bell et al., 2003).

Because the definitions of Nature of Science remain relatively stable across the empirical research, many of the studies are similar in that they identify specific aspects of Nature of Science and develop activities aimed to strengthen children's conceptions in those areas. But the similarities in methods also lead to similar limitations across the Nature of Science research. As in inquiry-based research, many empirical studies do not include a control group, making it difficult to draw strong causal conclusions. Additionally, in many cases, at least some of the children already have preexisting understandings of Nature of Science, which may affect the studies' overall outcomes.

The curricular trends in science education promote instructional methods that incorporate hands-on experience and a focus on the scientific thinking critical to performing and understanding science, building a foundation for further interest and education. Empirical research on both inquiry-based learning and Nature of Science not only demonstrates ways that interactive learning can be built into the curriculum, but also that such instructional methods are effective, increasing young children's science vocabularies, and enriching their explanations of scientific phenomena (Peterson & French, 2008; Kumpulainen, Vassama, & Kangassalo, 2003)

Children's Attitudes Towards Science

Researchers have found that children's attitudes toward science decline in middle and high school, and that these negative conceptions of science begin as early as late elementary school (Murphy & Beggs, 2003). However, there is little research that looks specifically at attitudes towards science in early childhood. The few studies that do exist suggested that children have generally positive attitudes toward science learning, and children often cite hands-on investigations and experiments as the primary reasons for science being enjoyable (Murphy 2011, Murphy & Beggs, 2003; Mantzicopoulos, Patrick, & Samarapungavan, 2008).

Other researchers posit that children's views of scientists are related to their views of, or interest in, science as a whole, and that much of what children think about science is influenced by sources outside of school (Buldu, 2006). For example, television, movies, and parents may influence children's conceptions of science and scientists based on how the people and images in their daily lives depict science. Additionally, children from families with higher socioeconomic status tended to represent scientists in more complex, less stereotypical ways than their peers, sometimes drawing social scientists and steering away from the common image of the "mad scientist" with glasses and wild white hair, indicating that perhaps exposure to broader ideas about science, possibly through family members, may affect how children perceive and respond to science (Buldu, 2006).

Because attitudes that develop at an early age seem to influence future behaviors, it is important for educators to promote student interest in the field of science. Peleg and Baram-Tsabari (2011) attempted to use theater as a means of both educating and promoting positive attitudes toward science. The study took place in Israel at two elementary schools. Children watched a 40-minute play called "Atom Surprise" in which basic concepts of matter were discussed, and children were given questionnaires before and after seeing the play. Results indicated that not only did children retain scientific concepts, but that the play seemed to alter student perceptions of what science *could* be, though children's attitudes toward science itself did not necessarily change. This distinction between attitudes toward science and beliefs about what science can be is an interesting one. Further research may investigate whether or not children's ideas of science may eventually change based on their experiences in the classroom and their conceptions of what science entails.

Review of the Methods: Empirical Research on Science Curricula, Children's Attitudes, and Assessment

Researchers focusing on curricula and children's attitudes both rely on similar data sources. Yet, the methods used to collect and analyze data in support of the results vary immensely—perhaps because of the challenge that comes with working with and assessing such a young age group. Howitt, Lewis, and Upson (2011), conducted a case study that took place in an Australian preschool. Data collection consisted of pre- and post- interviews with the teacher, recordings of children's responses to in-class questions, and a collection of student work completed during the science unit. While other researchers, such as Danish and Phelps (2011), used specific coding methods to evaluate student comments and interviews, as well as written work, Howitt, Lewis, and Upson (2011), did not specify any particular means of analysis, but instead they reported examples of student responses as evidence to support their conclusions.

