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# Varying Actions and Beliefs among Parents about Their Children's Science Learning when Visiting a Science Museum

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# Varying Actions and Beliefs among Parents about Their Children's Science Learning when Visiting a Science Museum

**by**

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# Dedication

To My Parents

Wen-Ching Lan (藍文卿) and Su-Ying Chang (張素瑛)

## Acknowledgements

**What would happen if I just kept going? (Murray, 2012)**

This story started on April 13, 2009. On that day, I logged in the UT Application Status Check page as usual to check whether a decision has been made. When the four little magic words "We are pleased to…" jumped into me, I couldn't finish reading the whole paragraph with any patience. I told my parents this exciting news immediately and none of us fell asleep that night.

However, like all fairy tales, the process is always not so smooth. Before "living happily ever after," the main character needs to conquer a great deal of challenges. Undoubtedly, I have no exceptions.

> As how I understand about you, I am sure you can make it, as long as you don't expect yourself to do as good as you were in Taiwan. I am not saying it is easy. Everybody had difficulties in her/his first year. But you absolutely will be able to make it! I have faith in you and you shall have faith in yourself too. Remember, don't expect yourself doing as good as you did in Taiwan.

My one former professor wrote this to me, after I emailed her about how I doubted my ability of getting through my PhD study. One word can fully describe my first semester at UT is "miserable." Being in a totally different culture consumed all my strengths and courage. I have to admit I wanted to give up as soon as I arrived at Austin. One more step, I would give up my PhD study. However, I was so fortune to receive encouragement from Dr. Lisa Cary, who shared with me her personal experience of studying abroad. This timely support motivated me to decide to stay rather than run away. Honestly, this is a tough journey, and only those who walked through the same process can understand how difficult it is. I am a blessed person. In addition to Dr. Cary's warm support, many wonderful people gave me love, encouragement, confidence, and courage to help

me get through one semester, and another, and another, and another…until this moment.

**As Bronfenbrenner (1977) noted, "If we can stand on our own two feet, it is because others have raised us up." I couldn't finish this alone, so I sincerely thank these important people in the past four years**:

First and foremost, I thank my parents. They do not really know what I was studying and I know they always have a concern with whether I can live on my early childhood major in the future. Yet they fully support me without questioning. My parents are the inspiration of this study. They remind me of how much parents can influence their children in a positive way. To me, my parents are the best teacher in my whole life. They taught me how to bath, eat, ride a bicycle, share things with others, look at the bright side of life, and so on. It is their faith in my ability that enables me to succeed. There is no word can describe my love to my dear parents. If this dissertation is a key accomplishment, I will undoubtedly dedicate this to them to honor their unconditional love and support.

I especially want to thank my mom for her insights. She never learned anything about qualitative research, early childhood education, or science education, but she is a senior parent, which makes her understand very well about how and why these parents thought and acted. Every time I struggled with how to interpret my findings, I talked with her. I could always get some inspiration from her; additionally, I learned how she perceived my education as well from the process of having a conversation with her.

Except for my parents, all the participants in this study deserve my most sincere gratitude. I am so blessed to have these families as my participants. I thank all the parents and their children for their precious time and willingness of sharing their perspectives with me. Before this study, I did not know most of them. I am really surprised and touched that these parents were willing to trust me and share these valuable thoughts with

a total stranger. The more I talked to these parents, the more I felt I am obligated to write about their ideas about early science learning. As a former kindergarten teacher, I have to admit that I did not offer parents in my class enough chances to address their thoughts and/or concerns. In this study, however, each parent's viewpoints challenged me, as a researcher and a former kindergarten teacher, to think more on what I can do to improve early science education in Taiwan and in other countries. I feel so grateful that they were willing to participate and lead me to see these important ideas. Without these participants, I would never have the chance to reflect my own thoughts on early science learning. I thank all the eight families from the bottom of my heart. This dissertation might not be a perfect one in many ways; yet, I will always remember what they have told me.

My wholehearted thanks go to Yen-Chen Chang and Yu-Ching Lai for their generous help. Without their kind support, it is impossible for me to access these wonderful participants.

I owe my most sincere thanks to my two mentors, Dr. Sylvia Miao-Hui Lin and Dr. Sheng-Hsi Lin, who also graduated from UT C&I. No proper words can express my heartfelt gratitude for them. They have supported me since I was in college; additionally, they motivated me to pursue this degree and always kindly provided me with any assistance I needed. They always stand by me and tell me how great I am. They provided me with lots of support at the initial stage of my dissertation. Their insights assisted me in seeing what I could do to develop and polish my project. They are FOREVER my role models in academia and life. Their insights, diligence, generosity, and passion deeply influence how I view early childhood education, life, and myself. If this dissertation is an important accomplishment in my scholarly career, I definitely owe this to them.

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I am truly sorry for those who have helped me in this process but I lost your names here. I sincerely thank you for all your support and love.

I owe my heartfelt thanks to Dr. Reifel. Although he has retired, he inspired and supported me in many ways. I learned a lot from his play class. I will remember his smile and his passion for children's play. I also want to thank my writing tutor Dr. Kevin Bourque. I always called him my Muse because he inspired me a lot and he really showed me what good English writing should look like. His kindness and humor always gave me lots of joy when we discussed my work together.

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I am very proud and confident in saying that I have the best committee EVER in the history of College of Education. Each committee member is incredibly supportive, warm, nice, and intelligent. They led me to see the strengths of this dissertation as well as pointed out the weaknesses in a kind way. With their inputs, I was given the chance to make this work a better one. I was so lucky to have these wonderful teachers on my committee. Thank you, Dr. Adair, Dr. Barufaldi, Dr. Brown, Dr. Marshall, and Dr. Schallert! You are the BEST in the universe!

I especially want to thank my supervisor Dr. Christopher Brown. I might be the luckiest student in this world because I have two amazing scholars as my advisors. Dr. Lin and Dr. Brown both are a model for me of how a great researcher looks like. They both show me the values and significances of hard work and honesty. I am so glad that I am their student.

Dr. Brown might not know how great he is as a supervisor. Honestly, I am not a typical Taiwanese student. I always had too many ideas; I changed my mind frequently and had arguments with him all the time. However, he showed great tolerance and patience in guiding me to finish this work. Frankly, I do not know if I could act in the same way if I had to supervise such a student. ☺ During my four years at UT, he taught me a lot. One thing that is very important is that he taught me to be responsible for any decisions I made. Every time I complained to him that I was very tired and stressful, he always asked me to stop and remember, “That’s your choice.”

Dr. Brown is definitely not the type of advisor who regularly praises his students. However, I know that he actually saw how much I devoted to my dissertation and other work. When I was struggling with my dissertation, he asked me to remember, “Persistence pays off” and encouraged me to keep moving. He always wants his students to succeed, so he tries his best to push us towards this goal. One of my favorite quotes of his is “I'm glad I can make your life miserable (Brown, 2011, per. comm.).” Because of his pushing, I can accomplish all the goals I set up for myself and sit here writing this acknowledgment. I really thank him for what he did for me in this journey and sincerely, he is an incredibly wonderful advisor.

I want to give Dr. Schallert my special thanks for her respect for international students. Respecting others' cultures is frequently mentioned in different classes; yet, only very few people show true respect. She is definitely one of them. Because of this cultural awareness, she carefully takes international students' needs into account in her classes. I learned the most important lesson in the past four years from such an action. She is one of the most significant people in my graduate school life in the United States. I will try my best to follow her considerate behaviors in the future when interacting with students from various backgrounds.

Finally, I want to say thank you to myself. I have committed so much time, energy, and passion to my dissertation, and I am so proud of this work. I thank myself for being this brave so I can get through the whole process eventually. Making a decision of going to graduate school might not be very difficult, but taking the responsibility for this decision is much harder. The struggles, frustrations, and discrimination I encountered could easily consume all my strengths. I am so glad that my fondness in early childhood education and my beliefs in myself became the strongest support. Thank you, Yi-Chin; you're such a fearless woman!

Thank you, my beloved ones. I will carry your love and encouragement with me to move forward. ☺

# Varying Actions and Beliefs among Parents about Their Children's Science Learning when Visiting a Science Museum

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The University of Texas at Austin, 2013

Supervisor: Christopher P. Brown

Before entering school, children begin their science learning with their parents at home. This study proposes that parents' beliefs and actions regarding science shape their children's knowledge and skills that they then bring to school. Studying parents' beliefs about and practices with their children within the topic area of science provided insight into their influence in helping their children make sense of the world. Therefore, the purpose of this study aimed to investigate parents' beliefs about children's science learning and their actions in facilitating their children's science learning when they visited a science museum from socio-cultural perspectives. To investigate this, a qualitative case study examining nine Taiwanese parents of kindergarteners was conducted.

The study was conducted in two parts. Data sources included field notes, parent interviews, and documents such as pictures of the equipment these parents bought for their children. First, through interviews with parents, their beliefs about their children's science learning were identified and examined. Four parts including parents' gendered science beliefs, parents' perceived importance of science learning, parents' beliefs about how science learning should proceed, and parents' beliefs about their engagement in science learning were found. Part two of the study examined how these nine parents' beliefs guided them in making decisions when they interacted with their children in a science museum through observations and follow-up interviews. In most cases, parents' beliefs appeared to be important resources for helping them find a proper way to interact with their children. Three issues including the person who took the lead at the family visits, the quantity of parents' intervention, and the scaffolding strategies these parents employed were found in their interactions with their children. Parents were aware of why they behaved in particular ways: because of their beliefs.

Based on the findings, the researcher suggested that parents' beliefs were an important mechanism for influencing children's science learning. A seemingly simple behavior, such as letting children explore one object longer than others, might reflect what was recognized as important in their beliefs. Lastly, the implications for early childhood educators, parents of young children, and future research were provided.

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# Chapter 1 Introduction

## Statement of problem

As we think, so do we act. (Lincoln & Guba, 1985, p. 15)

The regional and international focus on science education (e.g., the Project 2061 and the promotion of Science, Technology, Engineering, and Mathematics education, STEM in the U.S.; the Programme for International Student Assessment, PISA and the Trends in International Mathematics and Science Study, TIMSS) not only highlights the importance of science learning, but it also leads science educators to investigate one core question: In what way can educators prepare students to learn science well? In responding to such an inquiry, many (Samarapungavan, Mantzicopoulos, & Patrick, 2008; Seefeldt, Galper, & Jones, 2011; Silverton, 1993) have proposed that science learning needs to begin at an early age because longitudinal studies have provided abundant evidence that children's science learning at this stage influences their later science achievement (Sackes, Trundle, Bell, & O'Connell, 2011). Additionally, early educators need to know how young children's pre-existing experiences shape the ways they learn science in classrooms (Michaels, Shouse, & Schweingruber, 2007).

Before entering school, young children begin their science exploration and learning with their parents at home. Children's interactions with their parents regarding science, particularly parents' roles in these interactions (e.g., Crowley & Callanan, 1998; Gleason & Schauble, 2000; Graika, 1981; Palmquist & Crowley, 2007), interest researchers seeking evidence to support children's science learning. However, parents' perspectives, namely, their beliefs about their children's learning as well as why they should participate in their children's learning, are seldom examined in these efforts[1].

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[1] Barton, Hindin, Contento, Trudeau, Yang, Hagiwara, & Koch (2001) and Swartz & Crowley (2004) are two exceptions.

Nevertheless, parents' beliefs and their actions shape their children's knowledge and skills that they then bring to schools. Also, if parents believe that science is important and want their children to learn science, parents will encourage this "through the selection of toys, visits to museums, subscriptions to science magazines, and talk about topics and problems that involve science" (Miller, 1987, p. 177). All told, parents exert a marked influence on children's learning, and an influence which–thus far–has gone relatively unexplored.

Given the great impact parents have on their children, parents' beliefs toward science learning should be a significant concern. A lack of understanding of parents' science learning beliefs limits educators' abilities to understand as well as to assess the most adequate ways to help their students and their students' families. Thus, this study addressed this gap in the literature by examining parents' beliefs about their children's science learning in Taiwan. Studying parents' beliefs about and practices with their children within the topic area of science may provide insight into their influence in helping their children make sense of the world.

My approach was to interview parents about their beliefs about science and then to examine how they put these beliefs into action by observing their interactions with their children as they explored a science museum together. I chose to study such interactions at a science museum because most research examining parents' beliefs and interactions with their children take place in the context of the home (e.g., Cannon & Ginsburg, 2008; Drummond & Stipek, 2004; Lynch, Anderson, Anderson, & Shapiro, 2006) and school (e.g., Lin, 2008; Liou, 2006). Rarely are they studied outside these two settings—such as in aquariums or museums. Muller and Kerbow (1993) suggested that parental involvement should be studied in contexts other than the home, such as the community, schools, and other settings, because these settings have different contextual influences on parental involvement and different implications would be made depending upon the contexts. I argue this is also true when examining parental beliefs. Thus, I chose a science museum because visiting science museums is an important family activity (Dierking & Falk, 1994; Falk & Dierking, 1992) and offers the chance to study how parents activate their beliefs about their children's science learning. As Hou (2009) found in her research, families in museums actively construct their own context of knowledge according to their beliefs, motivations, and unique mental tools. Moreover, children extend what they gain from family visits to museums to their homes and schools (Ellenborgen, 2003; Hou, 2009; Lan, 2009). Thus, examining parents' beliefs about science-learning was expected to help early educators see a more holistic picture of young children's science learning, which can help them make better decisions when conducting science-related activities. As pointed out by Tran (2008), teachers have limited information about children's out-of-school experiences, and thus, struggle to integrate these experiences into their instructional practices. Examining parents' beliefs about their children's science learning and parents' participation in this kind of setting could enable early educators to assess the influences behind children's science learning and approach the emic view of children's families they serve (Moll & Greenberg, 1990). Such information could also encourage early educators to work with families so that they become "supportive, sensitive, and effective…science educators" (Ginsburg & Golbeck, 2004, p.198).

**Purpose of this study and research questions**

This study aimed to investigate Taiwanese parents' beliefs about children's science learning and their actions in facilitating their children's science learning when they visited a Taiwanese science museum. Parents' beliefs, although difficult to define conceptually, form the framework for decision-making and are the most reliable indicators of behavior (Lightfoot & Valsiner, 1992; Sheldon, 2002).

Its purpose was twofold. First, this study investigated parents' beliefs about their kindergarten-age children's science learning before turning to how they transferred such beliefs into action when visiting a science museum with their children.

Two questions guided this work:

1) How do parents perceive their children's science learning?
2) How are these beliefs reflected in their interactions with their children in science museum visits?

**Significance of this study**

While much research on parental rearing beliefs has been conducted, relatively little of this research has examined a) domain-specific beliefs, b) parents' beliefs through qualitative methods, and/or c) parental beliefs in settings other than their homes.

Therefore, I addressed these gaps in the current literature about how parents' beliefs could play a role in guiding their actions in helping their young children's science learning. In doing this, the significance of this research was four-fold.

First, the findings of this study amplified parents' voices regarding their beliefs about their children's science learning. Although studies of teachers' science teaching and learning beliefs have provided valuable insight into their practices in classrooms, the discussion of how parents think about and take action accordingly towards children's science learning is missing. Parents' beliefs about science are different from those of teachers (Barton et al., 2001). In fact, when comparing parents' and teachers' roles on the same field trip, parents and teachers viewed themselves as helping children's learning differently (Tunnicliffe, 2000). The findings of this study provided vital information on this issue.

Additionally, because this study focused on parents' science learning beliefs, the findings could give early educators and practitioners practical hints about how to encourage children's science learning through parents' positive support. Besides, although this study was conducted in Taiwan and only focused on a set of Taiwanese parents, the findings of this study could still provide some background understanding for those who work with families of similar cultural backgrounds in countries other than Taiwan. This study might stimulate teachers to conduct studies to know more about immigrant parents' perspectives on their children's science learning.

Third, instead of asking parents to fill out pre-determined questionnaires or surveys, this qualitative study used observation and interviews to examine parents' science learning beliefs. This enabled parents to have more space to talk about issues such as how their children learned science or why science learning was important to them.

Lastly, researchers have presented a considerable amount of evidence on parents' strategies in helping children comprehend the content/concepts of exhibitions in science museums (e.g., Ash, 2003; Crowley & Galco, 1999). Yet, little is known as to why parents adopt certain kinds of strategies and how and why they make decisions in the process of visiting science museums. Since parents have various beliefs and their actions or involvement may be guided by their beliefs (Lynch et al., 2006; Meagher, Arnold, Doctoroff, & Baker, 2008), examining this issue benefited the field of museum learning/education in terms of knowing how to utilize such beliefs to promote parents' related actions.

In all, this study provided early childhood educators with more knowledge about how parents think about early science learning as well as urged practitioners to take into account these parents' ideas and attitudes when promoting parents' involvement in children's school science learning.

## Positionality

Cousin (2010) has pointed out that "our knowledge of the world is always mediated and interpreted from a particular stance and an available language, and that we should own up to this in explicit ways" (p. 10). Thus, before diving into the literature review and the research design, I address my related experiences to show which stance I took as I conducted this study.

My interest in investigating parents' beliefs about their children's science learning comes from my own familial and science learning experiences. I was deeply influenced by my parents in almost every aspect of my life. In terms of this particular field, my parents do not have science-related backgrounds, and they did not explicitly show great interest in my younger brother's and my science learning. It now seems my parents did not believe in the importance of science and so I missed chances of accessing science. Yet, my parents in fact provided us with plenty of science experiences or activities. They just did not identify those specifically as "scientific experiences/activities." For example, we hiked up mountains on weekends and shared what we saw; my mother took us to parks or our school playground almost every day after we finished our homework. My mother generally kept a garden when we were around. In my family, we are immersed in and we enjoy science.

My science learning experiences reflect how I was educated in the Taiwanese context. In elementary school, I mainly learned science through experimentation or direct observation. Learning science was easy and enjoyable at this time. However, science became boring and difficult to understand after I entered junior high school. I was forced to memorize scientific terms, principles and facts that were far removed from my daily life. I learned science mainly through teachers' lectures all the way through my junior and senior high school days. As a result, my interests in school science quickly decreased because it became a “subject matter” instead of something appealing and engaging. My science knowledge was basically only used in standardized tests rather than applied to my real life. However, those positive experiences I had with my family protected me from giving up on accessing science. In other words, what my parents gave me cultivated my interests in science, even though my school science learning experiences were usually unpleasant and uninteresting. Hence, to schoolteachers, knowing what a child does with their family in his/her home and taking these into account when planning their curriculum will be critically important.

My experiences in my family and in school both shaped my perspectives on what I think early science learning should look like. First, science is a major part of children’s lives; they live within it. The shift from my elementary to my junior high school deeply influenced me towards advocating the importance of hands-on and first-hand experiences as well as meaningful, authentic, and not test-driven science learning-experiences. My personal experiences also make me a believer in and adherent of sociocultural theory; I believe that each member in a community contributes their knowledge and/or experiences to their learning. While adults are somewhat more capable individuals, they still construct learning together with children.

In addition, this belief, influenced by sociocultural theory, also makes me care about how young children’s scientific literacy is socially constructed through social interaction with their most intimate companions, their parents, in out-of-school settings. I find science museums to be excellent places for family visitors to learn based on their motivation, and believe that science museums offer families an opportunity to achieve the goal of socially constructed learning. This perception of science museums, and how learning is constructed, influenced how I read and interpret the research literature, the interview questions I asked participants, as well as where I planed to put my foci when interpreting the data.

### Summary

In sum, this study first examined parents' beliefs regarding the science learning of their kindergarten-age children, and then examined how parents put their beliefs into practice when they visited a science museum with their children. Vygotsky's (1978) socio-cultural theory framed this study and provided a foundation for investigating how these Taiwanese parents' science learning beliefs played a role in their actions and in their children's science learning. Using qualitative methods, this study could help to identify the complexity of parents' science learning beliefs. This study would provide qualitative insights that can be used to help early educators think more about how to appropriately incorporate parents' beliefs into their science teaching.

# Chapter 2 Literature Review

This literature review is composed of three parts. It begins with a description of parents' beliefs and behaviors, and the relation among these two and their children's learning/development. The review then develops ideas of children's science learning in terms of what and how they should learn as well as adults' roles in this kind of learning. Lastly, I propose the importance of out-of-school science learning as well as offer some notable points for discussing how science museums function in children's science learning at the end of this literature review.

## Parental beliefs, behaviors and children's learning/development

**Parental beliefs[2].** In what follows, I start with the discussion of characteristics of belief, which makes possible the attempt of defining "belief." I then present a definition of parents' beliefs by synthesizing various perspectives, following with the explanation for my choice of this construct by making a comparison between belief and other similar terms, which were often used in former studies.

***The features and definition of parents' beliefs.***

*Features*. Belief is a complex yet interesting construct. Various characteristics of belief make it different from other constructs. Below I use Hirsjärvi and Perälä-Littunen (2001) and Pajares (1992) to discuss some important features of belief.

1. Beliefs are not static; they are changeable.

Since changes in parents' beliefs have rarely been addressed, here I use findings from research on teachers' beliefs to discuss this feature. Studies on teachers' beliefs about their science teaching revealed that although beliefs were hard to change (Etchberger & Shaw, 1992), beliefs were mutable. Hirsjärvi and Perälä-Littunen (2001)

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[2] In the literature review, terms such as cognition, attitudes, ideas, thoughts might be used interchangeably based on its original use in the cited articles.

used the term "attachment" to describe how one adheres to his/her beliefs. Some people's beliefs are much easier to change than others. For example, Etchberger and Shaw (1992) found that it was difficult to change the beliefs of teachers who strongly adhere to their beliefs. Additionally, Brickhouse (1989) and Lee (1993) have supported the notion that beliefs "reside in episodic memory with material drawn from experience or cultural sources of knowledge transmission" (Pajares, 1992, p. 310)—finding that seasoned teachers' teaching beliefs were strengthened by their teaching experiences and therefore limited the possibilities of change in their teaching beliefs. These findings may also illuminate Goodnow and Collin's (1990) claim that even when people were presented with a great deal of rational evidence, they might still resist changing their beliefs.

In terms of how beliefs changed, in line with constructivist ideas, Etchberger and Shaw (1992) and Guskey (1985) proposed that changes in beliefs could be achieved by making individuals feel unsatisfied with their original beliefs, offering individuals' new ideas positive feedback, or helping individuals reflect on their beliefs. These all helped bring about changes in beliefs. Other researchers such as Olson (1981) and Peterman (1991) found that when facing changes in curricula, it was not easy for teachers to change their existing beliefs. However, if positive feedback was given, teachers' willingness to change their beliefs increased (Guskey, 1985; Peterman, 1991; Taylor, 1990). Additionally, changes in beliefs might then contribute to changes in behaviors (Krietler & Krietler, 1976; Rokeach, 1985). For example, Peterman (1991) found that the teacher in his case study not only changed her science teaching beliefs; this teacher also changed her practices according to those changes in her beliefs. Peterman (1991) also found that changes between this teacher's beliefs and practices were interactional with each other rather than causal. While teachers commonly resist change, under certain conditions and with certain kinds of feedback or encouragement, change is possible over time.

While there is almost no information about changes in parents' beliefs, some studies such as Scarr (1996) pointed out that parents' beliefs and children's behaviors are reciprocal. Thus, it is reasonable to suspect that children's actions or reactions to their parents' beliefs might cause changes in parents' beliefs, just as changes proved possible in the beliefs of teachers.

2. Beliefs involve affective and evaluative components.

Parental beliefs involve affective and evaluative components (Hirsjärvi & Perälä-Littunen, 2001). To be specific, parents' prior experiences of learning science, their preferences and/or emotions and feelings towards this subject matter can determine how they perceive science and to what extent they might get involved in their children's science learning (Barton et al., 2001). Evaluative components refer to parents' beliefs regarding the way children should learn, what they should learn, and so forth. One parent might believe science is interesting while another parent might believe science is difficult and frustrating. One parent might believe learning science though lectures is right while another parent might believe lectures are a wrong way for children to learn science. These differences in parents' beliefs might in turn affect how and what children learn of the subject matter. Since beliefs are a personal construct, one's feelings, affections, emotions, and judgments are not separable from them.

3. Beliefs are quite personal.

As proposed by Hirsjärvi and Perälä-Littunen (2001) and Sigel (1985), one's beliefs might or might not be based on knowledge, and may be true or not; as Pajares (1992) explained, "people believe them because, like Mount Everest, they are there" (p. 309). Beliefs contain existential assumptions (Hirsjärvi & Perälä-Littunen, 2001), beliefs in aliens, a god, or ghosts being some examples. Parents may have similar assumptions in their beliefs about their children. For example, they may believe their children are smart, timid, or lazy, et cetera. In terms of the existential assumptions in parents' beliefs about their children's science learning, parents might believe that their children do not perform well in science or are very suitable for being scientists, and so forth. Since these existential assumptions are a part of parents' beliefs and might not necessarily be rooted in reasonable evidence, a deeper understanding of these assumptions in parents' science learning beliefs is needed.

4. Beliefs can be held with varying degrees of awareness.

This feature is pointed out in Hirsjärvi and Perälä-Littunen (2001). People have a variety of beliefs about different aspects of their lives. Some of their beliefs are more explicit than others, and can be clearly expressed in words such as "I believe," as well as examined at some particular point or towards some task. In contrast, some beliefs are so implicit that they might operate at an unconscious level. Parents might be aware of and could easily express some parts of their science learning beliefs such as "I believe science learning is all about doing experiments." Yet, different methods might be needed to elicit other parts of parents' science learning beliefs.

*Exactly what are parents' beliefs?* It will not be possible for researchers to come to grips with teachers' beliefs about teaching and/or learning, however, without first deciding what they understand beliefs to mean and how this meaning will differ from that of similar constructs (Pajares, 1992, p. 308). This also holds true with attempting to understand parents' beliefs about their children's science learning. While this need has been recognized, to clearly define what parents' beliefs are is not easy. As Sigel and Kim (1996) directly highlighted:

> Over the years, researchers in this field have not offered precise definitions to allow for valid and reliable assessment. Rather, the term "belief" is often just stated, with the assumption that the term is consensual for all English speakers. Therefore, the meaning is shared. Thus, for most writers, developmental psychologists use the term "belief" interchangeably with the terms "opinions", "attitudes", and the like. ……

> The loose usage is more typical and it makes it difficult to devise consensual measures because the criteria for labeling a statement a "belief" are unclear. (p. 84)

This quotation supports Thompson's (1992) argument that most researchers have assumed that readers know what "beliefs" mean. While investigating beliefs has been a core topic in research among various fields (Hirsjärvi & Perälä-Littunen, 2001), this ambiguity has resulted in a variety of meanings (Pajares, 1992). Hence, the researchers' assumption that readers understand what they refer to when they use the word "beliefs" is misguided.

Sigel and Kim's (1996) statement also pointed out the vagueness of the existing definitions of "beliefs" and the difficulties that accompany these ambiguous definitions. Similarly, Sigel, McGillicuddy-DeLisi and Goodnow (1992) and Hirsjärvi and Perälä-Littunen (2001) stated that no one unified word was used by all the writers to identify parents' thoughts about their children. Terms such as attitudes (e.g., Holden, 1995; Schaefer & Edgerton, 1985), ideas, opinions and thoughts (e.g., Goodnow, 1988; Goodnow & Collins, 1990), expectations (e.g., Chen, 2001; Liou, 2006) and other concepts including cognitions (e.g., Bornstein & Cote, 2004; Sigel & McGillicuddy-DeLisi, 1995) and perception (e.g., Anton & Dindia, 1984; Gorelick & Sandhu, 1967) were chosen by different authors/researchers. The meanings of these different terms overlap to some degree; for example, attitudes and values might both include a cognitive component (McGillicuddy-DeLisi & Sigel, 1995). The messy usage of various similar terms, on the other hand, may indicate that researchers' different choices in investigating parents' beliefs were in fact showing the different layers of parental beliefs and their different foci, concerns and interests in this topic.

While belief is a complicated construct and no one unified definition has been used in the literature to date, this study intentionally chooses this construct. As synthesized by Hirsjärvi and Perälä-Littunen (2001), beliefs involve both cognitive and affective components; two often-used terms, namely, attitudes and perception, can only cover either affective or cognitive components. Hence, belief differs from those similar terms such as attitudes, cognition, perception, etc. Further, McGillicuddy-DeLisi and Sigel (1995) proposed one distinct characteristic of belief: "it consists of knowledge or ideas that are accepted as 'true'" (p. 334). Being seen as "facts" or "truth" makes belief a differential construct.

While clearly defining "belief" is not easy, according to Triandis's (1975) "three-component-model,"

> This model distinguishes between the components cognition, affection, and conation. While the cognitive component contains knowledge and concepts of the belief object, the affective component refers to the emotional relationship a person has to a belief object. Finally, conation means behavioral intentions and tendencies. These components mutually influence each other. They mostly are consistent, stable and lasting. Existing or arising inconsistencies among the three components influence the stability of the attitude structure and, thus, it gets open for change. (cited in Albersmann & Rolka, 2012, p. 3)

Yet, contextual meanings are not explicit in this definition. Thus, I add one layer to this definition: that parents' beliefs are a complex of parents' attitudes, values, judgments, knowledge, and so forth, concerning different aspects of a child (e.g., learning, development, behaviors, etc.), primarily according to their culture and personal and social characteristics. Parents' beliefs are not only the cognitive basis for parents' rearing behaviors, but they also influence children's future development (Lightfoot & Valsiner, 1992; Sigel, 1985). Parents' beliefs are not fixed or immutable; they are dynamic and might adjust in response to time, context or situation. Operationally, parents' beliefs are a dynamic construct that contain values, knowledge and other personal constructs that influenced by their culture and social positions. These beliefs serve as a foundation for parents to take actions and make decisions regarding their child's development, learning, and other important aspects.

***Individual characteristics and parents' beliefs.*** Since beliefs are a deeply personal construct, it is necessary to discuss the individual characteristics that influence parental beliefs. Characteristics including a parent's age (Liou, 2001), rearing experiences (Holden, 1988), socioeconomic status (Liou, 2001; McGillicuddy-DeLisi, 1982b), gender (Miller, 1988), educational level (Acock, Barker, & Bengtson, 1982; Goodnow, 1988; Kao, 1993; Liou, 2001; Tenenbaum & Callanan, 2008), and culture (Goodnow, Cashmore, Cotton, & Knight, 1984; Goodnow, 1988; McGillicuddy-DeLisi & Subramanian, 1996) are those more frequently discussed in research on parenting.

Previous studies usually compared two different groups within one culture to discuss how these characteristics shape parents' beliefs. Below I use some studies conducted in Taiwan as examples. One characteristic that has merited study is educational level; for example, both Cheng (2000) and Kao (1993) indicated that parents with different educational levels had different cognitions of their involvement. Kao (1993) found highly educated parents (i.e., parents who had Masters or PhD degrees) usually tended to believe that children did not necessarily have to obey them, while less educated parents (i.e., parents who only attended junior high schools and lower) thought it was improper for them to praise children too frequently or be too close to their children. Similar to Kao (1993), Liou (2001) found that highly educated parents tend to think that their children should play an active role in their own learning. These findings showed that parents coming from different groups (e.g., highly educated parents versus less educated parents) may have alternate beliefs about their involvement or children's learning/development.

Among these characteristics, parental age and gender are the two most interesting factors in terms of the purpose of this present study. Liou (2001) noted that every generation faced different trends in thoughts and ideas; hence parents who were born in different eras may hold different rearing beliefs. Since this present study aims at investigating the beliefs of parents of kindergarten-age children, whose ages usually fall into the range between thirty and early forties, the question of whether this generation reflects specific rearing and/or learning beliefs (Liou, 1999) is therefore worthy of more attention.

In terms of gender, Tenenbaum and Leaper (2003) found that mothers' beliefs tended to relate more to children's self-efficacy and interest in science. In their findings of the relations between parents' beliefs and children's self-concepts, they reported that the more difficult mothers believed science was for their children, the lower their children's interest and self-efficacy in science. But if mothers believed their children were more interested in science, their children showed higher interest and self-efficacy. However, as regards fathers, Tenenbaum and Leaper (2003) only found a negative correlation: the more difficult that fathers believed that science was for their children, the lower the children's self-efficacy. Tenenbaum and Leaper's explanations for differences in mothers' and fathers' contributions to children's self-concepts were: 1) mothers were more aware of their children's self-efficacy and based their understanding on children's actual self-efficacy, and 2) mothers might be more influential in children's construction of their self-efficacy than fathers. For the purposes of the present study, which will try to incorporate mothers and fathers, Tenenbaum and Leaper's (2003) work shows that researchers should pay attention to the influence of both mothers' and fathers' beliefs.

On the other hand, when explaining the results, Tenenbaum and Leaper also noticed that only very few mothers in their study worked full time while almost all fathers worked full time. They argued that the difference in working hours gave mothers and fathers different quantities of time in interacting with their children, and therefore, that mothers might have a more influential role in socializing their children's self-efficacy. Tenenbaum and Leaper's observation may indicate that other studies have misinterpreted external factors, such as working hours, as gendered ones. Chung (2009), for example, showed because of recent changes in Taiwanese societal values, family structures, and number of children, gender and educational level are no longer statistically significant barometers of parents' influence. External contextual influences such as societal values might have shape parents' beliefs regardless of their personal backgrounds. Although these two studies are not representative cases, when speaking of mothers' and fathers' beliefs, researchers might need to be more cautious based on this consideration.

Socioeconomic status is the characteristic that researchers were usually interested in when comparing parents' beliefs, involvement, and/or other interactions with their children (e.g., Davis-Kean, 2005; Johnson & Martin, 1985; Luster, Rhoades & Hass, 1989). This characteristic highlights Bourdieu's (1977, 1984) two constructs—habitus and taste—and how parents' beliefs are influenced by these two ideas. According to Bourdieu (1977), habitus is an accumulation of past life experiences, and is acquired and socially constructed rather than congenital. Habitus affects people's interests, motivations, and so forth and in turn affects people's perspectives and their views of the world they are situated in. Hence, Bourdieu (1977) pointed out that habitus is the foundation of people's perception, evaluation, appreciation and action; it is the resource and motivation guiding people's actions. In Bourdieu's ideas, habitus is the schema of cognition; its function is serving as the fundamental model for cognition, understanding and action. People with different socioeconomic statuses likewise differ in habitus (Bourdieu, 1984), and people then form different tastes (Bourdieu, 1984) based on their habitus. Applying these ideas to parents' beliefs about their children's science learning, parents from different socioeconomic classes might treat science learning in distinct ways. Parents of different socioeconomic statuses might also have different beliefs about the resources (e.g., science museums, encyclopedia, extracurricular science programs, etc.) which support children's science learning.

Parents' individual characteristics and their beliefs were discussed in a general manner in the above paragraphs, but what might influence parents' beliefs specifically about science learning? Current discourse on parents' beliefs points out that parents' prior experiences of learning science and their preferences and/or emotions towards this subject matter determines how they perceive science and to what extent parents get involved in their children's science learning (Barton et al., 2001). Similarly, in a study (i.e., Hou & Juang, 2006) conducted in one Taiwanese science museum, the researchers found that parents' science learning beliefs were influenced by their childhood experiences, their own habits of learning, and their religions. However, different from Barton et al., (2001), Hou and Juang (2006) found that parents try to construct the ideal way to teach their children science based on their own science learning experiences. If parents learned science in a negative way, namely focusing on standardized tests and memorization, they would now expect that their children should learn science in hands-on and explorative ways.

***The lack of fathers' beliefs and their behaviors.*** As stated earlier, gender is one influential characteristic in shaping parents' ideas and influence (Miller, 1988). Some research pointed out that mothers and fathers think differently about their children's learning, development, play, and other important issues (Mansbach & Greenbaum, 1999; Miller, 1988; Ragg & Rackliff, 1998; Sagi, Lamb, Shoham, Dvir, & Lewkowicz, 1985). For instance, in Hu and Tsang's (2008) study of one hundred Taiwanese parents' perceptions of parent-child interactions, they found that the willingness and participation of fathers were lower than that of mothers. Such a result was due to fathers' beliefs that mothers were the main caretakers; hence fathers did not think they had to participate. Still, these studies did not specifically compare mothers' and fathers' beliefs, and rather only described mothers' and fathers' ideas in a very general way.

In their review of parental beliefs, Hirsjärvi and Perälä-Littunen (2001) found when speaking of parents' beliefs or other similar constructs (e.g., ideas, expectations), the majority of attention was devoted to mothers (e.g., Bleeker & Jacobs, 2004; Korat & Levin, 2001; Park & Cheah, 2005), not fathers. Hirsjärvi and Perälä-Littunen (2001) only found one example in which the subjects were all fathers (i.e., Raina, Kumar, & Raina, 1980). The research is even more limited when specifically focusing on fathers' beliefs about science learning. Even though many studies on parental beliefs have been conducted, the limited quantity of literature reveals that there is a lack of investigation about fathers' beliefs. The importance of fathers in children's development and learning appears to be underestimated in current research. More investigation of fathers' beliefs about children's learning needs to be conducted to know fathers' perspectives on different aspects of their children. Such research could provide insight into how similar and different are mothers' and fathers' beliefs about their children's science learning and involvement. More empirical evidence of how fatherhood affects fathers' beliefs about children's science learning is especially needed.

Until now, the characteristics of parents were discussed to show what might influence their beliefs. As a final note, however, the relations between parents' beliefs and characteristics of children themselves are reciprocal (Scarr, 1996). In other words, parents' beliefs about a specific topic might depend on children's characteristics such as their age, gender, ability, and so on. Children's actions and/or behaviors might also shape or even change parents' beliefs about how and what children should learn. In some studies examining the interaction between young children (3-6 years old) and their parents in science museums, researchers found that parents' question-asking and explaining may depend on their perceptions of their children's skills and interests (Crowley, Callanan, Tenenbaum, & Allen, 2001; Palmquist & Crowley, 2007). In some studies particularly focused on gender, researchers have found that gender biases in parents' perceptions of children's competencies influence their children's self-perceptions of abilities and interest in many academic domains, including math and science (e.g., Andre, Wigham, Hendrickson, & Chambers, 1999, Eccles et al., 1983). Researchers have also found that parents were more likely to believe that science was less difficult and more interesting for their sons than their daughters (Tenenbaum & Leaper, 2003). Similarly, Andre, Whigham, Hendrickson, and Chambers (1999) found even at Grades K–3, parents perceived boys as more able in science than they did girls. They also found science was considered to be more important for boys than girls in both age groups (i.e., Grade K-3 and 4-6). As a result, frequently, parents explained more often to boys than to girls (Crowley et al., 2001). The specific characteristics of children, then, are easily as influential as those of parents, and should attract the same level of scholarly attention.

**Parental beliefs, behaviors, and their children's learning/development.** As Mills (1988) pointed out, researchers studied parents' beliefs largely focusing on two aspects: 1) the relations between parents' beliefs and their behaviors (e.g., Lynch et al., 2006; Meagher et al., 2008) and 2) parents' beliefs about their children's development or learning (e.g., Cannon et al., 2008; Miller, 1986). Since the present study aims to examine parents' science learning beliefs and how they reflect these beliefs on their actions when visiting a science museum with their children, below I discuss these two dimensions in particular to provide a background context of why discussing parents' science learning beliefs and their actions are necessary.

As McGillicuddy-DeLisi and Sigel (1995) pointed out, psychological investigations of parental beliefs have largely been derived from assumptions that implicit and explicit beliefs guide parental actions with children (p. 333). This assumption has been proven and the relation between parents' beliefs and their behaviors has been established by many researchers (e.g., Lynch et al., 2006; Meagher et al, 2008). Since there is a relation between parents' beliefs and their behaviors, one could likely infer parents' actions in a specific situation from their beliefs. However, an inconsistency between these two was also found in some studies. In their research on parental attitudes, behaviors and children's play, van der Poel, de Bruyn & Rost (1991) found that parents' attitudes towards play was not always accordant with their support in children's play. Despite inconsistencies identified by the research, parents' beliefs can reasonably be expected to influence their behaviors.

In terms of parental beliefs about their children's learning/development, researchers not only wanted to know parents' ideas about a specific domain of children's learning and/or development, they were more interested in how these parental beliefs in turn influence their children's learning/development (Jacobs, 1991). Research has provided profound evidence of how parental beliefs influence children's cognitive or socio-emotional development (e.g., McGillicuddy-DeLisi, 1982a; Mills & Rubin, 1990; Rubin, Mills, & Rose-Krasnor, 1989) and academic learning (e.g., Cooper, Lindsay, & Nye, 2000; Drummond & Stipek, 2004). While there is a growing body of literature on the general effects of parents' beliefs and participation (both at school and out-of-school), there are very few empirical studies which focus on the effects of parents' beliefs on children's science learning. In one instance, Tenenbaum and Leaper (2003) found that parents' beliefs significantly predicted children's interest and self-efficacy in science; in turn, this self-efficacy in science can influence the children's subsequent academic and career choices. The lack in current literature and the significance of parents' beliefs in children's science learning and later achievement supports the necessity of discussing this issue, which will be discussed in more detail in the subsequent section.

**Why does discussing parents' beliefs and behaviors in children' science learning matter?.** In a few studies (e.g., Barton et al., 2001), parents' beliefs and the actions they took regarding science were found not only to determine how frequently children could access science in the contexts out of school (Barton et al., 2001) but may also in turn shape the knowledge and skills that children bring to schools. That is, these beliefs influence their children's science learning inside and outside schools. In museum visits, for example, parents' beliefs concerning science learning could serve as a filter that selects experiences they think appropriate and/or meaningful for their children. When families visit a science museum, each family will not choose the same route as others do in their science museum visits, and what children learned from the visits will therefore be different.

On the other hand, while parents' active participation and support in their children's learning is expected, as Haden (2010) noted, parents' willingness of playing roles as scaffolders might be determined by their knowledge as well as their beliefs about their role in mediating learning. Some parents, who think science experiences "have to be formal and difficult for learning to occur" (Brewer, 1998, p. 344), might be afraid of doing science with their children or may identify children's science learning as the teachers' responsibility. Parents who hold such beliefs might not actively play roles as scaffolders in their children's science learning. Some key moments in learning science might be missed as a result.

Since one's ideas of the nature of science influence how s/he approaches their work (Devereux, 2007), Keyser (2007) encouraged early childhood practitioners to look for good ideas behind parents' requests or demands that may initially seem strange or inappropriate. Parents' beliefs are shaped by various personal and/or social factors such as those discussed earlier, for example, religion (Juang & Hou, 2009). Thus parents' beliefs about science learning might not fit *a priori* into teachers' expectations. However, as Daniel (2009) asserted, "If different values, attitudes, and behaviors are automatically considered wrong, it will be impossible to form a collaborative partnership with the child's 'first teacher'" (p. 12). While knowing teachers' beliefs about science teaching and learning is important, examining parents' science-learning beliefs will help early educators to see a more holistic picture of young children's science learning as well as inform them to make better decisions when conducting science related activities.

Further, research based on socio-cultural theory pointed out that science is rooted in the cultural context; science education is relevant to the cultural values of that particular group (Nersessian, 2005). Thus, science is a human endeavor as well as a social activity (the American Association for the Advancement of Science [AAAS], 1989; Brunkhorst, 1991); it cannot be separated from its contextual meanings. To be clear, by "cultural context," I do not narrowly refer to a geographical place; rather, I mean a group, such as a family, which shares the same values, language and beliefs (Hou & Juang, 2006; Hou, 2009).

The importance of cultural context is supported by Lemke's statement (2001) below, where the author points out the importance of studying parents' science learning beliefs in consideration of families' diverse backgrounds:

> . . . science education is increasingly a global enterprise, and even in one country, students today more and more often come from diverse cultural backgrounds. How welcoming is our received tradition of what science must be and how it must be taught of the beliefs and values of other, especially non-European cultures? Or even of non-middle-class subcultures? (p. 300)

Each family has its own learning culture (Ellenbogen, 2002, 2003). Each family or parent might hold different beliefs about issues of what science is or how their children should learn science. Children's science learning in classrooms might be an epitome of their familial cultures, which were often constituted by their parents' beliefs. Gaskins (2008) suggested that museums needed to recognize and value the ethnotheories[3] that visitors bring with them; so do schools, which serve diverse families. Early educators need to likewise be aware of this, and the science learning they provide in schools cannot favor only a certain type of learning style or values. In other words, children's familial cultures, which are shaped by parents' beliefs, need to be understood, valued, appreciated, and then taken into account in teachers' practices (Moll & Greenberg, 1990).

Gaskins (2008) proposed similar perspectives to Keyser (2007) and Daniel (2009). She pointed out that the significant benefit of studying parents' beliefs is that it "provides an opportunity for museum professionals to recognize more clearly their own beliefs about these issues," and therefore "helps museum professionals to identify more clearly the principles they wish to advance as they build informal learning environments for young children and their caregivers" (p. 11). This is also true for early educators who want to teach their children science more effectively and achieve the goals they set up for their science teaching.

Lastly, as noted by Bandura (1993), "Efficacy beliefs influence how people feel, think, motivate themselves and behave" (p. 118); "unless people believe that they can produce desired effects by their actions, they have little incentive to act" (Bandura, Barbaranelli, Caprara & Pastorelli, 1996, p. 1206). Parents' self-perceived competencies, which are affected by their efficacy beliefs, might decide their willingness in being involved in science with their children. Hence, parental support in science can not at all

[3] Ethnotheories is one of the historical roots of parents' beliefs (McGillicuddy-DeLisi & Sigel, 1995)

be taken for granted. Additionally, Bandura (1977; 1981) noted, self-efficacy is based on one's previous experiences and strongly influences behavior. As pointed out earlier, parents' own science learning experiences influence their beliefs. So does their fear of science or their awareness of insufficient knowledge (Barton et al., 2001). For example, in Solomon's (2003) survey research, she found for parents who had not enjoyed science, only 31% anticipated being able to help their children with science. However, 91% of those parents had themselves enjoyed science anticipated being able to help their children. Thus, if parents hold negative experiences or feelings towards science, then they might have less confidence in successfully doing science-related activities with their children. They might believe they will fail in learning science together with their children as well as feel more anxious about their ability (Bandura, 1977) in science.

In brief, values and beliefs are clearly related to the behavior and competence of adults, including their competence as educators of their children (Schaefer, 1991, p. 240). This especially establishes why discussing parents' science learning beliefs and their behaviors in children's science learning matter.

**Young children's science learning**

The main purpose of this study is to understand parents' beliefs about their children's science learning. Thus far, I have covered both the role of parents and the constructed nature of "belief." In this section, I turn my attention instead to children's science learning. I first discuss what science learning is and the current perspectives on how young children should learn science. I then bring up the importance of adults' roles in children's science learning to close this section.

**What is early science learning and what is important?.** While the importance of science learning in children's early years has been recognized (e.g., Sackes et al., 2011; Smith, 2001; Tu, 2006), very few studies, if any, clearly define what science learning is.

Before addressing the scope of children's science learning, it might be helpful to start with the discussion of what "science" is.

Researchers define science in various ways. Here the five most common definitions:

1. Science is a way of knowing/understanding of the world around us (AAAS, 1989; Brunkhorst, 1991; Devereux, 2007; Worth & Grollman, 2003).
2. Science is a process of inquiry (Chaillé & Britain, 1997; Jacobson & Bergman, 1991).
3. Science is the knowledge about phenomena (Abruscato, 1999; Kilmer & Hofman, 1995).
4. Science is an attitude exemplified by curiosity and interest in the world (Brewer, 2001; Brunkhorst, 1991).
5. Science is both a body of knowledge that represents current understanding of natural systems and the process whereby that body of knowledge has been established and is being continually extended, refined, and revised (Abruscato, 1999; Brunton & Thornton, 2010; Duschl, Schweingruber, & Shouse, 2007, p. 26; Coughlin, Hansen, Heller, Kaufmann, Stolberg, & Walsh, 1997).

