Development of a parent's guide for the Singapore primary science curriculum: Empowering parents as facilitators of their children's science learning outside the formal classrooms

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Abstract

Parents can play a vital and active role in facilitating their children's science learning outside the formal classrooms. Parental involvement in their children's science learning process not only could enhance their children's learning motivation and interest in science, it could also help to strengthen the family bond when parents and children learn together. This paper describes the development of a Primary Science Parent's Guide to complement and support the Singapore Primary Science Curriculum (from primary levels 3 to 6). The guide aims to empower the parents of Singapore primary school children as facilitators of their children's science learning to reinforce science concepts and develop their children's science process skills, creative thinking and curiosity outside the formal classrooms. In this paper, the author will provide a brief background to and the rationale for the development of the Parent's Guide. Theoretical perspectives underlying its development, implications and potential issues of parental involvement in their children's science learning process outside the formal science classrooms will also be discussed.

Keywords: Science learning, informal contexts, parental involvement, creativity, curiosity

Introduction

Parents can play a vital role in enhancing children's science learning experiences outside the school. Science education research has shown that children begin to develop science literacy even before they begin their formal education in schools

(e.g., Bredekamp & Copple, 1997; Chaille & Britain, 1991; Crowley, Callanan, Jipson, Galco, Topping & Shrager, 2001). It has been noted that learning is a cumulative process which involves making connections and reinforcement between the learning experiences a child encounters in school and at home (e.g., Dierking & Falk, 1994; Falk & Dierking, 1997). As such, science education cannot be based in school alone but must also include the full range of learning environments outside the formal classrooms in which parents play a fundamental role (e.g., Callanan & Jipson, 2001; Crowley & Callanan, 1998; Crowley & Galco, 2001; Gerber, Cavallo, & Marek, 2001; Schauble, Beane, Coates, Martin, & Sterling, 1996). In fact, research has reported that children's out-of-school activities and learning environments are linked to motivation and success in the formal classrooms (e.g., Gottfried, Fleming, & Gottfried, 1998). Therefore, successful informal science learning experiences not only allow children to acquire science knowledge and skills but also enable them to feel that science learning can be meaningful and rewarding.

Many informal learning settings outside the formal classrooms can provide good opportunities for children to engage in less structured and more authentic learning activities (e.g., Crowley & Galco, 2001; Dierking & Falk, 1994; Ostlund, Gennaro, & Dobbert, 1985; Schauble et al., 1996). Besides the more familiar home environment and neighbourhood places such as parks and gardens, playgrounds, and supermarkets, other examples of informal learning settings can include the more structured science museum, planetarium, zoo, and bird park. Sometimes, informal learning opportunities could even arise while walking on the roads, during a meal, or while watching a science documentary on television. Despite the fact that many informal learning environments are easily accessible and available for parents to support their children's learning outside the school, it is unfortunate that many parents are not aware that they could make use of the resources available in these informal settings to provide valuable learning opportunities, that many science teachers in the formal classroom could not easily offer, for their children to connect science learning with real life applications.

Therefore, the objectives of this paper are: (1) to discuss the theoretical perspectives of parental involvement in children's science learning in informal contexts; (2) to describe the development of a Primary Science Parent's Guide as an educational resource to empower parents as facilitators of their children's science learning in informal contexts; and (3) to provide examples of science learning

activities to demonstrate how parents can facilitate their children's science learning in informal contexts.

A Sociocultural Perspective of Parental Involvement in Children's Science Learning in Informal Contexts

Children are naturally curious about their surroundings and the things they encounter in their everyday lives (e.g., Rowe, 2004). Family members, especially parents, can play a vital role in providing science learning opportunities outside the school to help their children develop scientific thinking and interest in science (e.g., Hofstein & Rosenfeld, 1996; Ostlund et al., 1985). According to Vygotsky's sociocultural theory, it states that learning is strongly influenced by the social interactions which take place in meaningful contexts (Vygotsky, 1978). In this aspect, the family members and people in the child's immediate environment thus constitute an important social environment for the child's learning and development. It has been noted that learning in the family or with family members is probably one of the most crucial of all educational experiences for an individual (e.g., Ostlund et al., 1985). This is because parents and children share a common life, and the vast body of shared experience thus enables parents to facilitate their children's sense-making which is essential for their intellectual growth (e.g., Tizard & Hughes, 2002).

The sociocultural theory also states that a child can develop his or her intellect through internalising concepts based on his or her own interpretation of an activity or in communication with more knowledgeable or capable others (Roschelle; 1995; Vygotsky, 1978). Likewise, many out-of-school learning, such as informal science learning, is strongly socioculturally mediated (e.g., Falk & Dierking, 1997; Roschelle; 1995). Falk and Dierking (1997) also asserted that learning is the process of applying prior knowledge and experience to new experiences, and this effort is normally played out within a physical context and is mediated in the actions of other individuals. Thus, meaning making is not an isolated mental activity but as a joint product of the person and the mediational means operating in a particular setting (e.g., Roschelle; 1995; Wertsch, 1991). In this aspect, parents can play a fundamental role in facilitating their children's inquiry, knowledge and skills acquisition as well as arousing their curiosity and interest in science at home and other informal settings.