Across the studies, teacher experience varied considerably, as some teachers directing the inquiry-based unit were still participating in teacher-education programs (e.g., Howitt, Lewis, & Upson, 2011), while others had many years of teaching experience prior to the study (e.g., Peterson & French, 2008; Zhang et al., 2009). As noted earlier, there is limited research focusing specifically on preschoolers, and child participants in these studies ranged from preschool age (3-4), to third grade (ages 8-9). Subsequently, such differences in teaching experience and student age create difficulties when trying to compare multiple studies. The contrast in children's cognitive development and teacher familiarity with the curriculum and/or teaching method results in variability. More experienced teachers might be better at executing the intended curricula, thus affecting the children's experience of the material and ultimately, their science learning.

One trend that does remain consistent across studies in early childhood education was the use of oral responses in assessment; as young children are not yet adept at expressing themselves through writing, it makes sense that assessment of science learning and attitudes should occur through a verbal medium, and the majority of empirical studies used interviews as a primary data source, while other studies focused specifically on language development in relation to science learning (Kumpulainen, Vasama, and Kangassalo, 2003; Best, Dockrell, and Braisby, 2006). Often used in combination with manipulatives, drawings, or photographs, children's verbal explanations of class material can be an effective means of evaluating their learning (Brenneman & Lauro, 2008; Kumpulainen, Vasama, & Kangassalo, 2003).

As mentioned earlier, empirical studies on inquiry-based learning and Nature of Science are similar in structure, most often introducing a science-learning unit framed by pre- and post-assessments to measure children's learning (Akerson, et al. 2011; Quigley, Pongsanon, & Akerson, 2010; Danish & Phelps, 2011; Kumpulainen, Vasama, & Kangassalo, 2003). Because the goal of research in science learning curricula is to improve children's engagement and retention of skills and concepts, assessment is an essential part of the methods. In Table 1, a summary of the various assessments used in the empirical research is presented.

In order to assess student science learning, researchers draw on a variety of data sources including: formal and informal interviews, standardized measures, video recordings of classroom conversation and student interactions, drawings, children's explanations of their work, portfolios, journals, and questionnaires. Because of the diverse and generally qualitative nature of the data collection, a possible limitation of these studies is the reliability of the assessments. As many of the assessments with young children are oral, interpretation of the data may vary based on whether or not researchers coded children's responses, or even how responses were coded. Furthermore, as teachers sometimes administered the interviews or questionnaires, children's answers might have been affected by social desirability, responding in ways that they believed would please their instructor, particularly in terms of their attitudes towards the subject matter.

However, one way to analyze the methods is to examine the assessment tools used in the research. Howitt, Lewis, and Upson (2011), and Quigley, Pongsanon, and Akerson (2010), both drew on class work as evidence of child learning. Examples of class work included journals and drawings. The advantage of using class work is that researchers are better able to see progression in children's learning, the process that takes place between pre-test and post-test, as the treatment is being administered. Yet, despite the rich qualitative data that such sources can provide, a

Table 1

Assessments Used in Empirical Studies

Study	Assessments	Age of Children
Kumpulainen, Vasama, & Kangassalo (2003)	Student interviews, video-recordings of class sessions coded by NVivo	6-7 years
Murphy & Beggs (2003)	Questionnaires (adapted from a survey of attitudes towards ICT), recordings of children's responses	Primary School
Mantzicopoulos, Patrick, & Samarapungavan, (2008)	PISCES (Puppet Interview Scales of Competence in and Enjoyment of Science), Woodcock-Johnson III, videotaped lessons	Kindergarten
Peterson & French (2008)	Videotapes of child-teacher interaction	3-4 years
Samarapungavan, et al. (2009)	Science Learning Assessment, Science Knowledge and Passage Comprehension subsets from the Woodcock-Johnson III Tests of Achievement III, SLP Portfolio Rubric	Kindergarten
Quigley, Pongsanon, & Akerson (2010)	VNOS-D, videotaped class sessions, student journals, reflection sessions	Grades K-2
Akerson, et al. (2011)	Views of Nature of Science D (VNOS-D), Administered Young Children's' Views of Science (YCVOS)	Context 1: grades K-2; Context 2: grade 1; Context 3: grade 3
Danish & Phelps (2011)	Interviews, children's storyboards, videotaped student conversations with peers and with teachers	Grades K-1
Howitt, Lewis, & Upson (2011)	Interviews, teacher's lesson plans, children's responses to in-class, drawings, class observations	4 years 4 months – 5 years 2 months
Peleg & Baram-Tsabari (2011)	Questionnaires (4 sections: content knowledge, misconception, general attitudes toward science, attitudes/feelings toward play)	6-12 years
Zhang, et. al. (2011)	Teacher's research plan, videotaped classes, student assessment data, study group meeting notes, teacher's final report, longitudinal data collected over 4 years of teacher's participation in program	Kindergarten