While there are other perspectives on how science could be defined (visit the University of Georgia website at http://www.gly.uga.edu/railsback/1122sciencedefns.html, for a review), to conclude from these common definitions, science is about exploring and making sense of the world people live in. Science is a process as well as a product. People use science to satisfy their curiosity about things they do not understand and gain knowledge from the process.

On the other hand, some (e.g., Brewer, 2001; Brunkhorst, 1991; Kilmer & Hofman, 1995; Raper & Stringer, 1987) have defined what science is not: it is not learning facts, remembering scientific terms and memorizing formulas. Science is not equal to book learning (see Kilmer & Hofman, 1995, for a review). Science is not just a collection of facts (the U.S. Department of Education, 2005). Science is more than merely biology, physics and chemistry (Devereux, 2007). Science is not associated with certain materials or content (e.g., magnets, microscopes, etc.). To know what science is not is especially important because, as Chaillé & Britain (1997) argued, focusing on the surface manifestations of science can lead to inappropriate and non-constructivist science learning or teaching.

In accordance with the multiple definitions of science, children's science learning essentially includes attitudes, skills and content (Abruscato, 1999; Brunton & Thornton, 2010; Charlesworth & Lind 2009; Conezio & French, 2003; Riley & Savage, 1994). Davis and Howe (2003) categorized these instead as attitudinal knowledge, procedural knowledge, and conceptual knowledge. Among these three different categories, which is the most important? Or is each of them equally vital?

As Silverton (1993) noted, children's early years are "a critical time for capturing children's interest. If children are not encouraged to follow their curiosity about the natural world, then it may be too late" (p. 3). Conezio and French (2003) also identified children's curiosity as the beginning point of real science. While young children have a natural curiosity to explore the world around them (Ross, 2000), such curiosity needs to be nourished to maintain their positive attitudes towards science learning. While as stated, there are different viewpoints about how young children should learn science, in children's early years, cultivating children's positive attitudes towards science is generally believed the most crucial aspect when speaking of science learning. Additionally, as pointed out by Lind (2003), scientific facts change along with new findings (AAAS, 1989; Devereux, 2007). Thus, emphasizing memorizing scientific facts is meaningless for young children. Instead, children's positive attitudes towards science are more important and necessary because children can continue their exploration and willingness to know more about this world based on such attitudes, even after they leave schools (Abruscato, 1999; Brunkhorst, 1991).

Children's curiosity and willingness to try—their positive attitudes towards science—will lead them to use all kinds of science process skills to support their inquiries. When a child feels curious about something, for example, when s/he sees his/her rubber duck toy floating in the water when taking a bath, s/he might ask, "Why does the rubber duck float in the water?" S/he might continue to question whether other toys or objects will float or not. This curiosity then requires a child's science process skills, such as observation (what kind of materials will make the object float?), prediction (will soap float or not?), generalization (the rubber duck can float; so will my other rubber toys), analysis (is it because the rubber duck is very light, so it can float?), etc. When a child's curiosity initiates an inquiry, s/he then uses and practices various scientific skills. S/he might need to conduct an experiment such as putting different objects in the water to see the outcome; s/he might only observe to find the answer to his/her inquiry. While researchers separate attitudes and skills, as did Davis and Howe (2003), they are in fact interdependent with each other. Hence, Brunkhorst (1991) suggested assessment of children's science learning should "constantly look at what children are doing," and "value foremost children's attitudes and skills with thinking and applying their experiences to new questions" (p. 250).

While scientific knowledge should receive less attention in early science learning (Brunton & Thornton, 2010), it is not true that scientific concepts are unimportant to young children. Yet, science is more a verb than a noun (Brunkhorst, 1991), more about doing than knowing. Merely memorizing scientific words or facts without understanding what they mean is contrary to science itself (Brunkhorst, 1991). Children's understanding of scientific concepts emerges from their direct, first-hand experiences (Erden & Sönmez, 2011; Kilmer & Hofman, 1995). When a child is using science process skills, s/he is not simply mechanically going through motions; rather, they are starting to think scientifically and build up their own knowledge system like those in the example of the floating rubber duck.

**Perspectives on how young children should learn science.** A focus on different aspects (i.e., attitudes, skills, and knowledge) of young children's science learning determines scholars' perspectives on how young children should learn science. Nott and Wellington's (1993) five dimensions of the nature of science may provide some background information to explain the assumptions behind these perspectives. The five dimensions include 1) relativism versus positivism, 2) inductivism versus deductivism, 3) contextualism versus decontextualism, 4) process versus content, and 5) instrumentalism versus realism. Below I begin with constructivism, the main trend in the field of early science learning[4] (Seefeldt, Galper & Jones, 2011; Robbins, 2005), which views the nature of science as more relative, interdependent with cultural contexts. Science is more like a process, etc.

***Constructivism.*** Currently, constructivist ideas are broadly implemented in early science education. Vygotsky, Piaget, and Piaget's follower Kamii influenced many ideas about how children learn science (Cakir, 2008). Constructivism proposed that learning takes place through construction, either through individual construction (as Piaget would suggest) or through social interaction (as Vygotsky would suggest).

Despite criticisms of his theory, Piaget's four stages of cognitive development reminded educators of an important fact: that young children think differently compared

[4] See Solomon (1994) and Taber (2006) for an alternative view on Constructivism in science teaching and learning.

to older children and adults (Seefeldt, Galper & Jones, 2011; Sfard & Lavie, 2005). As Brooks (2010) noted, “It can be stated that unless the truth makes sense to the child, the child has no way to use that truth. …Inert truths are simply not valuable” (p. 18). This quote not only supports the notion that young children at a certain age (3-7 years old) view things differently but also underpins the constructivist idea that children construct their science learning and find meaningful “truths” through direct interactions with the environment, materials, and people around them.

Influenced by Montessori, Piaget asserted the importance of a supportive environment. When children interact with materials and environments, they will have chances to use their existing schemata to interpret the new information or refine their schemes (Cakir, 2008). Piaget also pointed out the importance of trial and error in children’s science learning. This fits the very heart of science that it is not merely for finding the correct answer. As Brooks (2010) noted, “If a child is not making mistakes, the child is likely not learning” (p. 33). Mistakes are viewed as chances for children to revisit, refine and reflect on their ideas, instead of as failures (Conezio & French, 2003). Through the process of trial and error, children can develop a higher level of their mental functions.

In contrast to the Piagetian idea that teachers play more passive roles in children’s science learning, the constructs of the Zones of Proximal Development [ZPD] and scaffolding proposed by Vygotsky posit that adults can and should actively maximize children’s learning. The crucial and active roles of adults will be discussed in more detail in a subsequent section.

In constructivists’ ideas, children’s previous experiences are important and should be valued (Cakir, 2008). Their science learning aims not only at gaining new information or knowledge; instead, their science learning builds upon what they already know. This perspective brings up the need to discuss the issue of children's misconceptions[5]. The aforementioned quotation from Brooks (2010) also supports this claim.

Michaels et al., (2007) proposed that four beliefs about young science learners needed to be challenged. One is that "Children's ideas about the natural world are primarily misconceptions that teachers should aim to identify and correct or replace with canonical science" (pp. 155-156). Indeed, in the past, the extreme view was that children's misconceptions needed to be corrected (Michaels et al., 2007). According to several early science researchers, however, children have their own theories and interpretation regarding how this world works (Michaels et al., 2007; the U.S. Department of Education, 2005). Children build their theories upon their limited experiences, theories which may be reasonable but incomplete or wrong (Michaels et al., 2007; Worth & Grollman, 2003). These ideas may not reflect the established theories, but children reveal a significant capacity to reason from their previous experience and knowledge. These "misconceptions" should be viewed as stepping-stones. Therefore, in assisting young children to learn science, it is important to provide them with more focused experiences to challenge their ideas and to help them to develop new and more complex theories about things and phenomena in the world around them (Worth & Grollman, 2003).

While constructivism (especially Piaget's ideas) has profoundly influenced early science learning and is broadly implemented in classrooms, it cannot be ignored that there are still some who believe that young children should learn science in a more traditional and positivist way. Parents, for example, might favor other methods than the constructivist approach. Hence, as Robbins (2005) reminded us, it may be helpful to

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[5] Some researchers (e.g., Sprod & Jones, 1997) used the term "alternative views". Recently, more and more researchers chose to use the term "naïve theory" instead of "misconception", for example, Stepans & Kuehn (1985) and so on.

consider methods other than those that are derived from Piagetian theory. This might be especially true when looking at parents' science learning beliefs.

***Doing science.*** "I hear and I forget. I see and I remember. I do and I understand." This motto, which is borrowed from the Boston Children's Museum, highlights the importance of the idea of "hands-on" and first-hand experience in children's science learning. When speaking of how to teach children learn science, Brunkhorst (1991) advocated that to learn science, children must do science (p. 245). The idea of "doing science" is broadly introduced and accepted in the field of early science learning.

Learning through hands-on or first-hand experiences is not new to the field of early childhood education. This idea was supported by Dewey (1938) and early childhood programs such as Waldorf (Nicol, 2006), Montessori (Issacs, 2006), and Reggio Emilia (Thornton & Brunton, 2009). Nevertheless, from the definitions of science in earlier sections one can see this idea is especially important to children's science learning because science is about exploring and making sense of this world. The National Research Council [NRC] (1996) stated, "learning science is something students do, not something that is done to them" (p. 20). Such a statement fits the core feature of science: the "how" of science is more important than the "what" of science. Learning science without hands-on experiences was just like learning swimming without going near the water (Shair, 1990). Without hands-on and first-hand experiences, children may find science abstract, boring and removed from their daily lives (Abruscato, 1999).

The idea of doing science is not only important for children but also offers adults a great chance to observe children and understand children's strength or needs (Conezio & French, 2003). If science is merely learned through lectures or books, adults may miss the best chance to promote children's science learning (Vygotsky, 1978).

While the importance of hands-on or first-hand experiences is repeatedly stated in literature, as Dewey (1938) stated, "All genuine education comes about through experience…but not all experiences are genuinely or equally educative" (p. 13). In line with Dewey's idea, Chaillé and Britain (1997) argued that the idea of learning science through hands-on activities may result in misunderstanding or over-simplification. The researchers argued that some teachers may misinterpret the role of hands-on science and think that touching or manipulating objects is enough to learn science. In their ideas, touching or manipulating objects is instead a means for children to generate further thinking. That is, hands-on is the springboard for minds-on (Pines, 1985), and the latter is much more important for young children to learn science. Similarly, Tu (2006) also noted that teachers needed to be aware that effectively utilizing science materials is more important than having science materials in classrooms. The "effectively utilizing" claim supports Chaillé and Britain's (1997) advancement of achieving minds-on through hands-on activities.

***Learning science though play.*** As a central way to "do science," play provides opportunities for many kinds of skills needed for learning in science, such as problem solving, abstract thinking, higher-order thinking, creativity, independent learning, research, exploration of complex issues and complex language (Dockett & Fleer, 2002, p. 210). Hence, Henniger (1987) argued that "[Play] enables children to learn key concepts and develop essential attitudes toward learning. Its value and importance to mathematics and science should not be overlooked" (p. 171).

Learning science through play begins at infancy (Lin, 1995). Infants are capable to use exploratory play to start their science learning. They use their hands, feet, or even mouth to "touch" any objects they can reach. Through interacting with objects, they will feel and experience the features of these objects, for instance, soft and hard, rough and smooth, and so on. They will then intentionally do something purposeful and experimental and gain joy over the outcomes of their actions. These intentional actions might include moving objects, pressing buttons, or dropping food when they eat in their high chairs. These are infants' and very young children's first steps in learning science through play, and they build up knowledge about causal relationships from their exploratory play.

Because of this close relationship between science learning and play, researchers frequently attempted to understand exactly how play can help children learn science. In a series of studies, Fleer and her colleagues further investigated the relation between children's science learning in play-based settings. This work especially focused on the role of play in children's concept formation (e.g., Cutter-Mackenzie, Edwards, & Fleer, 2009; Fleer & Ridgway, 2007; Fleer, 2009a, 2009b). Such scholars found that play enabled children to expand their everyday concepts, and that teachers can use play to help children to connect their everyday concepts with scientific concepts (Vygotsky, 1986).

Many curriculum frameworks and/or guidelines also clearly pointed out that young children should learn science through play. For example, the Foundations Phase Curriculum in Wales (DCELLS, 2008) noted, "Children learn through first-hand experiential activities with the serious business of 'play' providing the vehicle. Through their play, children practice and consolidate their learning, play with ideas, experiment, take risks, solve problems, and make decisions individually, and in small and large groups" (cited in Brunton & Thornton, 2010, p. 7). Similar ideas were also found in Scotland and England's curriculum frameworks (Brunton & Thornton, 2010).

While learning science through play is broadly accepted in early childhood education as well is promoted by the official curriculum frameworks as stated, parents, especially those who view science as a "subject matter" instead of a "part of their lives" or "something enjoyable," might not accept the perspective of learning science through play as a part of their beliefs.

Science and play share many commonalities: both are self-motivated, they allow children to explore, etc. This makes it hard to separate science from play; hence, children always have chances to learn science through play inside and outside the classrooms. Researchers such as Smith (2001) also pointed out that playgrounds are a great place for young children to approach science. When playing in playgrounds, children can test out their ideas with all kinds of natural materials such as water, sand, sticks, etc. These natural materials enable children to experience scientific concepts such as evaporation, dissolution, surface tension, and so on. Children also experience their science investigation by observing flowers, rocks, bugs and other natural creatures (Ramey-Rassert, 1997). Additionally, in their interactions with different facilities such as seesaws, swings or slides, children also acquire chances to learn science. For example, they might think up questions like "What makes a swing, swing?" "How can I use my body to push the swing higher?" or "How do we keep balance on the seesaw?" Questions like these emerge along with children's play in playgrounds, and in other words, science is naturally integrated into children's play in settings like playgrounds. Play, then, is not only one of the most immediate ways in which children learn; spaces devoted to play likewise promote science learning.

***Science learning is integrated into other areas.*** The term "science" is used in this literature review to separate science learning from other kinds of learning. It should be noted, though, that science learning in early years is difficult to separate from other curriculum subjects and areas (Abruscato, 1999; Conezio & French, 2003; Coughlin et al., 1997; Gordon & Browne, 2007; Harlan & Rivkin, 2000, NSTA, 1990), for they are inter-connected and integrated (Tu, 2006). This is not only important for those teachers who are afraid of teaching science, but also vital to parents who might hold beliefs that science is an isolated subject matter or is merely experiments, having nothing to do with other areas or their daily lives.

In the article "Start Science Sooner: Excellence in science education must begin in kindergarten," the anonymous authors pointed out teachers' worry that if more science needs to be taught, something important might be removed; many valuable things in the classroom compete for limited time. However, the authors of "Start Science Sooner" explain how nothing would be sacrificed to teach science in classrooms because – as with the Scientific Literacy Project developed by Purdue University – science can be seamlessly integrated with language. In the section about learning science through play, it is also clear to see how science can be integrated into children's play instead of being learned alone. These may alter adults' beliefs that science is an isolated discipline and increase their willingness and sensitivity of seizing chances for children to learn science.

Further, Moomaw and Hieronymus (1997) offered many ideas and activities to show early educators how they could easily integrate science into other learning areas such as art or music. In their ideas, science is "not relegated to an occasional experiment, activity, or field trip" (p. 1). Instead, every area in the classroom is full of potential for learning science. For instance, in the music area, children can pour water into two glasses and hear how each glass sounds when struck. They can also pour more water into the glass to see whether the sound becomes higher or lower. Therefore, they called this approach "whole science," which recognizes that science "cannot be separated from other areas of the curriculum or from children's everyday life experiences" (p.2).

Moomaw and Hieronymus (1997) and others' ideas (e.g., Coughlin et al., 1997; Gordon & Browne, 2007) strengthen one vital point underpinning why this learning should be integrated with other kinds of learning: science is everywhere (Questacon

Science Play program, n.d.; Yu, 2006) and is something children do naturally. Science learning is meaningful and authentic to children because they access and experience it all the time. In addition, this idea might also highlight the importance of Gardner's (1983) theory of multiple intelligences. When children learn "science," they use different intelligences such as logical-mathematical intelligence or intra-personal intelligence to support their science learning. Adults need to be aware of this interconnection between children's naturalist intelligence and other intelligences to integrate different content areas to strengthen science learning.

**The importance of adults in young children's science learning.** Vygotsky's (1978) construct of scaffolding establishes why it is necessary to address the importance of adults, either teachers, parents or others, in young children's science learning. In supporting children's science learning, adults might provide support in terms of knowledge, environment, and materials. Adults might also support children's science learning by asking questions to encourage children to express their ideas or reflect on their work or actions. The importance of adults also lies in reducing children's frustration when learning science (Eshach, Dor-Ziderman, & Arbel, 2011).

While children have a natural born curiosity to explore the world around them, adults are indispensible to help them to expand their science learning, since children do not always spontaneously discover things around them. The timely support of adults could compensate for these missed moments for further science learning. For example, Howell (1972) described the fascinating process of how a teacher and her three- and four-year-olds explored "spring" on the school playground. By asking key questions such as "Do you think the tree is alive?" (p. 98), the teacher in Howell's piece helped her young students to notice things they first ignored or more subtle changes. Concluding from this episode, Howell (1972) stated, "it is up to the teacher to create a climate of discovery" (p. 99).

The idea of "sciencing," introduced by Neuman (1972), reveals how adults could expand children's science learning in these science-related activities. Neuman (1972) divided sciencing into three different types, including formal sciencing, informal sciencing, and incidental sciencing. Adults assist children in these three types of science-related activity to different degrees. Adults either provide children pre-planned and structured science activities, magnify children's learning by giving them bountiful resources and time, or help expand children's spontaneously initiated science activities and/or discovery. While Neuman's (1972) "sciencing" emphasized children's active engagement and participation in all kinds of science activities, these active explorations could not be carried out without adults' explicit or implicit support.

In addition to offering children physical or intellectual support, adults are important as well in terms of cultivating children's positive feelings towards science. Talton and Simpson (1986) concluded, "[If] we are to truly develop positive attitudes toward science the home environment needs to play an important role" (p. 373). Parents support this science learning by the interactions they have with their children at home (Seefeldt & Galper, 2002). This science learning happens at any time and anywhere at home; for example, they learn science when "they wash a greasy dish, water a garden plot, ride their trike down a sloped surface, and so on" (Brewer, 1998, p. 344). Children may raise a dog with their parents and learn knowledge about dogs. Parents and children may cook together and discuss the changes in food. These daily life experiences are usually enjoyable and nourish children's positive attitudes towards science.

Adults' important roles in children's science learning were not only to be seen in school or home. Much research carried out in science museums has found parents indeed play a critical role in their family visits (e.g., Crowley, et al., 2001; Crowley & Jacobs, 2002; Melber, 2007). Among these studies, many of them compared the exploration process of children who were accompanied by parents to those who worked alone; or compared the outcomes of children who received more assistance from parents to those who received less. For instance, Crowley and Jacobs (2002) asked all the children involved in their research to identify each of the nine fossils that were shown in the educational session after their visits with their parents. They then found that both in the group of older (ages 7-12) children and the group of younger (ages 4-6) children, those who received more mediation from parents performed better identification than those who received less parental mediation. Crowley and his colleagues' research (2001) showed that for young children who engaged with their parents during their visit, their exploration was "longer, broader, and more focused on relevant comparisons" than that of children exploring the exhibit on their own.

**Science museums function in supporting children's science learning**

According to Ramey-Gassert, Walberg, and Walberg (1994), "Museum learning has many potential advantages: nurturing curiosity, improving motivation and attitudes, engaging the audience through participation and social interaction, and enrichment. By nurturing curiosity, the desire to learn can be enhanced" (p. 351). This statement of the benefits of museum learning well fits the characteristics and purposes of early science learning described earlier. In this section, the features of out-of-school learning are first presented to create a context for understanding science learning in science museums. I then specifically discuss how science museums support children's out-of-school science learning.

**Science learning in out-of-school settings.** ***Features of out-of-school learning.*** Three common terms (i.e., informal, non-formal, and free-choice learning[6]) are used to describe the learning that takes place in institutions such as science museums. For clarity and directness, I use the more general term "out-of-school" learning (Koran, Koran, Foster, & Dierking, 1988) to refer to any forms of science learning taking place outside schools.

Ellenbogen (2003) synthesized several studies (i.e., Crane, 1994; Greenfield & Lave, 1982; Resnick, 1987) to present the major characteristics of learning in out-of-school settings. These included contextualized reasoning, tool manipulation, reliance upon objects and exhibitions, learners as responsible for imparting knowledge and skill, voluntary participation, open-ended exploration and so forth (Ellenbogen, 2003, p. 20). It is clear to see that ideas such as contexts, authentic experiences and personal willingness are essential in out-of-school settings.

While exhibits are generally structured and sequenced, few visitors use the displays in this particular way (Falk & Dierking 1992). As Dierking & Falk (2003, p. 77) proposed, learning that takes place in out-of-school settings is guided by learners' needs and interests—the learning that people engage in throughout their lives to find out more about what is useful, compelling, or just plain interesting to them. The importance of personal interests and motivation makes the issue of choice and control in out-of-school settings more explicit. While the environments are structured by institution staff, individual learners and groups of learners determine for themselves how they interact with exhibits.

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[6] Eshach (2006) divided this kind of settings into informal and non-formal ones. Additionally, in the mid-1990s, the term "free-choice" began to be more widely used as an alternative to "informal" (Falk & Dierking, 1998).

Both choice and control make the idea of the "active learner" more clear. In other words, visitors do not passively accept what museum staffs or designers want to tell them any more; instead, they are more actively engaged in out-of-school settings. Thus, learning is a very individual process and museums provide good opportunities for people to learn independently and by choice (Griffin, 1998, p. 657). More specifically, museums incorporate a range of opportunities to accommodate a variety of learning styles and strategies.

***Does learning indeed happen in museums?.*** While many features of out-of-school learning were presented above, since family visitors' primary purpose for visiting, regardless of type of museum, is usually not for learning (Falk & Dierking, 1992), one might ask the question, does learning indeed happen in museums? In responding to this inquiry, what learning is in museums needs to be understood.

Museums are educational institutions (Ellenbogen, 2003); yet they are not the same as formal education environments like schools. Visitors' different foci in visiting museums as well as their learning and entertainment dual agenda (Falk & Dierking, 1992) also make the investigation and definition of their learning in museums more difficult. Thus, as Hein (1998) and Hooper-Greenhill (2007) stated, it is not easy to understand learning in museums. The heated debate of whether or not the museum experiences can be regarded as museum learning also brings up diverse opinions and ideas. Regardless, by discussing ongoing shifts in museums themselves, and in the research methods and theoretical approaches of visitor studies, one can still gain an understanding of learning in museums.

The growth in visitorship comes at a time when the mission of museums is shifting from an emphasis on collecting and preserving to one of educating the public (Hein, 1998; Roberts, 1997). This paradigm shift of museums from object-oriented to visitor-oriented

(Insulander, 2005; Koenig, 2000, both cited in Hou, 2009) may change researchers' thinking or their definition of learning. When collections/objects are the focus, museum professionals or researchers try to understand visitors' learning through how they passively receive knowledge transmitted from the exhibits (Blud, 1990). The evaluation of whether visitors learned also relies on using pre- and post- tests to examine their "learning." Yet, when visitors become the focus, what scholars care about is how visitors approach and understand exhibits, as well as what visitors gain and take in during the whole process (Palmquist & Crowley, 2007; Zimmerman, Reeve & Bell, 2010).

The shift in the research method approach alters the definition of learning in museums as well. In the past, studies of visitors were dominated by the quantitative approach. The usage of pre- and post- tests was therefore dominant in early museum studies. In these studies, researchers gave visitors tests related to exhibits' content right after their visit to measure their learning/knowledge. For instance, in Benjamin and her colleagues' research (2010), children's ability to identify pictures in the picture task was viewed as a kind of learning. Learning outcome is emphasized but the learning process and other factors are ignored. It is doubtful and worthy of further thinking whether these tests could really show all the learning that visitors gained from their visits. Such a point exposes the narrowness of the definition that learning is nothing but memory and passively accumulating new facts.

However, as Falk and Dierking (1992) argued, learning that takes place in museums was misunderstood as being the same as "school" or "education"; this misinterpretation makes learning mean gaining new concepts or information. Within these ideas, the importance of the social context within learning was neglected and so were personal interest, motivation, and emotions (Falk & Dierking, 1992). Yet, learning is not merely about learning new things (Falk & Dierking, 1992). How we learn might be more worthy of investigating. Motivation, emotion, interests, former experiences and the like should be also included when thinking about learning in museums. In responding to such an idea, in recent years a growing body of studies using qualitative research has pointed out a new direction, for better understanding visitors' learning as a whole rather than testing what they learned in their visits. These qualitative museum studies, employing methods such as observation, interview, document analysis and so on, describe museum learning from a different angle.

The shift in the theoretical approach also affects the method of investigating and defining learning in museums. Over the past 10 years, in research in museums, developmental psychologists and museum educators have increasingly focused on children's conversations with their caregivers that may promote early science learning (see Leinhardt et al., 2002, for a review). This work has been guided by sociocultural theory (e.g., Rogoff, 1990; Vygotsky, 1978), which emphasizes that to understand learning one must focus in detail on the process of learning.

Ellenbogen, Luke, & Dierking (2007) pointed out in the past decade that the use of sociocultural theory affected how researchers or museum staff think of learning in museums. As Brown, Collins, & Duguid (1989) noted, "Learning, both outside and inside school, advances through collaborative social interaction and the social construction of knowledge" (p. 40). Rather than quizzing children on static facts to see what they have acquired after visiting exhibits in a post test design, a collaborative model focuses on how parents and children engage with each other and with exhibits (Crowley & Callanan, 1998).

Still, with these shifts comes the realization that researchers still struggle with the definition of museum learning. Hooper-Greenhill (2007) made it very clear that learning is a "problematic concept" (p. 31). The term "problematic" points out how ambiguous the definition of learning is. This difficulty may emerge from the fact that scholars and researchers have different definitions and explanations of learning when employing different theories to describe "learning." In most museum research, there is no concrete definition of "learning." It seems researchers in this field assume learning indeed happens in all kinds of museums. Maybe just as Sefton-Green (2004) said in the foreword of his review, "When we think about learning, we often tend to think about schools, universities, and colleges. If we go a little further and think about learning outside school, we might begin to consider museums, galleries and science centers. What we often tend to overlook, however, is the sort of learning that goes on as part of our normal day-to-day activities when we don't even think we are learning."

While the definition of learning in museums is unclear as well as somewhat narrowly defined, some definition of learning in previous museum visitor studies may present a very small part of what "learning" is. For example, Tenenbaum, Prior, Dowling, & Frost (2010) employed the ideas from Crowley & Callanan (1998) and Matusov & Rogoff (1995) to define learning as "a collaborative process in which children and their parents actively co-construct knowledge" (p. 242). Blud (1990b) adopted Doise (1978)'s definition, which was influenced by Piaget, to indicate that learning is the resolution of cognitive contradictions or conflicts. Griffin (1998, p. 657) said "learning is a very individual process and museums provide good opportunities for people to learn independently and by choice." She also adopted Duckworth (1992)'s idea that "Learning involves toying with ideas in an attempt to reduce complexities until simple and elegant generalizations emerge; it involves time to explore and become thoroughly familiar with objects and ideas" (Griffin, 1998, p. 658). It is clear that the different theories employed by these researchers have different definitions of learning – for instance, Vygotsky's ideas in Tenenbaum et al., (2010) and Piaget's thoughts in Blud (1990b). Still, all these definitions pointed out some noteworthy points for researchers or museum staffs to consider what is "learning"—learning may not be only equal to the outcome; learning is situated in personal, social, and temporal contexts as well as other factors.

Among these researchers, Falk and Dierking's work (1992, 2000) may be a comprehensive expression of many views or ideas. Falk and Dierking first proposed the "Interactive Experience Model" in 1992. Then they elaborated the model to "The Contextual Model of Learning" later on (Falk & Dierking, 2000). The model draws from constructivist and cognitive as well as sociocultural theories of learning. Falk and Dierking (2000) emphasized the importance of the physical, social, and personal contexts for learning in museums. In this model, they view learning as "a dialogue between the individual and his/her environment through time." In their thoughts, learning is always a complex phenomenon situated within a series of contexts. To get closer to understanding learning in museums, it should be put into these three contexts—physical, social, and personal—and time is additionally needed for a learner to approach the "real" understanding. The occurrence of learning cannot be distinctly divided into a certain time; learner's experiences before and after their visits need to be considered as well. In other words, learning is the process and also the product.

**The contributions of science museums[7] in children's science learning[8].** When speaking of science learning, people tend to relate it to school science. Also, since people's museum visits are often short and infrequent, Jarvis and Pell (2002) proposed that people might question whether such short experiences are valuable. Some parents also asserted that children in interactive science centers appeared to be "playing" and

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[7] Here the term "science museums" is used in a general manner. It might include science centres, zoos, botanical gardens, etc.

[8] See the famous article written by Shortland (1987) for an alternative view on interactive science centres in children's science learning.

could not be learning (Wellington, 1990). Nevertheless, to people's surprise, studies on either children's field trip experiences or their family museum visits reveal the high values of these "short experiences" (Falk & Dierking, 1992). Science museums' long-term effects on science learning (e.g., Bamberger & Tal, 2008; Falk & Dierking, 1997) were also documented. Since "Most individuals will spend far more years as informal learners of science than as formal learners of science" (Crane, Nicholson, Chen, & Bitgood, 1994, p. 6), more and more researchers have proposed the significance of science museums in children's science learning.

Cognitive contribution (Braund & Reiss, 2006; Wellington, 1990) might be the first concern when discussing the roles of science museums. Field trips are the most common form of utilizing science museums in supporting children's science learning. In a study of comparing the effect of students' learning in the classroom and at a zoo, Falk, Balling, and Liversidge (1985) found that students who went to the zoo had better concepts about animals than those who only received related knowledge in the classroom. Falk et al. (1985) concluded that this kind of setting offered students real experiences to support and strengthen students' learning. They also noted that those who went to visit the zoo had an expectation that they would see real animals; this also made them are more willing to receive related information.

Those people who question the roles of science museums in children's science learning might ignore the affective contribution of science museums. As Rennie and McClafferty (1996) proposed, "The key question is not: do people learn science from a visit to a science centre? But, do science centres help people to develop a more positive relationship with science?" (p. 83) As stated, children's positive attitudes towards science might be the most important part in their science learning. However, some children feel frustrated with school science and these negative experiences might deter them from further learning science (DeWitt, et al., 2011). On the contrary, science museums are often seen as "exciting, challenging, and uplifting" (Braund & Reiss, 2006, p. 1374); this identification enables science museums to support children's positive attitudes and lifelong interests in science (Jarvis & Pell, 2002). As Semper argued, "If science had been taught like this (i.e., museum learning) when I was in school, I would have stayed with it." (1990, p. 4). For example, the parents in Hou and Juang (2005) reported that they noticed the advantages of science museums for their children's science learning. These parents also reported, that while their children did not perform well in terms of school science or mathematics, their children actively engaged in their science museum visits especially in those themes they were interested in.

Furthermore, since learning through authentic and first-hand experiences is one of the purposes of science museums, by directly interacting with exhibits and seeing authentic objects, children can easily engage in science learning in an interesting way. Additionally, children will have chances to access equipment that are often too expensive for them or too specialized for schools to afford (Braund & Reiss, 2006; the U.S. Department of Education, 2005).

**Summary**

In sum, parents hold their own beliefs about rearing and their children's learning or development. These different beliefs might be influenced by parents' personal characteristics and/or external contextual factors and in turn serve as a resource for them to take actions or make decisions regarding what is best for their children. However, in terms of parents' beliefs about their children's science learning, the current literature provides very little information, especially how parents reflect these beliefs in out-of-school settings – which are usually identified as places for giving children different, interesting, and authentic learning experiences. Although there are many perspectives on how young children should learn science, these might not fit what parents believe. Additionally, these current perspectives are usually geared to teachers and focus on the context of classrooms. Thus, the necessity of examining parents' beliefs about their children's science learning and their actions in an out-of-school setting becomes apparent. A more concerted research focus on the role of parents' science learning beliefs would assist both parents and teachers in better supporting young children's science learning.

## Theoretical Framework

As discussed in the literature review, parents' beliefs guide their behaviors/actions in their children's learning as well as shape how children view their abilities or learning. Vygotsky's sociocultural theory (1978), which focuses on more capable others and social interaction, underpins the interests of present study—parents' beliefs and actions about their children's science learning. Below, I review several key constructs in these two theories respectively and relate them to my study.

**Vygotsky's socio-cultural theory.** ***Social interaction.*** As Brown et al. (1989) noted, "Learning, both outside and inside school, advances through collaborative social interaction and the social construction of knowledge." (p. 40) Vygotsky (1978, 1981, 1986) offered the view that social interaction provides an essential means in the learning process. He stated that social interaction has a much more central role to play in learning. Vygotsky (1978) pointed out that individuals are guided by their own mental processes as they participate in social activities and are influenced by social experiences. Mental functions first begin on a social or inter-psychological plane and then move to an inner or intra-psychological plane. He called this process "internalization." Internalization involves transforming social phenomena into psychological phenomena or making meaning through both external and internal interactions (Vygotsky, 1981). Vygotsky stated: “When we speak of a process, ‘external’ means ‘social.’ Any higher mental function was external because it was social at some point before becoming an internal, truly mental function" (Vygotsky, 1981, p.162). For Vygotsky, the transformation of natural forms into higher cultural forms was one from the external to the internal. Additionally, social reality plays a primary role in determining the nature of internal intra-psychological functioning. What parents select for their children to learn based on their science learning beliefs might be then internalized by their children through these social interactions.

Vygotsky (1978) argued that both learning and cognitive development are related and cognition develops as a result of social interaction in which the child (or learner) learns how to complete a task by sharing responsibility for that task with a more competent expert or peer. In other words, learning is a dynamic social process in which the dialogue between expert and learner fosters the development of higher cognitive processes. Social interaction therefore mediates learning.

***Zones of Proximal Development and scaffolding.*** The Zone of Proximal Development, or the ZPD, is one of the most significant concepts in Vygotsky’s scholarly heritage. Vygotsky formulated two levels of children’s development to clarify how they transition from potential development to actual development, which is referred to as the ZPD – or “the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers” (Vygotsky, 1978, p. 86). Moving from one level to another may require assistance from adults or other knowledgeable persons; when such people use the ZPD knowledge to modify children’s activities, children will bring their best learning ability into full play. This assistance is portrayed as “scaffolding”—which is the temporary support which helps the learner extend his or her current skills and knowledge to a higher level of competence (Papalia, Olds & Feldman, 2001; Rogoff, 1990). Accordingly, the concept of scaffolding is indeed a metaphor about how people learn, as it demonstrates how interactive support functions as a symbolic tool to achieve goals.

One can say that the ZPD is the area in which children can achieve a goal with the support and guidance of more capable others. The adults or more capable peers, during the ZPD or scaffolding, assist skill development through "...prompts, clues, modeling, explanation, leading questions, discussion, joint participation, encouragement, and control of the child's attention" (Miller, 2002, p. 379). This interrelation among adults or peers and children will actively transform their knowledge and social experiences rather than passively internalizing them (Vygotsky, 1978). In the previous section on the importance of adults in children's science learning, I used Crowley and Jacobs (2002) and Crowley and his colleagues' (2001) studies to show how parents' support could promote children's learning in their science museum visits. It is in the ZPD that learners, at home, at museum exhibits, or in the classroom, "undergo quite profound changes . . . by engaging in joint activity and conversations with other people" (Edwards & Mercer, 1987, p. 19). However, if parents hold negative beliefs about science learning, they may not actively scaffold their children's science learning or not know how to better scaffold this learning.

In sum, this present study examined parents' beliefs about their children's science learning through the lenses of Vygotsky's sociocultural theory. Vygotsky's emphases on social interaction and ZPD lay the foundation for understanding how parents' science learning beliefs guided their actions, and how these beliefs and actions influenced their children's science learning, when they had science activities such as visiting a science museum together. Vygotsky's theory helped me to pay attention to distinct aspects of how parents addressed their science learning beliefs, reflected these beliefs in their actions, and in turn shaped their children's science learning.

# Chapter 3 Methods

This present study aimed at investigating parents' beliefs about their children's science learning and their actions when they visit a science museum. Below I begin with the preliminary findings in my pilot study to explain how this purpose emerged from the process of my pilot study. I then use it as a starting point to show how my research design was framed by this pilot study, including the rationale, methodology, and so forth.

**Pilot study**

In the summer of 2010, I conducted a pilot study at the National Museum of Natural Science that examined the process of parent-child conversation and how the family conversation promoted children's scientific literacy during their family visits. The same subjects, namely Kiki's family (Kiki's mother and Kiki were included) and Yuan's[9] family (Yuan's mother, father, her younger sister and Yuan were included) from my previous study (Lan, 2009) participated in this pilot study.

I observed each family as they visited the science museum on four separate occasions, and I interviewed the parents several times. As I analyzed my observations of parent-child conversations, I gradually found there were some reasons[10] behind parents' every action, behavior, decision, and/or strategy which I originally did not expect to see. For example, I noticed that Kiki's mother always stood aside and watched Kiki's actions when they were at interactive exhibits. When this phenomenon became a pattern, I interviewed Kiki's mother about my observation, and she answered quickly that she believed, "It is good for taking some time to see how Kiki interact with the exhibits. I need to watch her for a while to know how much she knew. If she needs my help, I will see how I can help her" (Interview #2). Further, to know whether such an answer was

[9] These two names are pseudonym.
[10] I use the term "reason" here because parental beliefs were not the focus of my pilot study. It might be improper to use beliefs or other similar terms such as perceptions, attitudes, thoughts, etc.

only a random response, I interviewed Kiki's mother about such phenomenon in different ways in later interviews. For instance, I asked her questions like "what kind of role does she think she needs to play when they are at interactive/hands-on exhibits" or "what might be the most important thing when they manipulate hands-on exhibits." Her responses were quite similar to her first response and showed she knew why she took a certain action. Similar findings were also documented in Yuan's family. Interestingly, parents from both families seemed not only to be able to provide reasons for the actions they took or the decisions they made and did not veer away from such a response. These strong, firm, personal value-driven ideas about why parents acted in some particular ways attracted and motivated me to keep track of these reasons guiding parents' actions and decisions.

In addition, when Kiki's mother and Yuan's parents were explaining the reasons behind their actions and/or decisions, they frequently associated those responses to with some contextual factors. The most common factor was their purpose for visiting the science museum. Kiki's family and Yuan's family respectively represented two types of families—the former visited the science museum for learning and the latter for having some fun together. The different purpose of visiting seemed to play a certain role in influencing how parents took actions and provided reasons for these actions.

While the focus of this pilot study was not parental beliefs about their children's science learning, the possibility of studying this topic was taking shape during my pilot. As described above, parents have their own reasons about what they do, their roles in their children's learning, and how their children should learn, etc. Because I was repeatedly finding similar evidence, these reasons seemed to be pretty close to what researchers identified as beliefs (Hirsjärvi, & Perälä-Littunen, 2001). These preliminary findings excited my interest in investigating parents' beliefs, especially their beliefs about their children's science learning. Kiki's mother and Yuan's parents' words in the interviews highlighted the varieties of different parents' beliefs. For instance, Yuan's mother said that she responded to Yuan and her younger sister in different ways according to their ages. Yuan's father regarded science as difficult for girls to learn and girls liked history much more than science. In Kiki's family, Kiki's mother valued Kiki's self-initiated exploration highly yet she played an important role in helping Kiki to learn science.

In addition to seeing the potential for investigating parents' science learning beliefs from my pilot study, my pilot study demonstrated that it is possible to investigate parents' beliefs by using qualitative research because parents were aware of the "what" behind their actions, decisions, and so forth. Thus, a qualitative study about "understanding how people interpret their experiences, how they construct their worlds, and what meaning they attribute to their experience" (Merriam, 2009, p. 5) seemed promising illuminate parents' various beliefs.

**Rationale**

Research on parental beliefs has been dominated by quantitative approaches. In these studies, surveys and questionnaires were the main means to examine parents' beliefs about their children's learning and/or development (e.g., Fogle & Mendez, 2006; Savage & Gauvain, 1998; Winsler, Feder, Way, & Manfra, 2006). In their review of parental beliefs, Hirsjärvi and Perälä-Littunen (2001) criticized the problems of questionnaires and scales that have been frequently used in previous studies on parents' beliefs by pointing out that the parents participated in these studies could only express their beliefs by choosing from what the researchers gave them. Hirsjärvi and Perälä-Littunen (2001) questioned, "What if the most important choice never occurred to the researcher?" They continued,

> A forced-choice questionnaire of any kind requires a great amount of previous knowledge on the part of the researcher in order to know which questions are relevant and what kind of statements should be included for the subjects to choose from (p. 92).

According to this critique, I came to believe that quantitative research would make it difficult for me to see the intricacies of parents' beliefs about children's science learning. Hence, this study adopted a qualitative approach, which provided parents more opportunities to express how they perceived and what they believed about their children's science learning without being restricted to certain types of questions and answers.

The uniqueness of the group "family" in museums adds another layer to employing a qualitative research to study the issue of parents' science learning beliefs. Family groups has been the core interest of museum visitor studies (e.g., Ash, 2004; Crowley, Callanan, Jipson, Galco, Topping, & Shrager, 2001; Szechter & Carey, 2009; Zimmerman, Reeve, & Bell, 2010), and this group has its own pattern of interaction and visiting behaviors (McManus, 1994) to separate them from other groups. As Dierking (n.d.) concluded from her experiences in working in museums, families all learn in different ways, and they create their own values in their personal observations and experiences by working, talking, and solving problems together. Thus, employing the qualitative approach that emphasizes a deep understanding of the complexity of individuals (Creswell, 2007) assisted me to understand this unique group's interactions in more depth and detail.

**Methodology**

To investigate parents' beliefs about their children's science learning and their actions, I employed a qualitative case study, which is ideal when a holistic, in-depth investigation is needed (Feagin, Orum, & Sjoberg, 1991, cited in Tellis, 1997). As presented in the literature review, parents from the same culture may still hold different beliefs according to their personal characteristics and social positions. In other words, parents from each family might have their own unique beliefs about their children's science learning. Case study provides nice framework for deep investigation on this complex issue.

Also, as stated, parental beliefs about their children's science learning were seldom investigated, when it comes to such beliefs in the context of out-of-school setting, related studies are even more limited. This study, conversely, specifically addressed this issue in one science museum. In Stake's (1995) definition, this study was an instrumental case study, which was used to provide insight into an issue; the issue being parents' beliefs about their kindergarten-age children's science learning.

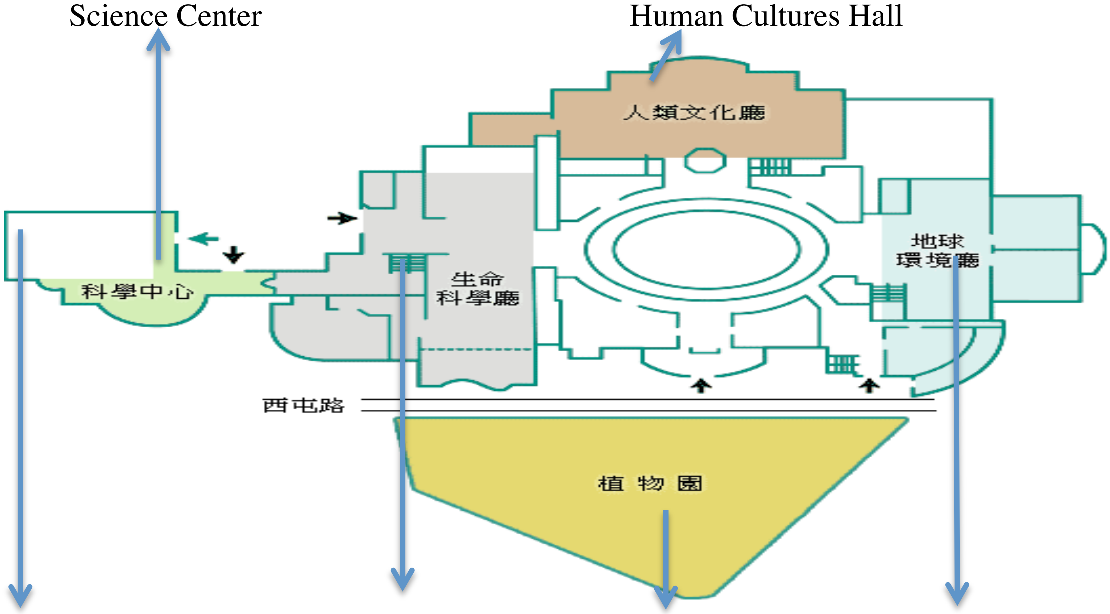
In their study of nineteen parents' beliefs about teaching and learning in a children's museum, Swartz and Crowley (2004) suggested that future research could "Develop a more in-depth case-study methodology with a smaller sample, might be successful ways to capture the complexities and varied nature of parents' philosophies about teaching their children in informal settings" (p. 14). Following their suggestion, this qualitative case study recruited eight families to investigate parents' beliefs about their children's science learning and their participation.

**Setting**

This study took place at the National Museum of Natural Science (NMNS) in Taichung, Taiwan. It is the biggest science museum in Taiwan, and approximately two to three million visitors come to the NMNS each year (the NMNS annual statistical report, 2011). In addition to collection and preservation of natural species, its primary missions are to "raise public knowledge of science, cultivate reasoning and independent thinking and encourage people's curiosity of natural phenomena." The NMNS aims to "stimulate the public's interest in the natural sciences and world cultures through creating engaging exhibits and educational programs" (excerpted from the NMNS official website).

I chose the NMNS primarily because of its accessibility and its richness in displaying multiple themes. The NMNS is a six-venue complex housing the Space IMAX Theater, Science Center, Life Science Hall, Human Cultures Hall, Global Environment Hall and the Botanical Garden. The NMNS has two types of exhibitions: the permanent exhibits and the rotating special exhibits. The former provides a historical foundation in the natural sciences in the fields of zoology, botany, geology, and anthropology, while the latter involves current scientific knowledge and concerns. The NMNS is a place filled with hands-on exhibits that will delight children and adults of all ages.

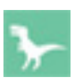
Science Center Human Cultures Hall




Space IMAX Theater Life Science Hall Botanical Garden Global Environment Hall

Fig 1 The NMNS map


Fig 2 Exhibition hall map

 Life Science Hall. It includes “The Age of Dinosaurs,” “Extinction,” “The Evolution and Adaptability of Mammals,” “The Journey of Human Life,” “The Story of Man” and other exhibitions.

 Human Cultures Hall. It includes “Oceania,” “Chinese Medicine,” “Chinese Science and Technology,” “Agricultural Ecology,” “Han People Spiritual Life,” “Taiwan Austronesian” and other exhibitions.

 Global Environment Hall. It includes “Microscopic World,” “Life on Earth,” Taiwan’s Ecology,” “Minerals Exhibit” and other exhibition.

## Participants

**Considerations and procedures of obtaining participants.** To be clear, the "parents" in this study referred only to a child's mother and/or father. All other caretakers (e.g., grandparents or other relatives) were not considered when recruiting participants. While I was aware of the complexity of the current society and family structure, I intentionally chose to limit parents only to mothers and/or fathers because their beliefs might differ from other caretakers.

I tried to recruit both mothers and fathers to participate in this study, because as indicated in the literature review, mothers and fathers usually hold different beliefs about their children's learning and/or development. Also, fathers' important roles were often underestimated. Yet, I did not limit the resources of participants to those families in which both parents were willing to participate.

I employed different strategies to recruit participants in two different phases. In the first phase (i.e., around middle April, 2012), I mainly recruited parents on the basis of convenience sampling (Merriam, 2009). I met my contacts and broadly explained the purpose of this study to them. Then, I asked them to introduce potential volunteer families. Any family interested in being my participants was welcome, which yielded seven families (five mothers and two fathers). Since I was interested in the role of children's gender in parents' beliefs, in the second phase (i.e., around middle May, 2012), I asked my contacts to only introduce me to parents of girls. With my contacts' introduction, four more mothers and their daughters agreed to participate in this study.