drawback of assessing student work is the uncertain reliability and validity of such measures. Unlike standardized measures, the researchers did not identify any specific methods to evaluate child work. Because the reliability of the assessment is in question, then, the internal validity of such studies is threatened.

In addition to class work, video recordings are popular sources of data that were used to assess children's science learning during the curricular intervention. Peterson and French, (2008), Danish and Phelps (2011), Quigley, Pongsanon, and Akerson (2010), Kumpulainen, Vasama, and Kangassalo (2003), and Mantzicopoulos, Patrick, and Samarapungavan (2008), all relied on videotapes as key sources of data. Most of the researchers coded the videotapes and identified several domains of verbalization that included science-related utterances, off-topic utterances, and various curriculum-specific speech. As young children tend to best express themselves orally, videotapes offer valuable insight into their thinking processes, allowing researchers to observe children's interactions with each other as well as their teachers, evaluating how children communicate ideas about science. Like children's class work, videotaped lessons provide data on the learning process, as opposed to pre- and post- assessments alone. Because the recordings are usually coded, the data may be quantified using methods that aid in establishing validity. However, when a coding program is not utilized, the coder's subjectivity may be a limitation.

Finally, a different, but still useful, source of evidence comes from standardized measures. Akerson, et al. (2011), Quigley, Pongsanon, and Akerson (2010), Mantzicopoulos, Patrick, and Samarapungavan (2008), and Murphy and Beggs (2003) used standardized instruments in their research. Because standardized measures are established for validity and reliability, they have a clear advantage. However, unlike the other data sources mentioned above, these assessments only address specific areas of content, and offer a limited view of children's learning and attitudes. Thus, it seems that the more comprehensive methods combine both standardized measures and other qualitative data in order to piece together a fuller picture of children's learning processes.

Effect on Young Children's Learning

From this literature review, it appears that current trends in science curricula, specifically inquiry-based learning and Nature of Science, have positive effects on children's learning as demonstrated through various data sources. Yet, regardless of the instructional program, it seems that children's attitudes toward science is also very important, shaping their future interest in science as well.

Research Focus

Given the empirical research on science learning programs and children's attitudes, it is clear that science is becoming an important part of early childhood education. However, despite ample evidence supporting inquiry-based and Nature of Science curricula, is a need to focus specifically on young children's attitudes toward science. Thus, the current study is designed to develop an instrument to assess young children's attitudes toward science.

Methods

Participants and Setting

Participants included a total of 53 preschool children, ages 3 to 5, from the University of Hawaii at Manoa Children's Center located in Honolulu, a school that serves children of students and staff at the University of Hawaii (2- to 5-year-olds). Of the participating children, nineteen were girls, and 34 were boys. Approximately 42% of children at the Children's Center were Asian or Asian American, 40% European or European American, 15% Pacific Islanders, while the rest represent African American and Latino ethnicities. Roughly 32% of the children spoke English as a second language, and every year 31-48% meet the requirements for free or reduced lunch (Yamauchi, Im, & Mark, 2012).

Instruments & Procedures

The instrument I developed uses a 3-point Likert Scale featuring the response options "Yes", "Maybe," and "No," and included a total of 23 items containing three subscales: experiments, nature, and specific class activities. (See Table 2).