I started to contact these potential parents around late May 2012 to ensure their willingness of being my participants again. After speaking with each parent, I lost two mothers because they had some unexpected family issues. Ultimately, nine families including seven mothers, three fathers, eight boys, and eight girls[11]were willing to participate this study (see Table 1 for details of each family). I lost one family after their first interview. Of the final eight families who participated in the study, 1 was mother-daughter dyad, 2 were mother-son dyads, 1 was a mother-twins triad, 1 was a father-son dyad, 1 was a mother-father-daughter triad, and 2 were mother-son-daughter triad. Except for Jay who was an only child, all other children had siblings.

Once the families agreed to attend this study, I met each family and had them sign the consent forms and let them know their responsibilities including being interviewed and observed and rights such as they were allowed to stop participating in this study at anytime. Since not every potential family was a museumgoer (Falk & Dierking, 1992), I explained to those who had never visited museums (i.e., Jay's and Chun's families) that visiting the science museum was a required part of this study.

**The demographics of participants.** Children in these eight families came from two public and four private kindergartens located in Taichung, Taiwan, the same city in which the museum was located. Among these children, Ting, Yen, and Wei were classmates.

[11] Not all the girls fit the criteria of this study. For example, Wei's two older sisters were both above the age limit (3-6 years old).

Table 1 Details of each family

| Number | Children's names and age (All the names are pseudonym) | Parents' demographic data | Other notes |
|---|---|---|---|
| 1 | Jay, a four-year-old boy (Jay was the only child) | Jay's mother was a former private kindergarten teacher. After teaching about two years, she chose to resign and became a "bride secretary" because she was interested in make-up. She now served as a part-time substitute teacher in a junior high school. Jay's mother had a Bachelor's degree in early childhood education.<br><br>Jay's mother self-reported that she was not interested in and not good at science at all. | They have never been to this science museum before participating in this study.<br><br>Jay's father was in military and went home at a low frequency. Jay's mother took the main responsibility for taking care of him. |
| 2 | Mei, a six-year-old girl, and her younger brother, four-year-old Kai | Mei and Kai's mother was now working as an accountant and a worker at a paper box factory. She has taught in a private kindergarten for about half year. She had a high school diploma in early childhood education. | They have been to the research site several times, yet they never purchased membership. |
| 3 | Yen, a six-year-old boy and his younger brother, four year-old Wen | Yen and Wen's mother worked in advertising-related business before being married. She was a full-time housewife. She had a high school diploma in advertising. Yen's mother self-reported that she had little interest in science and felt passionate for art. | They have been to the research site many times. They recently renewed their membership.<br><br>Yen and his younger brother Wen have been attending a private science class called "Sky and Grass" for about two years. Their mother chose this because she wanted them to have more outdoor activities and experiences. |

**Table 1, cont.**

| | | | |
|---|---|---|---|
| 4 | Lily, a four-year-old girl, and her younger sister Nana | Lily's mother was a nurse. She had a high school diploma in nursing. She was interested in outdoor activities, such as bird watching. | They have been to the research site, yet they never purchased membership. |
| 5 | Pei, a four-year-old girl, and her twin brother Ming | Pei and Ming's mother had a Bachelor's degree in agriculture and natural resources. She was an owner of an insurance company. | Pei and Ming both went to the same private Buddhist kindergarten.<br><br>They had purchased membership of the research site before, yet they did not renew their membership before participating in this study. |
| 6 | Ying, a six-year-old girl, and her older sister Ting | Ting and Ying's father had a Master degree in industrial engineering and enterprise information. Their mother had a Bachelor's degree in foreign language and literature.<br><br>Ying's mother self-reported that she always had difficulty in learning and understanding science. Instead, she felt learning math was easier because it was not that abstract. Ying's father was interested in science and felt that doing experiments was fun.<br><br>They were interviewed simultaneously. | They had purchased membership before, yet they did not renew their membership before participating in this study. |
| 7 | Wei, a six-year-old boy, and his two older sisters (one was in 4th grade and the other was in 6th grade) | Wei's mother originally majored in chemistry. She changed her major to accounting when she was a sophomore.<br><br>She self-reported that she was good at science and math, especially the latter. | They newly became members of the NMNS about two months before the data collection started.<br><br>Wei, Yen, and Ying were classmates. |

**Table 1, cont.**

| | | | |
|---|---|---|---|
| 8 | Chun, a six-year-old boy, and his older brother Hsuan | Chun's father had a PhD in educational psychology and was an associate professor in the college of education in one national university. According to him, he was a gifted student in science and math. | Chun's mother was a tenure-track assistant professor and was working on getting her tenure now. As a result, Chun's father was taking the main responsibility for taking care of Chun and his older brother.<br><br>Chun's father has been to the science museum several times. Yet, both Chun and his older brother Hsuan have never visited the research site.<br>Chun's father loved to bring them to outdoor rather than indoor settings. |

**Data collection**

Data collection began in the summer of 2012. The two primary sources of data for this study included in-depth interviews and observations of family visits to the science museum. Since parental beliefs were the focus of this study, the interviews were limited to parents. In what follows, I describe in more detail about the reasons for collecting data from these two resources and how I conducted the in-depth interviews and on-site observations.

**In-depth interviews with parents.** As pointed out by Pajares (1992), "Beliefs do not lend themselves easily to empirical investigation" (p. 308). Thus, one "must infer [people's beliefs] from what people say, intend, and do" (Hirsjärvi & Perälä-Littunen, 2001, p. 89). To do this, in-depth interviews became the primary method of collecting data about family's beliefs for this study. All the interviews were conducted in a semi-structured form. All interviews were digitally recorded and then transcribed verbatim for further analyses.

I conducted two initial interviews with each family before the on-site observation. Interviewing before observation was for the consideration that "Knowing about families' cultural ethnotheories can help identify relevant behaviors to observe" (Gaskins, 2008, p. 9). The purpose of the first initial interview was to obtain demographic information as well as some basic ideas about how parents perceived science. I first adopted an activity introduced by Devereux (2007) to offer parents an opportunity to reflect their ideas on science. Parents were asked to write down a list of words or phrases that they thought described their understanding of science. Then, I asked them to share the reasons of choosing these words/phrases. My hope was to gain a general understanding of these parents' beliefs about science and/or science learning. For example, the phrases Pei's mother chose were all related to something she could access in her daily life. She then elaborated her thoughts on the inseparable relationships between children's science learning and their daily lives (Pei's mother, interview#1). In this interview, I also asked parents to share information such as their own science learning experiences, their feelings about science/science learning and so on (see Appendix A).

In the second interview, I probed their beliefs more deeply through a set of questions (See Appendix B). Before it started, I did an initial analysis of their first interview. By doing this, I could use what I gained from their first interviews as a basis to elaborate more in the second interview. To be clear, I generated some new and more individualized interview questions from the first interviews. For example, I asked Yen's mother more about one of their recent science museum visits. Also, I asked her to talk more about the private science class she chose for her sons.

In the second interview, I also asked parents to fill in one form called "Nature of science" (see Appendix C). If both parents were participating in this study, I asked the mother and the father to fill out two separate forms. The "Nature of science" form was adapted from Nott and Wellington (1993). This survey was designed to get a general idea of parents' beliefs of the nature of science by asking them to choose true or false to each statement. It also served as a foundation of knowing if any inconsistency in these parents' beliefs of the nature of science across different data. After the two interviews, I then observed each family as they visited the science museum. The details of on-site observations will be given later.

I conducted follow-up interviews after each family's visit to the museum. I informally interviewed parents right after their visit to allow them to share ideas about their visit.

Then, I interviewed the parents again. Although these parents knew they were video taped during their museum visits, it should be noted that they did not know what the video was for beforehand. This was for reducing any observer effect. When interviewing these parents, I loosely followed the method developed by Dockser (1989) called a "reflection session." The interview started with watching the video of their family visit. I told parents that they were free to reflect on what they see as well as to interpret their feelings about their interactions with their children anytime during watching the video.

Dockser (1989) noted, "The outsider (i.e., the researcher) is recognized as having a unique perspective which is equally valid, however cannot substitute for the perspective of the insiders (i.e., the participants)" (p. 82). Through this reflection session, why these parents made decisions and why they acted in some specific ways became clear. For example, Lily's mother told me "I was not very familiar with this exhibition hall. So, I had to take time reading the panels. But it's impossible for me to always do this, because

I needed to take care of her safety" (Lily's mother, reflection session). This gave me more insights into their beliefs about their children's science learning as well as helped me to understand their thinking behind their actions and behaviors with their children. I also asked parents questions when I could not fully understand their behaviors based on other data sources (e.g., their family conversation). For example, I asked Wei's mother to clarify why she usually accompanied Wei instead of his older sister.

As Draper (1984) noted, "Sitting in the visitors' homes, a fuller profile of the variety of people who come to the Exploratorium was evident" (p. 128). The purpose of interviewing parents in their own home was to make them feel more comfortable as well as enable me to observe their home environments. Thus, when interviewing parents in their homes, I also collected documents, such as pictures of the books or equipment they bought for their children. Still, the parents were given the option of the interviews taking place in their homes or other community places. Except for the immediate informal interview, which took place in the NMNS, most of the other interviews were conducted in participants' homes. There were only three families (i.e., Lily's, Pei's, and Ying's families) who were interviewed at places such as McDonalds.

The protocols for the parents were piloted before the formal interviews began. I interviewed one mother who was not participating in the study to help determine where the questions needed to be refined. After reviewing the data from the pilot interviews, questions were adjusted to be less leading and to allow for some follow-up questions. The final protocols are included in the appendixes (Appendices A & B). Below, I will discuss the specifics of the on-site observation.

**On-site observations.** Before presenting how I conducted the observation of family visits, I expound on why observing families as they visit the science museum is necessary. As stated earlier, research has found there was inconsistency between parents' beliefs and their actions (e.g., van der Poel, de Bruyn & Rost, 1991). This result demonstrates how parents' beliefs may be inconsistent with their actions. The possible inconsistency between beliefs and actual behaviors therefore explains the need of on-site observation of family visits except for doing interviews with parents.

I observed only one family at a time. Although each family was only observed once, this proved effective. I will elaborate on this a bit more in chapter five. Families were allowed to choose their routes through and their duration in the NMNS. In the on-site observation, therefore, I paid particular attention to what exhibits they went to, how long they stayed as well as their engagement with the content of the exhibit and their style of social interaction. The natural route choosing through the exhibition with no predetermined path was helpful to reveal parents' beliefs and how those beliefs were reflected in their actions/behaviors. For example, when a family returned to an exhibit several times, I asked parent(s) about such a phenomenon (e.g., Wei's family).

Each observation of family visit was audio recorded as well as video taped. I asked both parents and children to wear digital voice recorders. In addition, I used a digital video to record parent-child non-verbal interactions in their family's visit. Although the NMNS was usually crowed on weekends, which made my presence not easily detectable, in order to enable the parent-child dyads to get accustomed to being observed, I informed both parents and their children I turned off the digital video during the first ten minutes of their visit. Also, I kept a distance (about 1 meter) behind them. The duration of not using the digital video was based on findings from my pilot study, which showed that parents and children started to ignore the presence of the observer after a few minutes of being in the museum and concentrated on their own visit. However, in consideration of the quality of my data, I took field notes to compensate for the absence of the video data.

**Data analysis**

Merriam (1998) suggested that after the first interview and/or first observation, researchers should review the purpose of the study, read and reread the data, write down their thoughts, reflections, tentative themes, and ideas about the data. Since data collection and analysis typically go hand in hand to build a coherent interpretation (Marshall & Rossman, 2011, p. 208), these processes are meant to help the researcher conduct further steps of data collection and data analysis. Thus, in line with Merriam's (1998) suggestion, I transcribed each audio file of interview and/or observation as soon as it was obtained, and then started the analysis.

After transcribing the data across different resources, I started to read the transcription and develop a codebook (Ryan & Bernard, 2000), which is informed by my research questions, literature review and theoretical framework. In consideration of not being limited to a certain set of pre-existing codes (Creswell, 2007), I did not have priori codes to guide my coding process. Nevertheless, when I read the transcriptions and field notes, I especially paid attention to the seven components including cognitive content, structure, source, function, relation to affect, intention, and value, which were proposed by McGillicuddy-DeLisi and Sigel (1995). Also, I used the in vivo codes (Marshall & Rossman, 2011), such as "the grapevine," "multiple experiences," and "fun." Lastly, I used some previous studies regarding parental beliefs (e.g., Sun & Chien, 2009) as a reference, to help me develop some possible codes.

One of the main purposes of this study was to investigate Taiwanese parents' beliefs about children's science learning. Here I provide some examples of how I coded these parents' beliefs as "beliefs." As Hirsjärvi and Perälä-Littunen (2001) noted, people have a variety of beliefs about different aspects of their lives. Some of their beliefs are more explicit than others. When a parent began to address his/her beliefs with "I believe," for example, “I believe these (science explorations) will become a foundation for their future science learning” (Pei’s mother, interview#1). I then coded it as her belief. In this case, she explicitly pointed out her belief in the importance of first-hand experiences in her children’s science learning.

As stated earlier, however, “Beliefs do not lend themselves easily to empirical investigation” (Pajares, 1992, p. 308). So, one “must infer [people’s beliefs] from what people say, intend, and do” (Hirsjärvi & Perälä-Littunen, 2001, p. 89). Fundamentally, I inferred their beliefs from their interviews because I would like to know how these beliefs manifested in their science museum visits. Below is a sample statement from the transcriptions of Yen’s mother’s interview. When she said, “Then you will find that, um, in terms of memory and every aspect, four-year-olds and five-year-olds perform better than my three-year-old son” (Yen’s mother, interview#1) I inferred that she believed older children are better learners. More to the point, in her beliefs, children’s age is an important factor in their science learning.

Because of the purpose of this study was to understand parents’ beliefs about their children’s science learning and how they reflected these beliefs in their museum visits, I adopted three different skills introduced in Ryan and Bernard (2003) to analyze the data qualitatively: looking for repetition, similarities and differences (which Strauss and Corbin termed Constant Comparative Method), and missing data. First, I read through the data and looked for topics that occur and reoccur (Bogdan & Taylor, 1975, p. 83). Finding the repetition helped me to see what parents believe as “truths” (McGillicuddy-DeLisi & Sigel, 1995) in their mind. In terms of these parents’ beliefs, I noticed that some topics such as parents’ roles in science learning, how children learn science, and children’s young age constantly showed up in the interviews. After the final pattern was formed, I then used it to analyze their actions and behaviors in their museum visits.

Then, I used the Constant Comparative Method to help me elucidate the nuances of ideas in what informants mentioned. For instance, although the term "hands-on" appeared for several times in the interviews, the meaning of this idea was used differently by Kai's mother and Pei's mother. By doing this, the variety of these parents' beliefs and actions was revealed. Additionally, I was able to figure out the exact meaning of what these parents expressed.

I also paid attention to those "missing data" (Ryan & Bernard, 2003) because knowing what parents intentionally or unintentionally avoided mentioning helped me see a more holistic picture of their science learning beliefs. For example, I asked Jay's mother why she never thought about taking Jay to any science museums when she had no attempt to provide an explanation (Jay's mother, interview#2).

**Reflexivity**

Etherington (2007) explained that "reflexivity is a tool whereby we can include our 'selves' at any stage, making transparent the values and beliefs we hold that almost certainly influence the research process and its outcomes." (p. 601) It is particularly important for me, given that I am going to study parents' science learning beliefs, to incorporate my reflexivity into this study because my professional trainings, my values, and beliefs might have different degrees of influences on how I view my participants and the information they provide. Through the use of reflexivity, I could show transparently how I discovered what I discovered.

Cousin (2010) proposed several seemingly typical reflexive questions and I particularly focused on two of them to address my reflexivity: "What is my power relationship with the people I am researching?" and "Am I researching *with* or *on* people (italic in original)?" (p. 11). In the process of conducting this study, I had multiple self-identities including being a Taiwanese middle-class female, a former kindergarten intern teacher, a former volunteer at the research site, a current early childhood education graduate student, an unmarried female, and so forth. These different identities affected how I saw and how I interpreted the phenomena as well as how I interacted with the participants.

As a former kindergarten teacher and a current doctoral student in early childhood education, I was aware of the power issues that emerged in the observations and/or in parents' interviews. Although I learned how to "teach" science and how young children "should learn" science in particular ways, I reminded myself of not criticizing or judging their beliefs—even though those beliefs sometimes contradicted what I believe. Additionally, I reminded myself that my role was not only a researcher but also a learner—learning these parents' beliefs and their interactions with their children. Hence, when analyzing both observation and interview data, I kept asking myself if I let my professional background become a barrier in the process. Finally, as an unmarried female, I was prepared for any tensions and/or challenges from my participants regarding child rearing, learning, and/or development. For example, Pei's mother pointed out that " You will know better when you become a mom someday" (Pei's mother, interview#1).

**Trustworthiness**

Creswell and Miller (2000) suggested a researcher to decide which strategy to use to address the trustworthiness (Lincoln & Guba, 1985) by the lens s/he used and his/her paradigm assumptions. By *lens* Creswell and Miller meant different viewpoints. Since the purpose of this study was trying to understand parents' beliefs about their children's science learning, I primarily used the lens of my study participants.

In achieving this goal, I adopted Richardson's (1997) idea of crystallization. This idea highlights the importance of offering my participants more chances to make their voices to be heard. More specifically, I, as a researcher, only reported and interpreted what I saw from my lens. My participants, on the contrary, might have their own interpretation of what happened. As Richardson (1994) noted, "Crystals are prisms that reflect externalities and refract within themselves. …What we see depends on our angle of repose" (Richardson, 1994, p. 522). Hence, the strategy I used was to employ the reflective-video technique in the in-depth interviews. Rather than merely asking participants to "check" my interpretation, such a strategy not only "invite[d] perspectives other than that of the researcher's" (Dockser, 1989, p. 77), but also empowered my participants in the study. For example, Ying's father corrected my initial assumption that his lingering was in fact a behavior of finding something interesting for his daughters (Ying's parents, reflection session). In addition to the reflection session, as part of the member checking process (Lincoln & Guba, 1985), I member checked with these parents the beliefs I had identified by asking them ""I think you believe X…Do I understand it correctly?"

I also used the lens of people external to this present study (Creswell & Miller, 2000) because the potential readers of this study might include parents who have similar or different science learning beliefs, practitioners who want to know parents' science learning beliefs, and others who interested in this topic. Therefore, in Kai's and Pei's visits, one assistant who has a master degree in early childhood education went to the visits with me. I also invited this assistant to watch Lily's video with me to discuss our interpretations of Lily and her mother's interactions. Additionally, I shared the initial drafts with two professors whose specialties included early science learning, children's play, and family interaction, to gain a better idea of how to interpret the data.

Lastly, several strategies such as addressing my positionality and reflexivity (England, 1994), prolonged engagement in the field, providing thick and rich description to the readers were employed (Creswell & Miller, 2000). For instance, I described how I situated myself in this study and how my backgrounds and experiences influenced my positions in my positionality. I also explained the issue of power or possible inequity between my participants and me in the section of reflexivity. Second, I took pains to build a trust relationship with my participant through my prolonged engagement in the field. This enabled my participants to feel more comfortable for revealing their beliefs. Finally, I described my findings as detail as I could to make my potential readers to experience and assess the similarities and difference between my study and them through my description.

# Chapter 4 How parents perceived their children's science learning

## How I am going to report the findings

This study was designed to answer two questions: 1) How do parents perceive their children's science learning? and 2) How are these beliefs reflected in their interactions with their children in science museum visits? The findings presented in this chapter focus on answering the first question, to show the complexity of parents' science learning beliefs. In the next chapter, I will describe how these beliefs manifested in their family science museum visits.

"Flowers in a garden" is the metaphor I use to structure my findings of how these nine Taiwanese parents perceived their children's science learning. I view each parent's beliefs as a flower. Just as flowers share some commonalities, four main themes emerged from the data I gathered: 1) Parents' gendered science beliefs, 2) Parents' perceived importance of science learning, 3) Parents' beliefs about how science learning should proceed, and 4) Parents' beliefs about their engagement in science learning. Yet even flowers of the same kind will have features that make each unique and special. Hence, each main theme contains individual sub-themes. Each major theme is visible in all eight families. The sub-themes, however, vary among the families.

In line with the theoretical framework I outlined earlier, data were analyzed through Vygotsky's work to answer the research questions. As Vygotsky (1978) noted, humans develop in context rather than in a vacuum. To continue the metaphor, the garden itself is a social context, and its flowers are nourished by the soil, just as parents' beliefs about science learning are influenced by the cultural context.

By structuring and presenting my findings in this way, this study not only aids early educators in better understanding how to integrate these perspectives into their curricula and teaching practices, but it also reminds early educators that each parent might perceive their children's science learning differently.

While I divide this chapter into several sections to capture the whole picture of parents' science learning beliefs, it should be noted that parents' beliefs about different aspects of science learning are intertwined together, just as a garden is a complex ecological system in which all creatures are interdependent.

**A snapshot of school science education in Taiwan**

When addressing their beliefs, these nine parents sometimes brought up their school science learning experiences to explain why they held a specific viewpoint. For example, they pointed out the school science education they received was boring, so they particularly stressed that science learning should be fun and interesting. Additionally, some terms they used (e.g., "natural science group") might be unfamiliar to those who have not been educated in the Taiwanese context. Thus, in the following, I provide a snapshot of school science education in Taiwan.

**Kindergarten.** Early childhood education (including childcare/nursery schools and kindergartens) is not part of compulsory education in Taiwan, and is therefore not strictly governed by centralized curriculum standards and guidelines. Still, the Ministry of Education has established a curriculum framework for kindergarteners in Taiwan (the 6$^{th}$ edition, the Taiwanese Ministry of Education, 2011), which clearly points out six main content areas for kindergarteners: 1) body movement, 2) literacy, 3) cognition (including science and math), 4) socio-cultural knowledge, 5) emotion, and 6) art and aesthetics. In Taiwan, kindergarten teachers have freedom in choosing what they want to teach and how long they want to explore a topic with their students. For example, one teacher might decide to focus on exploring the topic of dinosaurs for a whole semester, while another teacher might explore three different topics in one term. When designing the curriculum or the lesson plan, however, teachers are encouraged to balance children's learning among these six content areas (Tsai, 2004). For instance, a teacher might design an activity called “cooking for dinosaurs” as a springboard to let her students further investigate knowledge about dinosaurs. Such an activity might include literacy (e.g., designing cookbooks), socio-cultural knowledge (e.g., how do different families cook?), and cognition (e.g., how does the fern we are going to cook smell?).

**Elementary school.** When parents in this study were in elementary schools, learning areas included Mandarin Chinese, math, science, social science (i.e., local and world history and geography), health education, art, music, and ethics.

Curriculum reform began in 2001, and from that point, learning areas for Taiwanese elementary school students have included Mandarin Chinese, native languages (i.e., Taiwanese, Hakka dialect, indigenous languages), English, math, social science (again, local and world history and geography), science and technology, art and the humanities, health and physical education, and integrated activities (i.e., scouting, life education, and related issues).

In terms of science education in elementary school, not only the name has been changed. According to the Ministry of Education in Taiwan, science and technology courses should emphasize students’ abilities in applying scientific knowledge, problem-solving capacity, and independent thinking. Also stressed is the idea that science learning should occur through hands-on and inquiry-based activities. The standards for science learning, then, have shifted since these parents were themselves students.

**Junior high school and senior high school.** Taiwanese students are divided into two groups, social science majors and natural science majors, based on their aspirations at their second year in senior high school (the equivalent of $11^{th}$ grade in the U.S.). A student can change his or her choice if s/he wants, but very few students will do so. If a student chooses the “social science group,” s/he only needs to study Mandarin Chinese, English, mathematics, history, and geography. Among these subjects, Mandarin Chinese, English, and mathematics are titled "common subjects," which means students must study these three subjects regardless of their group. Students in the "natural science group" only study physics, chemistry, biology (which is optional), and the three common subjects. However, the level of mathematics difficulty between these two groups differs. In the University Entrance Exam, Taiwanese high school students are tested on those subject matters they study within their own group. Social science majors, then will not need to take physics, chemistry, or biology exams. In the end, a student's formal access to science ends at the senior year of high school.

The above overview of Taiwanese school science education is intended to offer a background understanding of the context where these parents were educated. In the following, I will begin to describe these parents' beliefs about their children's science learning.

**Parents' gendered science beliefs**

Gender is an important issue in science learning and education. The relationships of gender to achievement in science (e.g., Kotte, 1992; Manning, 1998), learners' attitudes towards science (e.g., Jones, Howe, & Rua, 2000; Weinburgh, 2006), and learners' views about science (e.g., Miller, Blessing, & Schwartz, 2006) have been examined. Some researchers have specifically examined how gender influences the ways parents interact with their children in science learning and activities (e.g., Crowley, 2000; Jacobs & Bleeker, 2004; Tenenbaum & Leaper, 2003; Tenenbaum, Snow, Roach, & Kurland, 2005). For example, Crowley et al. (2001) found parents were three times more likely to explain science to boys than to girls while using interactive science exhibits in a museum.

Kahle and Meece (1994) reviewed the research on gender and science education from the 1970s through the early 1990s and identified the individual, sociocultural, family, and educational variables that contribute to gender differences in science achievement and participation. According to Jewett (1996), the perceptions, behavior, and expectations of parents, teachers and peers can discourage girls from science in subtle ways and lead to less interest in science. Both studies reveal that parents are one crucial factor in shaping whether one's gender influences his or her success in science. Since the family is the most direct influence on a child (Bronfenbrenner, 1979), it is necessary to discuss parents' beliefs about gender and science learning.

Based on the data, I first present what gender looks like in these parents' beliefs when speaking of science. Then, I discuss the parental belief that a child's interest in science outweighs their gender.

**Boy's science? Changing beliefs about gender and science learning.** Gender is a social construct. When parental beliefs are conveyed in social interactions with their children, the parents' internalization of cultural values is unintentionally passed on (Schroeder, Graham, McKeough, Stock, & Palmer, 2010, p. 228). Mothers interviewed indicated that biases in Taiwanese culture, or even Asian society at large, meant they were expected to choose specific majors or jobs that were "more appropriate for girls"—almost none of them related to STEM fields (Ying's mother, interview#1; Yen's mother, interview#1; Wei's mother, interview#1). By explicitly or implicitly accessing the idea of "what is proper for girls" in Taiwanese society (such as being an elementary school teacher) through daily interaction with their own parents and relatives, many of these parents learned the expectations of what boys and girls should study and choose as their careers.

Growing up in this cultural context shaped parents' perceptions of gendered-science stereotypes. Jay's mother and Wei's mother were two parents who showed an explicit belief in men's advantages in learning science. Jay's mother, who admitted being afraid to learn science, revealed her fixed impressions of men's inherent scientific capacities through claims such as "men inherently stress evidence," "men inherently perform better than women in terms of science," and "I just think men are naturally more talented in science," while she thought women "do not understand science at all except for those who are especially good at it" (Jay's mother, interview#1 & 2). Wei's mother, who changed her major from chemistry to business administration, had concerns about girls' scientific disadvantages based on her friends' experiences and her own ideas. She believed that unless a girl performs exceptionally well, it's not easy for her to find a job in STEM-fields (Wei's mother, interview#1).

However, as Wei's mother recognized, "The whole environment is changing; you have no choice but to follow the change" (Wei's mother, interview#1). Wei's mother, who was the eldest parent in this study, accepts this new trend with reluctance. Still, most parents in this study seemed to have started perceiving gender in science learning in a different manner. Most parents did not believe boys were innately suited for learning science. Also, they did not insist that boys should show more passion in science or perform better than girls do. Even though Jay's mother and Wei's mother believed males have better ability in science, they did not want to impose such a belief on their children.

This is different from the research of Andre et al. (1999), which found that parents expected boys to perform better in science than they did girls, both in early (K-3) and older grades (4-6). They also found science was perceived to be more important for boys than girls in both groups. Parents in the current study, however, believed science to be equally important for girls and boys. I will elaborate on this finding in later sections.

These parents offered instances to underpin their beliefs regarding science as not specifically limited to one gender. These examples of non-traditional gender images may come from daily life and the external environment, such as a female motorcycle mechanic (Yen's mother, interview#1), or come from their own or relatives' experiences, as in Ying's two aunts, who had both majored in industrial engineering (Ying's parents, interview#1). Yen's mother, who noticed that Yen's younger brother Wen liked to play with dolls instead of toy cars, used Jason Wu's success in fashion design[12] to illustrate her belief that boys can succeed outside of STEM-related fields. She continued, "That doesn't matter. That only means he has a different interest. I'll let him develop whatever he is really interested in" (Yen mother, interview#1). Such nontraditional images of what girls and boys can or should do among parents led them to think in alternative ways. Jay's mother also used the example of Jason Wu playing with Barbie to show how not every boy is interested in science (Jay's mother, interview#1). Famous examples, such as Jason Wu's non-traditional choices and his great success, opened up the possibility of believing there is no specific route for either boys or girls.

While parents did not show a belief in the determinative influence of gender on their children's science learning as their own parents did, they did not fully deny the weight of gender, likely because they were raised in such a cultural context. While Wei's mother, who had a stronger concern about girls being disadvantaged in science, claimed that she did not agree with expecting children to learn anything in particular only because of their gender, she also emphasized, "I will share my experiences with my daughters as well as tell them the current and future economic situation to give them some references" (Wei's mother, interview#1). Similarly, although Ying's mother believed there were other reasons for not associating gender with science learning and used her sisters-in-law's experience to support her claim, in her analysis of why Ying's aunts chose to major in industrial engineering, the long-lasting influence of gender stereotypes was still evident. She said, "I think they were very suited for that was because their grades in Mandarin

[12] Jason Wu is a Taiwanese-Canadian fashion designer.

Chinese, history and geography were, well, you know" (Ying's parents, interview#1). The incompleteness in this response reveals that Ying's mother might still believe that girls should do well in some specific subjects. If they failed like Ying's two aunts did, then they have no choice but to choose majors from science-related fields. These mothers' statements might point out parents' struggles in believing something different from what they received from their own parents, as well as the contexts in which they grew up.

**The positive role of gender.** Gender, on the other hand, seemed to play a positive role when these parents talked about their beliefs about gender and science learning. Yen's mother, for instance, convinced herself to not deprive her sons of opportunities to learn science because of her low interest in science; since they probably would like science, she needed to expose them to this learning. She noted, "They might possibly have an interest in these [science] things" (Yen's mother, interview#1). Therefore, even though she did not have a strong interest in science herself, her awareness of boys' potential interest in science made her believe that she needed to provide diverse science-related experiences to her sons, rather then let her own lack of interest limit her sons' access to learning science.

Chun's father being careful about gender is also good evidence. Chun's father, who read research papers regarding gender stereotypes because of his work, emphasized,

> *Maybe because I have read those kinds of studies, I would remind myself that I shouldn't have that kind of stereotype. ……. So, I always pay particular attention to this idea. (Chun's father, interview#1)*

Similar to Yen's mother, Chun's father would be more careful about the gender issue and not associate his two boys with traditional gender-science stereotypes—his sons might like science, or not, but either inclination was fine.

Combined, gender motivates these parents to reflect on what this construct means to them. Such self-consciousness in turn prompts parents to be more alert to what they need to prepare for, or what they might need to offer their children.

**Children's interests are more important than their gender.** Even with an apparent gender bias among some of these families, the more significant question to investigate is: what really matters about these parents' beliefs when speaking of their children's science learning? The quotation from Yen's mother might provide some hint. She said, "It is not to say girls are definitely doing bad in this aspect…But whether you have interest in that really matters" (Yen's mother, interview#1). In this passage, what Yen's mother appears to believe could also be found in other parents' beliefs (e.g., Jay's mother, Pei's mother, Ying's parents): interest in science is a more important determinant of a child's science learning than is gender.

As mentioned earlier, Yen's mother was expected by her father to choose her major from business-related fields because "this is appropriate for a girl" (Yen's mother, interview#1). Although her father finally made a concession and let her choose what she was truly interested in, Yen's mother felt arguing with her father was a great pain, even though she acknowledged that her father's actions were "for her own good." She felt her interests were not taken into account at first. Hence, she believed, "I think they just go straight to what they are interested in" (Yen's mother, interview#1). Although she has two sons, she did not attempt to deliberately push Yen and his younger brother to put more effort in science simply due to traditional, gendered science stereotypes.

Kai's mother and Chun's father both pointed out each child is a unique individual (Kai's mother, interview#1; Chun's father, interview#1). This belief weakens the power of viewing a child's science learning from a dichotomous perspective of gender/sex. Instead, these parents indicated that children's individual interests are much more important and should be valued. As Jay's mother stated,

> *No, I don't feel that he must go in the direction of science. He will be in huge pain if he is not interested in that. If he feels interested in literacy or social science, but I force him to choose science, that doesn't make any sense. Why should I keep forcing him to do that?*

She added,

> *In those education theories I learned, they all pointed out that we needed to let children develop their own interests. So, I don't think I need to encourage him to develop an interest in science only because he is a boy. I think his learning should be balanced. I'll cultivate his interest if he is really interested in that aspect (science). (Jay's mother, interview#2)*

Her explanation illuminates that a child, especially a boy, should not be forced to learn science only based on the seeming gender "advantages." Ultimately, his/her interest in science is the key factor in deciding how much s/he should become involved in it. Lily's mother below pointed out a similar idea:

> *I don't think they should learn anything in particular only because of their gender. Anything proper is fine. I let them (Lily and her younger sister Nana) try whatever they have interest in. (Lily's mother, interview#1)*

In another quotation, Lily's mother also stressed, "The most important thing in science learning is 'they want to know'" (Lily's mother, interview#2). These claims all indicate that whether children are interested in science is the central emphasis in these parents' beliefs. In his first interview, Ying's father said he was injured in one science experiment when he was in high school. However, because he enjoyed science and liked it, he said he would not let this negative experience stop him from learning science (Ying's parents, interview#1). This example might show how his interest in science, not his gender, supported him in continuing to learn science regardless of an unpleasant incident.

In line with this idea, Pei's mother used the example of Jeremy Lin's persistence of playing basketball; no matter how tough the situation was, to strengthen her belief in the importance of interest rather than gender in learning science. She said:

> *Any kind of learning requires interest. Without interest, um, if Jeremy Lin feels playing basketball is boring, will he continue his practices? When he encounters*

*difficulties, will he try to make a breakthrough? So, in terms of children's learning in science, I think the most important thing is to elicit their aspiration to learn. (Pei's mother, interview#2)*

If a child is interested in one thing, then s/he will try his/her best to learn and to conquer difficulties. The examples given by Ying's father and Pei's mother support this claim. In contrast, if a child is expected to learn it because of his/her gender "advantages," it might be difficult for him/her to persist.

These parents' beliefs reveal that gender is not the main factor in science learning. Parents appeared to take steps to ensure they would not encourage or discourage their children's interest in science simply because of the child's gender. Whether children have an interest in science or not appears to be more critical for how these parents fostered their children's science learning.

**Parents' perceived importance of science learning**

In the last section, I indicated that these nine parents generally believed science was equally important for boys and girls. In this section, I focus on discussing why parents believe science is important for their children. I begin by presenting parents' beliefs in the various values of science learning. Then, I compare these nine parents' beliefs in the importance of science learning to those held by their own parents. I will use Bourdieu's construct of cultural capital to discuss the differences, thereby understanding this generation's Macro-system values of early science learning (Bronfenbrenner, 1979). Lastly, I extend several researchers' (Chen & Chen, 2006; Musun-Miller & Blevins-Knabe, 1998) findings to discuss why these parents both believe that science learning was not their first priority, and that science learning is important.

**Parents' beliefs in various values of science learning.** The most common and direct value these parents found in science learning is gaining scientific knowledge. Nevertheless, they believed science learning was important for their children not only in terms of gaining content knowledge, but also because they believed science learning permits their children to obtain broader skills and cultivate positive attitudes towards trying new things.

***Cognitive and affective values.*** In discussing whether science should be taught in early childhood, Eshach and Fried (2005) listed six assertions to support their claims. The values of science learning described by parents in this study are especially close to three of them: 1) children can reason scientifically, 2) science is an efficient means for developing scientific thinking, and 3) exposing students to science develops positive attitudes towards science (p. 333). Based on parents' responses, I view the first two as cognitive values and the last as an affective value.

Yen's mother, for example, deeply believed the primary advantage of learning science was that it provided a platform for Yen and his younger brother to develop logical thinking abilities. She said:

> *The logical thinking ability can be employed in your daily life. …..It will be very helpful for your future. Because you have better logical thinking ability, you will learn more quickly even though that's not science. (Yen's mother, interview#1)*

In her beliefs, her sons first obtained this ability through science and science-related activities (e.g., playing with LEGOs), but this ability could then be applied to numerous domains—even watching movies requires it (Yen's mother, interview#1). In other words, science learning is valuable because it enables her sons to gradually develop reasoning skills.

Jay's mother talked about the value of science learning slightly differently. She stated, "He will know there are various ways to do one thing from these science activities"

(Jay's mother, interview#2). Even though sometimes Jay only conducted very simple experiments, such as trying to find out how to make a ball roll faster, Jay's mother believed Jay could still gain an idea that problems can be approached from multiple perspectives and tackled through numerous methods, even while he might be unable to explain the principles of phenomena he saw in the experiment.

While Yen's and Jay's mothers valued science learning in terms of gaining certain skills, some parents valued science learning from an attitudinal aspect. For example, Pei's mother shared her belief that science learning enabled children to be more open-minded to various things:

> *I believe these things (science explorations) would become a foundation for their future science learning. Also, they won't reject it. They will generate interest in it. These explorations, on the contrary, might be a foundation for their scientific pursuits in the future. Even though they might not be interested in science, they will be, um, a person who easily feels happy. Having these explorations are not for pushing them to become a scientist; rather, it is for having them seeing the endless pleasure in their daily lives. (Pei's mother, interview#1)*

Since Pei and Ming were exposed to science experiences, they gained a positive attitude toward all kinds of possibilities. Likewise, in reviewing her childhood experiences with the natural environment, for example, catching butterflies or cicadas, Wei's mother, like Pei's mother, foregrounded the attitudinal values she found in her former experiences. "Of course these made me have less fear in science," she said. "You made contact with these [creatures] and that made you fearless" (Wei's mother, interview#1). Wei's mother not only felt fearless of science, but she also thought the attitudes gained from her early science learning experiences made her less fearful in new situations. She was also more willing to try new things (Wei's mother, interview#1). Both mothers' beliefs are close to what Abruscato (1999) and Brunkhost (1991) argued: that children's positive attitudes towards science make them more willing to continue exploring and gaining knowledge about the world, even after they leave schools.

> To conclude, Christie (1994) and Glickman (1984) explain that:
> *Allowing children to play around with science does not necessarily improve academic achievement, but may be a key to improved attitude, problem solving ability, creativity, and self-initiation. (cited in Jarrett, 1998, p. 182)*

Be it skills or attitudes, these parents appeared to believe that science learning laid an important foundation for their children's learning, related or unrelated to science. These parents' beliefs in the various values of science learning mirrors Halverson's (2007) argument that "these skills, attitudes, and ways of thinking are important to many areas of learning through life."

***Preparing for future learning is not the main value of science learning.*** When addressing their beliefs in the values of science learning, the word "future" was often mentioned (e.g., "I believed these things would become a foundation for their future science learning"). Although parents believed learning science could benefit their children in the future, they did not view science learning from a utilitarian perspective. To be more specific, they thought their children needed this learning because, as Wei's mother highlighted, "You don't know when you will use this" (Wei's mother, interview#1). She added,

> *I won't tell my children "you have to learn this, you have to learn that." Because this is very invisible, really, you don't know when you will use this. So, you just try your best to try different things. After you had these experiences, next time when you encounter [these things] you will have a foundation for knowing what to do. (Wei's mother, interview#1)*

This statement might suggest that these parents did not view science learning as having any specific purpose or as preparation for their children's future learning and achievements. For example, Yen's mother has been taking her children to a private science class called "Sky and Grass" for about two years. At first I assumed the family attended such classes because Yen's mother believed it was preparation for future academic achievement, yet as she explained:

> *I could catch a cockchafer without any effort when I was a kid, but it's very difficult for you to see cockchafers today. So, by attending the course, I hope they can see those interesting things I saw in my childhood. At least when they see a cockchafer they won't name it incorrectly. Many kids probably see a cockchafer and think that is a bigger ladybug. (Yen's mother, interview#2)*

Rather than expecting her sons to obtain extra knowledge about insects so they could learn faster than other children, she pointed out that the primary purpose of the class was to let them have a joyful experience. Yen's mother continued,

> *So, if this (attending the science class) is only for their future and makes them feel so painful, then quit it, I think. …I'm not doing this for their future. But if this triggers their interests in science, I won't reject it. (Yen's mother, interview#2)*

Yen's mother shared an example of how her relatives, who believed in the importance of math, did not allow her son to give up on attending a private math learning class (Yen's mother, interview#1). Yen's mother showed a totally different belief from her relatives in this quotation. Although she believed science was important for her sons and she was happy if her boys wanted to engage in science because of attending this class, this was not the original or main reason that she took them to this class.

In summary, rather than saying parents believed science learning was important because it could prepare their children well for future learning or academic achievement, the above examples reflect parents' beliefs in the long-term effects of science learning, such as serving as a foundation for understanding when encountering similar situations.

**The perceived importance of science learning between two generations: what has changed?.** As pointed out in the last section, parents in this study valued science learning in a variety of ways, and they believed this learning was necessary for their children because it benefited them in an implicit or explicit manner. Their beliefs in the importance of science learning reflected on their willingness to trade their economic capital to cultural capital (Bourdieu, 1984), including tangible household educational resources (Roscigno & Ainsworth-Darnell, 1999) and high status cultural signals (Eitle & Eitle, 2002). These families' tangible household educational resources included books (e.g., encyclopedias or picture books with science-related content), science magazines (e.g., *Little Newton Magazine*), science-related toys (blocks, toy excavators, LEGOs), equipment (insect catching kits, terrestrial globes, fish tanks), videos, and electronic devices (iPads, computers, smartphones). Also, frequently bringing their children to museums and other out-of-school settings represented these cultural signals. Yen's mother concluded that "Mothers nowadays are more willing to spend time and money on their children" (Yen's mother, interview#2). Her interpretation appears to reveal modern values of investing in children's science learning (Bronfenbrenner, 1979).

While parents in the past might acknowledge and believe in the importance of their children's schooling, as Wei's mother pointed out, "If we wanted to continue to study, my parents would provide us with financial support" (Wei's mother, interview#2), in the past, Taiwanese parents wholeheartedly concentrated on ensuring their whole family lived well. What they primarily cared about was taking care of children's physical needs. For example, Chun's father, who was raised by his grandparents because his parents were too busy to take care of him, said the only thing his grandparents provided him was to ensure he was safe and healthy (Chun's father, interview#1 & 2).

Therefore, many parents in this study noted their own parents did not have an inclination for bringing them to science museums and other institutions, to create more chances to stimulate or encourage their science learning. As Yen's mother said:

> *My parents were very busy; they might also have work to do on weekends. Unless you were in a wealthy family, you wouldn't have the chance [to go to out-of-school settings]. … The most fabulous places they took us to were department stores or theme parks. And you had to be very quiet and behave very well; you could then possibly have a chance [to go to these two places]. It's really difficult and rarely happened.*

She continued, “They didn’t even have enough time for making money; how could it be possible that they took us to [those out-of-school settings]?” (Yen’s mother, interview#1) According to these parents, in the past, parents expected their children to “take care of their own safety and behave well.” Hence, it is not odd that Yen’s mother would say going to department stores and theme parks was the best reward for children’s good behaviors. However, parents nowadays, like these nine parents, focus more on their children’s science learning and out-of-school experiences. Thus, Pei’s mother took Pei and Ming to the Nantou tea factory, Yen and Wen went to the “Sky and Grass” science course, and Ying’s family went to visit the Hsinchu Museum of Glass. Parents today do not bring their children to such places to praise their “good behaviors.” Rather, parents identified that these experiences were beneficial for their children, and these experiences give their children chances to establish their interests or cultivate their interest in science.

Lastly, even though some of these participants’ parents engaged in science-related occupations (for example, the parents of Jay’s mother engaged in the silkworm business), they rarely shared this knowledge with them (Jay’s mother, interview#1; Yen’s mother, interview#1). In contrast, parents in this study believed science learning offered their children a variety of values, so they were more willing to take time to engage in science-related activities with their children, regardless of whether their occupations were relevant to science or not.

**Science learning is crucial, but it is not the first priority.** While parents believed in the importance of science learning and clearly pointed out a variety of values that their children could gain from it, as Liou (2006) pointed out, “Parents gave different weights to different content areas.” Science, in these parents’ beliefs, was not their first priority. Under this sub-theme, I discuss two sections including “More important areas of learning than science,” and “The child in development” to address why these parents believed science learning is not most important.

***More important areas of learning than science.*** When comparing their statements towards, and in relation to, other content areas, these parents did not prioritize science learning. In this study, the two most-often mentioned areas parents believed were important for their children were reading and social competence (e.g., getting along with others, being well-behaved, being polite, obeying rules).

In this study, parents described how important they believed reading was and the efforts they made to cultivate their children's reading habits (e.g., Chun's father, interview#1; Lily's mother, interview#1 & 2; Ying's parents, interview#1). This shared belief in the importance of reading is similar to the findings of Musun-Miller and Blevins-Knabe (1998), yet different from what was found by Knudsen-Lindauer and Harris (1989). Musun-Miller and Blevins-Knabe (1998) explained that this different result might be because parents in Knudsen-Lindauer and Harris (1989) did not see reading as a main prerequisite for the kindergarten curriculum, but they did see it as of major importance when looking ahead to the first grade curriculum. While parents in this study did not specify that reading prepared their children for first grade, these parents' prioritization of reading over science learning might result from their belief that reading is a good way for children to recognize Chinese characters, which is usually seen as beneficial for pupils in Taiwan. More to the point, when their children gain more Chinese characters through reading, it opens a door for them to obtain all kinds of knowledge, such as scientific knowledge.

In terms of social competence, Wei's mother, for example, emphasized many times in her two interviews how deeply she cared about Wei and his two older sisters' good behavior. Similar emphasis was also found in other parents' interviews (e.g., Pei's mother, interview#1 & 2; Yen's mother, interview#2). Parents' prioritizing social competence in this study is not unique. In an examination of Taiwanese parents' beliefs about teaching young children to learn numbers and operations, Chen and Chen (2006) found that 24 out of 30 parents either identified social skills, emotion regulation, or self-help abilities as the most essential objectives in kindergarten. Other Taiwanese scholars such as Lin and Wang (1995), Wang (1997), and Liou (2001; 2006) found similar phenomena. Liou's (2006) interpretation of this common result was that this reflected the influence of traditional cultural values in Taiwan. There is a Chinese saying that reads "You Er Yang Shing," meaning that cultivating children's personalities when they are very young is critically important. This might explain why most parents in this study believed social competence was more important than science.

***The child in development.*** Although parents in this study recognized the necessity of science learning, in these parents' beliefs, children should not stress any one specific content area in their early years.

> *Yes, [science] should be taught in kindergarten, because learning in every field/domain should be balanced. (Jay's mother, interview#2)*
>
> *At least [I think] there are some academic requirements for them no matter what kind of interest they have. They still need to acquire basic knowledge. (Ying's parents, interview#1)*

What Jay's mother pointed out reveals her belief that young children need a balance of opportunities for different kinds of learning—including science and other areas. As explained earlier, Taiwanese students are divided into either social science or natural science majors in senior high school. Before that, students need to learn history, geography, Mandarin Chinese, science, math, music, and so on. Jay's mother used this as an example to explain why she believed it was improper to pay particular attention only to science learning. She asked, "Doesn't that mean our learning should be balanced when we are young?" (Jay's mother, interview#2).