I began by observing classes at the Children's Center to get a sense of how class activities operated and to allow the children to become familiar with me so that during the interviews they might be more comfortable. About three hours of observation took place at the end of May 2012. I also conducted individual interviews with at least one teacher from each of the six preschool classrooms in order to provide aid in developing items, with the help of a research assistant. Questions included:

What evidence do you see of the children's attitudes towards science?

How might you define the terms "nature" "experiment" and "prediction" so that the children will know what you're talking about?

Can you give me some specific examples of an experiment, investigation, prediction you did in class that the children will be able to relate the terms to?

Based on my class observations and teacher interviews, I created a questionnaire that underwent multiple drafts based on feedback from professors and educational specialists working at the Children's Center.

Table 2

Instrument Subscales and Items

Subscale	Questions
Experiments	I like to do experiments.
	I like to make predictions.
	I like to ask questions.
	I like hands-on activities.
	I like to figure out (or see) how things work.
	Guessing what will happen next is fun.
	I like to test (or see) if my predictions are right.
	Investigations are interesting.
	I like to make observations.
	I like to talk about investigations.
	I like to try out my ideas to solve problems.
Nature	I want to learn more about nature.
	Learning about nature is fun.
	I like to explore nature.
	I like class discussions about nature.
	I like learning about how plants and animals grow.
	I like to talk about nature.
	I like to think about nature.
Class Activities	Working in the garden is fun.
	I like learning about x*
	I like to observe x*
	I like to talk about x*
	I like to make predictions about x*

**refers to activities specific to each classroom (e.g., sink-float activity, butterfly lifecycle, food pyramid, etc.)*

Once the questionnaire was approved for usage, I conducted a small test-run with 16 children. The instrument was administered individually and orally in an empty room. I included definitions of the terms "experiment," "prediction," and "nature," and clarified the terms for each child as necessary. I also repeated questions and simplified terms if the children exhibited signs of confusion.

After two sessions of testing, I conducted a reliability analysis using SPSS, and a categorical factor analysis with a WLSMV estimator using the statistical software MPlus. The purpose of this small group analysis was to assess my items and delete poor ones. However, after this initial test, no items were deleted. I then re-administered the instrument to 41 different children using the same procedures, individually and orally. I met with children in an empty classroom over a period of three days.

Data Analysis

After completing data collection, I used SPSS to calculate the reliability for the instrument in its entirety, as well as the reliability for each subscale. I also ran a factor analysis with a WLSMV estimator using the M*plus* (Muthen & Muthen, 2007) for the scale and its subscales.

Results

The Cronbach's alpha for the instrument was .841, a fairly strong value for reliability. The Cronbach's alpha coefficients for the subscales were as follows: experiments (.611), nature (.667), and class activities (.591). Unlike the instrument as a whole, the reliability coefficients for the subscales are mediocre, indicating problems with the items. The values are presented below in Table 3.

Table 3

Reliability Analysis

Scale	Cronbach's Alpha
Instrument	0.841
Experiment	0.611
Nature	0.667
Class Activities	0.591

While I did run a factor analysis using M*plus* with the WLSMV estimator, the factor analysis was unable to be completed due to the fact that there was not enough variability among the children's responses. No results for the factor analysis were obtained for the instrument as a whole, nor two of the individual subscales. Although the subscale for Class Activities produced a result, the goodness of fit statistics were low (CFI, TLI, and RMSEA) and does not have much weight regarding the construct validity of the instrument. Table 4 provides the M*plus* results for Class Activities, and Table 5 illustrates the percentage of responses to each item.

Table 4

Results of Class Activities Factor Analysis

Goodness of Fit Statistics	Value
CFI/TLI	0.742
RMSEA	0.171

Despite the problems encountered with construct validity, I was able to establish content validity during the item construction stage of the instrument development. The Children's Center teachers and faculty with whom I consulted, can be considered experts in the field of the early childhood education and are familiar with the science curriculum implemented in the Children's Center classrooms. My committee member, Carol Brennan, who also assisted me in developing items, can be considered an expert in elementary science education and is knowledgeable of the Center's science curriculum. Using their feedback, I produced several drafts of items to ensure that the questions would be age-appropriate and content-appropriate.