Similarly, what Ying's father said above highlights the breadth of Ying and Ting's learning as more important. Ying's father then explained that focusing particularly on a specific domain, in this case, science, the case was not "the earlier, the better" (Ying's father, interview#2). If a child's learning is limited to a specific domain, it might ruin the breadth of their learning and may destroy their potential interest in areas other than science. He continued, "No matter what kind of learning it is, I think it's important to keep their interest. That is, to make sure that they won't reject any kind of learning" (Ying's parents, interview#2). In fact, Ying's father indicated that his daughters should access all kinds of things throughout their lives. Being open to all possible choices would maintain their children's love of learning and give them opportunities of finding out their true interests.

Besides, while parents knew very well about their children's current interests – for example, Yen's mother found her sons were very interested in insects – they believed their children were still developing. To be specific, their children were exploring all kinds of possibilities and their current interests might change later on. Pei's mother gave a real-life example about her twins to support this belief. Pei and her younger brother Ming have played with toy excavators together for a period of time. They came up with a variety of ways to play with the toy excavators; for example, they used screwdrivers to disassemble the toy excavators, then put them back together. However, as Pei's mother observed, Pei's interest in it gradually faded away after doing this for a while. Pei's mother noted, "Ming continued to invite Pei to play with him, but Pei did not want to. Pei felt she didn't want to play this anymore but Ming still had great interest in it" (Pei's mother, interview#1). Therefore, even though their children showed great interest or potential in learning science, parents believed that they should not focus only on science. Rather, they tended to believe that every area deserves the same attention.

Likewise, while Chun's father observed his firstborn's excellent visual-spatial abilities, he stated, "True, he is talented. But this is not the time to lead them to a specific direction, they still need all kinds of experiences" (Chun's father, interview#1). Ying's father, who noticed how differently his two daughters expressed interest in science, noted, "But it's really hard to say. It's hard to say what will happen in the future because they are still very young. It is our observation that Ying is more suitable for learning science than Ting. But it's hard to say if Ting will change when she is older" (Ying's father, interview#1). According to both fathers' observations of their children's current interest in science, in parents' beliefs, there was no need to limit children's interests to any specific domain. Even though parents saw evidence of their children's interest and/or potential in science, they tended to believe it was better to wait and see how their children's interests evolved.

Therefore, instead of intentionally pushing their children toward science, parents tended to believe that they should give their children diverse experiences and continuously observe how their children's "true interests" emerge through activities. This belief could be seen in the following examples:

> *It should say that we take them to experience various things at this stage. After they have these experiences, they might feel 'Hey mom, it's really interesting!' If they want to continue learning [in a specific domain], we can then go in that direction. (Ying's mother, interview#2)*

> *I'm still trying to understand their characteristics and personalities. It's meaningless forcing them to do something they are not suitable for. (Yen's mother, interview#1)*

Additionally, because parents believed their children were still developing, even though their children might appear disadvantaged in science learning at this point, parents did not worry very much. For instance, Chun's father noticed a huge gap between Chun and his older brother's visual-spatial ability yet believed, "Maybe we need to wait until

Chun is older. Can we say his older brother's spatial ability will still be as good as it is now in the future? Actually I don't know, because intelligence will continue to develop" (Chun's father, interview#1).

In short, parents in this study believe in the importance of science learning and are more willing to support this learning by taking children to various places or providing them with all kinds of materials. Nevertheless, because they know their children are still developing, they believe their children should cover every aspect and continue discovering what they really like.

**Parents' beliefs about how science learning should proceed**

Current discourses on how young children should learn science advocate for learning science through doing it (Brunkhorst, 1991; Gelman & Brenneman, 2004). Additionally, as Cook, Goodman, and Schulz (2011) and Gordon and Browne (2007) addressed, science learning should take place through play and be integrated into other areas (e.g., music, art, math). Science is better learned through inquiry-based activities (Minner, Levy, & Century, 2010; Worth & Grollman, 2003; Wu & Hsieh, 2006). However, these are suggestions from researchers' or teachers' perspectives. Thus, in this section, I will present parents' beliefs about approaches of learning science, means for science learning, and the extent to which their children should learn science, to discuss how these parents believed their children's science learning should proceed.

**Approaches of learning science.** I found four approaches of how children should learn science, including ideas that 1) science learning should be interesting and fun, 2) children should learn science with little or no pressure, 3) science learning should be relevant to life, and 4) science learning is more adult-oriented than child-oriented. Each approach reflects how these parents characterize early science learning.

***Science learning should be interesting and fun.*** When reviewing their own school science learning experience, parents who described science with negative terms or phrases such as “I didn’t understand it at all,” “boring,” “fear,” and “unfamiliar language” usually did not want to engage in science-related activities or learning. Those who identified science learning as fun wanted to keep accessing science even though they might encounter frustration. Jarrett (1998) pointed out that teachers who believe that science is serious, boring, and difficult are not likely to involve their students in the fun of scientific inquiry (p. 182). In this study, however, no matter how positive or negative these parents’ personal science learning experiences were, they all believed their children’s science learning should be fun and interesting. This approach could be explored through two aspects, materials and methods.

*Materials*. Jay’s mother, who showed strong negativity towards science, particularly acknowledged that Jay’s learning in science should take place through interesting means. When I interviewed Jay’s mother at their home, she read me one picture book about why kangaroos have a “pocket” (i.e., their pouch). This story starts with statements such as “They have pockets because they need a place to store their toys” to elicit children’s interest and curiosity. After several childlike assumptions, it discloses the real reason at the end of the story. Jay and his mother could have some interesting interactions with each other and the book. Jay’s mother then noted, “If it is interesting, um, if the science books are interesting like this and very easy, I will buy them for Jay” (Jay’s mother, interview#2).

Jay’s mother felt the ways she learned science were boring, so she chose books or videos based on one reason: they introduced science content in interesting forms, such as how the picture book introduced knowledge about kangaroos. More specifically, she believed the materials she offered her son needed to be interesting so he would want to learn something from them. Similarly, Ying's father chose "interesting exhibits" for Ying and Ting, and guided his daughters through them in their museum visits. As he claimed, when he "felt something was interesting," he would guide them to "take a look" (Ying's parents, interview#2). This also demonstrates his belief that materials introducing science to his daughters needs to be fun and interesting.

*Methods*. Yen's mother held a belief that was slightly different from these two parents. To be specific, she stressed that methods for learning science, as opposed to materials, should be interesting and fun. As stated, her two sons have attended the "Sky and Grass" science class for about two years. She believed the class was appropriate for Yen and Wen because it "tells them these very interesting things and let them obtain some special knowledge from these interesting things" (Yen's mother, interview#2). More specifically, the teacher taught these children science in an interesting way, so Yen and Wen could naturally learn science through fun activities, such as "shaking hands with butterflies (i.e., touch butterflies' mouthparts) or catching butterflies (Yen's mother, interview#1).

Be it materials or methods, these parents believed this approach would increase their children's interest and excitement for science. These parents believed in Trumbull's (1990) warning, that "Young children's curiosity can be stifled if schools take the fun and interest out of science" (cited in Jarrett, 1998, p. 181). Thus, the science-related experiences they provided for their children were full of fun. For example, Chun's family went to the train station to observe trains; Pei's family went to the flower market regularly and Pei and Ming could choose their own potted plants. Wei's mother, Wei, and his two older sisters used various materials to create different shapes to test whether the bubbles were always round. These activities did not necessarily center on science learning; however, parents would seize chances to relate them to science. For example, when seeing a night heron in a walk on a university campus, Chun's father pointed it out to his sons (Chun's father, interview#2). In their beliefs, science learning being interesting and fun is crucial for their children to find it attractive and enjoyable, and for them to want to learn more.

*The potential uncertainty*. While parents believed that science learning should be fun and interesting, their words also revealed a critical distinction, between simply having fun and learning through fun. Because the learning outcome through an interesting form might not be as visible as through a didactic form, without seeing concrete evidence, these parents sometimes had reservations. As Jay's mother brought up,

> *Well, because it has been a while, I forget what kinds of playground facilities the National Museum of Natural Science has. Perhaps he can learn something about science from those facilities. As for learning science through play, like you said, in terms of those not particularly designed for science, ok, like the slide or swings, can he learn from these facilities? Well, probably he can, but I think that's not cognitive learning. (Jay's mother, interview#2)*

In this quotation, Jay's mother points out this uncertainty. Unless the playground facilities were primarily designed for promoting children's engagement in learning science, she doubted that Jay learned from the equipment. Her elaboration strengthened her point. She told me that the learning Jay gained from playing was "knowing to not walk in front of the swing when there's someone playing on it," "knowing how to use it," or "cultivating his sense of balance" (Jay's mother, interview#2)—that is, learning mainly about playground rules, but not science.

Jay's mother's question, regarding what Jay could learn from playground facilities, is not very unique. Kai's mother, when talking about her family's visit to the Taichung English and Art Museum and the Museum of Glass, was very confused about answering my question, "Did you see any learning/science learning in these visits?" (Kai's mother, interview#2) While Kai's mother shared their experience of seeing their images grow and shrink in one exhibit, called "Alice's mirror," and said they had lots of fun, she concluded, "It seems a bit difficult to say what we learn from the visits. I feel what we gained from the visits was very general. But we really felt these were fun" (Kai's mother, interview#2). Fleer's argument (2009a) below might be helpful to understand this uncertainty. She noted,

> Playful events provide an important conceptual space for the realization of dialectical relations between everyday concepts and scientific concepts—but clearly the 'teacher as mediator' is central. (p. 302)

If these parents want their children to make the most of these play episodes, they might need to be more prepared to articulate the elements of "science" and give them some adequate support. Then, children's play would not be only "for fun."

To conclude, while parents such as Jay's and Kai's mothers expressed uncertainty about the fun and interesting approach, they still believed this was important for learning science. As Pei's mother stressed, "[They] must accumulate something in the process of playing" (Pei's mother, interview#2). Eshach and Fried's (2005) argument might be helpful in understanding her statement:

> Are not children just playing? Yes, they are, but as Vygotsky, among others, has made clear to us, playing is, in fact, very serious business; play is, for Vygotsky, a central locus for the development of relationships between objects, meanings, and imagination (e.g., Vygotsky, 1933/1978). The pleasure children take in nature, in playing, in collecting, in observing, make them, in this way, temperamentally first steps towards the ideas of science. (pp. 319-320)

While Pei's mother did not specify what the "something" was, when children are involved in play and other interesting activities, they might gain scientific knowledge, skills, and/or attitudes.

***Children should learn science with little or no pressure.*** The other important theme in these parents' beliefs is that children should learn science with little or no pressure.

Parents did not eagerly expect their children to quickly gain "something" when they learn science. Rather, their science learning took time and should not be pushed. Additionally, their children should learn science in a way that is emotionally comfortable.

*Science learning takes time*. In one example, Wei' mother shared how Wei's class went to a nearby park to observe cherry trees. She explained that she did not attempt to push Wei to memorize what he learned from the walk:

> *I don't expect him to remember what kind of tree this is. I think it's okay if he can't remember the name of cherry trees. I don't ask him to remember 'this is a cherry tree' only because his teacher has taught him about this and he needs to answer 'it's a cherry tree' when he is asked next time. I feel children are all like this. Maybe you give them more pressure and they might therefore resist it. (Wei's mother, interview#2)*

Wei's mother believed science learning should involve little or no pressure because children's science learning does not always immediately happen. After learning a new idea, in this case the name of a cherry tree, a child might remember or forget it. In her belief, parents should take this as a natural phenomenon and not stress their children out by asking them to instantly understand, absorb, and/or memorize it. Similarly, Pei's mother mentioned she did not expect Pei or Ming to learn a lot from a single science museum visit or a sole activity. In her word, that was too "utilitarian" (Pei's mother, interview#2), meaning that visiting science museums or doing any science-related activities should not merely push her children to achieve a particular goal. Rather, she believed the process of exploration without being rushed was much more important.

Both mothers' statements mirror French's (2004) argument that children's science learning will gradually evolve, so it should not be hurried:

> During their first exposure to one of these events, children may simply be interested and perhaps surprised. During the second exposure, they are creating a richer representation of similarities and differences across the two experiences. After several exposures, they have created a generalized understanding of that particular aspect of "how the world works" in that particular situation and freely make predictions about "what will happen next" or "what will happen if…" (p. 140)

This argument demonstrates children's science learning is a process of progressive construction of understanding. If children are pushed to produce a learning product, such as remembering the name of a new plant, they lose the chance of constructing their own understanding of the things and/or concepts they learn. Moreover, parents believed this approach was necessary because they thought "pushing children too much" was ineffective for learning science. Ying's father stated, "I feel if I force and push them to memorize things, they probably won't have a deep impression" (Ying's parents, interview#2). In fact, it might in turn ruin their children's initial interest in learning science, as Wei's mother suggested: "Maybe you give them more pressure and they might therefore resist it," and "Because I think I shouldn't let them learn [science] under pressure. If I make them feel very stressed, they may probably resist it. If you learn under pressure, um, honestly, who likes pressure?" (Wei's mother, interview#1)

Because parents did not want to produce such results, they seemed to also believe that pushing their children's learning in science was unnecessary. Thus, this approach might sometimes prevent parents from effectively scaffolding their children, because they want neither to frustrate nor put too much pressure on their children. This can be seen in parents' analysis of their roles in their past family science museum visits. For instance, Pei's mother said, "Sometimes I explain the content for them, but I don't always talk [in our visits]. Don't you think that's really tired? Don't my children feel tired? I think [if I had done so] their ears might feel very tired" (Pei's mother, interview#2). While Pei's mother did not use the word "pressure," her words revealed her belief that she should not talk too much to make both Pei and Ming and herself feel overwhelmed. In her belief, if she talked all the time in their visit, Pei and Ming would gain nothing but having their ears suffer from her talking.

*Emotionally comfortable*. Parents provided some empirical evidence from observations of their own or other children's science learning processes to strengthen their belief in this approach. Lily's mother shared her observation of Lily's reaction to discuss why this approach worked:

> I feel this way (no pressure), um, put it simply, it should say she is more suitable *for learning in an easy way. Yeah, easy, when she feels happy she will, um, she will learn something. But if I push her a lot, the effect…I don't force her to memorize, but I feel, um, it looks like I don't have to care about her [learning] too much, then she will be very okay. So, I always use this way, that is, I don't teach her anything in particular. I feel it is better if I don't have an expectation of requesting her to learn anything particular. (Lily's mother, interview#1)*

Lily's mother did not worry very much about how much Lily gained or understood the science content she told Lily, because "When she feels happy she will learn something." No matter what the "something" was, if the science learning was not stressful, Lily's mother believed Lily would learn it cognitively and/or emotionally.

Wei's mother, whose friend's son visited the science museum very frequently and showed great fondness for learning science, explained the boy's behavior in this way:

> *Probably because he doesn't need to learn science under pressure in that setting; when he goes to the science museum, there's no one to request him to do this or do that. This is my personal idea; I never asked him why he likes learning science in particular. (Wei's mother, interview#2)*

Although this assumption was never corroborated by the boy, it reveals why Wei's mother believed that science learning should be accompanied by little or no pressure. When there were no requirements to meet, no procedures to follow, and this boy could basically choose whatever he wanted to learn as well as well as control his learning pace (Piscitelli, Everett, & Weier, 2003), he seemed to enjoy learning science and performed better in school science.

In parents' beliefs, making their children's science learning stressful may cause their children to view this learning in a negative way and in turn not want to engage more in it. Parents in this study believed their children should learn science with little or no pressure, so they could take their time in what they wanted to learn and explore more. Science would be enjoyable for them, instead of something they resist.

***Science learning should be relevant to life.*** Compared to adults, young children are usually viewed as having limited experiences. However, personal experiences in the everyday world laid the foundation for young children's development (French, 1985a, 1985b; Lucariello, Kyratzis, & Nelson, 1992). As such, these parents believed their daily lives are the most relevant resources for learning science because they are meaningful, concrete, and direct.

*Direct, connected, concrete, and meaningful*. When responding to my question "Should science be taught in kindergartens?" Jay's mother responded with "yes." She continued, "I do not think [the teacher] needs to teach them something very difficult, probably teach them things they encounter in their daily lives" (Jay' mother, interview#2). When I asked her about why science learning should start with children's daily lives, she explained:

> *Because I think if you teach them something very difficult, they won't understand. But what a child gains from his daily life experiences is much more direct, isn't it? And what we learned before (the early childhood theories) all tells us that children begin [their learning] with something related to their life. So, why tell him, um, a chemical element? It is not practical and he can't understand it. (Jay's mother, interview#2)*

Just as Jay's mother said above, "What a child gains from his daily life experiences is much more direct." This highlights the parental belief that science learning should start with a child's most immediate environment and experiences, which constitute their daily lives. In line with Jay's mother, Pei's mother pointed out there were rich, meaningful and authentic resources for children to learn science from daily life: children could explore such questions as, why are there typhoons? What is the name of the tree nearby? Why are summer days longer than winter days? How do cicadas produce sound? These are commonly encountered phenomena in children's daily lives, all of which are a good starting point for children to begin their science learning because children directly and personally encountered them.

Parents also believed science learning should be relevant to life because it would not be too abstract or difficult for their children. Children would feel more "connected" to what they learned instead of feeling science learning is far removed from their lives, as in Lily's mother's school science learning experience:

> *Ah, didn't the textbooks introduce plants? I feel I was more connected to that part, um, that part was more relevant to our lives. Because we lived in the countryside and we saw many plants, or we would see more animals, like insects. So I felt more connected to those in the science textbooks. (Lily's mother, interview#1)*

Lily's mother could have direct access to the plants and animals in her everyday life, and therefore felt connected to the content in textbooks. Parents who believed in this approach thought their children should feel the concepts they learn are touchable, close and familiar to them, and easy to understand. Chun's father also shared an example, wherein Chun learned about calories from the ingredient table printed on a juice box. He added, "I think to some degree is that they can find answers from their daily lives. I take that as a kind of reinforcement. If they are reinforced, they will want to know more" (Chun's father, interview#1). This interpretation concurs with Feely's (1994) argument that "unless children see direct relationships between their everyday world and what they learn about science at school, there is little chance that they will go on to further science study or, more importantly, be able to use what they know in their lives" (p. 27). In other words, the opportunities daily life offered Chun and his older brother enabled them to engage in real-life problem solving and motivated them to learn more.

The examples came from Lily's mother and Chun's father explained why these parents believed science learning should be relevant to children's daily lives. In fact, when science learning is decontextualized from everyday life, learners feel alienated from it, and doubt the connection between their science learning and their real lives (Aikenhead, 2006). As a result, they let what they learn stay in textbooks and never engage themselves in actively learning science (Kim, Yoon, Ji, & Song, 2012). Jay's mother demonstrated how the irrelevance between her learning and her real life confused her when she was a student. She repeatedly doubted why she needed to learn science in school because it was "useless" and "meaningless," and she "didn't know how to apply it to life." She asked, "rather than teaching us the Periodic Table of Elements, why not teaching us that we should not use phones when it is thundering?" (Jay's mother, interview#1) Therefore, Jay's mother strongly believed that science learning should, indeed must, be relevant to life. Ying's mother, similarly, was confused about why she needed to learn physics and chemistry, which she identified as "useless" and "not helpful for life at all." Hence, she indicated that "if you want your children to continue their learning, you need to let them feel things they are learning are very relevant to their lives" (Ying's mother, interview#1).

Vygotsky (1987) pointed out that everyday concepts lay the foundations for learning scientific concepts. More to the point, Moll (1992) wrote that:

> It is through the use of everyday concepts that children make sense of the definitions and explanations of scientific concepts; everyday concepts provide the "living knowledge" for the development of scientific concepts. That is, everyday concepts mediate the acquisition of scientific concepts. (p. 10)

What Jay's mother and Ying's mother learned in school did not build upon their "everyday concepts." Thus, they found learning science difficult and disconnected from what they learn. Additionally, both mothers' statements support Reiss's (2000) claim that school science education can only succeed when pupils believe that the science they are being taught is of personal worth to them. (p. 156) Put simply, these two mothers believed it was very important for their children to view science in context. As Cakir (2008) proposed, "Meaningful learning does not occur by throwing more science facts and principles at the students" (p. 202). Instead, "Learning should be meaningful and derive from an authentic context" (Confrey, 1990, cited in Cakir, 2008, p. 198). Learners need to have opportunities to use their experiences and observations as the basis for science learning; then, science will become relevant, stimulating, integrated, and accessible to children.

*The potential concern.* Jay's mother also expressed uncertainty in how much Jay could learn science from daily life—as she intimated when talking about how science learning should be fun and interesting. Jay's science learning should correspond to these approaches, but they did not fully ensure that Jay would learn things related to science.

> *But he seldom has science learning. In his daily life, he goes to school in the morning. After he comes home, we have dinner, and there's nothing related to science when we eat. Then, ok, if he plays with Play-Doh, he only makes some shapes, so there's very little science learning in our daily lives. Okay, when he bathes and rubs the soap to make bubbles, this might be science, but I won't stress on the connection between the times he rubs the soap and making bubbles. Because based on my definition of what science learning is, I feel he needs to think about why you can make bubbles after rubbing the soap. Or we should try to see if we only rub the soap twice, would it generate bubbles? Then we are really learning; we are really analyzing this thing. (Jay's mother, interview#2)*

In this excerpt, Jay's mother viewed their daily lives as a set routine, and it was not easy to make science learning happen unless she purposefully guided Jay to experiment or draw conclusions from things they did in their lives, such as finding out how many times they needed to rub the soap to create bubbles or figuring out why they could make bubbles by rubbing the soap. If they did not do it, it would be "just daily life." Dewey

(1938) stated, “not all experiences are genuinely or equally educative” (p. 13). Such a reminder might reveal that adult guidance and/or intervention is needed to transform these “life experiences” into more valuable “experiences.”

In sum, parents believed their children’s science learning should not be separated from their daily lives. As Pei’s mother argued, “If a child can’t learn things in his/her daily life very well, how deep do you want to teach him/her? Especially about science” (Pei’s mother, interview#1). In constructivism, children’s previous experiences are important and should be valued (Cakir, 2008). Most of these previous experiences come from children’s daily lives and lay a foundation for further learning. Children can build their science learning on top of these experiences and investigate unfamiliar things with people around them, based on what they already have familiarity with. Children could then expand and deepen their science learning and exploration.

***Science learning is more adult-oriented than child-oriented.*** Parents believed science learning should be fun, interesting, low-pressure, and relevant to life, which seems very child-centered. Yet, this does not mean that parents believed science learning should be “child-oriented.” Rather, parents held the belief that their children’s science learning was primarily taken care of by adults.

Based on the data, children’s questions appear to be the most common form of starting their science learning. Nevertheless, when their children asked a science question, parents either directly provided an answer, if they happened to know it, or they found answers for their children. They appeared not to invite or encourage their children to find answers on their own. Many examples revealed this belief, as shown below:

> *Because she already asked the question, I would try to find answers to this question then told her what I found. (Lily’s mother, interview#2)*
>
> *Yeah…they ask questions, so we (Chun’s parents) try our best to find answers for them. If we can’t find, we might go look up the information in books or search for*

*answers online. (Chun's father, interview#1)*

*[When they ask questions], if I know the answers I will tell them. (Kai's mother, interview#2)*

The speakers of these quotes were parents, not their children. Parents believed they should find answers for their children and tell them what they found, but their children are not actively involved in this process—they only posed questions.

In Taiwanese culture, adults tend to ask children to listen to them passively and adults seldom encourage children to ask questions or express their thoughts (Cheng, 2010). A Taiwanese saying reads "Yin Tzai Ren You Er Wu Tzuei," and its underlying meaning is that children should only listen but should not speak or ask. As Jay's mother said, the traditional belief in Taiwan emphasizes children's passive reception of adults' answers—children are only responsible for "listening/receiving." When Jay's mother was little, her parents taught her the silkworms could not access water, yet she did not know why until now, because she only received this idea from her parents. Needless to say, they did not stimulate her to think further about this phenomenon either (Jay's mother, interview#1). Jay's mother therefore wondered, "Is this the main reason that we have fewer scientists here in Taiwan?" (Jay's mother, interview#2) All told, although parents in this study did not ask their children to stop asking questions, according to the above quotations, children were passive receivers of the knowledge their parents told them.

In Vygotsky's words (1978), shared knowledge and meaning are negotiated and co-constructed in socially-mediated, collaborative learning environments (Vygotsky, 1978, 1986). This approach, however, might not emphasize such elements as negotiation and collaboration very much. In fact, learners in a Confucius heritage context such as Taiwan are taught not to question or challenge adults (Wong, 2004). Rather, the "unquestioning acceptance of the knowledge of adults" (Murphy, 1987) is emphasized. This adult-oriented approach might reveal how parents' cultural conceptions of learning influenced their belief that adults' direct telling might be a more appropriate method of supporting children's science learning. As Spizzica (1997) asserted, different cultures value different types of knowledge and skills differently. These nine parents rarely express the belief that they needed to encourage their children to think, make arguments and predictions, compare and contrast, or infer from evidence. Instead, they manifested an emphasis on children's receiving static knowledge from authorities.

In short, parents in this study seemed not to engage their children in a co-constructed process of finding answers to children's science questions. Instead, they believed providing their children an answer or a fact was sufficient. Their belief in this approach might come from deeply rooted patterns of adult/parent-child interaction in the Taiwanese culture (Bronfenbrenner, 1979).

**Means for learning science.** The four approaches outlined above present how these parents characterized science learning. Operationally, these parents believed there were specific means for their children to learn science. All nine parents in this study believed their children should learn science through hands-on or first-hand activities and experiences. Unlike other parents, Yen's mother showed a belief in rote learning at the same time. In the following, I will first elaborate on how her beliefs stressed rote learning as effective learning.

***Science learning is rote.*** Rote learning, also known as learning by repetition, is a method of learning by memorizing information. The idea behind rote learning is that students will commit facts to memory after repeated study, and they will then be able to retrieve those facts whenever necessary (Li, 2004). Among all nine parents, Yen's mother was the only one who explicitly and implicitly believed that her sons should learn science in this way. Based on this belief, she would repeat a similar or even the same term or fact until her sons remembered it. Yen's mother told me that they would bring a keychain map of Taiwan (See Fig 3) every time they had a trip, so she could use it to repeat basic information to Yen and Wen. She explained, “If you repeat it several times, they will remember it” (Yen’s mother, interview#2).


Fig 3 The keychain Yen’s mother used when they travelled

In another example, she tried to strengthen Yen and Wen’s memory by repeating facts about butterflies’ mouthparts:

> *Those [concepts] I think are basic and they should know, I will ask them to repeat it again. By repeating it again, they will have a deeper impression. Every time we catch a butterfly, they will say they want to “shake hands with it.” Then I will pull out its mouthparts and let them take a look. I will repeat information such as “look, its mouthparts are curly, so it’s impossible for this butterfly to eat meat. It doesn’t have teeth, so it is definitely not carnivorous or polyphagious.” (Yen’s mother, interview#2)*

As some educators argue, rote learning is necessary in some situations because very young children who are just beginning their education may have to learn certain facts by rote (Perkins, 1914; Stolz, 1972). Such is her belief; as she said, “Repeating is how children remember things.”

Notably, however, Yen's mother did not equate this action with drill practices. More specifically, she did not think her sons merely parroted facts. She further elaborated on the above example:

> *Although this thing is always called "mouthparts," then, well, the size between a sulfur and a swallowtail is very different; the Sulfurs are very tiny. And the pea blue is very small; it's difficult to pull out pea blue's mouthparts. But if you catch a large-size butterfly, you don't even need to pull out its mouthparts, you only need to put it in the bug observation box and you can take a clear look." (Yen's mother, interview#2)*

By offering this example, Yen's mother argued, "Every time I described it a bit different. The little change will make it fresh to them; they will, at least they will be more focused. They won't feel that's very dull" (Yen's mother, interview#2). While Yen's mother did believe in rote learning, her clarification might reveal that her methods are closer to what Biggs (1994) termed "repetitive learning," which intends to understand meaning. Additionally, her attempts to "make it fresh to Yen and Wen" reflected her belief in fun and interesting approaches as well.

***Hands-on and first-hand experiences.*** To learn science, children must do science (Brunkhorst, 1991, p. 245). This belief was deeply held by all nine parents in this study. As Pei's mother put it, "Otherwise, why is conducting experiments so important in science?" Some of them emphasized the element of "doing science," while others stressed accessing real-life things. In sum, they all believed that science should be learned through hands-on activities and/or first-hand experience.

As stated above, some parents believed in doing science more than others. Only through hands-on experiences can children truly understand science content—"I do and I understand" (The Boston Children's Museum). For example, Kai's mother, who is a big believer in learning science through hands-on activities, shared an experience about a field trip to an orchid exposition when she taught in a private kindergarten:

> *Because I felt we needed to [let them] manipulate objects, the children would feel it was interesting. Because we just took a look around, when I asked them what we saw today after we got back to school, they said "flowers," that's all. So I felt that didn't have a…you know. (Kai's mother, interview#1)*

In this field trip, the children's thin answer supported Kai's mother perception that "doing science" is important. It is not enough if children only use their eyes; they need to have direct interactions with the objects they see. Kai's mother further emphasized that, without these hands-on experiences, "You won't remember when you are asked [about…] next time" (Kai's mother, interview#1).

Kai's mother seldom mentioned books or other means for learning science. When she talked about the *Little Newton*, a very popular science magazine for children in Taiwan, she said, "I would read it for them, but if there were too many words, I would just skip it. The hands-on activities were more interesting" (Kai's mother, interview#1). Although Kai's mother believed children could learn science from books, just as she believed children can gain some science knowledge directly from their teachers, it is only after they "do science" themselves that they gain a better understanding or deep impressions.

In addition to what Kai's mother pointed out, in parents' beliefs, hands-on experiences stimulated children to progress, as the following example:

> *Once you had the actual experience, like, if you connect this and that and see the power makes the bulb light, you'll feel, "Wow, this is amazing! Why is it that when I connected these two I got this result?" Then, won't you want to know more? It will then trigger your interest in learning. (Pei's mother, interview#1)*

Because the children used their hands to explore, they might want to search for additional possibilities—what would happen if I try to connect this and that part? What would happen if I put these two together? Chaillé and Britain (1997) and Tu (2006) reminded that hands-on is the springboard for minds-on. What Pei's mother noted reveals that children are not simply manipulating objects, and then gaining an impression. Rather, these children are stimulated by their interaction with these objects and might start to consider more advanced questions.

Parents believed first-hand experiences could facilitate and deepen children's understanding of scientific ideas (Griffin, 1998). Lily's mother provided an example, related to bringing Lily and Nana to several zoos in different cities in Taiwan. In this instance, Lily's mother highlighted that her daughters could gain plenty of opportunities to sense and make connections between animals and their environments:

> *It's better taking them to see real animals than reading books. Also, I think even though the animal you saw might be the same, because you saw it in several different places, it would bring you different impressions. For example, if you saw a monkey in Shou Shan Zoo and you saw another monkey in the Taipei Zoo, the animals accompanying the two monkeys were definitely different. Their cages were different as well. Also, their habitats were different. (Lily's mother, interview#1)*

In the above quote, Lily's mother indicated that the experiential experience could create an "atmosphere" for her daughters. Lily and her younger sister saw the same thing in different places, and would gain a different understanding of this object or phenomenon. Their understanding would be facilitated through first-hand experiences.

Pei's mother provided a more extreme, yet very interesting example, to explain how first-hand experiences open a door for children to start to explore things they never considered:

> *Why did Newton discover universal gravitation from a falling apple? You might have eaten hundreds of apples yet you never thought about this question. Why? One reason is that you did not see the complex meaning of a simple thing. Another reason is that you never see an apple tree in person! ……Sometimes I feel you can't just see [objects] from books. Well, if you compare your experience of seeing an actual watermelon tree [sic] versus seeing it in a picture, don't you think there's a difference between these two in terms of your science learning? (Pei's mother, interview#1)*

As a result, Pei's mother (interview#1) mentioned that she would take Pei and Ming to see real things in addition to giving them oral explanations. As she elaborated, "If you only read books, you have to rely on your imagination to know many things" (Pei's mother, interview#1).

As Kai's mother pointed out in the beginning, parents believed their children should learn science in such a way because they would then gain a long-lasting impression. After children had hands-on and/or first-hand experience, they would not easily forget it. Even though they might not remember all the details, they could recall their memory very quickly—because they have done it in person. Pei's mother told me she still remembers her experience of trying hard to collect creeping dayflowers for her science class about twenty years ago. Her memory of the name of creeping dayflowers came about not through intentional memorization; in contrast, it was because she involved in the process of collecting.

Pei's mother used another example to explain how first-hand experience creates deep memories. She indicated that many people have difficulty in distinguishing garlic sprouts from green onions because they look very similar. Pei's mother used this to state why authentic experience is indispensable for learning science:

> *If you don't take these two out and carefully observe exactly what the differences are between them, you will only feel they both are something long and green. You will always wonder, "Is this garlic sprouts or green onion?" But if someday you take a careful look at these two, you'll find out the green onion leaves are hollow and the garlic leaves are flat as well as solid. Okay, now I told you so, and if you go home and take a look to check my words, do you think you still need to memorize it by rote? (Pei's mother, interview#1)*

In contrast to Yen's mother, the above example proposed by Pei's mother stressed that "you can't learn science by memorizing; that's not true learning." This argument might show she was viewing rote learning merely as "mechanical memorization" instead of "memorizing with understanding" (Marton et al., 1996). Maybe if she told her children thousands of times about the characteristics of green onions and garlic sprouts, they would still have trouble in making a distinction between these two, assuming they did not go observe these vegetables – just as I quickly forgot the difference after the interview.

While parents in this study all acknowledged that their children should learn science through hands-on or first-hand activities and experiences, they did not agree that this was the single best way for children to learn science, as expressed in the following quotation from Jay's mother:

> *But you can't learn science solely from, um, news or non-academic reading. You should gain knowledge from various sources. You may obtain knowledge from science museums, which offer you more hands-on objects. … So, maybe [learn] from science museums, and mass media and news, and books, or what adults told you. (Jay's mother, interview#2)*

Similarly, Pei and Ming grew corn in school. Pei's mother used this to explain her belief that authentic experiences should go with books. She said,

> *They had this experience and read the picture book* Tops and Bottoms*; maybe after they read this book, they will want to grow other kinds of plants. Without the stimulation of this book, they won't think further about other aspects. So, these two should in fact tie in with each other. (Pei's mother, interview#1)*

All told, based on the above examples, parents perceived science could be learned from multiple ways; yet, learning through "doing science" was the most effective means. Furthermore, when doing science is combined with other resources (e.g., books, apps, videos), children will have a better understanding of the scientific phenomenon they learn.

**The extent of children's science learning.** While parents indicated various approaches and means through which their children could learn science, it was more important to them that their children be prepared. "Prepared," in these parents' beliefs, refers to children's motivation for learning science and how much should they know and/or learn regarding science at this age. Specifically, these nine parents had beliefs about the best time for learning science.

***My child should be intrinsically motivated.*** To be motivated means to be moved to do something (Ryan & Deci, 2000, p. 54). These nine parents believed whether their children were motivated to learn science or not was crucial, as Wei's mother indicated through an example from one of their previous family science museum visits. She remembered:

> *So, when she (one of Wei's older sisters) took a look at the exhibit and found no interest in it, I would try to ask her to think about why it functioned in that way. I would ask her "Do you want to explore it more?" but I wouldn't force her to. Well, because she left the exhibit after I asked her, I wouldn't ask her to come back and demand her to understand how it worked. I wouldn't do that. (Wei's mother, interview#2)*

In this case, Wei's mother tried to guide Wei's older sister to explore the exhibit further but gave up in the end. In her beliefs, if her child was not motivated to explore a scientific phenomenon, as when her daughter left the exhibit after her suggestion, she would just accept it because the timing was not right. She went on to elaborate,

> *I found even though sometimes I wanted to explain for them, they didn't really want to listen to me. Really, I feel, um, I feel the "timing" is really important. That is, when they want to know, they will try to find information. And the most direct way to get information is to ask me or people who have the knowledge. They will be really focused. If they are studying the exhibit and you keep talking, I think it's ineffective. (Wei's mother, interview#2)*

This passage reveals how important "timing" is in these parents' beliefs. "When they want to know" refers to the "right timing," which means their children are motivated and parents should provide scaffolding, such as offering them adequate information. Otherwise, parents believed their supports would be ineffective. Similarly, after their visit, Pei's family went to the museum store. Pei's mother found one toy fascinating, and after trying several times, she finally figured out how to play with it. She called Ming to come and tried to share what she found with him, but Ming refused his mother's attempt to teach him what to do. Instead, he tried different ways of manipulating this toy while his mother stood aside and watched his behavior silently. After a while, he found the correct method of playing with the toy and showed his discovery to his mother. (Pei's family, on-site observation, 120724) When interviewing Pei's mother about how she felt about this incident and why she chose to be quiet, she said:

> *It's not as though I wanted to teach him something and he would listen to me. He wanted to follow his own way. In the process of exploration he would slowly get the idea of how to manipulate the toy. (Pei's mother, follow-up interview)*

The statements "It's not as though I wanted to teach…and he would listen to me" and "I feel the 'timing' is really important" in these two mothers' interviews illuminate parents' beliefs in waiting until their children are motivated to learn science. The waiting, on the other hand, indicates parents believe in intrinsic motivation more than extrinsic motivation (Ryan & Deci, 2000). In Ryan and Deci's (2000) definition, intrinsic motivation refers to "doing something because it is inherently interesting or enjoyable" while extrinsic motivation is seen as "a construct that pertains whenever an activity is done in order to attain some separable outcome" (p. 55). In some of these nine parents' own school science learning experiences, they were extrinsically motivated because they wanted to earn the required credits or get grades so they could go to better senior high schools or universities. Yet, they found this method was not very effective. As Jay's mother shared, "I don't know and I don't want to understand more about science. So, I only needed to endure until passing that stage; I won't use it anymore anyway" (Jay's mother, interview#1). Hence, while parents could use some extrinsic ways to engage their children in learning science, they choose to wait until their children want to learn or ask directly, just as Wei's mother and Pei's mother pointed out above.

These parents believed that when children were intrinsically motivated to learn science, they really learned it. Yen's mother shared one recent incident as evidence to support such a belief. In this example, Yen's father tried to teach Yen and Wen how to roll their tongues and felt it strange that Yen's mother could not do that. Yen's mother was surprised that Yen's father did not know the tongue rolling is genetic, which Taiwanese students learn in the elementary school. She then explained, "He was not motivated when he was in junior high school. It was not until senior high school that his interest [in science] was boosted" (Yen's mother, interview#1). Based on this incident, Yen's mother believed that whether children were intrinsically motivated and/or whether they had an interest was vital. If others demanded they learn something, then like Yen's father, they would not really learn because they did not have any motivation.

Children are generally framed as having a curiosity for exploring the world around them (Gelman et al., 2010; Seefeldt, et al., 2011). The above examples show parents especially believed this curiosity-driven force in children's science learning as indispensible. This belief mirrors Conezio and French's (2003) notion that "Children's curiosity was identified as the beginning point of real science." According to parents, when children are intrinsically motivated by this curiosity, they are far more prepared for learning more about science. As Wei's mother said in the earlier example, "When they want to know…they will be really focused." The following example, given by Kai's mother, illustrates how science learning works better when children are intrinsically motivated by their inherent curiosity:

> *There used to be a bucket in our backyard, and many frogs laid their eggs in it in summer. Kai and Mei asked me what that was. I told them that were frog eggs and these eggs would become tadpoles. (Kai's mother, interview#1)*

Because Mei and Kai wanted to know about this unfamiliar creature, exploration happened. As Kai's mother indicated, "Because they have interest and curiosity, these make them want to ask and know more" (Kai's mother, interview#1).

Children's intrinsic motivation not only signals their parents that it is the right time to guide them, as Kai's example revealed. It further provides parents with hints of what kind of support children really need. For example, Chun and his older brother asked what debris flow was when they watched news about a typhoon. Chun's father then needed to find an animation to explain how the debris flow forms, to show them this phenomenon in a clear manner. When Chun and his older brother wanted to study how to eliminate cockroaches in their home, their father needed to provide them with proper materials to make a device. As Chun's father admitted, he was "bombed with all kinds of questions every day" (Chun's father, interview#1). When his two boys asked questions, he then assessed the type of support he should give them.

To sum up, these parents prioritized children's intrinsic motivation in science learning. The above examples both point out how these parents stressed the importance of children's motivation to learn when learning science. The statements "When they want to know" (Wei's mother, interview#2) and "When they feel there' a confusion…" (Yen's mother, interview#2) strengthen parents' emphasis on children's intrinsic rather than extrinsic motivation. When children are intrinsically motivated, as with Chun, Chun's older brother, Kai, and Mei in the above instances, they have more potential to learn about science, and it is easier for parents or other adults to provide adequate scaffolding.

***They are too young to know a lot.*** As the National Research Council (1996) pointed out, students should do science in ways that are within their developmental capacities (p. 121). In line with this idea, most of these parents believed "age" was a key factor to determine the depth and quantity of their children's science learning. This includes two important beliefs: "The older, the more" and "The emphasis on the now and enough."

*The older, the more*. Most of these nine parents held a belief that their children are still very young, and for that reason science learning at this age (i.e., 3 to 6) should only touch on short and basic information. An example from Yen's mother reveals such a belief:

> *You don't have to tell them too much at such young age. You only need to tell them 'that's a dinosaur,' 'that's a T-Rex,' that's enough. (Yen's mother,*

*interview#2)*

What she continued to express strengthens this idea a little further: "I'll go in more depth when they are older. I will then tell them, 'look, its teeth are sharp because it eats meat'" (Yen's mother interview#2). How deeply children should engage with a science idea depends on how old they are – "the older, the more." When they are older, as Yen's mother expressed, they will need to advance to a more difficult part of a specific topic (dinosaurs, in this case).

Lily's mother, similarly, described how much she chose to share with Lily news about an annular solar eclipse:

> *At Lily's age, I just need to let her know there is a phenomenon called "annular solar eclipse". … As for going in more depth, I think that needs to wait until she is older and has the actual experience [of seeing the solar eclipse]. She will understand better at that time. Because she is too little, I won't teach her something very difficult. I only let her know the existence of this phenomenon. (Lily's mother, interview#2)*

Lily's mother pointed out that Lily's age was the key to determine how much she would tell Lily. Although she mentioned having the actual experience would lead Lily to a better understanding of this phenomenon, in her belief, the "until she is older" is still an important determining factor. This might mirror Tenenbaum, Snow, Roach, and Kurland's (2005) argument that children may need to be more cognitively advanced themselves within the domain of science to be able to benefit from parental input (p. 14).

In this study, all but Jay's family contained at least two children. The nine parents in the present study also expressed a belief that older children are more able to learn science. They believed their older children had a better ability to comprehend science-related ideas, to ask more logical questions, and so forth. This finding is similar to a study by Andre and his colleagues (1999), in which parents believed older children (i.e., 4-6 grades) are more capable in science than younger children (i.e., K-3). Parents' habits of explaining more to the older child might reveal parents' beliefs about how much they needed to explain or share based on children's different ages. In the above example, Lily's mother only shared the news about the annular solar eclipse with Lily because "Lily is a bit older" (Lily's mother, interview#1). In another, Wei's mother described the difference between how she explained the phenomenon of surface tension to Wei and his older sisters:

> *Yeah, I will try to use the language he can understand to make the same principle more, um; I will explain it in more simple terms. …I might tell Wei's older sisters that is about surface tension, but when explaining to Wei, I won't use this term. (Wei's mother, interview#2)*

Because Wei is younger, the quantity of the same content his mother told him was therefore less than those his older sisters received. He only needed to know that which "he could understand." In sum, because of children's different ages, parents either excluded the younger child from information-sharing like Lily's mother did, or they used simpler words when talking with the younger child, just like Wei's mother.

*The emphasis on the "now and enough."* The other side of "the older, the more" may reveal parents' belief that "telling them this much is enough now." There is, then, no need to investigate science too much at this age. The "enough" and "now" have particular meanings in parents' beliefs about science learning. First, when children are young, parents focus more on their "knowing" instead of "understanding." What Yen's mother and Lily's mother addressed in the beginning examples is relevant evidence: their children only needed to know "what" rather than the "why" or "how," such as the name of a dinosaur or a particular science phenomenon.

The "enough" and "now" also reveal that most parents seem to focus more on children's current cognitive development rather than on their emergent ability to learn science, which might lead parents to unintentionally underestimate children's potential to learn science and miss a key moment for scaffolding. That Yen's mother chose to merely name dinosaurs (e.g., "that's a T-Rex") for her sons instead of guiding them to observe these dinosaurs' characteristics might be a good example.

There is a Chinese saying that reads "ya miao zhu zhang." The literal translation is "pulling up the seedlings to help them grow," meaning that adults who do not care about children's current development and hurriedly push them to move on will negatively impact children's development. Such an idea is deeply rooted in Chinese and Taiwanese culture, and may explain why these parents tend to believe in the "now" and "enough."

Parents' belief in how much their children should learn based on their age might show that they care about not letting mismatches happen, thereby ruining their children's interest in learning science. But what is "enough?" Parents did not seem to have a clear criterion for this. Unlike parents' understanding of the order in which math should be learned (e.g., identifying numbers was prior to adding numbers) in early years (Chen & Chen, 2006), in most cases, the extent to which children should learn science is a bit intuitive. In other words, parents seemed not to understand that a careful evaluation of children's zones of proximal development was necessary before knowing how to properly scaffold their children was. As Lily's mother said:

> *If I feel this is their current need, they can know these things. I will let them pay attention to things around us. For example, if I heard the cicada sounds, I would ask them 'did you hear any sound?' This is for training their observation skills; this is what they need now, so I'll put more effort in this aspect. (Lily's mother, interview#2)*

Observing is certainly important, especially in science learning. However, as Lily's mother continued, "They don't need to know what happens in the kitchen now. I just hope they don't make trouble in the kitchen, that's all" (Lily's mother, interview#2). So, when Lily posed a question like "Why there is a big noise?" when her mother was cooking, Lily's mother believed telling Lily "it's noisy when we cook" was "enough" because she perceived cooking was not something Lily needed to do at this age—although this is otherwise relevant to life. Lily probably does not need to help in the kitchen; yet, she could definitely start her science learning and learn a lot in this place—just as Seefeldt and Galper (2002) suggested.

Parents' "instinctive evaluation" may sometimes fit children's current cognitive development, while at other times undermining children's potential in learning more about science. This instinctive evaluation in fact might involve potential risk, as Ashbrook (2005) argued:

> For the most part, children can participate fully in the process of inquiry at age-appropriate levels. Simplifying the process, or even the vocabulary, is a disservice to the students' interest and ability to observe closely, ask questions, wonder, use tools, collect data, use logical thinking, consider alternative explanations, record findings, share information, and build on new experiences to develop new ideas about the world. (para. 15)

If parents focus too much on the "now and enough," they might deprive their children of opportunities to go beyond their independent capabilities, with the help of adults or more capable peers (Vygotsky, 1978).

*Seeing other possibilities beyond children's young age*. Most parents in this study believed their children were too young to learn more about science, which resulting in them in only giving their children simple and basic information. Nevertheless, among all nine parents, Chun's father was more open to what his sons could understand. While he did explain scientific phenomena in more simple language – for example, he analogized the lipophilic group and hydrophilic group to a human's two hands, to explain how a soap cleaned our body (Chun's father, interview#1) – most of the time, Chun's father believed it was very natural to use scientific terms such as "cyclone," "sodium chloride," "crystal," etc. He noted, "Because I think they can understand, and if they don't, they will ask me immediately. … If they don't understand, they will keep asking me what's this and what's that" (Chun's father, interview#1). If a scientific construct was too abstract for Chun and his older brother Hsuan to understand, Chun's father still did not regard it with skepticism. As he explained, "I will try, um, I will try to find some resources. Like, um, actually there are lots of animations of cyclons on line. I will find some and show them" (Chun's father, interview#1). In fact, Chun's father was aware of his children's limits. He said:

> *But actually I think what we can tell them still has limits, their questions have limits as well, because probably their cognitive systems only develop to a certain level. So, you start with things that they can understand. Of course we don't tell them something too complicated, you know; some things are really complex, they won't understand even if you provide explanations for them. (Chun's father, interview#1)*

He then gave an example of trying to explain a tachometer reading, although Chun and his older brother could not understand at all:

> *The number needed to be multiplied by one thousand. And they asked me, "Why has it stayed at 5 after such a long time?" I told them it was because we needed to multiply by one thousand. I told them the meter was too small to squeeze in many long numbers, so each number needed to be multiplied by one thousand. It is really difficult for them to understand why. But we adults can understand that immediately: 1 stands for 1000, 2 means 2000. (Chun's father, interview#1)*

He did view his two sons' limits in a positive manner, however, adding:

> *They will ask their original questions next time. Maybe someday they will get it. I feel the advantage of talking to them is that they will gradually remember what I have told them, and one day they will feel, "Oh, this is blah blah blah." (Chun's father, interview#1)*

Hence, these limits did not mean he should merely provide Chun and his older brother very simple and basic information. According to Bronbenbrenner (1979), the child in the middle of multiple systems receives the most direct stimulation from the Micro-system, simultaneously; parents in the Micro-system accept feedback from the child. Chun and his older brother's responses reinforce Chun's father's belief that he does not need to intentionally simplify the terms he uses. This belief also mirrors Duschl, Schweingruber and Shouse's (2007) conclusion below:

> What children are capable of at a particular age is the result of a complex interplay among maturation, experience, and instruction. Thus, what is developmentally appropriate is not a simple function of age or grade. What children can do is in large part contingent on their prior opportunities to learn and not on some fixed sequence of developmental stages (p. 336)

That is, Chun's father believes that his sons' capability is a "complex interplay" of several factors; their age is only one among them. Thus, the extent of Chun and his older brother's science learning is not limited to a certain degree in the first place only because of how old they are.

Interestingly, the issue of "age" was interpreted differently in relation to science as compared to other areas. As presented in section titled "More important areas of learning than science," many parents mentioned the importance of cultivating children's reading habits and/or their social competence. They typically believed these habits, attitudes, and/or skills were timely and appropriate for their youngsters. Additionally, they felt these good habits should start at an early stage. The key time for picking up an American English accent in the early years was also mentioned (i.e., Chun's father, interview#1). However, when it came to science learning, parents usually had opinions like "When s/he gets older, his/her ability of understanding will be better," or "Even if I tell them, they are too young to understand."

In sum, although parents believed their children should learn science, this belief was limited depending on a child's age; most parents in this study tended to believe they should limit information for young children, or refrain from sharing information that is "too difficult." According to Vygotsky, scaffolding should be a form of "support and challenge" that leads to development (Reiman, 1999). Parents' "now and enough" might miss a key moment to provide effective scaffolding.

### Parents' beliefs about their engagement in their children's science learning

The central role of adults in children's science learning has been recognized by many scholars (e.g., Seefeldt & Galper, 2002; Eshach, Dor-Ziderman, & Arbel, 2011). Parents' active participation in and support of their children's learning is also expected (e.g., Keyser, 2007). As Russell (1992) pointed out, "The characteristics of parents, such as their attitudes, beliefs, or values which may lead them to be more or less involved, or to be involved in one way rather than another" (p. 274). Parents who think science experiences "have to be formal and difficult for learning to occur" (Brewer, 1998, p. 344) might be afraid of doing science with their children or may identify children's science learning as the teachers' responsibility. Hence, in this section, I turn to a discussion of parents' beliefs about their engagement in their children's science learning.

Barton, Drake, Perez, Louis, and George (2004) deliberately chose to use the term "engagement" instead of "involvement" to "expand [their] understanding of involvement [typically understood as what parents do] to also include parents' orientations to the world and how those orientations frame the things they do" (p. 4). In line with this idea, I adopt the same term to describe parents' beliefs in this section. In the following, I begin with a presentation of parents' self-efficacy beliefs, in which I discuss parents' sense of their ability to engage in their children's science learning. Then, I present parents' beliefs regarding adequate participation in their children's science learning. Lastly, I discuss parents' beliefs regarding their engagement in school, because home and school may differ in beliefs regarding children's science learning.

**Parents' self-efficacy beliefs.** Bandura (1997) defined self-efficacy as people's judgment of their capabilities to complete a designed task successfully. As Bandura stated, self-efficacy belief is task-oriented. Hence, this section focuses on parents' beliefs in their ability to teach their children science, answer their children's science questions, and to do relevant activities with them.

To understand parents' self-efficacy beliefs, first I need to present how I quantified a parent's self-efficacy as low or high. As Cheng (2010) held, parents view themselves as experts when they were good in a specific area. In the findings, I also noticed this phenomenon. For example, Ying's father had higher self-efficacy beliefs in earth sciences and chemistry, yet he did not feel as competent in physics. Yen's mother had abundant experiences with insects, so she was competent in talking about these creatures with her two sons. For the convenience of discussion, however, I rated parents' self-efficacy beliefs as high or low in a more general manner.

Among the nine parents, Jay's mother and Ying's mother appeared to have lower self-efficacy because they both identified themselves as bad at science and as having no interest in science. Kai's, Lily's, Pei's, and Wei's mothers and Ying's and Chun's fathers appeared to have high self-efficacy. The unique case is Yen's mother. Although she claimed, "I can do the entry-level parts, that's fine. But if you ask me to tell them something really difficult, I don't think I'm capable" (Yen's mother, interview#1), she also said, "I don't think that explaining for them is very difficult" (Yen's mother, interview#2). Hence, I identified Yen's mother as a parent who held positive attitudes toward her self-efficacy in engaging in her children's science learning.

According to Bandura (1993), "Efficacy beliefs influence how people feel, think, motivate themselves and behave" (p. 118). Parents who held low self-efficacy beliefs, such as Jay's mother, firmly believed she did not know how to "explain the science principles" for Jay. In one instance, Jay's mother talked about how she would guide Jay to mix different colors if they decided to draw. She then added, "Just don't ask me why. I don't know why" (Jay's mother, interview#2). However, for parents who hold high self-efficacy beliefs, this is not a concern at all. One example is how Kai's mother talked about the principle of leverage with Kai:

> *I would let him to, um, how should I say…I bought him a small toy crane truck, and I told him when you did this [she made a gesture], it would be easier. I wouldn't intentionally tell him this is the principle of leverage; I just let him manipulate the toy crane truck and let him take a look at it. (Kai's mother, interview#1)*

Compared to Jay's mother, who was always worried about not knowing how to provide explanations for Jay, Kai's mother strategically used an actual object to demonstrate this principle.

Bandura pointed out, that people generally avoid tasks where their self-efficacy is low, but will undertake tasks where their self-efficacy is high. The following reflection made by Jay's mother represents her frequent avoidance:

> *Because I reject science myself and actually, um, if you didn't interview me, I probably ignore this, um, my rejection of science actually leads me to ignore lots of his science learning. (Jay's mother, interview#2)*

When parents believed "I am not capable of doing this," they would avoid engaging in their children's science learning. This often resulted in parents unconsciously missing moments for scaffolding.

In addition to avoiding engagement in their children's science learning, parents who held low self-efficacy beliefs demonstrated a tendency to transfer responsibility to other, more capable people, such as schoolteachers or their spouses. In their minds, these people were more capable than they were in engaging in their children's science learning. For example, Ying's mother told me that in their previous science museum visits, she "always follows her family and watches Ying and Ting" and "lets her husband take the lead to play the role as a guide" (Ying's parents, interview#2). Jay's mother expressed a very similar belief. However, because Jay's father served in the military and came home infrequently, she could not tell Jay, "Go ask your father." Hence, she told Jay, "Ask your teacher" instead. As a former kindergarten teacher, Jay's mother said her role as a teacher pushed her to take her students' questions seriously, because she needed to maintain her professional image (Jay's mother, interview#2). This experience shaped her belief that schoolteachers must be more capable in supporting children' science learning.

Nevertheless, there might be potential risks. First, as Chun's father objected, "not every father is good at science" (Chun's father, interview#2). If this task was transferred to a father who was also held a low self-efficacy, the child's science learning might be ignored. Also, Jay's mother, who believed that Jay's teacher would carefully deal with Jay's science learning, might overlook the fact that science is usually schoolteachers' most feared subject (Harlen, Holroyd, & Byrne, 1995; Murphy, Neil, & Beggs, 2007). The "more capable" others identified by the low self-efficacy parents might not be adequately prepared to engage in science learning with children either.

People with low self-efficacy will tend toward discouragement and giving up, where someone with high self-efficacy—that is, those who believe they can perform well—are more likely to view difficult tasks as things to be mastered rather than things to be avoided (Bandura, 1993; 1997). Obstacles often stimulate people with high self-efficacy to greater effort. The two examples below illustrate the differences between parents who hold low and high self-efficacy beliefs when they encounter difficulty:

> *People who are good at science probably can use some vivid ways to [teach their children science]. Because they know a lot, they can use many ways to explain one thing to let their children understand. But because we know very little about science, when I encounter something and I'm unable to explain, I will choose to shirk and give up. (Jay's mother, interview#2)*

Jay's mother identified herself as not as competent as those "who are good at science," so she chose to avoid the task when she did not have an explanation for Jay. In fact, Jay's mother said she would try to find information, yet she "still did not know how to explain the information she found" to Jay. (Jay's mother, interview#1) This seemed to gradually feed her habit of avoiding this difficult task.

Lily’s mother, on the contrary, demonstrated how a high self-efficacy parent might behave when encountering a problem:

> *One time in our bedtime story time, I told Lily “Hey, let me tell you a story about bunnies.” After I said that, I quickly realized that I actually knew very little about bunnies. All I knew is from the magazine we subscribed to. I only knew very basic things, like what bunnies eat, that’s all. So I only told her a very short story, then I tried to find data when I was available to know more about bunnies, which enabled me to have more things to tell her. (Lily’s mother, interview#2)*

Lily’s mother believed the reason she could not tell a long story about bunnies at the outset was her insufficient preparation. After finding and learning more, she could perform this task competently. Unlike Jay’s mother, Lily’s mother did not avoid this task and let it prevent her daughters from learning more about science.

The National Science Teachers Association (NSTA) identified seven myths about science among parents, two of which are “science is difficult” and “I'm not a scientist and don’t know enough about science to help my kids” (NSTA, n.d.). Parents who hold a low self-efficacy belief not only ascribe to these two myths, their low self-efficacy belief also leads them to believe engaging in their children’s science learning to be harder than it actually is. Jay’s mother said,

> *I don’t reject science activities or experiences, but I won’t actively keep providing these science experiences for him. If we encountered some opportunities in our daily lives, we probably could do some, well, simple experiments. For example, when he plays with a ball, I will try my best to ask him “How about trying to play with it in other ways?” But after trying, he still only knew the part of playing; neither he nor I knew how to explain what we found in the experiment we did. (Jay’s mother, interview#2)*

In fact, as suggested by many science educators (e.g., Martin, Jean-Sigur, and Schmidt, 2005), parents do not have to assume all responsibility for explaining. Jay’s mother could, on the contrary, co-construct some understanding through her interactions with Jay. According to sociocultural theory, collaborating in changing one’s ZPD is crucial (Chaiklin, 2003). Because she believed providing explanations for Jay was not easy at all, the task of engaging in and guiding Jay to learn science from activities like this therefore became harder than it actually was.

On the other hand, her description of how she viewed Jay's literacy questions tells another story:

> *The literacy thing is much easier to explain. For example, while there are some difficult terms (e.g., jealous, splendid, well-prepared) in picture books, I can use some daily life instances or plain language to explain. But I don't know how to explain the science thing to let him understand. (Jay's mother, interview#1)*

Jay's mother also mentioned one difficulty in an interesting way: "This is what it is. It is a natural phenomenon (e.g., The moon shows up at nights [sic]); how do I explain?" (Jay's mother, interview#2) Because she was always worried about not knowing how to offer Jay adequate explanations, the task of engaging in Jay's science learning became very difficult for Jay's mother.

**The roles parents believe they should play.** Musun-Miller and Blevins-Knabe (1998) found that when parents valued math and saw their role in their children's learning as important, they engaged in more mathematics-related activities with their children. Although these nine parents tended to believe that learning science was important for their children, most of time, they seemed to believe that playing a passive role in their children's science learning was enough. Even though some parents, such as Chun's father, appeared very actively engaged in their children's science learning, he said he "actually did not intentionally do that." Instead, he just "likes to talk with them," and "if they come to talk to me, I'll have a conversation with them until we finish our talk." Yet, he "did not actively do this" (Chun's father, interview#1).

***An answer provider, knowledge agent, and guide.*** Holding a belief in the adult-oriented approach, parents in this study put an emphasis on their children's passive reception of what they gave them, more than stimulating them to think or explore further. Hence, instead of regarding themselves as a learning facilitator, the first role these nine parents believed they should play in their children's science learning is being an answer provider.

Put simply, performing as an answer provider entails finding and giving answers to children when they pose science questions such as "Does the moon only show up at night?" This role is passive because parents wait until their children seek information from them.

When Lily's mother talked about her role in one of their previous museum visits, the belief in her role as an answer provider is clearly revealed:

> *If she asks, I will tell her. But since she doesn't ask, [I won't] actively tell her [the content of the exhibits]. I just let her play. (Lily's mother, interview#2)*

Depending on whether Lily asked a question, Lily's mother would then take actions to engage in her learning. If she did not verbally show her mother her confusion or curiosity, her mother would not actively lead her to move forward. Jay's mother, who never took Jay to science museums, responded in a similar manner when she was asked about what kind of role she might play in the forthcoming science museum visit. She said, "When he asks me, when he can't read the words and asks me what that is, I answer his questions" (Jay's mother, interview#2). Both mothers positioned their role as an answer provider. This positioning indicates that they believe they only need to provide supports when their children ask for them. "If she asks" and "When he asks me" highlight their reticence. This might be influenced by their belief in the importance of children' intrinsic motivation. Thus, unless their children asked questions, they did not actively engage in their children's science learning. Additionally, they did not express the belief that their children were capable of finding answers on their own.

Some parents expressed a knowledge agent role. As Wei's mother pointed out, because of Wei's "illiteracy" [sic] (Wei's mother, interview#1), "there must be adults accompanying him" (Wei's mother, interview#2). In her belief, parents' explanations could help "illiterate" young children to understand more about what they are learning. Similarly, Yen's mother said, "it is impossible to ask a four-year-old to read the explanation panels on his own" (Yen's mother, interview#1). This role looks like an active one. Yet, as shown in these two mothers' quotes, it is results from knowledge that children have limited ability in interpreting Chinese characters. Hence, parents believed that they have to play this role to give their children some basic understanding of the science books they read, or the exhibits they visit in science museums.

The other role parents believe they should play is as a guide. For example, Chun's father told me that when he found special insects in their front garden, he would sometimes call his sons to take a look. He would also encourage them to pay attention to the changes in the plants they planted (Chun's father, interview#1). A similar idea was also brought up by Lily's mother, Pei's mother, Wei's mother, and Ying's parents. Lily's mother, for example, found that when she did this, Lily would actively notice the changes in the world around her and share with her (Lily's mother, interview#2). This role is more active than the other two roles, because parents lead their children to observe and to care what happen in their daily lives.

In short, although some parents believed that acting as a guide was crucial, most parents tended to believe performing as answer providers and knowledge agents is adequate and enough to support children's science learning. Both roles are more passive than active. Parents' perception that they should play these two roles might result from perceiving their children did not have the ability to find answers and/or read words on their own.

***The concern of misconceptions.*** Rather than acknowledging their engagement had a positive influence, most of the parents in this study appeared to be more aware of their potential negative impact on children's science learning, which primarily referred to giving their children misconceptions. Therefore, when parents played roles as answer providers and knowledge agents, many parents (i.e., Jay's, Yen's, Lily's, Wei's mothers and Chun's father) believed that they needed to be careful about not telling their children something "wrong."

> *[What I told them] might give them wrong concepts, and a small wrong scientific concept might cause future learning issues. So, I will be more careful and cautious about this. (Chun's father, interview#1)*

Despite Chun's father's high self-efficacy belief in engaging in his sons' science learning, he worried that if he unconsciously gave his sons misconceptions, they might carry these "wrong" ideas with them and encounter a conflict when introduced to the "correct" concepts. Wei's mother possessed a similar concern, as described in the following:

> *But if I don't understand something myself, I don't dare to explain for her because I'm afraid of saying something wrong. What if my wrong explanation becomes her impression of that? If next time she learns the correct knowledge and it is not what I told her, it might cause confusion. So, unless I'm pretty sure about the information, I won't explain for her. (Wei's mother, interview#2)*

Wei's mother, as well as Chun's father and some other parents in this study, believed if they were not careful enough when answering their children's science questions, it would create problems in their children's future science learning.

Moreover, while parents agreed that misconceptions were dynamic and could be "fixed," some of them (e.g., Jay's mother) worried their children might never have a proper chance to correct misconceptions, or that altering them might require significant effort. Below is an example of how Chun's father perceived the difficulty of making the changes happen:

> *I feel this (being careful about misconceptions) is quite important. I feel I had lots of misconceptions in my previous learning process, and those were very difficult to correct. Let me give you an example, like, um, we had lots of exams in junior high, then I would find out every time I made the same or similar mistakes in my exams. Um, that might mean my understanding was wrong at the very beginning, so every time I made the same mistakes. I feel I would analogize this experience to those (misconceptions). Probably because our patterns were fixed, so how we think and how we solve problems would follow that pattern. Then we would have a tendency of doing it wrong or having a wrong idea. (Chun's father, interview#1)*

Chun's father, who is an associate professor of Educational Psychology, is very familiar with cognitive development theories. His understanding of these theories strengthened the above point; as he added, "Making the changes happen in concepts and attitudes are the two most difficult things" (Chun' father, interview#1). Ausubel's (1968) claim below might explain his worry:

> Preconceptions are "amazingly tenacious and resistant to extinction" and that "unlearning of preconceptions might well prove to be the most determinative single factor in the acquisition and retention of subject-matter knowledge" (p. 336)

Because Chun's father knew very well about how difficult it is to change misconceptions, he believed being careful about answering his sons' science questions was especially important.

Parents in this study believed their children trusted what they told them. In their children's eyes, these parents were usually seen as the most direct and credible resources to get answers and information (e.g., Chun's father, interview#2). Because of this trust, parents believed they needed to be especially cautious. Therefore, parents expressed a strong belief that, as several parents put it, "if I don't know, then it is better saying 'I don't know' than telling my children something wrong." When children asked their parents a question—in their home or in science museums—parents appeared to believe that they only needed to tell their children things they were very sure about. An example from Wei's mother illustrates the idea:

> *My related background laid the foundation for me; of course, that makes understanding the content easier so I can explain for them with confidence. But sometimes I only know a small part of it; in that case, I won't give them explanation. Or I will tell them what I understand and let them know there's still something I don't know. (Wei's mother, interview#2)*

If parents were quite sure about the answers—regardless of whether the answers were in fact correct or wrong—they would share with their children. Otherwise, if they were not fully sure about the answers to their children's question, they thought it was better to say, "I don't know."

This finding differs from several previous results. For example, Alagumalai (2005) pointed out that when confronted with children's questions, parents or other family members would give incorrect answers rather than admit that they did not know the answers (cited in Thompson & Logue, 2006). Falk and Dierking (1992) also pointed out that in most cases, if parents were asked by their children to explain the content of an exhibit the parent did not understand, parents would fabricate explanations. This main difference might be because parents in this study did not want to risk giving their children misconceptions.

While this concern may result in parents' missing some key moments for actively scaffolding their children's science learning, on the other hand, it created an opportunity of demonstrating how alternative scaffolding strategies could be used. Yen's mother gave an example:

> *Normally, if I'm unable to answer the question, I will tell them "mommy can't answer you because I don't understand it." [I will tell them], "If I answer your question at random and you share the answer with your friends, then everyone will have a wrong idea about it. So, if we don't understand it, we can look it up online." (Yen's mother, interview#1)*

Looking up information online is one way of scaffolding (Brown, et al., 1993). Parents' asking other, more capable people (e.g., museum staff) and/or using other resources (e.g., books, encyclopedia, the internet) modeled how to use different resources to scaffold their own science learning.

**The boundary between home and school.** The nine parents in this study often voiced opinions about children's science learning in contexts outside of school (e.g., home, science museums, zoos), which made me wonder, "How well did parents feel informed about science practices and curriculum content in their children's schools?" and "In what ways do parents believe they should engage in their children's school science learning?" Thus, in this section, I turn to a discussion of parents' beliefs concerning school-based engagement and children's science learning to provide more understanding on this issue.

***Science is a neglected area of communication.*** According to the data, these nine parents had very limited knowledge about what their children had done in school regarding science. Among all parents, only Kai's, Lily's, and Pei's mothers were able to describe the science-related activities their children did in schools. However, these three mothers were unable to give detailed descriptions. They might be able to talk about the "what," but not the "why" and "how." For instance, Lily's mother knew only about what kind of objects were put in the science area in Lily's classroom, yet she did not know specifics, such as why Lily's teacher chose these objects, the relationships between the objects and curriculum, and how Lily and/or her classmates interacted with these objects (Lily's mother, interview#2). The other six parents were much like Jay's mother, who needed to check with Jay about how an egg-cooking activity was proceeding when I interviewed her (Jay's mother, interview#2).

Without interviewing the teachers of these children, I cannot determine what actually took place in their classrooms. Still, parent interviews revealed that conversations with their children seemed to be the primary channel of knowing what children have learned in schools, or what parents should do to support their children's science learning (e.g., Yen's mother, interview#2). Hence, it is challenging for parents of those children who did not actively talk about their school life, such as Wei's mother, to understand their children's school science learning.

This prompts a question: exactly how much science learning is happening in schools? Did parents' lack of knowledge indicate little science learning, or was this due to inadequate communication? My field notes from my interview with Wei's mother might provide a possible answer:

> *Today was the first interview with Wei's mother. I arrived at his home a little earlier, before the interview started. Wei's mother asked me to wait for a while because she had just finished cleaning the house and she wanted to take a quick shower. I sat on the couch and randomly picked up Wei's learning portfolios to read. It looked like they had done many science-related activities; for example, they had a unit called "More Than Paper" and another called "Mothers and Babies." (Field notes, Wei 1)*

Yet, when I interviewed Wei's mother about Wei's school science learning, she replied:

> *No, Wei didn't have those kinds of activities in school. Most of the activities were more related to art. I don't know whether those count or not. (Wei's mother, interview#2)*

Through this explanation, it is clear to see that Wei's mother did not understand units as related to science unless Wei's teachers particularly told her that what he gained from these units was relevant to science. On the contrary, Wei's artwork offered concrete evidence to his mother that art learning happened.

In this study, Yen, Ying, and Wei were classmates; all three children's parents identified that learning in school was more connected to self-help skills. Ying's parents provided a thought on why it was difficult for them to describe Ying's science learning in school; as Ying's mother started:

> *It should say we don't intentionally categorize their learning into specific areas. Like, this is art and this is science and this belongs to another area. So, probably they had [science learning] in school, but we…*

Ying's father added that another possibility "is that science is very associated with daily life." Ying's mother concluded, "So we don't intentionally think 'Oh, this is science'" (Ying's parents, interview#2). The explanations proposed by Ying's parents might reflect their beliefs that science is a part of people's daily lives. As Ying's father added later, "What they are learning now is actually things we commonly observe in our daily lives. Once they go deeper, they will then talk about scientific principles" (Ying's parents, interview#2). What Ying learned in school might be viewed as "common sense" instead of "science" in her parents' beliefs.

Ying's parents offered an alternative interpretation. Based on parent's reporting, however, even though the school provided home-school communication books, the content "mainly addressed their school life, for example, things that happened today. It seldom mentions their curriculum" (Chun's father, interview#2), and "only tells us what material my child needs to bring to school. It doesn't tell us what they learned in school" (Kai's mother, interview#2). Unlike art, music, or even literacy, which is indicated to parents through children's artwork, the songs children sang, or the stories they told, science learning in school was more difficult for young children to describe to their parents. It appears that there was not much communication between parents and their children's teachers about science, and as such, many parents in this study believed there was almost no science learning in school.

***Knowing little about school science is fine.*** Regardless of their knowledge about activities in their children's schools, parents believed it was fine that schoolteachers did not make information about school science learning transparent to them. When I asked why they never asked schoolteachers for help in assisting their children's science learning, or why they never wanted to know more about children's science learning in schools, a common response was "Um…since you ask me now, I'll try to ask the teacher next time" or "Well, you are right; I indeed never thought about seeking help from his/her teacher" (e.g., Lily's mother, interview#2; Pei's mother, interview#2). The reason parents believed this was acceptable might be because, as Chun's father pointed out below:

> *I especially care about their health and safety, oh, and whether they are treated equally in the school. As for the science [activities] and how the teacher teaches [it], I think that's okay. (Chun's father, interview#2)*

In this quotation, Chun's father pointed out that what he believed was important in school was not how much his sons learned about science. If his sons' teachers let him know they were physically well and treated just like other children, then this was enough.

In most parents' estimations, being safe, being healthy, and being happy are the most important priority in children's school life. None of the nine parents particularly associated children's school-going with cognitive learning. Therefore, although communication regarding children's school science learning between parents and teachers was infrequent, as long as teachers ensured their children were safe, healthy, and happy, parents did not perceive a lack of knowledge about their children's school science learning as neglect.

Parents' awareness in acknowledging teachers' limits seemed to reinforce their belief that knowing very little about their children's school science learning was fine. Lily's mother knew from Lily that she seldom chose to go to the science area; however, not wanting to bother Lily's teacher, she decided to take this responsibility on herself:

> *So I realized I need to pay particular attention to train her observation ability. Because the teacher is unable to take care of every child, I need to do this myself. (Lily's mother, interview#2)*

Lily's mother then gave an example of how she deliberately guided Lily to observe flower buds. Like Lily's mother, several parents held the belief that "it was impossible for the teacher to take care of every child's needs or provide rich as well as engaging science curriculum for their children." Therefore, parents who held such a belief chose to show an understanding for teachers' limits, as Yen's mother did below:

> *Honestly, I don't think they have extra time to specially arrange the science curriculum. I think the opportunities [of doing this] are very few. For instance, they had one English story telling time every couple of months. So, it's demanding to ask the teacher to teach this and that. You know, it's a public kindergarten. Having all kinds of courses is not its main purpose. Cultivating children's healthy habits for life and having them getting along with others in groups are the purposes. Hence, I won't ask the teacher to [provide these courses]. (Yen's mother, interview#2)*

What Yen's mother pointed out reveals a parental belief that if schoolteachers offered science learning at school and were willing to communicate it with them, it would be ideal. But if they did not, parents were not seriously concerned.

**Parents' engagement in school science.** In Taiwan, it has been difficult for parents to become involved in their children's school activities because parental participation has not been a part of Chinese culture (Hung, 2007). While these parents believed science was important for their children, they seemed to believe that they did not have to engage in their children's school science learning very much.

***Respecting teachers' specialty.*** A repeated phenomenon in these nine parents' beliefs is that most parents clearly separated their home lives from children's school lives, which made them not attempt to extend what they did at home to school. As covered earlier, these parents provided their children with rich science-related experiences in their home and/or in out-of-school settings. Yet, parents believed these out-of-school science activities were usually only "for fun" instead of "learning" or "obtaining scientific knowledge." Thus, they did not view these experiences as meaningful or valuable enough to be a part of children's school science learning. None of other parents actively made their out-of-school science experiences a part of school curriculum or activity except that Yen's mother once shared their experience of observing fireflies with Yen's class (Yen's mother, interview#2).

Moreover, as Hung (2007) pointed out, in the larger Chinese culture, "In fact parents have generally considered that teaching is the responsibility of teachers alone" (p. 116). These nine parents' beliefs seemed to reveal that they maintained a professional image of their children's teachers. For example, although Chun's father is an associate professor in the Department of Education in one university, he believed it was better to fully respect the teacher despite his professional training. When answering the question, "What if your beliefs do not align with the teacher's science practices?" Chun's father quickly responded:

> *You send them to school; you should respect the approaches the school chooses to adopt. I think I should respect the teacher's specialty in early childhood education. I don't want to interfere in the teacher's teaching. Maybe I will offer them some opinions, but I won't ask the teacher to follow my preferences. (Chun's father, interview#2)*

This response reflects Hung's (2007) assertion that "teachers are highly regarded in Chinese culture, and they are respected as authority figures because of their knowledge" (Hung, 2007, p. 116). Although the notion of partnership between parents and teachers is a 'taken-for-granted feature' (Hedges & Lee, 2010, p. 257) of education, parents in this study did not seek opportunities of "being schoolteachers' partners" by making their out-of-school science learning a part of school curriculum. Instead, they trusted in schoolteachers' ability to handle children's science questions or engage their children in science. They believed their children's teachers would properly support such learning.

***The message from school.*** Seefeldt et al., (2011) suggested that involving parents as active partners in the classroom provides both parent and teacher with firsthand information about home and school expectations; additionally, classrooms work best and children learn more when parents are involved (p. 40). Nevertheless, Hung (2007) indicated that in Chinese culture, teachers have not encouraged parental participation. In this study, the messages parents received from school were not very positive. After Jay's mother checked with Jay about how an egg-cooking activity was proceeding in his class, I asked her whether she went to Jay's class and joined in the activity. She quickly replied, "No, I didn't. His school did not invite parents to participate [in this activity]" (Jay's mother, interview#2). This implicitly unfriendly hint made Jay's mother believe that it was unnecessary for her to engage in her child's school science learning.

Although some parents volunteered in school (e.g., Ying's mother served as a "story-mom" in Ying's class), their engagement only consisted of minor assistance – for example, helping put sports equipment in order (Wei's mother, interview#2). In other words, even though parents physically engaged in school activity, they did not have opportunities to engage in children's school science learning, not to mention sharing their home science learning with the schoolteacher. Thus, even though they did engage in school affairs, none of these was related to science learning.

**Chapter summary**

The purpose of this chapter was to answer the research question, "How do parents perceive their children's science learning?" using Vygotsky's theory as a guide for interpretation. To accomplish this task, I presented parents' beliefs using four main themes: 1) Parents' gendered science beliefs, 2) Parents' perceived importance of science, 3) How science learning should proceed, and 4) Parents' beliefs about their engagement in their children's science learning.

Each theme provides an understanding of different issues of children's science learning from parents' perspectives. Here, I review the main points in each theme to portray a whole picture of these parents' beliefs about their children's science learning:

1. Growing up in the Taiwanese context, these parents were influenced by traditional Taiwanese values about gender and science. However, parents believed that science learning was equally important for boys and girls. They also used this construct to

remind themselves not to limit the possibilities of their children's learning in science and other content areas. Additionally, they believed that their children's interests in science weighed more than their gender.

2. Science learning was important in children's early years because of a variety of values. Cognitively and affectively, children benefited greatly by learning science. Due to a belief in these values, parents were more willing to invest in their children's science learning by purchasing various materials, visiting museums, and cognitively supporting them. Still, they also believed that their children should balance their learning among different content areas, and that they should remain open to all kinds of possibilities to find out what they really liked.
3. Science learning should be fun, interesting, relevant to life, adult-oriented, and low-pressure. Science was fundamentally learned through hands-on and first-hand experiences or activities. Children's motivation and their ages determined the breadth and depth of their science learning.
4. Parents' self-efficacy beliefs influenced their engagement in children's science learning, and what forms this engagement took. Parents usually assumed roles as information/answer providers, knowledge agents, and guides. These parents indeed engaged in school affairs, yet those rarely concerned science.

These four themes provide multiple understandings of how these parents view the influence of gender, the necessity, forms, and quantity of science learning, and how they should engage in this learning. In the next chapter, I will examine how parents reflect these beliefs in their science museum visits. Doing so will provide a further understanding of how parents use their beliefs to guide their actions and make decisions when visiting science museums.

# Chapter 5 How parents' beliefs were reflected in interactions with their children in science museum visits

## Introduction

In the last chapter, I presented parents' beliefs about different aspects of their children's science learning. The second research question this study investigated is: "How are these beliefs reflected in their interactions with their children in science museum visits?" The findings presented in chapter four provide a resource for understanding how parents' beliefs inform interactions with their children during science museum visits. To further understand how these nine parents' beliefs guided them in making decisions when they interacted with their children, I analyzed their science museum visits through Vygotsky's work, paying especial attention to several constructs, including the Zone of Proximal Development, scaffolding, social interaction, contextual influence and other related ideas. As a result, three main themes emerged from the data: 1) Who takes the lead at their family visits, 2) The quantity of parents' intervention, and 3) Parents' use of scaffolding strategies.

In this chapter, I will describe each of these themes to demonstrate how these parents' beliefs emerged in their family visits to the science museum. In doing so, I hope to illustrate how these parents' beliefs assisted them in acting and making decisions. Before reporting on these three themes, I begin with background information concerning these eight families' museum visits, as well as how I selected and used the images which accompany the findings.

**Details of each family's visit.** Each family visited the National Museum of Natural Science once. Among the eight families, Kai's visit was the longest (3 hours and 55 minutes). The shortest was Pei's family (56 minutes). Generally, a family stayed in the science museum for about two hours (See Table 2 for more details of each family's visit).

Table 2 Details of each family's visit

| Family | Duration of visit | Route | Members in the visit |
|---|---|---|---|
| Lily 120708 | 1 hour 46 minutes | Life Science Hall->Science Center | Lily's mother and Lily[13] |
| Yen 120711 | 1 hour 34 minutes | Life Science Hall->Human Cultures Hall (They only visited two exhibition halls: "Oceania" and "Agricultural Ecology") | Yen's parents, Yen, and Yen's younger brother Wen |
| Kai 120714 | 3 hours 55 minutes | Life Science Hall->Science Center | Kai's mother, Kai, and Kai's older sister Mei |
| Pei 120724 | 56 minutes | Life Science Hall | Pei's mother, Pei, and Pei's twin brother Ming |
| Ying 120728 | 2 hours 20 minutes | They spent the first 1 hour and fifteen minutes on a museum tour (which took place in the exhibition hall "Chinese Science and Technology")<br><br>Life Science Hall (They only visited the exhibition hall "2012 End of the World Exhibition-Catastrophe and Revival")->Science Center | Ying's parents, Ying, and Ying's older sister Ting |
| Jay 120807 | 1 hour 42 minutes | Life Science Hall->Science Center | Jay's mother and Jay |
| Wei 120809 | 1 hour 39 minutes | Science Center->Life Science Hall (They only visited the exhibition hall "The Journey of Human Life") | Wei's mother, Wei, and one of Wei's older sisters |
| Chun 120819 | 1 hour 14 minutes | Life Science Hall | Chun's parents, Chun, and Chun's older brother Hsuan |

**Criteria of choosing the images.** To make these families' interaction and conversation more understandable, each example is accompanied by an image. I took pains to anonymize these images, either shooting them from behind the participants, or adjusting clarity to make participants' faces unidentifiable. I sent these images to my participants, too, so they could confirm that my use of these pictures would not reveal

[13] Lily's younger sister Nana was sick, so she did not go to the visit.

their identity.

**Who takes the lead at their family visits?**

Why does a family visit this exhibit, but skip that one? Why does a family stay a long time at a particular exhibit? Why does a family return to the same exhibit several times? These questions have been a core interest in museum studies (e.g., Borun & Dritsas, 1997; Falk, 1991; Sandifer, 1997; Sanford, 2010). However, rarely do researchers examine these issues by way of parents' beliefs. In this section, therefore, I will present how parents' beliefs determined who chose exhibits, when the family left, and whether they returned to an exhibit later.

**Choosing what to visit.** According to the follow-up interviews and the reflection sessions, "who is going to decide what to visit" was usually not discussed prior to a family's visit. However, each family seemed to adhere to a pattern regarding who in their family chose the exhibits. Parents showed their acceptance of children's exhibit choices by silently following them or verbally checking with them about the next choice. For example, Lily's mother would follow Lily when Lily drew her to exhibits she wanted to visit (Lily, on-site observation, 120708). Kai told his mother "Mommy, let's go over there" or "Mommy, I want to see that" (Kai, on-site observation, 120714). Before moving on, Ying's father also asked Ying and Ting, "What do you want to visit next?" in addition to his observing his daughters' physical movement (Ying, on-site observation, 120728).

First, I present how parents following the lead of their children showed their prioritization of children's intrinsic motivation and interest. Then, I discuss those instances where parents actively chose exhibits because of their evaluation of children's potential interest. Lastly, I present how parents' choices of what to visit reflected their self-efficacy beliefs.

***Letting my children make choices may reveal what motivates and interests them.*** Children's interests and curiosity are the primary issue driving exhibit choice, because parents believe such a small choice can relate important information: how prepared a child is to learn science, what kind of support s/he needs from them, and/or how much the child could benefit from the support. In other words, allowing their children to choose exhibits helps these parents to discover children's intrinsic motivations and developing interests.

In Wei's visit, a frequently observed phenomenon was Wei's mother lingering at one exhibit alone and then catching up with her children, as shown in Fig 4. Wei's mother might be personally interested in an exhibit, or feel its content was important; in a few cases, she recommended these exhibits to her children. Yet, she rarely asked her children to visit the exhibit she chose.

Fig 4 Wei's mother, reviewing exhibits about semiconductors alone

Wei's mother explained that she let Wei and his older sister choose what they wanted to look at or manipulate because, as she said, "I think I should let them actively explore." She went on to explain:

> *I didn't want to limit them to "come to see this or come here to see that"; this is the way I adopted. They didn't necessarily like what I like. Anything they learned there (the science museum) was useful; what I took them to take a look at wasn't necessarily the most useful." (Wei's mother, reflection session)*

The above explanation indicates Wei's mother believes her children to have their own interests. Giving her children freedom in choosing exhibits seems to be an effective way for her to learn what Wei and his older sister are curious about.

When Wei or his older sister found an exhibit appealing to them and seemed eager to know something about it, they would call their mother to provide them with some sort of support (Wei, on-site observation, 120809). Wei's mother explained, "I won't come to them unless they said 'Mom, I don't know how to use this!' or 'Mom, what is this?'" (Wei's mother, reflection session) Her explanation confirmed that it was an intentional action and she was aware of it. Her children's help-seeking served as precise indications for her to know it was the right time to give them more. More to the point, because Wei and his older sister could choose exhibits themselves, their mother was then able to know what interested her children, and as well as how to provide adequate scaffolding.

One thing that should be noted is Wei's mother implicitly identified the role of the science museum as a "gatekeeper," meaning that the science museum has chosen valuable and important content and knowledge for its visitors. As she said above, "Anything they learned there was useful." This might make Wei's mother more comfortable with allowing her children to make choices.

In Pei's visit, while Pei's mother sometimes chose what she was interested in for Pei and Ming (Pei's mother, reflection session), her explanation for letting her children make choices was similar to Wei's mother's. She explained:

> *Just like you were observing us, I was observing them as well. I was observing what interested them, what they still felt was strange, and whether the way they viewed things indicated the level of their maturity had changed, etc. If you did too much during this part, it would be difficult for you to see. (Pei's mother, reflection session)*

As Pei's mother highlighted, if parents usually chose exhibits for their children to visit, explore, and/or learn from, they would miss an opportunity to understand what their children were curious about or how familiar their children were with certain content. This action demonstrates Moll's (1992) statement, "Caring adults are sensitive to the directions in which children's curiosity takes them, their attempts to express needs or understandings, and the meanings they are creating" (p. 228). Both Wei's and Pei's mothers deliberately let their children choose exhibits, because they believed it was helpful to see what their children were interested in and whether they were prepared to explore a specific concept.

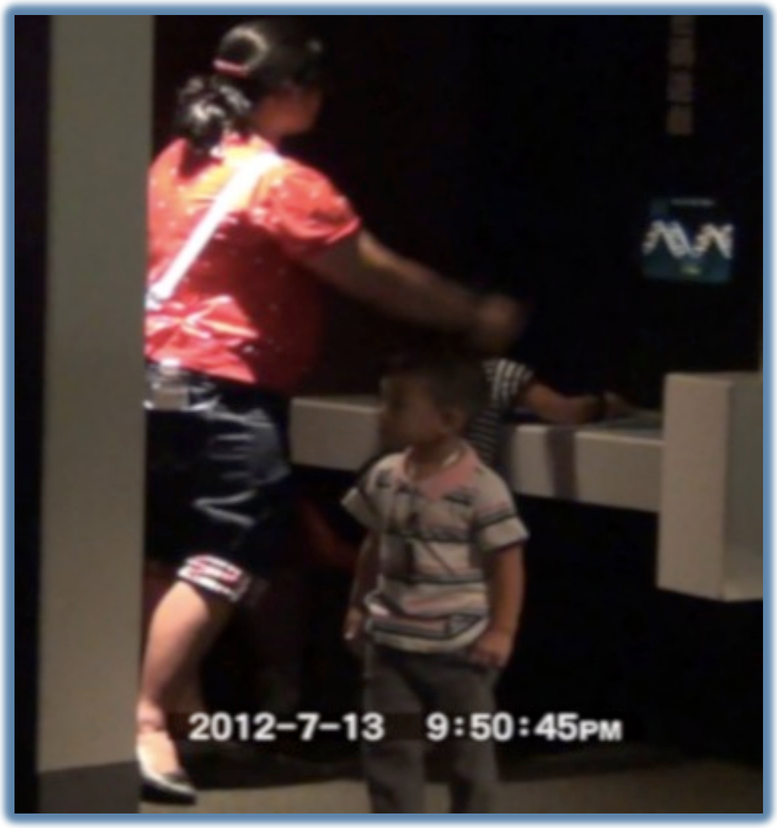
Piscitelli, Everett, and Weier (2003) wrote that "giving children a say in what they will do and see during a museum visit results in higher levels of enthusiasm" (p. 15). Parents who let their children make decisions also reflected upon what sparked their children's curiosity, and felt the science learning was most powerful when children followed their own interests. For example, Pei's mother found Pei and Ming showed great interest in knowing whether dinosaurs ever existed and whether they might still see this creature in the present (Pei's mother, follow-up interview). She said she never knew they were so eager for information about this issue, bringing her surprise up again in her reflection session. Her discovery might strengthen Piscitelli et al.,'s (2003) argument.

***Children's respective choices.*** Sociocultural theory underscores the importance of individual differences (Haden, 2010). Children's different choices show their parents they are interested in different things, as well as their individual understandings of exhibit content. Excluding Jay's family, the families in this study contained more than one child. When two children wanted to visit different exhibits, their difference was acceptable for parents because, as Pei's mother pointed out, "You can't ask everyone to have the same interest. It's okay as long as I can take care of their safety" (Pei's mother, reflection session). Therefore, in their visit, a family may sometimes move together as a group and sometimes move separately to address each child's interests (See Fig 5).

Fig 5 Mei and Kai, manipulating different exhibits about different senses


One example in Kai's family visit arose when Kai's older sister Mei wanted to play a game about DNA base pairing and called her mother to help her (See Fig 6). Kai first watched how Mei played the game; he then left his family and glanced curiously around the exhibition hall. After a while, he came back to play with Mei. After they finished the game, Mei rushed to the "The Beginnings of Life on Earth," while Kai picked another exhibit (Kai, on-site observation, 120714).

Fig 6 Kai, looking around when his family played the DNA game




In the reflection session, Kai's mother and I discussed Kai's behavior in this instance:

> *Kai's mother: I wouldn't ask him to follow us.*
> *YC: Why?*
> *Kai's mother: Because he felt bored. If he felt bored then he wouldn't want to continue watching this with us. He would try to find something he wanted to visit.*
> *YC: So, when one of your children is moving around like this, you wouldn't push him/her to follow you to make sure they learned the same thing?*
> *Kai's mother: No, I wouldn't. [In this case,] because I thought he was not mature enough to a certain level, unless he was interested in [this exhibit,] then I would tell him, "look how we play." (Kai's mother, reflection session)*

The above passage indicates parents were aware of each child's own interests, and believed they should be respected by not forcing them to join in the same activity. More to the point, Kai might not be motivated by this exhibit as much as his older sister. Kai's mother understood and accepted this, and waited until he wanted to play this computer game with them. Additionally, the "because I thought he was not mature enough to a certain level" in this quotation might indicate another reason why Kai's mother did not ask Kai to join them: because he was too little to understand, and it was therefore counterproductive to ask him to learn something about the content.

*The difficulty of handling children's different choices*. Parents who let two children choose different exhibits also pointed out this was in fact a burden to them, especially for those who went to the science museum without the assistance of a spouse or other adult relatives. In the follow-up interview, Kai's mother said, "What they liked/disliked was different, so I felt it was tough to handle them. It's really difficult without their father's accompanying. …I'm exhausted!" (Kai's mother, follow-up interview) Kai, Pei, and Wei attended with only one adult. Originally, allowing children to make different choices was to permit them to show their own interests. However, as Kai's mother said above, doing this alone is not easy. Similarly, Wei's mother admitted that she sometimes did not know about the other child's interactions with exhibits, because it was usually difficult for a parent to handle two children's different choices simultaneously (Wei's mother, reflection session). When Wei's mother was watching the video, she said she "finally knew what the other child was doing" (Wei's mother, reflection session). Therefore, while children's respective choices might provide parents with hints about their interests, in many cases, parents were not as capable to detect these signals because they were only able to focus on one child at a time.

In addition to being tired, as Kai's mother highlighted, parents' concern about children's safety is also an issue. Concerned about their children's safety, sometimes parents seemed to be torn over whether to visit separately or to move together. In one such example, Pei's mother asked Pei to quickly catch up because the chosen exhibit was out of her mother's sight (Pei, on-site observation, 120724). In such a situation, it may look as though parents abandoned their beliefs. However, when contextual influence is considered, this is understandable because children's safety is the primary concern. In other words, although parents' beliefs served as a decision-making resource for them, when something like children's safety trumped those beliefs, parents might need to adjust their behaviors in response to external factors.

*The older sibling has advantages*. In this study, only Lily and Yen are the oldest children in their families[14]. Parents' letting their children make their own choices seems also to stress their "the older, the more" belief (See p. 115).

Wei's older sister, who was the eldest child (4th grade) in all eight families, seemed to be identified by her mother as more capable. She could basically make choices without her mother's supervision. Her mother said, "She is older; she can explore on her own. Also, she knows very well about how to stay safe" (Wei's mother, reflection session). This claim is supported by Wei's mother's actions, as she usually accompanied Wei while his older sister visited exhibits by herself (Wei, on-site observation, 120809). In short, her age permitted her independence, in addition to her mother's belief in the importance of children's intrinsic motivation.

Kai's older sister Mei, who was also identified by her mother as "more active and more sure of what she wanted," could move around in the exhibition halls alone in most cases (Kai's mother, reflection session). Similar to Wei's mother, Kai's mother usually stayed with Kai but seldom checked on what Mei was doing. Yet, in a slight difference from Wei's mother, Kai's mother noted, "I feel we need to tell her [information about the exhibits,] then she would know what this is and what that is" (Kai's mother, reflection session). This stipulation suggests that, although Kai's mother allowed Mei to take

[14] Jay is the only child. Pei and Ming are twins.

initiative in their visit, she seemed to stress the necessity of parents' support. This might echo parents' belief that being a knowledge agent is required.

***Recommending exhibits to children based on their potential interest.*** Most parents in this study (e.g., Chun's father, Lily's mother, Ying's parents) were well aware of their children's current interests. At the same time, they believed their children were still developing and should not limit their interest to a specific domain. Thus, in some cases, parents would actively recommend their children exhibits to visit. For example, Yen's mother noted, "Unless I feel there's something they might be interested in, I would ask them whether they want to take a look" (Yen's mother, reflection session).