Table 5

Percentage of Responses to Each Item

	Yes	Maybe	No	Total
Item 1	83.8%	2.7%	13.5%	100.0%
Item 2	70.3%	2.7%	27.0%	100.0%
Item 3	86.5%	0.0%	13.5%	100.0%
Item 4	70.3%	2.7%	27.0%	100.0%
Item 5	86.5%	8.1%	5.4%	100.0%
Item 6	94.6%	2.7%	2.7%	100.0%
Item 7	97.3%	0.0%	2.7%	100.0%
Item 8	86.5%	2.7%	10.8%	100.0%
Item 9	86.5%	5.4%	8.1%	100.0%
Item 10	94.6%	0.0%	5.4%	100.0%
Item 11	91.9%	2.7%	5.4%	100.0%
Item 12	91.9%	2.7%	5.4%	100.0%
Item 13	91.9%	2.7%	5.4%	100.0%
Item 14	91.9%	0.0%	8.1%	100.0%
Item 15	94.6%	2.7%	2.7%	100.0%
Item 16	89.2%	0.0%	10.8%	100.0%
Item 17	97.3%	0.0%	2.7%	100.0%
Item 18	94.6%	0.0%	5.4%	100.0%
Item 19	89.2%	0.0%	10.8%	100.0%
Item 20	94.6%	0.0%	5.4%	100.0%
Item 21	89.2%	8.1%	2.7%	100.0%
Item 22	89.2%	2.7%	8.1%	100.0%
Item 23	83.8%	5.4%	10.8%	100.0%

Discussion

From this research I learned how to interview and develop items for young children. The drafts of items I went through with feedback from Children's Center teachers and staff taught me to think critically about the items from the children's point of view. However, even with the definitions of "experiment" "prediction" and "nature" that I provided as part of the instrument, the interviews made clear that the children were still having difficulty comprehending some of the questions. As a result, in future revisions I would re-phrase items 1, 2, 10, 12, 13, and 18 to eliminate any potentially difficult words. In contrast, the most successful items were those that focused on specific class activities or nature. It seemed that the children had a good grasp of what nature is, and could readily answer those items. In short, the children could talk about the content of their science activities, but did not fully recognize the process or the terms that described science inquiry. Thus, it makes sense that they struggled with questions like, "Do you like to make predictions."

These observations are consistent with Piagetian theory (Piaget & Inhelder, 1969). Piaget's theory breaks human development into four stages: sensorimotor, preoperational, concrete operational, and formal operational. Because the children I interviewed were ages 3-5, they fall into the preoperational stage that is characterized by egocentric thinking, beginning to think in words, and symbolic representational ability (Birney & Sternberg, 2009). Essentially, as explained in Gelman & Baillargeon, (1983):

> (T)he preoperational child is egocentric [. . .] his reasoning is perception bound: he is easily distracted by the perceptual of or spatial properties of objects and, for this reason, often fails to detect more abstract, invariant relations among objects. (P. 172).

At this point in development, young children's reasoning skills are not fully developed, making it difficult for them to think abstractly. Instead of focusing on the relationships and patterns, they focus on the visible elements of the world around them. In fact, according to Piaget, abstract thought does not occur until the final stage of development—formal operational (Birney & Sternberg, 2009). Thus, in applying Piaget's theory, the children interviewed in this study may have had difficulty understanding concepts like "experiment" because they have not yet developed the cognitive skills required to comprehend such concepts. Even if I told them that an experiment was like a test, or gave specific examples of experiments they did in the classroom, the children might not be able to make the connection between experiments and the processes involved in the activities they did in the classroom. The ideas are too abstract. With questions dealing with nature, however, the children can easily reference their memories of working in the school garden or playing with plants outside. At the preschool level, "nature" is essentially the outdoors, which is something that young children can understand based on personal experience. Because young children tend to focus on the observable qualities of the environment, they are more likely to accurately respond that they like to work in the garden, than that they enjoy doing experiments. They can relate to the physicality of touching seeds and looking at plants rather than the process of making and testing a prediction.