In one example, Ying's father was looking at other exhibits while his family continued watching a scientist sketching an animal (See Fig 7 & 8). At first I thought this was because he was feeling boring, since his two daughters had spent a long time watching. Yet, as Ying's father explained, "Oh, actually I would try to find the next place to visit. If there was something suitable for their interests, I would take them to take a look" (Ying's parents, reflection session). This behavior was observed again later when Ying's mother was helping Ying and Ting make a Hmong textile pattern (Ying, on-site observation, 120728). When explaining his criteria for "interesting exhibits," Ying's father said, "It's something they feel interested in. They see something and stand there for a while, and then we probably approach them. Sometimes we see something interesting and if we feel they can take a look at it, we'll guide them to the exhibit" (Ying's parents, interview#2). While Ying and/or Ting did not make such a decision, their father recommended exhibits for them based on his knowledge of their potential interests. Whether his daughters accepted his recommendation told him what their interests looked like.

Fig 7 Ying's father, examining the next exhibit


Fig 8 Ying's father, recommending the exhibit to his family

In this case, after Ying and Ting decided to leave, Ying's father then recommended they visit the "2012 End of the World Exhibition: Catastrophe and Revival," which he discovered when his family were at the last exhibit. Ying and Ting accepted this suggestion and moved to this exhibition hall together with their parents. This whole process reflects that Ying's father believed his daughters were still developing and should be exposed to various experiences (Ying's parents, interview#2). His recommendation was a strategy to both evaluate and cultivate his daughters' interests (Ying's parents, interview#2).

***The choice was made because I know better.*** While Jay explicitly told his mother "Let me find interesting stuff for you!" or "Follow me!" and largely controlled the choice of exhibits, in a few cases, I noticed Jay's mother actively chose exhibits for Jay because she was more confident in talking about the content of these exhibits with Jay. In one example, Jay's mother actively called Jay to see an exhibit introducing the development of a fetus (See Fig 9). Below is their conversation at this exhibit:

> *Jay's mother: Hey, this is how you looked like when you were in my belly. Come See this.*
> *Jay: (Walked towards his mother) Looked like what?*
> *Jay's mother: When you were a baby, you looked like this.*
> *(They both moved a little closer to the exhibition wall. Jay's mother pointed at one of the pictures.)*
> *At first, you looked like this (pointed at the picture of "fertilization"). You looked like this in my belly. Then, you became like that (pointed at another picture). S/he has feet [sic], do you see his/her feet? Then s/he has a head [sic]. Then you can see his/her hands (pointed at another picture). And then…s/he was getting bigger and bigger, see? (They stood in front of the exhibition wall for a few seconds, and then Jay moved to the next exhibit.) (Jay, on-site observation, 120807)*

Fig 9 Jay and his mother, visiting the exhibition wall


By examining the conversation a little further, it becomes apparent that Jay's mother only briefly introduced fetal development to Jay, rather than talking about advanced concepts (e.g., Wei's family touched on the concept of "amniotic fluid" at this exhibition wall). Yet, compared to other exhibits they visited, her experience of pregnancy seemed to not only make her more confident in handling Jay's potential questions without misleading him, but also gave her confidence to actively choose this exhibit to visit.

In the pre-visit interviews, Jay's mother was identified as a parent who held lower self-efficacy beliefs in terms of conducting science-related activities with her child. Thus, her active choice of exhibits is unique because, when parents have more confidence, it opens children's science learning to more possibilities. A personal association with the exhibit, too, may be a good entry point to help low-self efficacy parents build up confidence. As Patterson (2007) suggested, to help children of low self-efficacy parents get the most out of their experience, science museums should make every effort to understand the complex connection between informal learning experiences in museums and experiences in everyday life, because personal experiences play an important role in helping people to understand novel concepts (Crowley & Jacobs, 2002; Eberbach & Crowley, 2005). The example of Jay's mother supports such a claim and points out a possible way to support parents.

**Leaving.** In a family's museum visit, "leaving" looks like a natural occurrence most of the time. Generally, a family stayed at an exhibit for couple of seconds or a few minutes and then moved to the next exhibit. However, "leaving" was not as natural as it looked in these families' visits, especially when children stayed at a specific exhibit for a long time. In the following, I present three subsections to demonstrate how leaving reflects parent's beliefs: "My child's curiosity/interest is the first concern," "We will leave when my child feels satisfied," and "Parents' control of when to leave."

***My child's curiosity/interest is the first concern.*** Parents' belief in the importance of their children's intrinsic motivation was not only reflected by their letting children choose exhibits, but could also be seen in their timing when to leave an exhibit.

If their children had no interest or lost interest and wanted to leave, they accepted it because they took this as an indication that "this was not the timing for giving children more." In one example (See Fig 10 & 11), Pei walked towards to "The Rocks of the Earth," followed by Ming and their mother. Pei's mother then encouraged her children to touch different rocks and experience the various textures. Pei and Ming hurriedly touched the rocks and looked disinclined to stay at this exhibit. Ming then went back to the last exhibit while Pei said a little impatiently to her mother, "That's enough!" Their mother did not ask them to come back. (Pei, on-site observation, 120724)

Fig 10 Pei's mother, guiding her children to touch different rocks

Fig 11 “The Rocks of the Earth”


In the reflection session, Pei’s mother actively explained her interaction with Pei and Ming in this case:

> *I told them to observe these rocks, the differences among the rocks, but they didn’t necessarily…well, sometimes I guided them to [do something] but they might not be interested in it. Having interests [in a particular thing] or not depends on their maturity and many other factors. (Pei’s mother, reflection session)*

Exploring the differences among these rocks might be an important experience for Ming and Pei. However, as Chak (2001) noted, “A child’ s readiness to move forward depends not only on the appropriateness of the cognitive demand, but also on their motivation to engage in the activity.” (p. 388) The mother’s explanation reflects Chak’s statement and shows her belief in waiting for her children to be intrinsically motivated to learn more about rocks.

Additionally, as Pei’s mother pointed out in her pre-visit interviews, her children’s interests were still developing. They might maintain their interest in one particular thing for a long time (e.g., Ming’s fondness of evacuators); they may feel uninterested in one thing at a particular moment (e.g., rocks in this case). If the time is not right – in other words, when a child is more interested in something else – parents should pay attention to the child's current interest and provide support for the subject their child is interested in.

In other cases, even when parents were themselves curious, they left an exhibit if their children did not find it attractive, instead of asking them to stay. A conversation I had with Lily's mother about her behavior during a museum tour (See Fig 12) reveals that children's interests are the main priority in deciding when to leave:

> *YC: So, there was a museum tour; did you choose to stay because you wanted Lily to listen to the tour?*
> *Lily's mother: No, it was because I wanted to listen, then we stayed there. I was very curious about what the guide was talking about. But it was because she probably felt that was unattractive to her, then we left. Also, because I was unable to explain the content of the tour to her, I didn't know myself, I chose…*
> *YC: So Lily is your primary priority.*
> *Lily's mother: Yep.*
> *Lily's mother: Then she wanted to visit this (i.e., the "The Beginnings of Life on Earth"), so we went to visit this. (Lily's mother, reflection session)*

Fig 12 Lily's mother, listening to a museum tour


Although Lily's mother was very interested in this tour, her understanding that Lily was not as interested as she made her move on to what Lily wanted to visit. As I said in the beginning of this section, such a seemingly natural behavior in fact constituted an intentional decision. The behavior of Lily's mother once again highlights parents' beliefs in the importance of children's interest and curiosity.

***We will leave when my child feel satisfied.*** Because parents believed their children needed to take time to satisfy their curiosity as well as to acquaint themselves with the exhibits, these parents did not think they had to push their children to move quickly to the next exhibit. Thus, even when children spent a long time on one exhibit, their parents would not demand they leave. Ying and Ting, who spent almost ten minutes watching a female scientist sketch a bird specimen, are one example (See Fig 7 & 8).

In the very beginning of Pei's family visit, Ming did not want to leave an exhibit called "The Beginnings of Life on Earth (See Fig 13)." This was an interactive exhibit, simulating the Earth 3.8 billion years ago to demonstrate how life began. Ming showed great interest in this exhibit, returning repeatedly, while his twin sister Pei seemed satisfied after her first visit. His mother asked him several times, "You want to take a look one more time?" to gauge his interest. Then, Pei and her mother went to see other exhibits nearby while Ming stayed at this exhibit by himself (See Fig 14) (Pei, on-site observation, 120724).

Fig 13 Pei's family, at the "The Beginnings of Life on Earth"

Fig 14 Pei, moving on to another exhibits


When watching the video of their visit, I asked Pei's mother about her thoughts on Pei and/or Ming spending a long time at an exhibit. She quickly responded, "No, I wouldn't push them to move on to other exhibits" (Pei's mother, reflection session). She explained Ming's behavior in this episode, stating "he needed to satisfy his curiosity." She also gave a recent example of letting Ming and Pei spend a whole morning watching a worker set up an air conditioner because they felt curious about the process (Pei's mother, reflection session). Because of believing that satisfying children's curiosity is important as well as knowing that science learning takes time, Pei's mother would not abbreviate her children's experience at any one exhibit.

Additionally, Pei's mother pointed out that the time and chances to explore are very limited for today's children (Pei's mother, reflection session). In her explanation, making progress from "not knowing" to "understanding" was vital for children. Therefore, she would not pressure her children to learn something from an exhibit and then hurry them to other exhibits. Still, she mentioned that she would guide them to visit exhibits that were unfamiliar to them; as she said in the reflection session, "This is something I would do" (Pei's mother, reflection session).

While noticing her son's curiosity about the "The Beginnings of Life on Earth," Pei's mother did not attempt to extend Ming's science learning at this exhibit. She simply let Ming stand there, watching the simulation. As mentioned earlier, parents are concerned about safety. In this case, Pei's mother needed to make sure her daughter was safe, so she could only occasionally check on Ming. As a result, she was unable to scaffold Ming at the most proper time even though Ming had signaled to his mother that "this is the right timing" for giving him support.

***Parents' control of when to leave.*** Parents sometimes controlled when to leave because they believed their competency in discussing the content was inadequate. In other situations, parents believed their children should be able to demonstrate or acquire certain knowledge. Therefore, parents would not consent to leave until their children showed them they did possess the knowledge.

*I didn't know much about the content, so we left*. The self-efficacy beliefs of Jay's mother not only caused her to actively choose exhibits for Jay, but also caused her to suggest Jay leave exhibits. For example, when they visited the "2012 End of the World Exhibition: Catastrophe and Revival," Jay was attracted to an exhibit called "Earth's Catastrophe and Life's Reemergence," which simulated the Earth's possible state after catastrophe by continuously displaying a video (See Fig 15). Although Jay was very curious about the content of the video, he and his mother did not have much verbal or nonverbal interaction at this exhibit. After Jay stayed here for a while, Jay's mother told him, "Let's go. Let's go find some other interesting stuff" (Jay, on-site observation, 120807).

In the reflection session, Jay's mother had an explanation for her request that Jay to leave. She said, "I didn't know what to provide for Jay. …I didn't know how to explain for him because there was no adequate information for me to use" (Jay's mother, reflection session).

Fig 15 Jay and his mother, at "Earth's Catastrophe and Life's Reemergence"


While Jay's mother indeed acknowledged Jay was curious about this exhibit, this passage reveals that she asked Jay to leave because of her low self-efficacy—she did not have the skills and knowledge to help Jay (Sheldon, 2002). Moreover, because the explanation panel was not easily found—she still could not find it when watching the video—she had no idea what this exhibit was about, and thought there was nothing she could use to talk with Jay. In other words, without support from the science museum, she did not know what to do except simply echoing Jay's description of the content or asking some very basic questions (e.g., "how do you know this is the Earth?"). In the end, she instructed Jay to "find some other interesting stuff." The problem of insufficient science museum support will be further elaborated in the next theme.

*Show me you know this*. The “show me you know this” demand might be a reflection of parents’ beliefs in the “now and enough” (See p. 116). If the content were appropriate for children at this age, parents would ask their children to demonstrate their understanding before moving to the next exhibit. The following conversation between Jay and his mother is such an example (See Fig 16 & 17):

Fig 16 Jay and his mother, talking in front of an African dwarf crocodile model

Fig 17 The African dwarf crocodile model


*Jay: I want to see this! (running excitedly towards the crocodile model)*
*Jay's mother: (moving slowly from the last exhibit) Hey, don't touch it. DON'T touch it.*
*Jay: Come see this, quickly, come here, come here!*
*Jay's mother: I'm coming; what's that?*
*Jay: I don't know.*
*Jay's mother: You, You don't know what is that?*
*Jay: I don't know what the disgusting thing underneath is.*
*Jay's mother: That's water. What is this one (pointing at the crocodile model)? YOU don't know what that is (pointing at the crocodile model again)?*
*Jay: I don't know.*
*(Jay's mother repeated her question again with her finger pointing at the crocodile model.)*
*Jay: I don't know. (Pausing for about three seconds) A crocodile!*
*Jay's mother: That's correct! Why did you say you don't know?*
*(They left and moved to the next exhibit.) (Jay, on-site observation, 120807)*

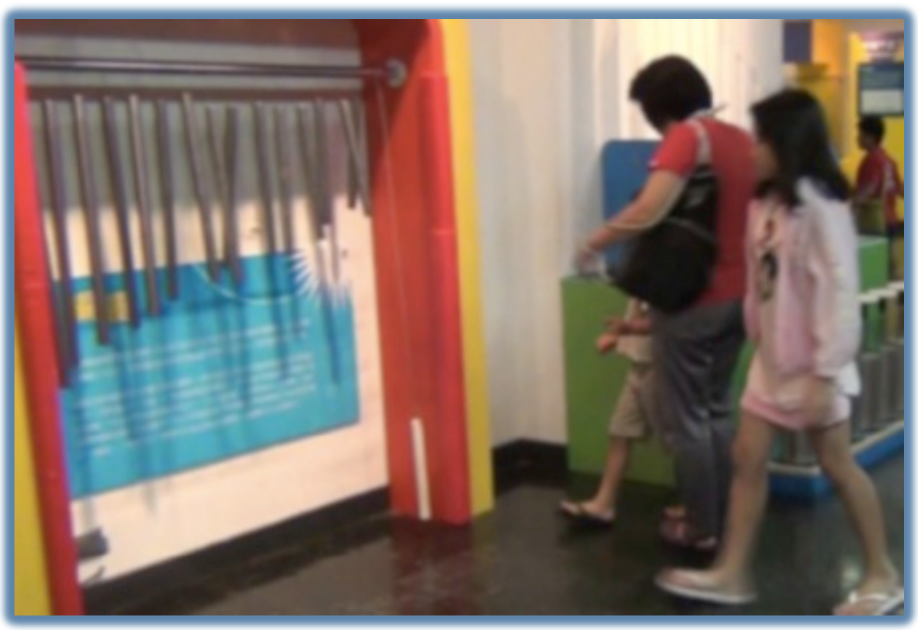
In this conversation, Jay's mother pushed Jay to answer her question by repeating it several times. Because Jay's mother identified this as something he should already know, Jay had to draw on his memory of what this was until he came up with the correct answer. Only then was he allowed to leave. Later in their visit, when they saw models of a zebra and a kangaroo, Jay's mother also demanded Jay correctly name these two animals before allowing him to leave (Jay, on-site observation, 120807). Her actions in these instances reveal how a parent uses "leaving" as a strategy to request a desired answer, if they believed their children should know or understand it.

In Wei's family visit, similar actions were also observed. While Wei's mother took her two children's curiosity into consideration by letting them choose exhibits, in some cases, she asked Wei to think more before he could move to other exhibits. One example occurred when Wei was manipulating the "Chime Bell" (See Fig 18 & 19):

> *At first, Wei was manipulating the "Chime Bell" while his older sister was manipulating the other exhibit next to him. It looked as though Wei was only randomly knocking on the Chime Bell without noticing that the different lengths of the bells makes each one chime differently. After a while, Wei moved to his older sister and manipulated the exhibit with her. Wei's mother quickly called him back to the "Chime Bell" and asked him, "Does each one sound the same?" Wei and his older sister came back together and Wei tried again but said nothing to his mother. Wei's mother asked her children, "Do they sound the same?" twice, but did not get responses. Then, Wei left and moved to the other exhibit. His older sister stayed at the "Chime Bell" for a few seconds and also left. (Wei, on-site observation, 120809)*

Fig 18 Wei's initial manipulation

Fig 19 Wei's mother, asking him to come back



The action taken by Wei's mother seems to contradict my earlier claim that she always gave her children unlimited freedom to choose exhibits. However, compared to other exhibits in this exhibition hall, the "Chime Bell" Wei chose in this episode is more age-appropriate for a young child like Wei. His mother's behavior in immediately drawing him back to this exhibit demonstrates that she believes Wei is "able" to distinguish the different sounds. That is, Wei's current cognitive ability was advanced enough to understand the content presented by the Chime Bell. Thus, Wei's mother did not endorse his leaving as she did in other cases. Instead, she wanted him to explore a little further.

Compared to Jay's crocodile example, both mothers' directive actions mirrors Rankin's (2004) argument that "more advanced functioning can best be strengthened when teachers pay attention to and use the prior knowledge and beliefs of children as the foundation on which to invite more advanced abilities" (p. 31). Their behavior was purposeful; their questions built upon on what these children have already encountered or obtained, and might have prompted their children to study the exhibit more.

On the other hand, while both mothers controlled leaving by repeating the same question, the major difference between these two examples lies in contextual influence in Wei's example. When reviewing this instance, Wei's mother explained,

> *I asked him to try to find out whether the longest sounds lower or higher, so he could experience it by himself. But it seems that he didn't give me an exact answer on the spot. But I think that's fine anyway. There were too many people there. Next time, when we go there and he tries it again, he might know which one sounds lower or higher. Actually, there were too many people, so it was unavoidable that people would interfere. Maybe someday when there are fewer people and he tries again, he will remember what I have told him. (Wei's mother, reflection session)*

Even though Wei's mother believed Wei was capable to detect different sounds, she understood that interference from other visitors might make this task more difficult (Falk & Dierking, 1992). This awareness of contextual influence, however, nicely integrated into her faith in the low-pressure approach; if they did not have the opportunity that time, then they could try it again in their future visit.

*I want you to know this*. In other cases, parents wanted their children to acquire specific knowledge before leaving, whether the content was in fact age-appropriate or not. Their children needed to listen to their teaching because they identified what was important. This seems to reflect their intuitive evaluation of how much their children should learn (See "The emphasis on the now and enough" section on p. 116).

Yen's family conversation at a Brontosaur diorama (See Fig 20 & 21) exemplifies such control over leaving:

> *Yen's mother: Yen, this is a brontosaur, the biggest one (she pointed at it to show Yen where it is). And there is a stegosaur, do you see the stegosaur? Um…it says there is a stegosaur, ah, it is at the back [of the window]. Do you see it?*
> *Yen: I did.*
> *Yen's mother: The stegosaur is at the back [of the window], and [that is] a coelurus. The one over there (she used a gesture to show its location), the small one is a coelurus.*
> *(Wen made some sound to complain that he couldn't see the dinosaurs. Yen's mother asked Yen's father to lift Wen up and told him to tell their younger son where the stegosaur is.)*
> *Yen's mother: …a coelurus. The one over our head is a brontosaur. It's very long, isn't is? It is 20 meters high. But is it herbivorous or carnivorous?*
> *Yen: It eats grass.*
> *Yen's mother: Correct, it eats…(Yen interrupted, asking his mother when the brontosaur will come down again.)*
> *Yen's mother: It will come down later. It is eating grass. See? It is like a giraffe, they both eat shoots.*
> *Yen: Let's go.*
> *Yen's mother: Is a coelurus herbivorous or carnivorous?*
> *Yen: Herbivorous.*
> *Yen's mother: Carnivorous (she stressed when she said this). It eats rotten meat. It eats the leftover meat after the bigger dinosaurs have eaten. (Yen looked around when his mother was talking) You see, what is it eating? (Yen, on-site observation, 120711)*

Fig 20 Yen's family, having a conversation at the Brontosaur diorama

Fig 21 The Brontosaur diorama

In this conversation, Yen's mother tried to share knowledge about dinosaurs with her sons. In Pei's example earlier, when Pei verbally signaled her wish (i.e., "That's enough"), her mother knew it was ineffective to stay at the exhibit. While Yen told his mother "Let's go" to show he wanted to leave, however, his mother chose to continue talking until she finished stating basic information, such as "A coelurus is a carnivorous dinosaur." At the end of this conversation, it seems that Yen had lost interest in the diorama; because he did not pay attention to his mother's talking at all. Yet, he still needed to stay at the exhibit until his mother finished.

In the reflection session, Yen's mother had an explanation:

> *If you make your explanations really interesting, then they will continue listening to you. If they didn't feel interested in my explanations, they would leave as well, don't you think? (Yen's mother, reflection session)*

In this episode, because Yen and Wen still stayed with her, she interpreted their actions as interest in her explanation. Thus, she continued to tell them things she wanted them to know. However, she might overlook verbal or nonverbal hints that her sons had lost interest in either the exhibit or her talking. I will elaborate on these two boys' distraction in a later section.

In sum, most parents in this study revealed a belief prior to visiting the museum that their children were too young to know a lot; hence, in most cases they did not initiate the departure. However, as in Jay's, Wei's and Yen's mothers' actions, when they felt their children should acquire or were capable of demonstrating age-appropriate knowledge (e.g., this is a crocodile), they would use "leaving" as a strategy to achieve these goals. Obviously, Yen's mother was unable to request Yen stay every time, because sometimes he quickly moved to other exhibits. Similarly, Wei's mother also said, "I wanted to teach him, but you see, he left like this" (Wei's mother, reflection session). Nevertheless, the examples above still provide an alternate understanding of why parents sometimes allowed their children to leave while sometimes they did not.

**Returning to an exhibit.** "Returning to an exhibit" is defined as a family's going back to the same exhibit they visited earlier. The return might be initiated either by children or by parents. When child-initiated returning was permitted, it seemed to reveal parents' valuation of children's intrinsic motivation. Additionally, this may also reflect a low-pressure approach because children need time to explore unfamiliar phenomena. On the other hand, parent-initiated returns might show that parents seize chances to enhance their children's learning but avoid making them feel emotionally stressed. Below I first discuss the child-initiated returning, followed by parent-initiated returning.

***Child-initiated returning.*** Child-initiated returning indicates a child actively returning the same exhibit more than once. Jay, Kai, Ming, Wei, and Wei's older sister showed this behavior. These children's parents did not perceive this as wasting time or ask them to visit something they have not yet visited. On the contrary, their response tended to resemble that of Kai's mother, who, when she saw her children returning to an exhibit several times, said, "I give first place to their interest" (Kai's mother, reflection session).

Wei returned to the "Balancing Ball" (See Fig 22) at least three times. This was an exhibit designed to introduce Bernoulli's Principle. When Wei and his older sister first approached the "Balancing Ball," Wei's mother did not provide them with verbal or non-verbal assistance. Rather, she watched how her two children interacted with this exhibit and she checked the explanation panel. When Wei and his older sister went back to this exhibit again, Wei's mother then guided them to think about why the ball could float in the air, which she did not do in their first visit at this exhibit (Wei, on-site observation, 120809). Chak (2001) noted, "Awareness of the child's cues in the ongoing interaction is essential in assessing the zone" (p. 386). At their first visit to this exhibit, while Wei's mother said nothing, her observing her children's interactions with each other and with this exhibit might have enabled her to detect how much her children understood about this exhibit and what she might discuss with them.

Fig 22 Wei's family, manipulating the "Balancing Ball"


In short, letting children choose whatever they wanted to learn is important in these parents' beliefs—even though they have already visited a certain exhibit. Hence, when a child returned back to the same exhibit s/he has visited again and again, parents would observe this behavior, as they were very curious about it and wanted to figure out what the exhibit was about.

***Parent-initiated returning.*** As many parents pointed out in the pre-visit interviews, they did not want to make their children's science learning too stressful by requesting they quickly remember anything from a single visit or a science activity. For example, Ying's father, when explaining that he did not want to pressure his daughters, said, "I feel if I force and push them to memorize things, they probably won't have a lasting impression" (Ying's parents, interview#2).

Both of Ying's parents mentioned that when they encountered a situation similar to one they confronted before, they would try to review it for their daughters because, as Ying's father noted, "[We] don't have any attempt to ask them to learn anything" (Ying's parents, interview#2). In their visit, they reflected this belief by initiating returns back to particular exhibits. One example happened when Ying's family was manipulating the "Xylophone" (See Fig 23 & 24):

> *Ying and Ting manipulated the "Chime Bell" together for a while, then they moved to another exhibits. When they went to manipulate the "Xylophone," which was directly opposite the "Chime Bell," Ying's father asked Ting, "Does the longer or shorter one sound higher?"*
> *Ting: The longer one! (Ting said this a little impatiently and without checking it one more time.)*
> *Ying's father: Do you want to try it one more time?*
> *(Ying's father patted Ting on her shoulder; it looked like he was encouraging her to try. Ting did not accept her father's suggestion at first; she kept manipulating the Xylophone with her mother and Ying. After a few seconds, Ying's father asked Ting, "Does the longer one or the shorter one sound higher?" again. Ting went back to the "Chime Bell." She knocked on the shortest and the longest bells respectively. After she tried, initially, she seemed a little hesitant about the answer to her father's question. Then she turned to her father and said, "The shorter one sounds higher.") (Ying, on-site observation, 120728)*

Fig 23 Ying's family, at the "Xylophone"

Fig 24 Ting, trying the Chime Bell again

The behavior of Ying's father in this episode is very close to what Wei's mother did in the earlier example (See Figure 18 & 19). Both parents identified their children as cognitively mature enough to tell the difference, so they asked their children to try again. The only difference between these two is that Ying's father suggested Ting return to this exhibit when they encountered a similar concept (i.e., the musical scale). According to what Ying's father said earlier, he did not want his daughters to learn anything purposefully. Thus, if they did not manipulate the "Xylophone," one can assume that no suggestion to return to the "Chime Bell" would be made—since Ying's father emphasized many times that their purpose in visiting the museum was only to "have various experiences" (Ying's parents, interview#1 & 2).

In this episode, Ying's father suggested Ting return to the "Chime Bell" twice. First, Ting answered quickly but did not accept her father's suggestion. However, her father did not force her to go back to check the difference. His suggestion was accepted the second time. The process is pressure-free and is not intended to be directive.

In sum, parents let their children direct the visit because they believed in the importance of their children's interests and intrinsic motivations. Furthermore, they believed their children needed sufficient time to explore these exhibits. Still, sometimes parents intervened due to low self-efficacy or their judgment of children's cognitive ability. Guided by their beliefs, these families were not just randomly moving through the exhibition halls. Instead, their behaviors were usually deliberate. In the following, I will focus more on their conversation to continue discussing their beliefs.

**The quantity of parents' intervention**

In these parents' beliefs, the "how much" is a critically important issue. First of all, parents in this study pointed out that their children should be intrinsically motivated. When they want to know, it is the time to more forward. These parents believed that their children's young age and limited experiences should also determine the depth of their science learning.

In this section, I focus on how the "how much" issue manifested in their interactions with their children. In accordance with the data, I present three subsections, including "The person who directs the conversation," "The selection of language and content," and "Parents' behavior in being silent" to discuss this theme.

**The person who directs the conversation.** Most parents in this study usually let their children direct the conversation or spoke with their children in turns. Similar to their motivation for letting their children choose exhibits, permitting children to direct conversation may aid parents in assessing what interests them. I will use Chun's case to demonstrate child-directed conversation.

Among all eight families, however, Yen's family visit represents a unique type: Yen's mother was usually the person who directed the conversation. This differs in many ways from the beliefs expressed in her pre-visit interviews. Below, I will start with Yen's family visit to talk about parent-directed conversation as well as how Yen's mother viewed these "gaps" in her actions.

***Conversation directed by parents.*** The parent-directed conversation means parents decide how the conversation should develop. The parent-directed conversation was frequently observed in Yen's family visit while parents in other families only used this type of conversation in some cases.

Yen's mother usually communicated in two ways. One was to give her sons lots of information; this can be seen in the earlier example of their talk at the Brontosaur diorama (See Fig 20 & 21). Additionally, she often talked to her sons in a way similar to the IRE (Initial-Response-Evaluation) sequence (Cazden, 2001) in classroom talks, as in the following conversation (see Fig 25 & 26):

> *Yen's mother: Come here to see this. Wen, what is this? (Wen did not answer the question; Yen answered it instead.)*
> *Yen: A snake…Snake bones.*
> *Yen's mother: Correct, so, does a snake have a spine?*
> *Yen & Wen: It has.*
> *Yen's mother: Correct, so, is a snake a mollusk?*
> *Yen: No.*
> *Yen's mother: Correct, so, a snake is not a mollusk. It has a spine.*
> *(Yen, on-site observation, 120711)*

Fig 25 Yen's family, viewing the python's bones

Fig 26 The python's bones

In this episode, Yen's mother not only chose the exhibit, she also brought up the idea that "a snake is not a mollusk because it has a spine" by using the IRE-like sequence. All the questions were asked by Yen's mother in the entire conversation; Yen and his younger brother had no chance to communicate anything they might want to talk about or ask. This type of conversation has little room for developing the available opportunities for Yen and Wen to actively construct their own science learning. Also, these two boys' possible curiosity appears to be ignored in such an interaction. These two boys merely followed these questions and were responsible for giving the correct answers.

Although Yen's mother directed where the conversation should go by giving abundant information or using IRE-like talk, she did not believe her constant explaining or telling violated her belief in the low-pressure approach. She noted,

> *I don't think I gave them pressure. They had curiosity themselves. In fact, it was because they approached an exhibit first that I explained for them. But if they didn't approach an exhibit, I wouldn't force them to do. Unless I felt it was something they might be interested in; then I would ask them whether they wanted to take a look. (Yen's mother, reflection session)*

Yen's mother expressed that her two sons' approaching an exhibit signaled to her that they were motivated to learn about a specific idea. She noted, "If they approach an exhibit, then it indicates that they feel interested in it. I will then actively explain for them" (Yen's mother, reflection session). Thus, she believed her directing conversation did not pressure on her sons. On the contrary, she believed it met their curiosity. In her explanation, directing the conversation is not only intentional but also beneficial; moreover, as she said later, "They would be more interested after explaining" (Yen's mother, reflection session). She further clarified:

> *If we go out for play, then I won't. I won't intentionally [tell them]. But in this kind [of visit], they will ask questions themselves because there are too many things they can take a look at or I can explain for them. And…they would ask questions. ……If we go out for play, I won't act in an intentional manner. Unless they have an interest, I will then explain for them. (Yen's mother, reflection session)*

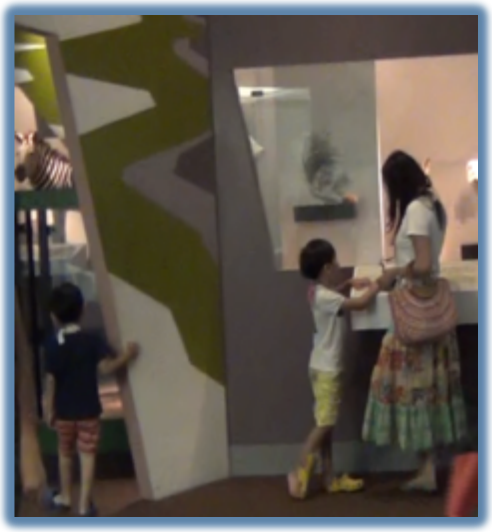
This explanation might point out why she often directed conversation in their visit—because this was not the place for "play." More specifically, the science museum creates an atmosphere of "learning" for her. Thus, once her sons approached an exhibit or accepted her recommendation, she would then become a knowledge agent—even if her sons might not really be interested in the exhibit.

*Children's negative reactions in the parent-directed conversation.* Yen and his younger brother Wen did not always pay attention to what their mother was saying. Fig 27 depicts Yen and his mother's interaction when they were at one of the agriculture dioramas. Yen's mother was explaining how people processed their crops. After a few seconds, Yen looked distracted because he was playing with his sandals. Then, he looked around when his mother asked him why people processed the crops in a specific way. Yen's mother, on the contrary, appeared very interested from the beginning in telling Yen about this diorama. (Yen, on-site observation, 120711)

Fig 27 Yen, looking around while his mother was asking him a question


In a similar example (See Fig 28), Yen and Wen first were together listening to their mother introducing the *lepus timidus*. After about half a minute, Wen (in black) walked to another exhibit while his mother was still talking. Although Yen did not act as his younger brother did, he also kept looking around when his mother was talking. (Yen, on-site observation, 120711) Similar phenomena were observed repeatedly in their visit. In yet another example, when Yen's mother asked Yen, "What will happen if there are too many people in the world?" Yen did not respond, but looked distracted instead. Murray and Arroyo (2002) indicated that the ZPD can be characterized from both cognitive and affective perspectives. From the affective perspective, the learner should avoid the extremes of being bored, confused or frustrated. Both boredom and confusion can lead to distraction, frustration, and a lack of motivation (p. 750). According to Yen's mother, these two boys liked visiting science museums very much (Yen's mother, interview#2). Despite their enjoyment of the environment, Yen or Wen seemed uninterested in what their mother wanted to talk about. Yen's playing with his sandals and constant looking around seem to reveal that he was bored by the exhibit and his mother's explanation. As a result, they often did not engage in talk with their mother.

Fig 28 Yen's family, at the *lepus timidus* specimen      Fig 29 The *lepus timidus* specimen



Chak (2001) pointed out that in actualizing the zpd, the child is not merely a passive recipient nor is the adult solely a technician (p. 385). Whether a lesson is within the child's optimal zone may be revealed through his or her emotional responses and non-verbal cues. (Chak, 2001, p. 390) In the reflection session, Yen's mother finally noticed her sons' impatience. As she reflected, "I feel my firstborn seemed to be very impatient; he was a bit unable to focus on [the exhibits]. He quickly moved to the next exhibit" (Yen's mother, reflection session). In their visit, she seemed not to be very conscious of her sons' feedback, such as ignoring her questions. She either probably did not notice these signals or did not value the meaning of these reactions. In other words, she overlooked these meaningful responses when she interacted with her children in their visit.

*Children's effort to direct the conversation*. Children did not always passively accept their parents' direction or use negative responses to express their desires; they actively tried to take over direction of the conversation. Yen and his mother's interaction at the "Excavations at Huilai Archaeological Site" (See Fig 30) is an example. In this conversation, Yen seemed interested in a particular aspect of this exhibit and tried to pose a "what if…" question. After trying twice to ask his question, and being interrupted both times by his mother, he gave up on the question. In the whole process, Yen's mother did not stop talking about how archaeologists discovered the Huilai archaeological site. She seemed not even to notice that Yen did not finish asking his question. (Yen, on-site observation, 120711)

The way Yen's mother behaved in this instance contradicted what she had expressed to me earlier: "When they feel there's confusion or they are curious about something and want to ask me, I feel they will be more focused" (Yen's mother, interview#2). Although Yen tried to interrupt his mother, his efforts were in vain. Making progress in response to Yen's curiosity was not reflected in his mother's actions.

Fig 30 Yen and his mother, at the "Excavations at Huilai Archaeological Site" exhibit


The behavior of Yen's mother in this and the aforementioned examples seems to demonstrate inconsistency between parents' self-reported beliefs and their actions. To use Sigel and McGillicuddy-DeLisi's (2002) words, what Yen's mother expressed in the pre-visit interviews was her "ideal beliefs." More specifically, she believed she should not pressure her children and that she needed to support them when they were intrinsically motivated. The disjunction between ideal beliefs and actual behaviors might explain why she did not pay attention to Yen and Wen's physical messages (e.g., constantly looking around) or value Yen's questions in the above examples.

There might be another possible implication of their interaction at the "Excavations at Huilai Archaeological Site." In her self-reported beliefs, Yen's mother said she believed acting as a knowledge agent (Yen's mother, interview#1) was necessary. Their interaction at this exhibit might present her struggle with balancing her multiple beliefs in her behaviors. Additionally, this example might illustrate that when there was a conflict between two beliefs (e.g., children's intrinsic motivation versus adults' playing a specific role), a parent might prioritize particular beliefs to the detriment of others, as Yen's mother did in this instance.

***Conversation directed by children.*** In contrast to how Yen's mother talked with her sons, the conversation between Chun's father and his children was like an exciting tennis match. Usually, Chun or his older brother Hsuan first asked one question, and after their father answered, they quickly asked questions based on their father's answers. Chun and/or his older brother Hsuan directed the development of the conversation. Their conversation at "The Beginnings of Life on Earth" (See Fig 31) is one example:

> *(Before the program started, Chun's mother told Chun and Hsuan they had to wait for three minutes before the program began.)*
> *Hsuan: Why do we need to wait for three minutes?*
> *Chun's mother: Because it is controlled by a computer. The program will start after three minutes.*
> *Hsuan: And it will be very shaky.*
> *Chun's mother: Because the volcano erupts, the movement of the Earth's crust…*
> *Hsuan: Why it is shaky when the volcano erupts?*
> *Chun's father: Because of the volcano's movement, there's an earthquake.*
> *Hsuan: An earthquake.*
> *Chun's father: Yes.*
> *Hsuan: How strong is it?*
> *Chun's father: Try to feel it yourself. This won't be too strong. Maybe 2 or 3 [on the Richter scale]. (Chun, on-site observation, 120819)*

Fig 31 Chun's family, waiting for the program to start


Unlike Yen or Wen, who only passively answered their mother's questions, this conversation was under Hsuan's direction. Hsuan exhibited a great deal of confusion about the volcano eruption and earthquake. Throughout the conversation, he actively asked questions to gain the information he needed. Piscitelli, Everett, and Weier (2003) pointed out that choice and control influence children's levels of interest and motivation during museum visits. Young children demonstrate higher levels of motivation when they have choice and control over their learning in museums. This instance illuminates that when the conversation is directed by children, it allows them to express their curiosity and concerns, and that children might become more engaged in the conversation.

In another example, Chun's family visited the Python's Bones exhibit (See Fig 32), which was also visited by Yen's family. Nevertheless, Chun's family had a totally different type of conversation.

*At first, Hsuan was asking his father about the python's bones and Chun and his mother were observing the bones. Then, Chun proposed a question:*
*Chun: Does it eat people?*
*Chun's father: It does. It has…In the World War II, um, in the Vietnam War; it ate American soldiers.*
*(Chun's mother pretended to be a python and used her hands to "bite" Chun's face.)*
*Chun & Hsuan: Why?*
*Chun's father: Because [people] found guns and helmets in it later on. This is true.*
*Hsuan: Those couldn't be digested.*
*Chun's father: Yes, right.*
*(They walked to the other exhibit to study how a reptilian moves.) (Chun, on-site observation, 120819)*

Fig 32 Chun's family, observing the python's bones


Compared to Yen's family's conversation at this exhibit (See Fig 25 & 26), Chun's father did not deliberately lead his sons to reach a certain conclusion, such as "a snake is not a mollusk because it has a spine" in Yen's case. In Riedinger's (2011) words, Chun's father was "talking with"—not "at"—his two sons (p. 127). He was open to following where his sons' curiosity took them (Moll, 1992), and he let his sons engage in asking things they cared about—just as they wanted to know whether a python eats people or not, rather than whether it is a mollusk.

One similarity in these two examples is that the two boys used their father as a resource to learn things they were curious about. Bruner (1962) pointed out that one condition for change in a zpd is the capacity to make use of the help of others, that is, the capacity to benefit from give-and-take in experiences and conversations with others (cited in McNamee, 1992, p. 288). Both boys had their own ideas. This type of conversation enabled them to seek support from their parents to communicate these ideas with them. As a result, either their assumptions were confirmed, or they gained new viewpoints on the topic.

**The selection of language and content.** Most parents believed their children were still young and only needed to know some short and basic information regarding science. The kind of language these parents used and which parts of the content they shared with their children seemed to reflect this belief. Still, when selecting knowledge, parents encountered some difficulties as well. These difficulties could limit their ability to choose the most age-appropriate part of the content for their children.

***Parents' use of simplified language.*** Simplified language is defined in one of two ways: avoiding professional terms or choosing alternate ways to explain. In some cases, parents use these two means simultaneously.

*Avoiding professional terms*. When Jay was curious about the creature in the round bottle (See Fig 33 & 34), his mother said, "It says that's something like a small mouse" instead of telling him it was a *morganucodontans*, as indicated on the panel (Jay, on-site observation, 120807). Heywood (2002) noted that the core purpose of analogy as a teaching strategy is developing an understanding of abstract phenomena from concrete references (p. 233). Compared to the professional term, "mouse" is more familiar to Jay. Thus, Jay's mother used this analogy to give Jay a basic idea of this animal.

When they talked in front of the "Jade Burial Suit" (See Fig 35), Jay's mother again changed the term she used to avoid scientific jargon. In this example, she first told Jay "the dead man wore a suit made of jade," and Jay wanted to know what "made of jade" meant. Then, Jay's mother told him "The suit was made of one kind of rock" (Jay, on-site observation, 120807). From "jade" to "one kind of rock," the change in her usage of the term shows how Jay's mother simplified the term to a concept Jay could understand more easily. Catering to the age of children was an important issue in these parents' self-reported beliefs, and these two examples might reveal how parents – in this case, Jay's mother – avoided using professional terms to take into account their children's young age.

Fig 33 Jay's family, having a conversation at the Morganucodontans model

Fig 34 The Morganucodontans model

Fig 35 A jade burial suit

*Choosing alternative ways to explain*. Vygotsky wrote, "We assist each child through demonstration, leading questions, and by introducing the initial elements of the task's solution" (Vygotsky, 1934/1987, p. 209). The first alternative method parents used to explain was a series of leading questions and demonstration. One example comes from Ying's family interaction at the "Billiards" exhibit, which introduces "elastic collisions (See Fig 36):"

> *(Ying walked towards "Billiards," followed by her parents and Ting.)*
> *Ying's father: Hey, you can move these.*
> *Ting: We…we saw a smaller one at the WenXin Forest Park last time.*
> *Ying's father: Yes.*
> *Ying's father: What would happen if I take a ball from each end?*
> *Ying's mother: I don't know.*
> *(They tried and observed what happened)*
> *Ying's father: How about taking two balls?*
> *Ying: It seems like…um…*
> *Ying's father: Two balls…okay, take two balls. Okay, go!*
> *Ying's mother: Then two balls will come from that end.*
> *Ying's father: Yes.*
> *Ying: How about taking three balls?*
> *Ying's father: How about taking three balls? (Simultaneously) Well, that's too far. It's too far for daddy to reach the third one. I can only reach two balls. If you take two [from this end], then there will be two balls coming from that end. (Ying, on-site observation, 120728)*

Fig 36 Ying's family, manipulating the "Billiards"


In this case, Ying's father posed questions, including "What would happen if I take a ball from each end?" "How about taking two balls?" and "How about taking three balls?" Rather than simply prompting these two girls to answer, the questions built upon Ying and Ting's curiosity and focused their attention on the exhibit. Along with their father's demonstration, these questions provided a different way to enable Ying and Ting to gain a basic understanding of the phenomenon.

Another alternative way parents used was to point out the significant cues when their children interacted with exhibits. In one example, Ying and Ting manipulated the "Gyroscope" (See Fig 37), while Ying's father guided his daughters in this way:

> *Ok, spin it, spin it. Look, your chair starts to spin now. When you spin it, your chair will follow [your direction], see? See? Ok, Ying, it's your turn. Can you hold it? (Ying, on-site observation, 120728)*

A gyroscope is a device for measuring or maintaining orientation. Although Ying's father did not mention what this instrument is for, the discernible differences he pointed out in fact spell out the purpose of the gyroscope. Instead of referring to the "principle of conservation of angular momentum" or using terms like "inertia/rigidity" and "precession," his pointing out changes seemed to be effective in letting Ying and Ting pay attention to their movement, so they could make sense of the principle presented by this exhibit.

Fig 37 Ying, manipulating the "Gyroscope"


Similar to Ying's father, when Wei and his older sister were manipulating the "Simple Mechanism" (See Fig 38), their mother neither told them, "This is the Lever Principle," nor mentioned such terms as "fulcrum" or "lever arm." Instead, she told them to feel for which one was easier and which required additional effort during their manipulation (Wei, on-site observation, 120809).

Fig 38 Wei's family, manipulating the "Simple Mechanism"


In the reflection session, Ying's father explained why he and/or Ying's mother chose to explain through these alternative ways. He said,

> *We just let them know there are these scientific phenomena and how these work. At this age, even though you tell them some principles, they probably don't understand. So, we just let them know these are some situations we see, and let them actually manipulate to know this. [In this case,] if you push two balls, twoballs will then come from that end. (Ying's parents, reflection session)*

Based on this quotation, it appears that Ying and Ting's age was the key to their father's actions in the above two examples. In consideration of their young age, Ying's father did not attempt to tell them the principles at work (Ying's parents, reflection session). Rather, he chose to simply point out some features of these phenomena and let them manipulate the exhibits by themselves, to gain a basic understanding from the actual manipulation. Ying's mother made the issue of age more evident:

*But probably when they are older, um, when they have different curriculum in school, maybe we will…will have some different, um, the way we interact with them might be different. (Ying's parents, reflection session)*

This quote reveals that children's different ages determine the ways and to what degrees their parents interact with them. When they are older and have more experiences, they might be able to comprehend something more complicated—so their parents could explain the content differently. When looking back to parents' beliefs that they would tell older children more and give less to younger children, it is understandable why Ying's mother would adjust interactions with her daughters according to their ages.

***"Translation": sharing information with their children after selection.*** Previous studies have found that parents read aloud to their children, or read labels in silence and then interpret the text for them (Allen, 2002; Dierking & Falk, 1994). In this study, when parents read for their children, their only selected a small part of the content of an exhibit to share. The abridgement of content seems to reflect their beliefs in youngsters' limited cognitive ability due to their young age. As Wei's mother addressed,

*Sometimes you told him too much; um, in fact children at his age don't, um, they don't necessarily understand. Even though what you told them is correct, I feel they are unable to, they are unable to comprehend it without difficulty. (Wei's mother, interview#2)*

Because they believed that telling young children "too much" is ineffective, most parents thought it essential to select a small part of the content to introduce to their children. What Yen's mother pointed out below might reveal the beliefs underlying such behavior:

*It was impossible for me to read them the whole panel. I only told them the key points. The time I had was very limited. I could only tell them the key parts.*

The "key points," in her words, were based on specific criteria. As she added:

*And I picked up those they would feel interested. …I avoid telling them those professional terms, I only told them those very basic. (Yen's mother, reflection session)*

Pei's mother termed this action, on the parts of Yen's mother and other parents, as "translation" (Pei's mother, reflection session). These parents did not "translate" information verbatim from the explanation panels. In contrast, as Yen's mother said in the above, they chose only that which was "basic, vital, and interesting to their children." Parents deliberately selected the parts they thought their children could understand.

In her reflection session, Pei's mother said, "Their age is too young to have certain discussions." She said she therefore usually simplified, as well as roughly introducing the information to her children (Pei's mother, reflection session). In one example, when Pei's mother explained her interaction with Pei at an exhibit called "Life on the Earth," she highlighted such behavior. This is an exhibit requesting visitors to pair a specific animal and its habitat (See Fig 39). Pei's mother said she knew the content "was difficult for them" based on their interaction; Pei "just ran all the buttons" and "couldn't fully understand" (Pei's mother, reflection session). Yet, Pei's mother said they could talk about some simple concepts; for example, different animals need different habitats. She also pointed out that this experience could become a building block when they encounter similar situations in the future. For instance, she could remind them of the concept of "different animals living in different kinds of environments" when they go hiking in the mountains (Pei's mother, reflection session).

Fig 39 Pei's mother, guiding Pei to manipulate the "Life on the Earth"


Jay and his mother's conversation at a set of exhibits about the origin of life is a good example of parents' selective information-giving. Below is their discussion at the "Life Only Comes from Life[15]" exhibit (See Fig 40):

> *Jay: Look, there is a fly in it, but it's not flying. (Jay's mother echoed him and he asked his mother, "why?")*
> *Jay's mother: It (the explanation panel) says…(reading the panel)*
> *Jay: What does it say?*
> *Jay's mother: It says flies will generate in that (the container).*
> *Jay: Why?*
> *Jay's mother: It says some bottles were open and some were closed, and flies will generate in the opened one because flies flew into it and produced babies. (She continued to read the panel before talking) So…it says the meat will produce flies only because flies lied their eggs on it, not because the meat produces [the flies]. Understand? If the meat was covered, it won't produce flies. It is because the flies laid eggs in the opened bottles. (Jay, on-site observation, 120807)*

[15] Francesco Redi's experiment.

In the reflection session, her explanation of the content revealed she was translating according to what she thought Jay could understand. She said, "at least that's something (rotten meat) he had some knowledge of" (Jay's mother, reflection session). Therefore, she picked up on this part to explain the experiment.

When they visited "The Microorganism also Comes from Life," an exhibit introducing Pasteur's experiment (See Fig 40), Jay's mother explained for Jay like this:

> *It says if it is a long bottle, then the soup in it wouldn't easily be polluted. If the bottle rim is bigger, then the germs will go in there. (Jay, on-site observation, 120807)*

Similar to how much she shared with Jay in the previous example, based on her judgment of Jay's current cognitive ability, she selected the part Jay might best understand and skipped those he could not comprehend at this time. She told Jay the results of this experiment, but did not touch on why the different shapes of bottles resulted in such findings.

This set of exhibits included three different displays: "Life Only Comes from Life," "The Microorganism also Comes from Life," and "How do Lives Begin?" Yet, Jay's mother skipped "How do Lives Begin" (See Fig 41) and told Jay "I'll explain this for you when you're older" after she read the panel. Her explanation for this omission was, "I felt even though I explained for him, he still would not understand" (Jay's mother, reflection session). When parents made an evaluation based on their children's current cognitive ability and found nothing they could "translate" for them, they might do what Jay's mother did in this instance—skip it outright.

Fig 40 Jay’s family, at the set of exhibits about the origin of life

Fig 41 The “How do Lives Begin” exhibit

In Jay's two examples, the selection of a part of the content may also reflect parents' self-efficacy beliefs as well as their concerns about misconceptions. Jay's mother, identified as a low self-efficacy parent based on her pre-visit interviews, said she only told Jay those she was sure about when she was asked to explain something she did not understand very well (Jay's mother, reflection session). Taking a close look at the rotten meat example (See Fig 40), the part she picked up was one she was able to quickly understand and simplify.

Children's young age as well as their limited ability in recognizing Chinese characters pushed their parents to serve as knowledge agents. In playing this role, parents would evaluate their children's interest as well as their current cognitive ability and then gave them information after purposeful selection. In a study of parent-child conversation in the dinosaur hall in the National Museum of Natural Science, Chin (1998) indicated the quality of parent-child conversation was low because the parents he observed only provided their children with simple descriptions. While it is difficult to distinguish whether such behaviors were intentional, since Chin did not interview parents about their behavior, Chin might view parents' ability to support children's science learning from a deficit perspective and underestimate its potential. According to examples above, giving children simple and short information might come from an intentional decision: "I do this because my children are still young, and this is what they can currently understand and need."

Before moving to the next section, I would like to discuss Chun's father, who seemed to behave differently from the other parents. Sigel' s (1986, 1992) research on the relationship between parents' belief systems and their teaching strategies has demonstrated that parents' beliefs about how children learn influence their inclinations toward using certain strategies (cited in Chak, 2001, p. 387). Thus, Chak (2001) argued, regardless of whether the adult is consciously aware that his beliefs guide his behavior, certain dominant patterns can be identified (p. 387).

In the pre-visit interviews, Chun's father clearly stated, "I would tell them what I know. Sometimes if they don't understand, I will explain for them a little more" (Chun's father, interview#1). Similar to other parents, Chun's father was aware of the limit of his sons' current cognitive ability (Chun's father, interview#1). Yet he kept a more open attitude. Compared to other parents' focus on the "now and enough," he seemed to focus on how much his sons could benefit from his support. Thus, as Chak (2001) argued in above, in their visit, Chun's father rarely avoided using professional terms and seldom "translated." For example, terms he used included "double helix," "purine," "absolute zero," and "Australopithecus afarensis." Furthermore, compared to how Ying's father guided his daughters, Chun's father directly communicated principles to his sons. For example, when they walked to an exhibit introducing "Brownian Motion," Chun's father told his family "Oh, Brownian Motion means moving randomly. One object will move above absolute zero" (Chun, on-site observation, 120819).

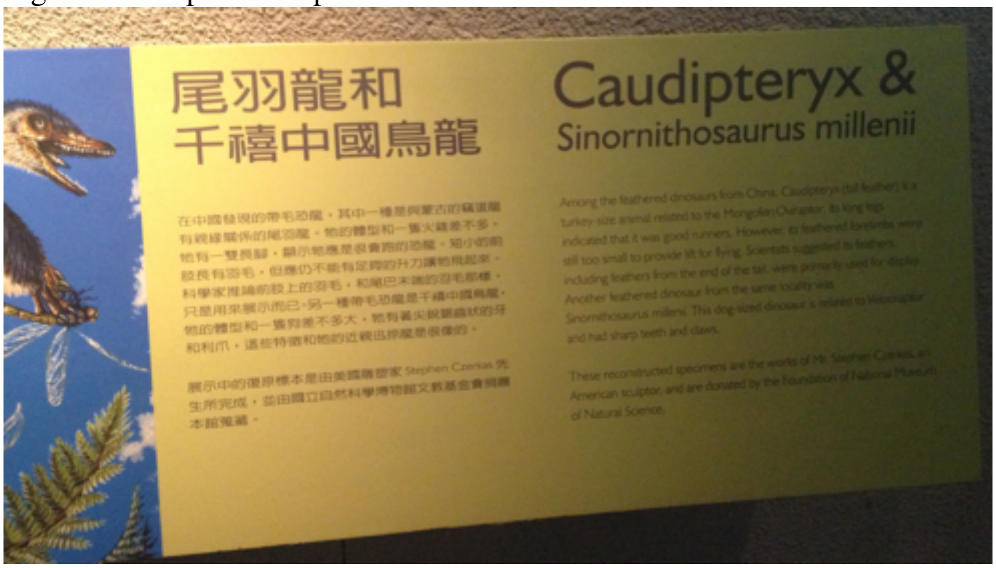
Like Jay's family, Chun's family also visited "The Microorganism also Comes from Life." Unlike Jay's mother, Chun's father directly used the term "Pasteur's experiment," and he thoroughly described what this experiment was about. Chun's family had a long conversation discussing why bottles of two different shapes would affect the generation of germs.

Still, there is a potential risk in his reliance on his sons' reactions. It might sometimes be difficult to tell whether, in not asking questions, his sons really understood what he said. These two boys might not understand these terms, principles, and/or other scientific knowledge. There were also instances when they happened to ask no questions about what their father shared with them. More to the point, in some cases, Chun's father might overestimate his sons' cognitive ability yet think they understood what he told them.

***The difficulty in selecting the language and content.*** In consideration of their children's young age and limited cognitive ability, Jay's mother, Ying's parents, and most of the other parents in this study used simplified language to help their children make sense of exhibits. Nevertheless, parents deemed this difficult work. As Ying's father said, "explaining for them in a simple way is not always that easy" (Ying's parents, reflection session). He agreed that having scientific knowledge does not necessarily mean parents know how to explain in children's language. Therefore, Ying's parents both admitted that sometimes they "pretended they didn't hear their daughters' questions" when they "didn't know how to answer the questions" (Ying's parents, reflection session).

Parents also encountered difficulty in choosing "appropriate" parts for their children. When reviewing her behavior in the video of their visit, Yen's mother said, "You see, I was reading the panels. It's difficult to…The text is too long" (Yen's mother, reflection session). Yen's mother and other parents (e.g., Wei's mother) indicated that the science museum failed to assist them in performing this task well (See Fig 42 for an example of the panel). As a result, although parents claimed that they usually purposefully selected what they thought was appropriate for their children, in some cases it seemed like they were not capable to "translate" the content well, because they needed to quickly do so. Because of this difficulty, the suitability of the information given after a careful evaluation of their children's zpd may be unclear.

Fig 42 One explanation panel




Bertschi, Benne, and Elkins (2008) pointed out that parents of young children have little time for label reading, because they are busy mediating other aspects of a museum visit. For museums, they stressed that parents "must be able to quickly find the information they need to facilitate their child's experience" because, as several parents in this study mentioned, they needed to quickly find out what they could "translate" for their children before their children lost interest in the exhibits. I will elaborate more on how inadequate science museum support influenced parent-child interaction in the following sub-section.

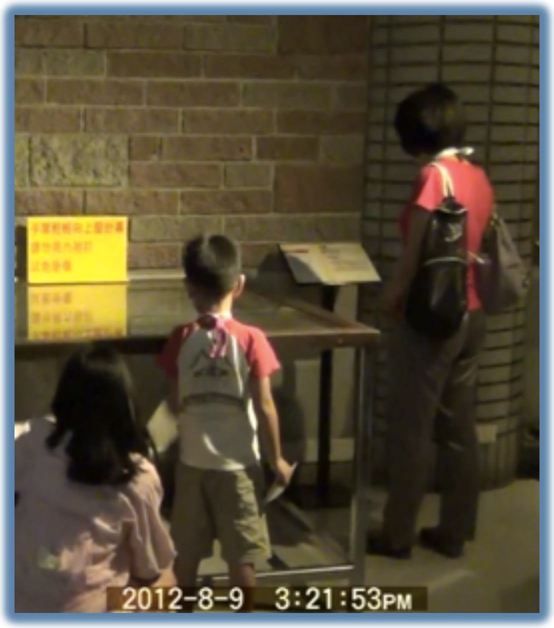
**Parents' behavior in being silent.** The selection of language and content shows how these parents took their children's young age into account when verbally interacting with them. However, parents did not always interact with their children in verbal forms. Sometimes they chose to be silent. According to how these parents associated their silence with their beliefs, I divide examples of parents' remaining silent into two categories: intentional and unintentional silence.

***Intentional silence.*** When parents chose to be silent on purpose, their belief in children's intrinsic motivation, their advocacy of the little/no pressure approach and their concern over misconceptions became evident.

*We will have opportunities in future visits*. As pointed out earlier, Wei's mother usually gave Wei and/or his older sister adequate support when they asked for it. (Wei's mother, reflection session) Being silent might show her belief that children learn best when they are motivated. In Moll's (1992) words, Wei's mother mediated the learners' transactions with the world in minimally intrusive ways, supporting without controlling it (p. 228). In other words, she served as a resource if her children needed help. Here I focus a little more on discussing her silence and her belief in the little/no pressure approach.

The following two pictures (see Fig 43 & 44) show Wei's mother, focused on reading the panels. These were not the only two times she acted in such a way during their visit; on the contrary, she frequently read the panels thoroughly while her children interacted with the exhibits. Her explanation for this behavior was she needed to understand the content first, so she could teach her children (Wei's mother, reflection session).

Fig 43 and Fig 44 Wei's mother, concentrating on reading the panels




Wei's mother was aware that in most cases she did not have a chance to explain the content for her children to deepen their understanding of the exhibits. However, Wei's mother made it very clear that this visit would not be their only visit. Thus, their science learning in the science museum did not need to "immediately happen" (Wei's mother, reflection session). Although Wei's mother spent time reading the panels, she rarely called her children back to give them a "science lesson." Instead, it was fine to delay discussing content with Wei or his older sister, because they would "have opportunities in the future." Her silence in these instances might reflect her belief in the low-pressure approach—science learning should not be pushed and children should maintain their own pace.

*Being careful about misconceptions*. Lily's mother had very limited verbal interactions with Lily in their two-hour visit. When I expressed curiosity about this lack of conversation, Lily's mother explained:

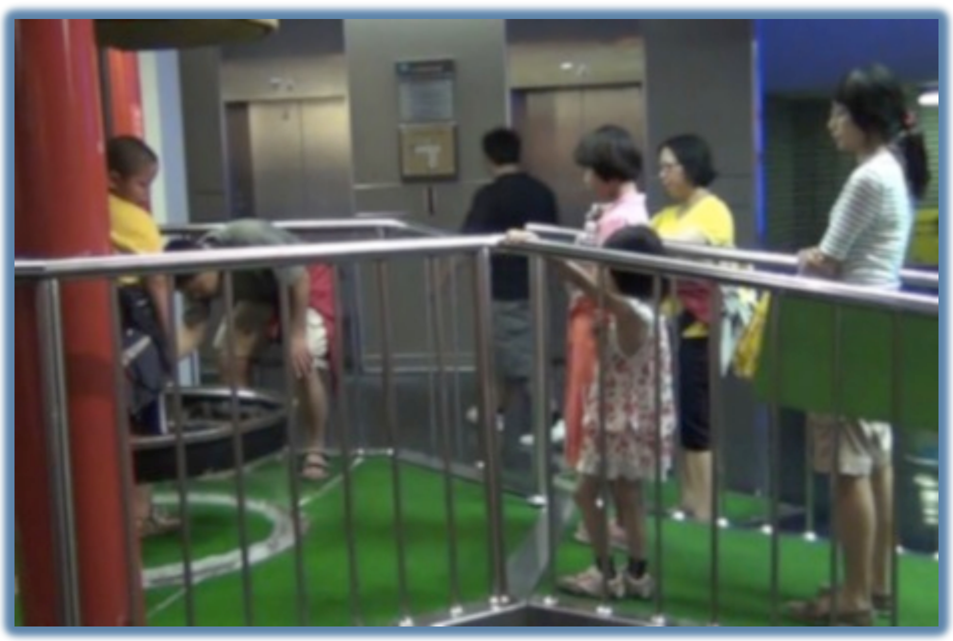
> *Lily's mother: But we had movements, um, such as playing together or doing something else.*

*YC: So, you let her understand the content of the exhibits by movements?*
*Lily's mother: Right, because that was something like "Hey, look!" then I manipulated it to show her. Why did I have to explain it? (She paused) I don't know; I think this is how it is. (Lily's mother, reflection session)*

Lily's interaction at the "Fantastic Space" exhibit (See Fig 45) supports her statement. "Fantastic Space" is a very popular exhibit in this exhibition hall; visitors can use produce a large bubble and wrap themselves in the bubble. When Lily and her mother waited in line for this exhibit, they did not have any conversation. They only waited and watched others' movements. Although Lily looked very curious about the bubble making, her mother simply stood behind her and said nothing. Lily and her mother made a big bubble together in the end, yet they still had no conversation (Lily, on-site observation, 120708). Their interaction at this exhibit resembled something Lily's mother said in one of her pre-visit interviews:

*If she asks, I will tell her. But since she doesn't ask, [I won't] actively tell her [the content of the exhibits]. I just let her play. (Lily's mother, interview#2)*

Fig 45 Lily and her mother, waiting for the "Fantastic Space"



Because Lily did not ask her mother questions, such as "How can we successfully make a big bubble?" Lily's mother only assisted her and showed her through "movements." It may appear as though she was respecting Lily's intrinsic motivation; however, she seemed to only focus on verbal to the detriment of non-verbal messages of motivation.

Moreover, as she said in her pre-visit interview, she would not tell Lily and Nana that "things are ambiguous." She only told them "things she was very sure about" (Lily's mother, interview#2). Lily's mother explained, "Because the content was unfamiliar to me, I needed to take some time reading [the panels]" (Lily's mother, reflection session). Her remaining silent looks similar to Wei's mother's explanation above; yet, she pointed out that her silence was not meant to reduce pressure on Lily. It resulted mainly from her need to understand the content prior to explaining it. Holding such a belief, Lily's mother did not feel her being silent was odd at all.

These two mothers both mentioned they needed to understand the content before explaining. This seems to suggest that learning is not co-constructed by parents and their children. To be specific, this might show their belief in the adult-oriented approach. In Lily's case, Lily's mother did not attempt to lead Lily to learn "together." So, she chose to be silent even though Lily might show interest in the exhibit.

Although Lily's mother did not have much verbal interaction with Lily, she still termed Lily's accessing these exhibits as "stimulation" (Lily's mother, reflection session). More specifically, Lily received new input from direct exposure to these objects.

***Unintentionally being silent.*** In other cases, parents' silence is an unintentional decision. Kelly, Savage, Landman, and Tonkin (2004) argued that "Well-written, legible and clear text is critical in facilitating [parents'] playing the role as an interpreter" (p. 41). Although parents believed they needed to play certain roles in supporting their children's science learning, having no such text in hand influenced how they actually interacted with their children. More specifically, their unintentional silence was a passive response to this contextual influence.

Jay's mother became silent when there was no proper information for her to use. If she did respond to Jay's questions or interpretations, "I don't know either," "oh," and/or "is it?" were usually employed. Their conversation below is an example illustrating this type of interaction (See Fig 46):

*Jay: Look, there are fishes! Here are fishes!*
*Jay's mother: Oh.*
*Jay: A Skate.*
*Jay's mother: Which one?*
*Jay: This one. A Skate looks…*
*Jay's mother: (She interrupted Jay's talking) Is it?*
*Jay: It is.*
*Jay's mother: Is it?*
*Jay: It is.*
*Jay's mother: I don't know because there's no explanation panel. (Jay's mother pointed at one of the exhibition displays; Jay imitated her and touched the glass.) Okay, hey, don't touch it. (Jay's mother showed Jay an exhibit nearby and they walked to it.) (Jay, on-site observation, 120807)*

Fig 46 Jay's family, talking in front of the exhibition wall

In the reflection session, Jay's mother first indicated her use of "Is it?" in this conversation was a performance of uncertainty. She criticized museum staff: "Is the science museum assuming every parent is good at science?" She went on to elaborate, "Only those who know a lot and know how to explain for their children in children's language are suited for visiting this place" (Jay's mother, reflection session). Even though she believed she should play roles as answer provider or knowledge agent to help Jay make sense of these exhibits, when the science museum failed to assist (Schauble, et al., 2002) her in doing this task, she viewed herself as having poor understanding of the content, and felt apprehensive about incorrectly answering Jay's science questions. In turn she chose to be silent.

Kai's mother indicated a similar problem in their visit; she said, "Because sometimes it didn't provide labels/panels, I didn't know what the exhibits were about"

(Kai's mother, reflection session). Kai's mother point out that, because of the lack of information, she was unable to explain for her children even though she wanted to. Unlike Wei's mother or Lily's mother, who chose to be silent due to particular purposes, Kai's mother chose to be silent because she had insufficient information from the science museum.

Dudzinska-Przesmitzki and Grenier (2008) pointed out that contextual factors such as exhibit design have a direct impact on visitors' learning. These two mothers' reflections both indicate their silence resulted from insufficient information. If the exhibit design was changed and met these parents' needs, they might have behaved differently in these instances.

Parents' silence, a common phenomenon in family museum visits (e.g., Blud, 1990b; Brown, 1995; Fang, 2004; Hsu & Lin, 2005), has often been identified as a passive or even a negative behavior. For example, Hsu and Lin (2005) denigrated this type of parent as only playing a nanny role; such parents did not understand the content of the exhibits, and interacted with their children infrequently. In these eight families' museum visits, the same behavior has various meanings, which reflected their multiple beliefs about their children's science learning. Some of them in fact were positive, such as Wei's mother's decision to be silent because she did not want to rush her children's science learning. Being silent does not necessarily constitute a refusal to engage in children's science learning.

In short, holding beliefs regarding their children's interest, intrinsic motivation, and their young age, these parents gave their children different guidance at different quantities. Above, I presented three sub-sections including "Who directs the conversation," "The selection of language and content," and "Parents' behaviors in being silent." Each section reveals why parents sometimes provided their children with more, while sometimes they gave them little help. Next, I will provide close-ups of these parents' scaffolding strategies to show how their beliefs guided them.

**Parents' use of scaffolding strategies**

Parents provided support for helping their children make sense of the exhibits they visited. The main scaffolding strategies included: 1) providing answers to their children's questions, 2) correcting children's wrong responses, 3) guiding their children to think, and 4) making the science museum experiences more meaningful.

These scaffolding strategies may be understood through their beliefs in serving as information/answer providers and guides, their concern over misconceptions, and their idea that science learning should be relevant to life. Guided by these beliefs, these parents found the most proper way to assist their children in understanding what they encountered in their museum visits.

**Providing answers to their children's questions.** Haden (2010) pointed out that providing important information in response to questions accounts for one kind of scaffolding. The most common scaffolding strategy parents used was to provide answers to their children's questions. When their children posed a question, parents usually quickly gave their children an answer from their existing knowledge or from the explanation panels. For example,

> *Ming: Mommy, look! What's this?*
> *Pei's mother: Um…this is the first creature on Earth. It first lived in water, then it gradually moved to the ground. (Pei, on-site observation, 120724)*

Such actions might reflect these parents' valuation of children's intrinsic motivation—when they want to know, they will try to find information (Wei's mother, interview#2). Goody (1978) argued that children's questions are not valued equally in all cultures. These parents' actions in providing answers to their children's questions might indicate that they took these questions seriously, because these questions might tell them it is the right time to talk more about certain content.

Still, this seems also to show their faith in the role of information/answer provider. In these families' visits, the most frequented asked question was "what is that, mom/dad?" This type of question is a very closed one, usually used to obtain very basic information, such as asking for a name of an animal. In parents' thoughts, it might be difficult for their youngsters to come up with an answer on their own; they recognize a very limited quantity of Chinese characters and have restricted experiences and knowledge. Thus, when children posed a question, their parents would then directly provide a proper answer for them, such as Pei's mother above.

***Children's different types of reactions.*** Bronfenbrenner (1979) noted, "In any dyadic relation, and especially in the course of joint activity, what A does influences B and vice versa" (p. 57). Most children in this study seemed to be rather accustomed to their parents' direct provision of answers. Most of them seemed to be satisfied with a quick answer and most of time they did not keep asking questions unless their parents actively provided them with more information about the exhibits. As a result, children may have influenced the type of talk that parents addressed to them (Tenenbaum et al., 2005, p. 14). Their reactions might reinforce their parents' self-reported belief that "science learning is more adult-oriented than child-oriented," because the answers they provided seemed to quickly satisfy their children.

Nevertheless, Chun and his older brother were an exception. As shown in the earlier examples (See Fig 31 & 32), these two boys hardly ever stopped asking questions when given an answer. This might be a personal characteristic; as their father pointed out, they liked to "bomb him with questions" (Chun's father, interview#1). Thus, although their father provided answers for them when they asked questions, as other parents did, their conversation went in more depth and touched on more ideas.

It might also be due to the kind of question asked. Callanan and Oakes (1992) found that, when children asked "why" questions about the world around them, parents often responded in ways that helped children delineate science domains and begin to understand causal information about science. The answers provided by Chun's father usually started with "Because…," which seemed to stimulate Chun and Hsuan and prevent them from being quickly satisfied with an answer.

**Correcting children's wrong responses.** Parents' corrective actions commonly appeared in these families' conversations. The high frequency of correcting children's wrong responses might reveal most parents' beliefs that they needed to carefully avoid children's misconceptions, so they would not encounter learning issues in the future. Thus, when their children gave incorrect answers or made wrong interpretations in the visit, they usually immediately corrected them.

When Yen's family was talking at a model demonstrating plate tectonic movement, Yen responded, "I saw two Taiwans" to his mother's question "Do you see where Taiwan is?" Yen's mother then emphasized "ONE Taiwan! There is only one Taiwan!" (Yen, on-site observation, 120711) In the pre-visit interview, Yen's mother said it was a "shame" and a "serious issue" if her sons shared their misconceptions with their peers (Yen's mother, interview#1). Therefore, Yen's mother not only immediately corrected him, but also stressed the right answer.

In the earlier example of Yen's family visiting the Brontosaur diorama (See Fig 20 & 21), Yen incorrectly answered his mother's question, "Is a coelurus herbivorous or carnivorous?" In the reflection session, Yen's mother explained her immediate correction in this example by saying, "He is very interested in dinosaurs, then…um, but he still gave a wrong answer" (Yen's mother, reflection session). In her mind, because Yen should be very familiar with dinosaurs, he should not demonstrate a wrong idea. However, as

Veresov (2000) reminded, children can be out of the zpd not because of their lack of ability, but simply because they are not in tune with a task. In that example, Yen already told his mother "Let's go" and looked distracted before she asked the question. He might not pay carefully attention to his mother's question and only randomly give an answer.

As shown in an earlier example (See Fig 25 & 26), Yen's mother frequently talked with her sons in an IRE-like sequence; this might also be her way of ensuring Yen and Wen reached "correct" knowledge. When reflecting on her behavior in correcting her children's mistakes throughout their visit, she said, "Because I feel the wrong concepts will deeply influence my kids, I only tell them [something] when I'm very sure [about it]" (Yen's mother, reflection session). In addition to being careful not to tell her sons something she is unsure of, this type of conversation provides a platform for Yen's mother to monitor whether her sons' understanding is correct or not.

***The phenomenon of using professional terms.*** In an earlier section (i.e., "Avoiding professional terms"), it became clear that parents used almost no professional terms when talking with their children. However, when the purpose of "correction" was emphasized, professional terms were then used in conversation. One example comes from Jay's visit (See Fig 47):

> *Jay: Look! The ancient dinosaur had wings [sic]. It had a fin.*
> *Jay's mother: That's not a fin; that's called (she read the panel)…that's called a spine.*

Fig 47 Jay’s family, visiting the Spinosaurus model

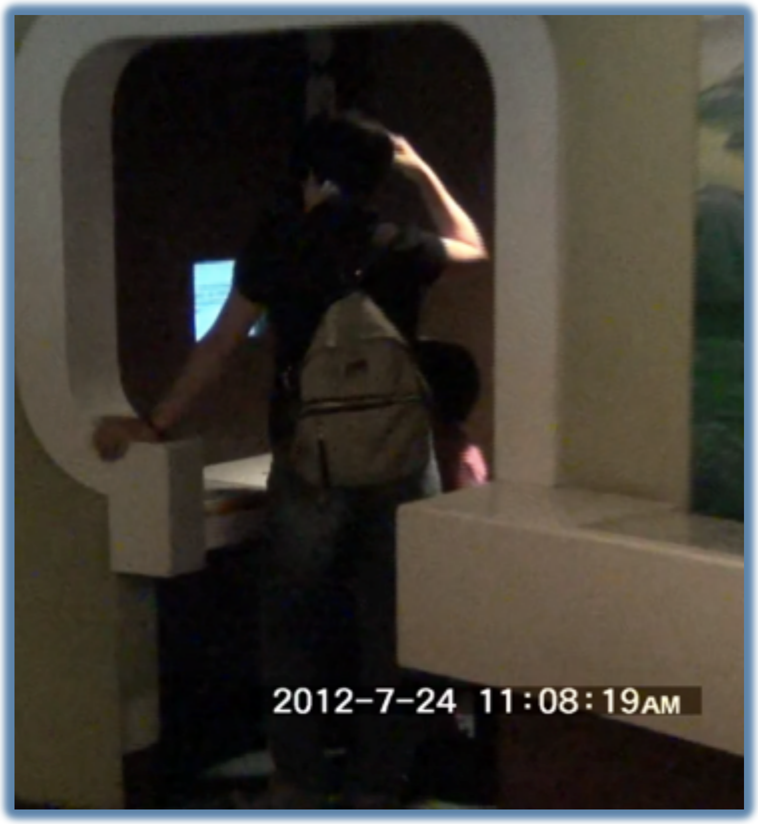
Another example took place when Jay saw a dinosaur which looked a little scary to him. He named it a “ghost dinosaur” when seeing it. Jay’s mother instantly corrected him, telling him the correct name: *sinornithosaurus* (Jay, on-site observation, 120807). “Ghost dinosaur” was obviously incorrect, so Jay’s mother used an official term to replace the wrong naming.

The notable phenomenon in these two examples is that Jay’s mother used official terms (i.e., “spine” and “sinornithosaurus”) when correcting, because her purpose was to correct Jay, not to give him an explanation. She needed to let him know he was wrong and correct knowledge existed. In the second example, if Jay had asked for an explanation, she might have told Jay “That’s a bird-like dinosaur” rather than tell him “That’s a sinornithosaurus.” Compared to her use of simplified language, she did not avoid using terms in these cases.

***Flexibility in correcting.*** Although parents believed they needed to be cautious about children's misconceptions, they did not always seriously correct their children's wrong ideas. It seems because parents were aware that children at this age (i.e., 3-6 years old) have their own cognitive limitations and features (Piaget, 1964).

Pei's family interaction at a computer game regarding plate tectonics movement is an appropriate example (See Fig 48). When Pei's family was playing the game, Pei's mother asked Pei and Ming, "Why does it (the plate) move?" Ming quickly answered, "Press this (the button), then it will move!" Pei's mother paused for a while; it felt as though she did not know how to respond to such an answer. Then, she said to Ming, "Well, this is a very good reason. This is a very good reason. You said you pressed that and it will move? Actually it is because…" (Pei, on-site observation, 120724). In the reflection session, their mother pointed out that such an interpretation reflected Ming's intuitive thinking (Pei's mother, reflection session). Hence, while she tried to explain what caused the plate move, she did not overrule Ming's interpretation or considered it "wrong."

Fig 48 Pei's mother, helping her children to play the computer game




Similarly, while Jay's mother did make corrections as listed those above, she did not always do so. For example, Jay saw a dinosaur model and he believed it to be very old. He told his mother, "The dinosaur was fifty-three years old" (Jay, on-site observation, 120807). While this was definitely incorrect, Jay's mother only responded "Oh" instead of correcting him. Jay's mother, who was an early childhood education major, might acknowledge and recognize this behavior as a cognitive feature at this stage (Piaget & Inhelder, 1969). It is assumed that her action in not correcting might be because Jay's behavior is common at this age and he will adjust his cognition when he is older.

**Guiding children to think.** According to these parents, they seldom stimulated their children to think by asking questions such as "what do you think" or "Why….?" when their children asked questions, these parents tended to quickly give them answers or find answers for them. However, I found that Wei's mother and Ying's father frequently asked this type of question in their visits. In other words, Wei's mother and Ying's father seemed to serve as facilitators instead of merely providing answers to their children in their visits.

In the earlier example of the "Chime Bell," Wei's mother asked a more stimulating question, "Does each one sound the same," to guide Wei to find out the answer, rather than directly telling him which bell sounded the highest or lowest (See Fig 18 & 19). In another episode, Wei's mother guided her children to think in a similar way (See Fig 49, 50, & 51):

*Wei: How to play this? Do I roll them at the same time?*
*Wei's mother: Yes. Which one rolls the fastest?*
*Wei's older sister: That one!*
*Wei's mother: Why?*
*Wei's older sister: I don't know.*
*Wei: Because it is bigger?*
*Wei's mother: Is it? I think it is because each weighs differently. Try it one more time.*
*Roll all of them at the same time. Try it.*
*Wei: This one is heavier, but why does it roll so fast?*
*Wei: 3, 2, 1, go!*
*Wei's mother: Roll all of them at the same time. Their size is pretty close.*
*Wei's older sister: And their weights are different.*
*Wei's mother: Yes, so, roll them at the same time to see which one rolls the fastest.*
*Wei's older sister: 3, 2, 1!*
*Wei: 3, 2, 1, go!*
*Wei's older sister: The lightest rolls the slowest.*
*(Wei's mother missed her daughter's answer; Wei's older sister repeated it again)*
*Wei's mother: Yes, but these two have almost the same weight; why does this one roll faster than that one?*
*Wei's older sister: No, this one weighs more.*
*Wei's mother: Does it?*

*(Wei's older sister said yes and her mother then echoed her)*
*Wei's mother: So, it is the weight to decide their…their what? Their speed is decided by their weight. (Wei, on-site observation, 120809)*

Fig 49 Wei's mother, guiding her children to manipulate the "Downhill Race"


Fig 50 The "Downhill Race"

Fig 51 The “Downhill Race”

While Wei’s mother was the person who concluded that “their different weights decide how fast they roll,” she guided her children to reach it by asking questions and suggesting they try. Her guidance was “purposely mediated, almost hidden, embedded in the activities” (Moll & Whitmore, 1993, p. 38), which gradually led Wei and his older sister to change their original assumption, “the size determines the speed” to the idea that the objects’ weights determined their speed.

Wei’s mother, who claimed she usually waited until Wei sought her help and believed her being an answer-provider was enough, indicated the important role of adults’ facilitation. She said, “Good stimulation could stimulate children’s creativity or to think more.” She also pointed out parents’ explanations could make the most of children’s play (Wei’s mother, reflection session). These two statements mirror Fleer’s (2007) argument, that if children are to gain the most of a playful context for learning, they require adult mediation in order to pay attention to the scientific opportunities being offered (cited in Blake & Howitt, 2012, p. 294). In this case, her question, “Which one rolls the fastest?” effectively stimulated her two children to try several times and share ideas about possible factors. Wei and his older sister’s manipulation might have original been “just for fun.”

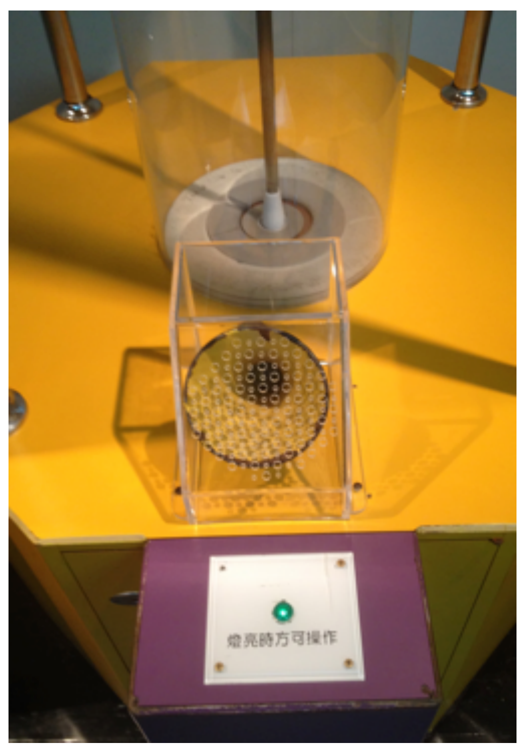
However, because of their mother's guidance, they gained a better idea of the content of this exhibit than through only having pleasure in collaborative manipulation.

Wei's mother's guidance successfully stimulated her children to figure out the connection between objects' weights and their speed. The example below may similarly show how a parent guided his child to think, although no response from the child was documented. Here, Ting manipulated the "Why The Ring Jumps" exhibit, which demonstrated Lenz's law; when the microphone detects a visitor's voice or noise, the copper will "jump" based on the sound volume (See Fig 52, 53, & 54). In this conversation, Ying's father tried to guide his older daughter to think about this phenomenon:

> *(Ting approached this exhibit and started to make sounds. Her father walked to her and looked at her manipulation.)*
> *Ying's father: What's this?*
> *(Ting said "Ha!" to the microphone. Her father looked at her and laughed. Ting tried it again.)*
> *Ying's father: Hold on, wait until the light is on.*
> *Ying's father: Why does this work like this?*
> *(Ting kept trying.)*
> *Ying's father: Hold on, the light is not on yet.*
> *(Ying, on-site observation, 120728)*

Fig 52 Ying's father, guiding Ting to make sense of the "Why the Ring Jumps"


Fig 53 and Fig 54 The "Why the Ring Jumps"



In this conversation, Ying's father wanted to guide his older daughter to think more about the result she created. According to Crowley and Callanan (1998), the "[g]uidance of parents is an important bridge between the intentions of the exhibit designer and the experience and knowledge of the child" (p. 12). Although it is difficult to know how much Ting benefited from her father's question, since she did not respond to it, her father's inquiry might implicitly inspire her to notice the connection between the voices she made and the height the copper "jumped."

**Making the science museum experience more meaningful.** One important belief these parents held is that science learning should be relevant to life. For example, Pei's mother noted, "If a child can't learn things in his/her daily life very well, how deep do you want to teach him/her? Especially about science" (Pei's mother, interview#1). Holding this belief, these parents tried to make their children's de-contextualized museum experiences become more meaningful by connecting the visit to their daily lives and prior experiences, or by extending these experiences after their visit.

***Connecting what happens in the visit to previous experiences.*** When Jay and his mother saw a platypus specimen (See Fig 55), Jay wanted to know what it was. His mother told him, "That is a platypus," and immediately connected it to the cartoon *Phineas and Ferb*, which Jay had watched before. Jay's mother told Jay, "Hey, Perry the Platypus is this [animal]!" (Jay, on-site observation, 120807)

Chun's family also connected the platypus specimen to this cartoon. When they saw the real specimen (See Fig 56), they established that the platypus is indeed duck-billed and otter-footed. Additionally, Hsuan asked his father whether a platypus might have more than one color, because Perry in the cartoon is colored in green. After his father told him, "No, its color is a bit grey," Hsuan concluded that Perry was accidentally drawn in the wrong color—a platypus has its color, but that color is definitely not green. (Chun, on-site observation, 120819)

Fig 55 Jay's family, at the "Platypus" specimen


Fig 56 Chun's family, at the "Platypus" specimen


Fig 57 The "Platypus" specimen

Although a platypus is not an animal that children typically see in their daily lives, because the children knew this animal from this cartoon, the connection made by these parents enabled their children to make the visit more relevant to them. In Chun's case, the connection helped him and his older brother to "enter a discussion at a personally meaningful level" (Piscitelli, Everett, & Weier, 2003, p. 25). The question proposed by Chun's older brother is evidence of this idea; because of the link, he could doubt the color of the platypus.

Ying's father also made a similar connection when they visited the "Dancing Dinosaurs," an exhibit designed to introduce the concept of static electricity (See Fig 58 & 59). At the very beginning of their conversation, Ying's father told Ying and Ting that this was something they had experienced before. He said, "This is the [activity of] static electricity you did last time; remember? The one your hair raised, remember?" Ying's father then manipulated the exhibit to show his daughters what static electricity looked like. (Ying, on-site observation, 120728)

While Ying and Ting could observe static electricity directly from this exhibit, the term "static electricity" and the phenomenon might still be new to them. However, as with the platypus in Jay and Chun's example, Ying and Ting have been exposed to this construct and experienced a fun phenomenon (i.e., hair-raising) in person. Thus, the action Ying's father took helped these two girls to link their personal experience to the scientific phenomenon, thereby producing a more meaningful understanding (Tharp, 1997).

Fig 58 Ying's family, talking in front of the "Dancing Dinosaurs"


Fig 59 The "Dancing Dinosaurs"

***Extending the museum experiences.*** Jay's, Chun's, and Ying's examples illustrated how parents actively connected an immediate experience in their visit to earlier experiences, to make learning more meaningful and relevant. Pei's family exemplifies another way science learning was made relevant: Pei's mother extended what they took from the visit to things that happened after the visit.

When they visited "Water: The Definite Necessary Liquid," (See Fig 60), Pei and Ming were very interested in the model demonstrating that water is vital for most creatures. Pei's family had a conversation about this issue on the spot. In their conversation, Pei's mother told Pei and Ming that the major component of the human body is water. When I interviewed Pei's mother again after their visit, she told me:

> *They checked out a book called* World of Water *from the library recently. Then we talked about this again. Um, for example, how much water is there on Earth? And only 3% is fresh water. So we talked about these issues again. (Pei's mother, reflection session)*

Different from those parents who used prior experiences to make the science museum visits more meaningful, Pei's mother seized the chance to go through what they encountered in their visit one more time. Her action in making connections resembles Falk and Dierking's (2000) argument, that "it is only as events unfold for the individual after the museum visit that experiences that occurred inside the institution become relevant and useful" (p. 133). The concept they gained from their visit would not only stay at the science museum, thereby having nothing to do with their lives.

Pei's mother added, later in her reflection session, that each exhibit in the science museum demonstrated a scientific phenomenon people can see in their daily lives in a detailed manner. So, "after you have a better understanding [from visiting these exhibits], when you view these things in your daily life next time, you will generate a different meaning [of these phenomena]" (Pei's mother, reflection session). Read (2004) pointed out that Vygotsky believed that the tools acquired from everyday experience were closely related to real phenomena, but lack coherence, whereas those acquired in a school environment were coherent but were isolated from real phenomena by the context in which they were acquired (p. 3). The statement made by Pei's mother suggests that what children gain from science museum visits and their daily lives are dependent on each other; they could apply the knowledge they learned from the science museum to life, and understand subtler aspects of their life experiences through science.

Fig 60 Pei's family, talking in front of the "Water: The Definite Necessary Liquid"


**Chapter summary**

In this chapter, through each family's conversations and interactions as well as a reflection session with each parent, I discussed how these parents' beliefs caused them to act, behave, and/or made decisions in particular ways (e.g., "Should I let my children return to the same exhibit?"). Below are the main points from each theme:

1. Fundamentally, parents let their children choose exhibits because of a belief in the significance of individual interest and curiosity. Nevertheless, parents sometimes chose exhibits due to their self-efficacy beliefs. Similarly, parents sometimes used "leaving" as a strategy to reach some goals. Leaving or staying, and deciding whether to return to the same exhibit, reflected their respect for children's curiosity and the importance of learning with minimal pressure.

2. Parent-directed versus child-directed conversation showed how parents responded to their children's curiosity. Parents' selection of content and language reflected their belief that children's ages influence how involved their science learning should be. Lastly, parents' intentionally remaining silent showed their beliefs in the low-pressure approach and their concern over misconceptions, whereas unintentional silence was a passive response to contextual influences.
3. Parents mainly used four scaffolding strategies to support their children. These strategies reflected their beliefs about the roles they should play, their avoidance of misconceptions, the idea that science learning should be relevant to life, and so forth.

In most cases, parents' beliefs appeared to be important resources for helping them find a proper way to interact with their children. Parents were very aware of why they behaved in particular ways: because of their beliefs. In a few cases, parents seemed to believe their behaviors indeed followed what they believed, while in fact they did not. In the next chapter, I will first review these parents' beliefs about their children's science learning. Then, I will further discuss the relationships between parents' beliefs and their actions to provide researchers, early childhood educators, and parents of kindergarteners additional understanding of how the present findings can further support young children's science learning.

# Chapter 6 Coda

The purpose of this study was to investigate a set of Taiwanese parents' beliefs about their children's science learning, and to assess how these beliefs guide their actions when they visit science museums with their children. The following discussion is based on my analysis of findings emerging from these two research questions. I start by discussing important insights gained from this study's findings. I then outline the limits of this study, and finally, I discuss the educational and research implications of this work.

## Revisiting the findings

Kloos et al., (2012) characterized early science learning as a "rather unorganized terrain." (p. 46) This description is also reflected in this study. When addressing their beliefs, parents seldom focused on what should be learned in terms of science; rather, they talked about how they believed science should be learned, why this learning was important, their and schoolteachers' roles in this learning, and so forth. To lend the terrain some degree of organization, I characterized these four main themes in chapter four. In the following, I first revisit these parents' beliefs about their children's science learning. Then, I discuss whether these beliefs served as a resource for their behaviors, based on what emerged in their interactions with their children when visiting the science museum.

**Revisiting parents' beliefs.** After re-examining these nine parents' beliefs, six important issues emerged:

1. Parents' beliefs are complex.
2. There is no single best method for supporting young children's science learning.
3. Science is seen as separate from other fields.
4. "Doing science" is distinguished from "doing science activities."

5. “This is enough” should not be confused with underestimating children’s ability of learning science.
6. Science learning possesses cultural resonances.
7. What is a kindergarten for?

***Parents’ beliefs are complex.*** Current qualitative studies tend to group parental beliefs about science learning and/or teaching (e.g., Barton et al., 2004; Swartz & Crowley, 2004). For example, Barton et al., (2004), who examined 24 mothers’ perspectives on science, categorized their participants’ beliefs (the term they used in the text) into four discrete groups: “science as schoolwork/knowledge,” “science as fun projects,” “science as a tool for maintaining the home and family,” and “science as an untouchable domain.” However, they noted this was reductive, as these mothers’ perceptions of science were not static and some mothers presented multiple perceptions of science based on context.

Barton et al., (2004) offer an important reminder. Taking a close look at these nine parents’ beliefs in chapter four, it becomes clear they present a very complex set of beliefs about their children’s science learning. For instance, even though these nine parents believed their children should learn science through first-hand experience, some (e.g., Kai’s mother) suggested visual learning must be accompanied by hands-on activity. In another example, when addressing why science learning is important, Pei’s and Wei’s mothers stressed the affective value of science learning, while Jay’s and Yen’s mothers emphasized its cognitive value. These two cases might show the complexity of parents’ beliefs—even when they appeared to be similar, each parent had his/her own emphasis.

Regardless of whether the participants were teachers or parents (e.g., Tsai, 2002; Chen & Chen, 2006); researchers often categorized participants’ beliefs about science/math learning/teaching according to either Traditional or Constructivist views

(Tsai added another category, called "Process view"). In this present study, most of the nine parents' beliefs appeared to be Traditional viewpoints – for example, the idea that parents or other adults are usually children's main answer-providers. However, it may be problematic to simply understand them from any single perspective or theory, because these parents' beliefs do not constitute a single statement. These beliefs should be carefully examined and understood in context, to establish why these beliefs favored a specific view rather than the other. I will discuss this a little more when articulating cultural meanings, in a later section.

In addition, different facets of a parent's science learning sometimes appeared rather contradictory to each other. For example, although these parents believed science is important, they may not believe that they should actively stimulate their children's science learning. I named this phenomenon the "conflicting nature" of parents' beliefs. Interestingly, many parents readily subscribed to multiple conflicting beliefs. Looking at the above example a bit more closely, many possible reasons, such as parents' concern over giving their children misconceptions or their children's young age, all led to seemingly contradictory results.

In short, parents' thoughts about different aspects of their children's science learning become a set of complex beliefs. Every parent expressed preferences and emphases, and these make their beliefs unique and discernible. Each parent's beliefs do not constitute a very simple, single statement of what science learning is. Every aspect of a parent's science learning beliefs is interconnected–even though in some cases their beliefs might look contradictory.

***There is no single best method for supporting young children's science learning.*** The idea that science is best learned through hands-on and first hand experiences is widely accepted and advocated in the field of science education (e.g., Armga et al., 2002;

Gelman & Brenneman, 2004; Inan, Trundle, & Kantor, 2010; Murphy, Murphy, & Kilfeather, 2011). Additionally, researchers agree that young children's science learning should involve the element of "play" (e.g., Fleer, 2009; Moyles, 2010; Wilson, 2012). These two ideas also constitute a significant part of these nine parents' beliefs about their children's science learning. Nevertheless, based on what these parents addressed in terms of how science learning should proceed, no so-called "best" method to support their children's science learning existed in these parents' beliefs.

Indeed, these each had his or her own preference; Yen's mother, for instance, believed it was effective to ask her sons to repeat specific terms several times. However, the multiple approaches (e.g., "science learning should be interesting and fun") and means given by these parents show that how young children learn science is not limited to a single path. In these parents' beliefs, different approaches and methods afford their children various advantages and therefore enable them to better learn science. For example, learning science through diverse hands-on and/or first-hand experiences is the primary means for learning science for these parents because children will develop long-lasting memories and want to know more. Likewise, if the first-hand activity is relevant to their daily lives, these parents believe children feel more connected to what they are learning.

In sum, different resources and methods will offer children diverse understandings of the same object or phenomenon. Children's science learning therefore benefits from various approaches, methods, and materials. Jay's mother's statement, "You should gain knowledge from various sources" (interview#2), may highlight that there is no one "best" method to support this learning.

***Science is seen as separate from other fields.*** Many have pointed out that science learning is actually implicated in other areas (Conezio & French, 2003; Gordon & Browne, 2007; Tu, 2006). However, in these parents' beliefs, science learning seemed to be separate from other content areas. Several parents found it difficult to see how their children could gain an opportunity to learn science from other content areas. For example, Ying's mother asked me, "Does frying an egg count as a science activity?" (Ying's parents, interview#2) The sole counter example came from Jay's mother, who stated she would guide Jay to mix colors if they decided to paint with watercolors (Jay's mother, interview#2).