Introducing children to science via nature appears to be a common trend in early childhood science education. Many studies in young children's science curricula use nature-related concepts as the subject matter when implementing instructional techniques: bees collecting pollen (Danish & Phelps, 2011), changing seasons (Kumpulainen, Vasama, & Kangassalo, 2003), the growth of plants (Zhang et al., 2011). It makes sense then, that children like those interviewed in the current study, were comfortable responding to nature-related items. Consistent with current research in children's science, the Children's Center focuses on nature-related science activities such as the evolution of a caterpillar into a butterfly, food groups, and a school-wide garden project in which the children are able to participate in growing fruits and vegetables on campus.

The children also appeared more comfortable answering questions related directly to class activities. Like nature questions, the class activity items drew on the children's experiences, and therefore, they may have been more likely to give accurate answers to these items. This is reinforced by the fact that the class activities subscale was the only subscale that produced a result from the M*plus* factor analysis, indicating that future revisions of this instrument may want to draw more heavily on class activities to assess children's attitudes and define concepts like "experiment."

A second point of discussion regarding the results of this study is the data collected from the children's responses. A number of children appeared to be replying "Yes" by default, almost automatically, without really considering the question. As discussed earlier, it is doubtful whether children actually understood what many of the items were asking, and said "Yes" to provide a response. Furthermore, there was a definite difference between the 3- and 5-year-olds' responses. The 3-year-olds tended to answer "Yes" more automatically, while the 5-year-olds generally took more time to respond, as if they were actually considering the questions. The indication is that age is an important factor in the children's comprehension. Furthermore, while there are a number of studies in early childhood science, few of them rely on Likert-scale assessments—likely for the reasons discussed above. It is difficult for young children to focus for extended periods of time, and while it only took 5-10 minutes to complete each questionnaire, there were 23 questions. That is quite a few questions for young children, and their attention may have wandered during the assessment, resulting in automatic "Yes" answers. The lack of attention is evidenced by the number of children who started to go off topic in the middle of the interview. Several children would respond "Yes" to a question about growing plants in the garden, and then proceed to tell me about their collection of dinosaurs or how today is water play day.

Another possibility is that the children were reluctant to answer "No" for fear of displeasing me. It might make a child nervous to say that "No, I do not like to learn about nature," for example, thinking that perhaps they *should* like learning. Even though I am not a teacher, I am an adult figure, and the children may have wanted to please me. However, the extreme responses are consistent with research on young children's responses to Likert Scales, where 5- and 6-year-olds tended to give extreme answers to questions focusing on emotional or social subjects (Chambers & Johnston, 2002). It seems that young children are more likely to select extreme options than older children, thus ignoring the more moderate degrees of emotion or, in this case, attitude (Goodenough, Kampel, Champion, Laubreaux, Nicholas, Ziegler, McInerney, 1997). A possible explanation for this phenomenon may lie in Piagetian theory, which posits that children's thinking is primarily dichotomous, (Gelman & Baillargeon, 1983). Dichotomous thinking is believed to derive from centration that is characteristic of children in Piaget's preoperational stage; children's tendency to see things from a single point of view leads to the inability to relate to others and distinguish between their own feelings and the feelings of those around them. Thus, it is difficult for them to discern between levels of emotion or attitude; the extreme responses recorded in this project are likely the result of the children's developmental stages.

As alluded to earlier, the major limitation of this study has to do with the children's ages. Because they are so young, it is difficult to discern whether or not they fully comprehended the questions and the terms discussed in the questions. The high number of "Yes" responses and the neglect of "Maybe" led to a lack of discrimination that made it impossible to successfully calculate validity evidence. The instrument needs to be revised so that the discrimination issue is corrected and we can validate the results.

Another limitation of this study was the administration of the instrument. I administered the instrument in several different settings to different groups of children. I used an empty conference room, a teacher's office, and classrooms. Noise level was dependent on the setting, and in some cases, like in the classroom, there were several other children around when I was working with an individual child. The distraction of other children, noise, the option of playing rather than speaking with me, may have affected the children's responses and ability to concentrate. Furthermore, during one set of interviews, a teacher was sitting with me at the table while I interviewed the child. The presence of the teacher may have influenced the children's responses.

Although the instrument developed in this study is in need of further revision, this research was successful in that I was able to get a sense of how young children react to Likert Scales and develop items focusing on preschool-appropriate science questions. I was able to complete the first steps towards creating an assessment tool that will be useful for teachers and educational researchers to determine how curricula and teaching strategies may influence how children react to science (Peleg & Baram-Tsabari, 2011). As emphasized earlier, attitude development often plays a crucial role in how children react to science later in life, sometimes affecting decisions regarding career choice. Thus, instruments like this will be helpful tools in assessing children's attitudes, particularly when used in combination with other, perhaps qualitative, measures.

Further Research

The next steps to take to further develop this instrument would involve clarifying the questions, and figuring out how to administer the measure in such a way that children would not be so likely to automatically answer "Yes." However, as that appears to be age-related, there will probably always be some error due to lack of discrimination. This is why it is also important to find alternative methods to assess preschool children's attitudes towards science. While a Likert-Scale instrument is quick and convenient, it should be used in conjunction with other data sources, such as recording class discussions and activities that may be more indicative of how children feel about science learning. Most studies on young children's science abilities and attitudes use a combination of data sources when assessing knowledge and learning (Patterson & French, 2008; Quigley, Pongsanon, & Akerson, 2010; Howitt, Lewis, & Upson, 2011; Kumpulainen, Vasama, & Kangassalo, 2003). Other alternatives include using a visual scale—such as a bar graph—that children can point to in order to show how much they like certain activities.

Based on this study, more research needs to be done not only on young children's attitudes, but also on how young children understand and respond to Likert scale instruments. A better understanding of how children differentiate between degrees of emotion will help us to improve the way we assess young children using quantitative scales. Additionally, this study highlights the difficulty involved in measuring young children's feelings about school activities, indicating pathways for further studies that look closer at children's attitudes towards science and other topics.

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Appendix A

Preschool Children's Attitudes Towards Science Assessment

Yes	Maybe	No	1. I like to do experiments.
Yes	Maybe	No	2. I like to make predictions.
Yes	Maybe	No	3. I want to learn more about nature.
Yes	Maybe	No	4. I like to ask questions.
Yes	Maybe	No	5. Learning about nature is fun.
Yes	Maybe	No	6. I like hands-on activities.
Yes	Maybe	No	7. I like to figure out (or see) how things work.
Yes	Maybe	No	8. Guessing what will happen next is fun.
Yes	Maybe	No	9. Working in the garden is fun.
Yes	Maybe	No	10. I like to test (or see) if my predictions are right.
Yes	Maybe	No	11. I like to explore nature.
Yes	Maybe	No	12. Investigations are interesting.
Yes	Maybe	No	13. I like to make observations.
Yes	Maybe	No	14. I like class discussions about nature.
Yes	Maybe	No	15. I like learning about how plants and animals grow.
Yes	Maybe	No	16. I like to talk about nature.
Yes	Maybe	No	17. I like to think about nature.
Yes	Maybe	No	18. I like to talk about investigations.
Yes	Maybe	No	19.I like to try out my ideas to solve problems.
Yes	Maybe	No	20. I like learning about x*
Yes	Maybe	No	21. I like to observe x*
Yes	Maybe	No	22. I like to talk about x*
Yes	Maybe	No	23. I like to make predictions about x*

Definitions:

Experiment: A test to see what will happen, trying to see if something works.

Prediction: A guess about what will happen in the future.

Nature: Anything that is part of the earth; things that come from outside.

*refers to activities specific to each classroom