The separation of science from all other forms of learning could be seen in the perceived importance parents gave science learning. Although they believed science learning is vital, simultaneously, they indicated science learning should not receive particular attention as distinguished from other content areas. This "particular attention" might reveal that they believe science is self-contained and disconnected from other content areas, and that they therefore do not want to spend too much time on "science learning." Additionally, while the nine parents in the present study believed in the importance of science learning, they rarely identified the activities they offered their children as related to "science." This contradicts Bottle's (1998) finding that, although all her participants provided many mathematic activities, only half of all parents recognized the importance of math. One example, from Pei's family's visit to the Nantou tea factory, supports this claim:

> *Well…I don't know. I'm not quite sure whether this is included in science because we didn't talk much about, um; we didn't particularly focus on this aspect. …What they felt curious about was those machines in the factory. The smell there was really nice. And some stuff there. …And I told them the trees we saw were for making tea. We also saw a very unique bird there. (Pei's mother, interview#2)*

Broadly speaking, her children's curiosity in the machines, the smell of tea, their observation of trees and the bird are all a part of science learning. Nevertheless, her seeing no science learning happening might suggest that parents only interpret learning related to biology (e.g., animals, plants), physics (e.g., the functions of machines), astronomy (the sun, moon, and planets), and/or chemistry (as in food changes), as "science learning." Otherwise, it seems difficult for them to notice science learning.

This distinction also became clear when parents felt it was fine that they knew little about their children's school science learning. Several parents, such as Yen's mother, felt it was too demanding for schoolteachers to squeeze science learning in their full classroom schedule. As Yen's mother said, "I don't think they have extra time to specially arrange the science curriculum" (Yen's mother, interview#2). The "extra time" and "specially" in her statement might indicate her assessment of science as a less relevant content area. However, as Gelman et al. (2010) pointed out:

> When science is understood as a process of studying the objects and events in the world by asking and answering questions, the scientific process can be integrated throughout the school day and included in a wide range of activities. Science is not a collection of unrelated activities that are inserted into particular time slots in a classroom schedule (p. 8).

Science learning is in fact connected to or even embedded in other content areas (e.g., reading, music, math). Yet these parents did not frame their children's science learning as an integrated process, and therefore felt it too difficult for schoolteachers to "arrange the science curriculum." If their children did an art activity, parents might not think this activity involved any element of "science." On the other hand, several parents in this study believed it was far easier to tell children gained literacy/art/music/math learning because their children could demonstrate a concrete product.

In sum, although parents pointed out there were many opportunities in daily lives for their children to learn science, when addressing the relationship of science to other content areas in school, these parents were usually unable to see how a content area not specifically devoted to science could nevertheless offer their children opportunities for learning science. Even though children engaged in activities full of "science," parents tended to believe there was no or little science learning happening. This belief also influenced their understandings of their children's school science learning.

***"Doing science" is distinguished from "doing science activities."*** As Moscovici and Nelson (1998) argued, there is a definite difference between "doing science" and "doing science activities." Broadly speaking, in the former learners begin with questions and experiences and co-share the responsibility of learning with others (e.g., adults) while the latter is prepackaged as well as product-oriented, and the learner therefore has less control of his/her learning. This is especially important when discussing parents' beliefs that science learning should be learned from hands-on/first-hand experiences and that science learning should be fun and interesting.

All nine parents in this study believed in the advantages of hands-on/first-hand learning experiences. However, they also believed that science learning should be more adult-oriented. To be clear, if any questions emerge from a hands-on activity, the adults rather than the child should take responsibility for finding answers or giving information. Parents seemed to seldom encourage their children to think more about the activity they completed. For example, when Lily's family went to a zoo and saw a male peacock with beautiful feathers, Lily's mother conducted a "science activity" with her daughters by directly telling Lily and Nana, Lily's younger sister, "It is because it is male that it has feathers like that." (Lily's mother, interview#2) If Lily's mother were to do science with Lily and Nana, she might have encouraged them to compare peacocks to learn why some peacocks' feathers are pretty while others are not, or why male peacocks have such colorful feathers. Doing science with Lily and Nana, in this case, could facilitate their scientific inquiry skills through the use of guiding questions (Moscovici & Nelson, 1998).

The NSTA (2009) encourages parents to "Foster children's creative and critical thinking, problem solving, and resourcefulness through authentic tasks such as cooking, doing household chores, gardening, repairing a bike or other household object, planning a trip, and other everyday activities" (para. 4). This statement shows that it is not science activities per se that are important to children's science learning. It is instead central to engage in activities with children that challenge them to think critically about what they are doing or to prompt them to make arguments about their experiences and/or assumptions. Essentially, "doing science" is the main point.

Play can be viewed as one type of "doing science." In this study, while parents seldom directly used the term "play," the notion they described (see the section "Science learning should be interesting and fun" on p. 92) resembles to this construct. However, these parents' potential concerns, such as the notion that their children's play is just for fun, seems to reveal that they want control this "activity" more and use it to reach specific goals (Moscovici & Nelson, 1998). In these parents' beliefs, their children's play might not count as "doing science." Therefore, they would have reservations about what their children could gain from this type of activity.

***"This is enough" should not be confused with underestimating children's ability of learning science.*** One salient characteristic in these parents' beliefs is their emphasis on their children's age. To put it more pointedly, most of these parents believe their children's young age makes for immature cognitive ability, insufficient knowledge and/or limited experience. In chapters four and five, I provided an initial discussion on how children's young ages played an important role in parents' beliefs and actions. In this sub-section, I go into a deeper discussion of whether these behaviors underestimate children's ability to learn science, or, as they believe, a lower level of science learning is "enough" for their children.

Compared to other areas (e.g., reading, social competence, English), parents seemed to consider science learning particularly in terms of children's age. Most parents believe their children are still young, and they therefore neither should tell their children too much nor need to cultivate scientific skills such as making inferences and predictions. Spodek and Saracho (1991) stressed that "what children are capable of learning is heavily dependent on their level of development" (p. 119). This antiquated statement, which current research contradicts (e.g., Tenenbaum, Rappolt-Schlichtmann, Zanger, 2004; Mercer, Dawes, Wegerif, & Sams, 2004), is reflected in most of these nine parents' beliefs; they believe how much they should give their children in terms of science is primarily determined by their children's age—the older, the more.

The other side of the "the older, the more" is the "enough and now." Because of believing "it is enough now," most parents in this study tended to underestimate the potential in and the complexity of young children's minds. As a result, they might miss key moments for scaffolding. According to their self-reported beliefs, these parents seemed to believe young children could not absorb abstract knowledge. Therefore, most of these parents concretized or simplified their teaching and ignored the possibility of challenging children's abstract thinking (Duschl et al., 2007; Katz & Chard, 2000). Although such behaviors may reduce their children's frustration when they learn science, this might limit young children's science learning and make it become superficial as well (Hou, 2012).

In this study, Chun's father knew his two boys had their own limitations, but he believed it was beneficial for them if he gave a little more and then adjusted in response to their feedback. Because Chun's father did not set a boundary on their cognitive abilities in advance, based on their conversation, their science learning seemed to go in more depth in their museum visit. For instance, they had a long conversation about how archaeologists discovered dinosaur fossils (Chun, on-site observation, 120819). Previous findings have shown that parents' educational levels influence their beliefs, cognition, and/or parenting styles (e.g., Kao, 1993; Liou, 2001; Tenenbaum & Callanan, 2008). Indeed, Chun's father and mother both have PhDs and are university professors, and are therefore members of families who occupy a relatively privileged position within Taiwanese society. However, researchers such as Bradley et al., (1989) and Gottfried, Fleming, and Gottfried (1998) have argued that a stimulating family environment supports cognitive development more than high socio-economic status does. The interaction between Chun's father and his boys demonstrates that a science-rich environment exerts more influence on science learning than do parents' educational levels or their occupations. Hence, I would argue that the openness of Chun's father to the potential in his two sons' learning caused Chun and his older brother to exhibit more sophisticated scientific thoughts than other children in this study.

Martin (2011) noted that "we must be careful not to ask children to do something they are not cognitively capable of doing." (p. 115) Fenichel, Harteker, and Allen (1996) similarly warned that when children's abilities are not taken into account, "children do not learn as much as they could learn about science. Equally important, they do not enjoy science" (p. 119). Thus, these parents' using age as a criterion to judge how much they should give their children might be reasonable. Yet, as Elkind (1999) argued:

> There are limits to what one can effectively teach young children in the fields of math, science, and technology. But there are no limits to the young child's curiosity and imagination if we support and encourage his or her own ways of thinking. (para. 22)

This is very close to what Vygotsky's zpd and scaffolding highlighted. With proper support, a child can do more than s/he does alone. These parents' focus on the "now" and "enough" may prevent them from moving their children's science learning a little further.

Vygotsky's zpd and scaffolding emphasized one crucial idea: giving children something below their actual development bores them, whereas giving them something too difficult might frustrate them. Being careful to not giving their children too much, and avoiding ruining their interest in science, is important. In these parents' beliefs, however, the "how much is enough" seems to be primarily based on how old their children are. Yet, the answer to this question might not be this simple. Challenging children appropriately, neither overestimating nor underestimating their abilities, is an art. Based on the findings of this study, further study should be devoted to the ways in which parents might properly challenge children's minds and thereby promote science learning.

***Science learning possesses cultural resonances.*** Guided by Vygotsky's theory, I paid especial attention to how these parents' beliefs were situated in the context of Taiwanese society. Although these parents did not specifically connect their beliefs to any Taiwanese or Chinese cultural values, on a closer look, many of their statements appear to be rooted in Taiwanese cultural values.

In one apparent trend, parents seemed to believe it adequate for their children to passively receive the information they give them. Although Vygotsky's focus on social interaction and culture suggests that children should be encouraged to interact, discuss, and argue with each other and adults (Inan et al., 2010, p. 1189), Chinese learners have been brought up to respect the wisdom, knowledge and expertise of parents, teachers and trainers (Chan, 1999, p. 298). Hence, in these parents' beliefs, science learning is often a one-way transmission. The question-answer format is a very common method by which parents supported their children's science learning. Also, these parents rarely mentioned any belief in the importance of engaging in arguments from evidence, reasoning, and inferring, which researchers have shown to be important scientific skills that can be promoted and cultivated in early childhood (e.g., Gelman et al., 2010). These parents seemed to place their faith in adult-oriented science learning than in child-initiated inquiries. In Taiwanese culture, adults rarely expect children to express their own thoughts (Huntsinger, Jose, Liaw, & Ching, 1997). This might be one critical factor in shaping these parents' beliefs in the adult-oriented approach.

Another notable phenomenon in these parents' beliefs is answering children's science questions with "I don't know" if parents felt unsure of the answer. Such a finding differs from Alagumalai (2005) and Falk and Dierking (1992), who found that parents in Western contexts tended to make up answers. To my knowledge, no particular study focuses on discussing why the correctness of scientific knowledge would be more emphasized by parents in Eastern contexts such as Taiwan. However, comparing this study to the two aforementioned studies, one might say these nine Taiwanese parents cared about their children obtaining correct science knowledge, whereas Western parents might stress their responsibility to offer their children answers even though they might not be correct. It is of course problematic to generalize about all Taiwanese parents. Nevertheless, it is intriguing to note that these Taiwanese parents shared similar beliefs about what they would do if they were unable to answer their children's questions.

The more I conversed with these parents, the more I noticed some of them were aware of cultural influences on their beliefs and/or actions. For example, Jay's mother associated the small amount of scientists in Taiwan with Taiwanese educative values (Jay's mother, interview#2). Ying's mother also revealed her initial awareness of educative values in Taiwan, when she explained why she seldom guided her daughters to think more about the content of the exhibits. She said, *For example, when we were little, we asked our parents some questions and they couldn't give us the answers, they would tell us, "You will know when you are older." They wouldn't tell us "Hey, let's find out the answer together." You know, we were not treated in that way, so [we] are somewhat influenced by that. (Ying's parents, reflection session)*

This statement shows how parenting styles are passed on to the next generation through social interactions, and how they then become part of their beliefs (Bronfenbrenner, 1979). Because these parents grew up in this cultural context, they might internalize such values unconsciously. As Savage and Gauvain (1998) pointed out, "Through participation in everyday activities, children learn about the practices that reflect and maintain cultural beliefs." (p. 321) Before participating in this study, Ying's mother might never have questioned this kind of interaction with her daughters, because she was raised in a similar way. As Taiwanese insiders, parents are immersed in this culture and appear to accept cultural values without conscious questioning.

As I pointed out in chapter five, similarly, when parents offered their children an answer—even though it might be simple and contain less information—most children in this study seemed accustomed to this type of interaction/response and rarely questioned what their parents told them. This seems to show that these children might have gradually learned this type of response through repeated interactions with their parents; in turn, they will likely see it as a good way to interact with their own children if they become parents in the future (Caudill & Schooler, 1973).

Parents and children do not exist in a vacuum; therefore, Liou (1999) suggested that any interpretation of parenting behaviors and their impact requires an understanding of the setting itself and its relation to the larger socio-cultural context. In "Parents' beliefs are complex," I argued that categorizing parents or teachers' beliefs about science teaching learning into either Traditional or Constructivist positions made it difficult to see how culture subtly influences parents' beliefs. Based on the findings of this study, these nine parents did not fully belong to any of these two groups. Rather, some parts of their beliefs are close to the Traditional view (e.g., science learning should be adult-oriented) while other parts might be similar to the Constructivist view (e.g., science is learned through hands-on experiences). According to Bronfenbrenner (1979), parenting methods are affected by various contextual factors in multiple systems (i.e., Micro-, Meso-, Exso-, and Macro- systems), and parents who live in one specific culture would find "the best" ways of how to interact with their children. These parents' beliefs might result from the current societal needs and/or educative values of Taiwanese society.

Researchers have found parents in different cultures or ethnic groups differ in their beliefs about parenting, children's ability, learning, and other such issues (e.g., Chen & Uttal, 1988; Galper, Wigfield, & Seefeldt, 1997; Keels, 2009; Parmar, Harkness, & Super, 2004). Above, I presented the particular cultural norms that manifested in these parent's beliefs. Still, the findings of this study also echo similarities in current literature. In other words, there are commonalities between parents from different cultural contexts. For example, a set of American parents of kindergarten-aged children in Musun-Miller and Blevins-Knabe (1998) ranked reading and social skills first and the second among several content areas. While science was not in their list, and the study did not explain parents' rankings, this finding seemed to indicate that parents of kindergarten-aged children have a similar tendency to stress the importance of reading, as opposed to science or math.

Also, similar to other scholars' findings (e.g., Beckert et al., 2004; Liou, 1998; Shaw, 1994), these nine parents' thoughts were influenced by Western educational values—more play, valuing children's individual interests, and so forth (Cannella, 1997; Jose, Huntsinger, Huntsinger, & Liaw, 2000). Compared to these nine participants' own parents, it is evident that some values concerning the importance and necessity of science learning in Taiwanese society are changing (Bronfenbrenner, 1979), which might open more possibilities for children's science learning. For example, boys will not be expected to learn science only because they are boys. Rather, boys and girls both need equal opportunities to access science. Nevertheless, this and other studies (e.g., Chen & Luster, 2002; Liou, 1998, 2001) found that native culture still had a great impact on the formation of beliefs.

In sum, situated in a Taiwanese context, these parents demonstrated particular yet similar beliefs about how science learning should proceed. Simultaneously, it is apparent that these parents were influenced by both Taiwanese cultural values as well as some Western notions. While some cultural meanings manifest in these parents' beliefs and/or actions, unfortunately, the current literature does not provide much understanding of how culture may play a role in shaping parents' beliefs about science learning. This issue deserves more attention, so that early educators might more fully understand how culture explicitly or implicitly impacts different aspects of parents' science learning beliefs.

***What is a kindergarten for?*** In the final section of chapter four, I reported how parents' beliefs revealed a disjunction between science learning at home and in school. In that section, reports of infrequent communication about school science learning, unfriendly messages from school, and the need to respect schoolteachers' specializations in education were presented. These findings lead to one question: What is a kindergarten for?

In pre-visit interviews, the words "learning" or "science learning" were seldom used by these parents when talking about their children's school life. Generally, they talked more about peer relationships, safety, and so forth. The only exception might be Kai's mother, who purposefully chose this kindergarten for her children because it offered students abundant hands-on/first-hand experiences. Parents such as Chun's father and Wei's mother stated their primary concern was not how and how much their children's teachers offered science-related activities and curricula in school. Rather, they send their children to school with the expectation that they will be safe, healthy, and happy. Their putting less stress on their children's school science learning may reveal that these parents do not view this setting as primarily for "learning." Rather, it is a place for meeting children's physical (e.g., being safe) and emotional needs (e.g., being happy). Thus, if their children's teachers communicated issues related to these needs with them, these parents would feel content.

Parents in this study were aware of the fact that their children would face heavy pressure after entering elementary school (e.g., Chun's father, interview#1). So, kindergarten might become a place where their children could enjoy their childhoods. A child could definitely learn things from his/her school life, but exposing them to different kinds of learning seemed not to be the main purpose of a kindergarten.

This finding is especially important for engaging parents in school science learning. Because parents did not see this learning as necessary for kindergarten, schoolteachers might need to figure out how to effectively involve parents as partners in supporting children's science learning inside and outside schools.

**Revisiting parents' actions and their beliefs.** Earlier studies have revealed that there may be a level of consistency between parents' beliefs and their actions with their children (e.g., Lynch et al., 2006; Meagher et al, 2008; Swartz & Crowley, 2004). However, according to the findings of this present study, the relationships between these two constructs are more complicated than originally assumed. Therefore, in this section, I will further discuss whether parents' beliefs guide their actions.

Chak (2001) pointed out that adults are likely to be more conscious of their inputs in formal rather than in informal learning settings (p. 388). In reflection sessions, however, these parents could and usually would quickly associate why they made particular decisions in their visit with their beliefs. For example, when I asked Wei's mother why she read the panels yet seldom explained for her children, she readily explained that she did not hurry Wei and his older sister to learn, as they needed to be motivated (Wei's mother, reflection session). This case and other findings of this study, additionally, reveal that these parents' "natural and common" behaviors and interactions with their children were in fact intentional decisions, made according to what they believed.

This finding resembles Swartz and Crowley's (2004) study on parent beliefs about teaching and learning in a children's museum, in which what parents said was generally consistent to what they did. Based on the findings of chapter five, I would also state that these nine parents' actions were generally guided by their beliefs. Yet, as I also noticed, the consistency between parents' beliefs and their behaviors may be influenced by contextual factors, such as the need to be safe in a public setting, properly using exhibits, obeying the rules of the science museum, having no clear explanation panels, and interference from too many other visitors. These all caused parents to make adjustments and take alternative actions based on the context. For example, Kai's mother clearly indicated that lacking useful information was the primary reason for saying nothing to her children (Kai's mother, reflection session). Nevertheless, they kept their beliefs in mind and maintained flexibility at the same time. To be more specific, although these parents altered their behaviors slightly due to contextual influences, they knew very well what they would do if these outside influences did not exist.

As I outlined in chapter one, one of the anticipated significances of this study was to understand why parents adopt certain kinds of strategies and how and why they make decisions in the process of visiting science museums, so that museum educators and/or curators could utilize such beliefs to promote parents' related actions. Grenier (2010) noted, "Museum educators need to be made aware of the museum's geographical and contextual influence on learning, and how these multiple factors come together to influence the learning experience." (p. 512) For instance, parents' silence was usually identified as passive or even negative (Hsu & Lin, 2005), because parents did not engage in children's science learning very much. However, six of the nine parents' reflections showed this was not always the case. Thus, museum curators and early educators might need to be more careful about how contextual influences impact parents' actions and how they relate to their beliefs. They could then avoid underestimating their seemingly passive behaviors and/or engagement, such as the adjustment Kai's mother made in the above example.

As I stated in the very beginning, parents' beliefs and their behaviors have a very intricate relationship. When parents took action or made a decision, they seemed not to rely on any one aspect of their beliefs. Rather, they might be guided by multiple beliefs, and then make the final decision. This might be due to the complexity of their beliefs. Thus, a parent might favor a specific part more than other parts of his/her beliefs. For example, when Yen and his mother visited "Excavations at Huilai archaeological site" (See Fig 30), it looked as though Yen was curious about the exhibit, because he tried several times to pose a question. Yet, his mother ignored his attempt and chose to function as a knowledge agent. This finding might reinforce the idea that parents have complex beliefs. When a parent is strongly attached to a particular aspect, s/he might mainly use it to direct his/her actions.

Here I want to discuss Yen's mother a little further to reveal the complicated relationships between parents' beliefs and their behaviors—because many of her behaviors seemed to contradict her beliefs. At first, I thought her actions revealed an inconsistency between her beliefs and actions. After interviewing her, I found she did not believe she had abandoned her beliefs. Instead, her beliefs were still the main resource when she explained why she acted in a specific way. For example, she started to explain for her sons because she thought their approaching a particular exhibit demonstrated curiosity (Yen's mother, reflection session). Thus, rather than concluding her actions reveal an inconsistency between a parent's beliefs and his/her behaviors, I would say there was a "gap" in the cognition of her beliefs, meaning that she believed she followed her beliefs when interacting with her sons, while there was in fact a mismatch between these two constructs.

Although there seem to be inconsistencies between parents' beliefs and their actions, based on the findings of this study, I would argue parents' beliefs are an important mechanism for influencing children's science learning. Based on the findings in chapter five, parents' beliefs mediate their behaviors and then have an impact on children's science learning. More specifically, a seemingly simple behavior, such as letting children explore one object for very long time, might reflect what was recognized as important in a parent's beliefs. In general, parents' decision-making and actions/behaviors are more meaningful and complicated than they might appear. To change parents' actions, it might be necessary to first understand their beliefs.

**Study limitations**

According to Creswell (2002), delimitations are used to narrow the scope of a study while limitations are provided to identify potential weaknesses of the study (p. 148). Following this idea, Kuiper (2009) proposed that some limitations arise from circumstances beyond a researcher's control; while others derive from the way a researcher defines his or her scope and delimitations (p. 255). In this section, I will first address the two main limitations of this study, based on Kuiper's (2009) interpretations. Then, I will discuss two smaller issues: the number of visits and the impact of my following these families and videotaping their every move.

**The limited quantity of fathers as participants.** In chapter two, I addressed the present lack of understanding concerning fathers' beliefs and their behaviors, especially those related to their children's science learning. With this idea in mind, while this study adopted convenience sampling, I tried to recruit as many fathers as I could to reveal more about how fathers perceive their children's science learning and make decisions based on those beliefs.

However, in contacting potential participants, I encountered two difficulties. First, I found all mothers quickly positioned themselves as the only interviewee and eliminated their husbands from participating in the study. Fathers' being busy (e.g., Wei's mother, interview#1) was the primary reason given by mothers when I attempted to urge the participation of their spouses. Additionally, many fathers are involved in economic activities that take them away from home. For example, Wei's father was frequently not at home because he needed to work in other cities. Jay's father served in the military and was usually not at home. As a result, there were only two fathers[16] in this study (i.e., Ying's father and Chun's father).

While Ying's father and Chun's father shared many valuable thoughts, their backgrounds were similar. They both had science-related backgrounds and were highly educated (one had a Master's degree and the other had a Ph.D.). Their mutual characteristics might limit my perception of the variety of fathers' beliefs about their children's science learning. For example, how would a father with no science-related background express his beliefs concerning his child's science learning?

Additionally if infrequently, I noticed that some mothers in this study believed engaging in their children's science learning should be a father's responsibility, because

[16] Originally there was one single father in this study. However, I lost this parent after his first interview because he was too busy at work.

fathers "are good at science." (Yen's mother, interview#1; Jay's mother, interview#2, Ying's mother, interview#1) However, Chun's father objected to this idea although he indeed excelled in science. What might other fathers think about their responsibilities in supporting their children's science learning?

Lareau (2000) found fathers were not useful sources of information about the routines of family life; she also noticed that most of what fathers knew came from their wives. The present study, however, found these two fathers knew a good deal about their children's strengths, weaknesses, and interests, as well as other important issues in relation to their children. Chun's father in particular assumed responsibility for science activities with his sons, because Chun's mother was struggling with getting tenure. Although rearing children is often regarded as a mother's responsibility, there are families that operate like Chun's family. The limited quantity of fathers as participants in this study made it difficult to understand fathers' familiarity with and thoughts about their children's science learning. Are these similar to or different from their wives' beliefs? The difference between Lareau's findings and my own may point out the need for having more fathers as participants, to provide more empirical evidence on fathers' science learning beliefs.

**The choice of context**. As I pointed out in chapter one, I purposefully chose to examine how parents' beliefs about their children's science learning manifested in the science museum. As Muller and Kerbow (1993) suggested, parental involvement should be studied in contexts other than the home, because different settings exert different contextual influences on parental involvement and different implications could emerge depending upon context. However, examining these parents' expressed beliefs in one single science museum is like a double-edged sword. Although I indeed observed some important contextual influences on how parents adjusted their actions when interacting with their children in this science museum, at the same time, this delimitation made it impossible to know the contextual influences of other types of science museums (e.g., aquariums) or other kinds of settings (e.g., homes, schools, playgrounds).

**The two minor limitations.** Lastly, I would like to discuss the two minor limitations. First, as Murphey (1992) pointed out:

> Beliefs that are of some central importance in a parent's psychology are likely to have a host of subtle effects not easily captured through brief observation. For example, ideas about what is valued, expected, tolerated, disapproved, and so on are likely to be communicated to the child not only through what the parent does but what the parent does not do. ……Thus, many beliefs are probably revealed over a history of interactions in a variety of contexts, rather than in isolated observations. (p. 205)

Observing each family only one time proved effective because these parents could explain why they made decisions and acted in specific ways. However, what I reported in this study was limited to a single visit in a precise setting. Based on Murphey's (1992) reminder, I might miss more subtle aspects of these parents' beliefs because of a limited number of visits.

Lastly, although I turned off the digital video for the first ten minutes to make these families feel more comfortable, my observation, videotaping, and following might have still affected their behaviors to some degree. While many parents told me they quickly ignored my presence because "there were too many people" (e.g., Lily's mother, follow-up interview; Pei's mother, follow-up interview), Wei's mother also confessed "she was afraid of not showing me enough interactions" (Wei's mother, follow-up interview). Thus, my attendance in their visits unavoidably influenced their interactions with their children.

## Implications

Based on the findings, I now discuss the implications that this study offers for different groups, including early educators, parents of kindergarteners, and researchers in the field of early childhood education and early science learning. My hope is that these implications provide directions to better support young children's science learning.

**Implications for early educators and schools.** One of the expected significances of this study was to give early educators and practitioners practical hints of how to encourage children's science learning through adults' positive support. While these nine parents' beliefs cannot represent all Taiwanese parents' beliefs, teachers can at least gain some ideas regarding how parents think about their children's science learning. Four main implications for early educators and schools were made based on the findings, to give them some hints of how to incorporate these beliefs into their practices.

***Offering parents chances to vocalize their ideas about early science learning.*** Bronfenbrenner (1990) asserts,

> The effective functioning of child-rearing processes in the family and other child settings requires establishing ongoing patterns of exchange of information, two-way communication, mutual accommodation, and mutual trust between the principal settings in which children and their parents live their lives. (p. 36).

Thus, early educators need to provide parents with opportunities to express their thoughts. This does not have to be face-to-face communication. Teachers could use social media (e.g., classroom blogs, Facebook, Twitter) or other traditional media, such as phone communication, to reach this goal. When talking with parents, teachers could ask them their thoughts on a recent science activity that was conducted in an inquiry-based form. They could also ask parents what they might think about a field trip to a zoo. By doing this, early educators could have a better understanding of how to address parents' beliefs when designing the curriculum, promoting parents' engagement, and/or interacting with the children they teach.

While these nine parents were a convenient sample, some of them (e.g., Yen's mother) particularly stressed the importance of articulating their thoughts regarding their children's science learning. Parents such as Jay's mother found participating in this study offered her a chance to reflect on what she never paid attention to, as well as prompted her to take Jay to the science museum more frequently to explore ideas new to them.

Barton et al. (2004) noted, "Parents' roles and involvement in schools have been understood largely in terms of 'what they do' and how that fits or does not fit with the needs of the child or the goals of the school." (p. 4) However, "what they want" might be ignored in teacher-parent communication. By offering parents chances to voice their ideas about early science learning, early educators could understand and respect their beliefs as well as accept why they view science learning in specific ways. This is critical before developing strategies to increase parental involvement. Early educators could then properly help parents to refine their beliefs and become a more confident and effective supporters of children's science learning. Additionally, instead of criticizing how parents think about science, teachers could try to challenge parents' ideas about this learning by introducing new ideas to them. For example, they could introduce the idea of multiple intelligences (Gardner, 1983) to parents, to enable them to see science as everywhere—in math, music, art, and fundamentally in their daily lives.

Lim (2003) indicated that teachers' knowledge is horizontal and parents' is vertical. Where these two points intersect, parents and teachers can strengthen each other (p. 142). Such a point not only supports why teachers need to communicate with parents, but also brings up the importance of knowing about and connecting children's experiences inside and outside school, which I will discuss in the next sub-section.

***Knowing about and connecting children's experiences inside and outside school.*** As Brooker (2002), Tizard and Hughes (1984), and Tran (2008) indicated, early years practitioners seem largely unaware of children's learning experiences at home and fail to capitalize on them (cited in Cumming, 2003, p. 483). Similarly, according to these nine parents, their children's out-of-school science learning experiences were separate from those that happened in school. However, as the findings of the present study showed, children had rich out-of-school science learning experiences.

Pursuant to the above idea, I would suggest early childhood teachers familiarize themselves with their young students' experiences outside school and find proper ways to connect these experiences to science learning in school. Teachers must be well prepared for connecting children's school and out-of-school experiences because, as these nine parents stated, "children's daily lives are a good starting point for learning science." "Circle time" might be an appropriate occasion to encourage children to share what they did outside school with their families regarding science. For example, a teacher might know from a child that she baked a cake with her mother and relate this to the cooking activities they will perform in school. Meanwhile, this would give teachers starting points to deeper science investigations. A teacher might use a child's sharing of her aquarium tour as a foundation for developing a project about underwater creatures.

***Organizing parental science learning groups.*** I propose that schoolteachers try to form and host professional groups and communities (Cheng, 2010). By establishing this kind of group, parents could figure out some effective methods to support their children's science learning as well as have opportunities to hear other parents' voices. Such a group may help parents to expand their social capital (Bourdieu, 1983) as well.

Parents with low self-efficacy beliefs about science could see how others succeed in addressing their children's science questions and supporting their science learning. Also, schools could invite professional guest speakers to offer parents more strategies, such as possible science activities parents can do at home with their children so that they could play a more active role.

This kind of supportive group could enable parents to share ideas, information, and/or concerns with each other, and stimulate them to think more by create cognitive conflicts in discussions. While parents in this study had individual beliefs about different aspects of their children's science learning, they had shared concerns as well. Parents often wanted to know other parents' thoughts while interviewing. In her reflection session, Pei's mother mentioned recently sharing thoughts and concerns about child rearing with her friends and learning from them. She viewed that as a beneficial experience. Bandura's theory of self-efficacy (1977) emphasizes the role of observational learning; the experience of Pei's mother supports the need for creating such groups.

Chak (2001) noted that self-awareness of one's own belief systems is perhaps the initial step toward the process of change (p. 387). Parents who may have never thought about supporting their children's science learning could learn from others through such programs and start to refine their own beliefs.

***Conducting teacher/action research.*** The findings of this study can also encourage early educators to conduct more teacher research/action research (Lytle & Cochran-Smith, 1992; Ritchie, 2011). As a former kindergarten intern teacher, I was challenged by what these parents told me in the interviews. The thoughts they shared with me greatly differed from what I expected before the data collection started.

Conducting teacher/action research is a possible way for early educators to know more about parents' perspectives on science learning and what they could do to assist students' parents in confidently and effectively supporting their children's science learning. Assessing parents' beliefs about science and science learning through teacher/action research may help early educators come up with strategies to empower parents to do science with their children, either in school contexts or out-of-school contexts such as science museums. For example, one possible question to explore might be how to engage parents in participating in school science. They could also investigate how to better inform parents about what is going on in school in relation to science.

**Implications for parents of young children.** According to the interview data and the findings of this study, I have several implications for parents of young children.

First and foremost, I would suggest parents be more open-minded to the possibility of children's science learning whether they like science or not. In this study, Jay's and Chun's families were the only two who had never been to science museums. Jay's mother, who disliked science and identified science museums as not suitable for young children to visit, expressed that she would take Jay to science museums again after seeing his excitement during their museum visit (Jay's mother, reflection session). Her reflection highlights the importance of not limiting children's opportunities for accessing science. Thus, I encourage parents to be sensitive to what children are curious about instead of being afraid to investigate science with children. Also, I would suggest parents not let the concern of misconceptions become a burden when engaging in science with children.

Secondly, one significant finding in chapter five is that these parents supported children's curiosity and intrinsic motivation by letting them choose exhibits and/or decide when to leave. However, I would argue it is important to encourage children to express why they are curious about the content they chose. Family members could then share each other's thoughts, feelings, and questions about exhibits. This strategy could be applied to any scientific phenomena and activities they encounter and conduct in their daily lives.

Additionally, Haden (2010) pointed out that open-ended questions which follow up on children's interests may be essential in motivating sustained engagement in science and developing scientific thinking (p. 64). Thus, I would encourage parents to actively ask their children questions to elicit their curiosity. By asking them wh- questions such as "Why does the rubber duck float in the water?" parents could also have their children engage in the scientific process, which might involve predicting, observing, evaluating, and so forth (Gelman et al., 2010). In line with the above suggestion, I would advise parents to encourage their children to use oral or written language to express their thoughts. As Malaguzzi (1998) noted,

> Vygotsky reminds us how thought and language are operative together to form ideas and to make a plan for action, and then for executing, controlling, describing, and discussing that action. This is a precious insight for education. (p. 83)

Before quickly offering answers to their children's questions, parents might invite their children to find answers through various ways. Additionally, rather than providing children with plenty of information, parents should stress children's meta-cognition (Hou, 2012) – that is, the use of language to monitor their own learning.

Lastly, parents in this study tended to believe that they should say "I don't know" to children's science questions if they did not know or were unsure about the answers. This might be positive in terms of avoiding misconceptions, as parents claimed. Yet, when parents respond, "I don't know" to their children, they might miss a key moment for scaffolding. The NSTA (2009) suggested, "Take advantage of not knowing all the answers to your children's questions, and embrace opportunities to learn science together." Following this idea, I would encourage parents to pretend they know nothing even though they have answers in mind, and view the "I don't know" as one kind of invitation—to invite their children to find answers with them. As Martin, Jean-Sigur, and Schmidt (2005) noted:

> Isn't it wonderful not to know all the answers? When we don't know certain answers, we aren't able to lead the children to "correct" answers because we don't know for sure what they are! Children have to *inquire* to find out what they can (italic in original). (p. 24)

Martin et al., (2005) and the NSTA statement (2009) both underscore the importance of taking a chance in not knowing to co-construct science learning with children. Thus, when children ask questions and parents do not know the answers (or pretend they have no idea about the questions), a good method for parents to try is to stimulate their children to think about the questions they ask and/or encourage them to collect evidence to support their thinking.

**Implications for future research.** In the following, I discuss implications for future research particularly from three aspects, including 1) choice of participants, 2) methods, and 3) techniques.

***The choice of participants.*** First, I would suggest that researchers who are interested in parental beliefs and science education recruit parents of children with special needs as the participants. In the second phase of recruiting participants, one of my contacts was trying to introduce me to a mother whose son had Down syndrome. Unfortunately, because this mother was too busy, I did not have the chance to invite her and her child to be participants. I have to admit that, before this study, I never thought about the issue of science learning/education for children with special needs. When I served as a kindergarten intern teacher in Taiwan, there was no child with special needs in my class; hence, I did not consider this a terribly important topic for early childhood educators to think about. Since the idea of inclusive classrooms is widely accepted in the U.S. and in global contexts (Taiwan included), better assisting children with special needs to learn science is definitely worthy of additional attention from early childhood educators and researchers.

Before writing this section, I tried to search for more data on what has been done regarding special education and science education/learning, because of my unfamiliarity with these two areas. I found the current studies largely focused on teachers' teaching and other classroom issues (e.g., Aydeniz, Cihak, Graham, & Retinger, 2012; Norman, Caseau, Stefanich, 1998; Southerland & Gess-Newsome, 1999; Zembylas & Isenbarger, 2002), Yet, this line of inquiry seldom devoted efforts to understanding the science learning of younger children with special needs from parents' perspectives. In fact, after I knew that I lost the mother I mentioned above, I kept thinking about how she, as a mother of a child with special needs, might believe her son should learn science.

Since the present study was unable to offer information about how parents of special needs children think about science learning, I would suggest researchers actively recruit parents of children with special needs as participants. By obtaining more empirical evidence, I believe the field of early childhood education and science education will better understand how to cooperate with parents of children with special needs and offer them more appropriate support.

I would also suggest future researchers recruit single parents as participants. At first, a single father attended in this study; unfortunately, I lost this case after his first interview because this father was too busy at work. His two sons were mainly taken care of by their grandparents. Although I did not have any assumptions that single parents would hold different science learning beliefs, it should be noted that single parents are usually identified by teachers as "difficult to reach" parents (Rockwell, Andre, & Hawley, 1996). Hence, understanding their beliefs might be urgent and necessary for future research.

Some science education researchers have started to pay attention to issues regarding science learning and students from single-parent families (e.g., Hong, Lin, & Lawrenz, 2008; Mulkey & Morton, 1991). Recruiting single parents as participants is important due to two main reasons. First, as many empirical studies on science education have pointed out, families not only provide early support, they also lay an important foundation for students' science learning, interest in science, and/or achievement in science. Knowing single parents' beliefs might help educators give them adequate support in assisting their children's science learning. Second, some parents in this study noted they would transfer responsibility of engaging in science to schoolteachers. Since single parents might need to devote more time to work, would they hold a similar belief? Or there are other agents (e.g., grandparents) who assume this responsibility? Hence, future researchers could try to recruit as many single parents as they can to provide more empirical evidence on this issue, so that educators could have some direction for helping single parents properly support their children's learning.

***Methods.*** Based on the literature review and the interviews with parents, I would suggest future researchers employ cross-cultural studies and longitudinal studies. Details are discussed in the following section.

*Cross-cultural studies.* In the discussion, I reviewed cultural themes that emerged in parents' beliefs. Generalizing the findings of this study to all Taiwanese parents might be problematic because, as many studies have pointed out (e.g., Cheng, 2000; Liou, 2001; Kao, 1993), parents within one culture could still have very different beliefs due to their various social positions (e.g., SES, educational levels, age). Still, these findings illuminate the possibility of conducting cross-cultural studies. When I analyzed the interview data, I continually wondered how parents in other countries, say, Japanese parents, might think about their children's science learning.

There are similarities between previous findings and my findings, despite differences in cultural context. For example, according to several studies, children's science learning tends to be a neglected area of communication between parents and teachers in other cultural contexts (e.g., Solomon, 2003). Yet, these studies did not specifically stress parents' beliefs regarding their children's science learning; thus, it is difficult to see the complexity of parents' beliefs in terms of cultural influences.

As several scholars have pointed out (e.g., Brunkhorst, 1991; Nersessian, 2005), science education is a cultural endeavor and cannot be separated from cultural context. While some researchers have provided cross-cultural perspectives regarding teachers' science teaching (e.g., Aikenhead, 2001; Cakiroglu, Cakiroglu, & Boone, 2005; Gao & Watkins, 2002), unfortunately, there is no study addressing how parents from different cultures think about their children's science learning.

Finally, a cross-cultural study is necessary because it will help educators address immigrant families' needs. With the cultural-deficient model now called into question, educators and researchers are attempting to view children as individuals with abundant cultural resources. Conducting cross-cultural studies on parents' science learning beliefs would help educators and researchers see the role cultures play in these beliefs (Bronfenbrenner, 1979). For example, researchers could interview or survey Vietnamese-immigrant parents' and Taiwanese parents' beliefs to compare similarities and differences between these two groups. Researchers could also compare Taiwanese parents' to American parents' beliefs to see how their beliefs about their children's science learning resemble and/or differ from each other. Such empirical evidence might provide local educators a better understanding of how to effectively cooperate with parents of other cultures.

*Longitudinal study*. In our last interview, Pei's mother was curious about whether she and other parents in this study would change their beliefs about science learning when their children are older. She encouraged me to do a follow-up study to see how these nine parents thought about their children's science learning—has anything changed?

If so, what produced the changes?

Pei’s mother was not alone in this interest. Jay’s and Yen’s mothers also thought their beliefs might change after their children entered elementary or junior high school, due to additional academic requirements and pressures. Their assumptions were very reasonable because, just as Bronfenbrenner’s theory indicates the continued interaction of systems, a change in one system (e.g., a new educational policy issued by the government) might influence parents’ beliefs about their children’s science learning.

Additionally, while a child receives the most direct influence from the Micro-system, his/her parents also receive reactions from the child (Bronfenbrenner, 1979). As Scarr (1996) pointed out, parents’ beliefs and children’s behaviors are bi-directional. Hence, a longitudinal study might help researchers to see whether and how children’s actions or reactions to their parents’ beliefs cause changes in these beliefs.

To sum up, the findings of this study merely “capture” these parents’ beliefs and actions at a specific moment. They might adhere to their beliefs in the future. It cannot be denied, however, that parents might make adjustments in their beliefs and actions in reaction to changes in other systems. Based on the above ideas, I would suggest future researchers conduct longitudinal studies to see how strongly parents adhere to their beliefs.

***The techniques.*** As pointed out by Hirsjärvi and Perälä-Littunen (2001), some beliefs are so implicit that they might operate at an unconscious level. While parents in this study were aware of and could easily express some aspects of their science learning beliefs, such as “I believe these (i.e., explorations) will become a foundation for their future science learning (Pei’s mother, interview#1),” parents sometimes had difficulties in putting their beliefs into because they were never offered a chance to speak about abstract things like this. Kai’s mother, for example, usually said “How should I say” prior to expressing her thoughts.

While several techniques were employed in this study, other techniques might be necessary for eliciting harder-to-reach parts of parents' science learning beliefs. In the reflection session, I noticed that watching a video seemed to provide a good starting place for some parents to talk about their beliefs. Thus, to help parents who have difficulties expressing their beliefs, future researchers could either watch videos of family interactions with parents, or give parents various scenarios regarding children's science learning to ask them what they might do if they were the parents in these situations. Future researchers could produce animations beforehand as material for interviewing parents. Doing so might more effectively stimulate parents to express their beliefs about their children's science learning. Moreover, this might also reduce the effect of interviewer effect (Merriam, 2009) because there will be less non-verbal cues.

# Appendices

## Appendix A Sample semi-structured interview questions for initial interview

Below are some guiding questions I asked parents in the initial interview. I neither followed this sequence nor limited myself only to these questions. The final questions I asked depended on parents' responses. I also asked parents if there were any final thoughts that they were not given a chance to share.

1. Could you share something about your school life?
2. Could you share your experiences of learning science?
3. How do you feel about your experiences of learning science?
4. Why do you think you have these feelings towards your science learning?
5. Have you been to any science museums? If yes, how do you feel about your science museums visits? If no, why didn't you have a chance to visit science museums?
6. Are your science learning experiences in schools different from those outside schools? How are they similar or different?
7. What is your most favorite part when you learned science (either in school or outside school)? Why?
8. Could you share one significant event in your science learning? Why do you choose this particular incident?
9. If you could change one thing in your science learning, what would it be? Why?
10. In your experience, what have you found to be effective ways to help you learn science? Why do you identify these ways are "effective"?
11. What difficulty did you encounter in learning science? Why do you think that is a difficulty to you? Did anyone help you solve this difficulty? If yes, how did they do?
12. Did you have any science-related activities with your parents or siblings at home? If yes, what are those? How are these activities helpful in terms of your school science learning?

## Appendix B Sample semi-structured interview questions for the second initial interview

Similar to the protocol in the initial interview, these questions only served as resources and other important questions emerged from the process of interviewing the parents as well. Before jumping into these questions, I first asked them to share their general thoughts on their involvement with their child, their goals and hopes. In addition to these questions, I also asked the parents if there was anything they would like to add that they thought was important but not included in these questions.

### Questions about children's science learning

1. Could you share with me something about your child?
2. Could you share with me you thoughts about science being taught in kindergarten?
3. How should science be taught and what should be learned in children's early years? Why do you believe in these ways?
4. Have your children's school conducted any science-related curriculum, projects and activities? If yes, what are those? How did you engage in these curriculum, projects, and activities?
5. How would you support or encourage your children to learn science? (If parents gave negative answers, I will then ask them why they would not support or encourage this learning.)
6. Last time we talked about one thing you wanted to change, your most favorite part, and one significant event in your own science learning, how do you think these happenings influence your perspectives on your children's science learning?
7. Based on your own science learning experience or your interaction with your children, do you believe a particular way is more effective than others in learning science? Why or why not?
8. What kind of activities do you usually do with your children at home? Do you have any activities for the whole family to do on weekends? Could you give me some examples and describe how do you usually do these activities with your children?
9. Do you see any science in these activities? Why and why not?

10. What makes you believe “this is science learning”? Why? How do you know that science learning occurs? Could you give me some examples?
11. Could you give “science learning” a definition?
12. What is the most important thing/aspect do you think in your children’s science learning?
13. How are your own science learning experiences similar to or different from your children’s science learning experience?

**Questions about families’ museum visits**

1. Could you talk about why do you choose to go to science museums?
2. How frequent do you visit science museums and/or other kinds of museums? What motivates or discourage you to visit museums?
3. What might be the importance of science museums? (I will focus on what science museums can offer in terms of children’s science learning.)
4. When you and your family visit science museums, do you have any expectation of your visit? How about your expectation of your children in your visits?
5. Based on your interactions with your children in your visit, how do s/he/they learn science in the science museum?
6. What usually excites or attracts you and your children in your science museum visits? Why do you think these things are exciting or attractive?
7. What are the roles might you play in your visits?

## Appendix C Nature of Science

RP: Relativism/Positivism

ID: Inductivism/Deductivism

CD: Contextualism/Decontextualism

PC: Process/Content

IR: Instrumentalism/Realism

| | | |
|---|---|---|
| 1. | Science is essentially a masculine construct. (CD) | |
| 2. | Science facts are what scientists agree that they are. (CD, RP) | |
| 3. | The object of scientific activity is to reveal reality. (IR) | |
| 4. | Scientists have no idea of the outcome of an experiment before they do it. (ID) | |
| 5. | Scientific research is economically and politically determined. (CD) | |
| 6. | Science education should be more about the learning of scientific processes than the learning of scientific facts. (PC) | |
| 7. | The processes of science are divorced from moral and ethical considerations. (CD) | |
| 8. | The most valuable part of a scientific education is what remains after the facts have been forgotten. (PC) | |
| 9. | Science proceeds by drawing generalizable conclusions (which later become theories) from available data. (ID) | |
| 10. | Human emotions plays no part in the creation of scientific knowledge. (CD) | |
| 11. | Scientific theories describe a real external world which is independent of human perception. (RP, IR) | |
| 12. | A good solid grounding in basic scientific facts and inherited scientific knowledge is essential before young children can go on to make discoveries of their own. (PC) | |
| 13. | Scientific theories have changed over time simply because experimental techniques have improved. (RP, CD) | |
| 14. | Scientific theories are as much a result of imagination and intuition as inference from experimental results. (ID) | |
| 15. | Scientific knowledge is different from other kinds of knowledge in that is has | |

| | | |
|---|---|---|
| | higher status. (RP) | |
| 16. | There are certain physical events in the universe which science can never explain. (RP, IR) | |
| 17. | Science is essentially characterized by the methods and processes it uses. (PC) | |

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