For optimal and meaningful learning to take place, the sociocultural theory also states that the 'zone of proximal development' needs to be taken into consideration in the child's learning process. The 'zone of proximal development' in the Vygotskian theory is essentially the difference between what the child can do on his or her own and what he or she can do with the help from a more able adult or peer (Vygotsky, 1978). When children have the appropriate guidance of more able and knowledgeable adults in informal learning contexts to provide intellectual stimulation and guide them in conducting intellectual searches, it will encourage them to go further in their learning explorations about the world they live in (e.g., Callanan & Jipson, 2001; Gleason & Schauble, 2000). Parents, as the more knowledgeable others, can provide scaffolding instruction to facilitate the child's process of knowledge construction (Jaramillo, 1996; Vygotsky, 1978). Scaffolding instruction, as defined by Vygotsky (1978), is the role of knowledgeable others in supporting the learner's development and providing support structures to help the learner achieve the next stage or level of learning. In Vygotskian's learning, scaffolding is temporary (Jaramillo, 1996; Vygotsky, 1978). As the child's abilities increase, the scaffolding provided can be reduced or withdrawn so as to help the child become an independent, self-regulating learner and problem solver (Jaramillo, 1996).

As effective science learning is essentially a process of inquiry and discovery, it is important that parents create a conducive learning environment, as a scaffold which supports openness, questioning, reflecting, and experimenting, to help their children explore how things work in their everyday lives. For instance, parents can create opportunities for their children to engage in investigative, hands-on science activities at home or provide outdoor experiential opportunities for them to make connections between classroom content and real world experiences. In addition, with the advancement of information technology (IT) and the availability of internet and online resources, parents can leverage on IT to facilitate their children's science learning process so that children not only can develop information-gathering skills but can also gain broader perspectives and deeper understanding into the scientific issues and topics explored. Some studies have found that everyday parent-child conversations can contribute to supporting children's scientific understanding as meaningful parent-child interactions are a possible mechanism for cognitive change (e.g., Gauvain, 2001; Szechter & Carey, 2009). Hence, parents can also initiate discussions on science and technology in

daily events whenever the opportunities arise to engage their children in scientific thinking.

When playing the role of a facilitator of learning to their children, it is also important that parents adopt the mindset that effective science learning is not just providing their children with direct instructions or spoon-feeding of content knowledge, but more essentially, they should help their children acquire scientific inquiry skills and gain confidence in self-directed problem-solving so that their children can become independent learners in the long term (e.g., Jonessen, 1998). By seizing 'teachable moments' at home or in other informal settings to 'talk' and 'do' science together with their children, parents can make valuable contributions to their children's science learning, especially in enhancing their children's scientific inquiry experiences. More importantly, family bond could also be strengthened when both parents and children spend quality time together.

Parental Involvement in Children's Science Learning: Some Issues and Considerations

Unlike the science teachers in schools who are usually well-trained in the teaching of science, parents are generally not equipped with the pedagogical knowledge and skills to understand how to develop science literacy in children and design effective learning processes to facilitate children's science inquiry in the informal settings. It is therefore unrealistic to expect parents to play a teaching professional role like the school science teacher when guiding their children at home. However, parents can be guided to play a complementary role to support their children's science education by being active collaborators in their children's science learning journey if three issues can be adequately addressed: *parental awareness, acquisition of basic science knowledge and facilitation skills*, and *availability of relevant resources*.

First, *parental awareness* is important. Many parents do not realise they can make a difference in their children's science education. If they are aware that there are ways which they can partner their children in science activities outside the school, they will feel more enthusiastic to engage actively in their children's science learning process. They may not need to be a content expert in science in order to guide their children in learning about science. Instead, they could provide a conducive environment outside the school to engage their children in meaningful

science learning. As science learning is a process of inquiry and discovery, parents can learn to play the role of a facilitator of learning instead of a presenter of knowledge in their children's learning process. It is important for parents to be aware that instead of 'spoon-feeding' or giving answers to their children all the time, they could provide science learning activities to allow their children to actively engage in making observations, asking questions, problem-solving, interpreting data, and communicating their findings to others. In fact, an important aim of inquiry-based science learning is that children will gradually take charge of their own learning to initiate their own inquiries and investigations as they become more independent and self-directed in their learning process.

Second, *acquisition of basic science knowledge and facilitation skills* is necessary. Parents need to acquire some basic science knowledge and facilitation skills in order to effectively facilitate their children's science learning at home and in other informal settings. Parents are strongly encouraged to self-read, or form partnerships with school teachers, science education professionals and other enthusiastic parents to learn the knowledge, skills and strategies necessary for facilitating their children's science learning effectively. In this way, parents will feel more competent and confident to provide a conducive environment or meaningful learning experiences for their children. In this aspect, schools could consider organising workshops for enthusiastic parents to give them a better understanding on the new trends in science teaching and learning as well as to support them by enhancing their knowledge in elementary science content, basic pedagogical and facilitation skills. Learning networks and regular sharing sessions can also be formed and organised for enthusiastic parents to come together to share their own experiences and support each other in guiding their children's science learning outside the school.

Third, *relevant resources* need to be available. Very often, parents have the impression that science activities can only be conducted in the science laboratory with sophisticated equipment or specially ordered materials and reagents. It is therefore important that parents are aware that simple objects and materials which they can easily access at home or supermarkets could be used for conducting simple science activities at home. As such, guidebooks and other relevant educational resources can be made readily available for parents to provide them with ideas about what kinds of science activities can be conducted at home such that they could directly use or adapt these ideas to engage their children in science

learning at home or in other informal settings. It is essential that the science ideas or activities provided in the guidebooks are simple yet interesting enough for parents and children to engage in science knowledge acquisition and make connections to real world applications. In this way, parents will feel more confident and be more willing to invest their time to do and learn science together with their children.

The Singapore Context: Parents as a Potential Source of Science Learning Support in Informal Contexts

In Singapore, it has been observed that there is an increase of more educated parents as compared to about twenty years ago. As stated by the Minister of Education at the 5th Teachers' Conference 2010,

*"Twenty years ago, only about 9% of parents of a Primary 1 student would have degree, diploma or pre-university qualifications. Today, that figure has gone up to 54%." (*Ng, 2010*)*

Hence, the potential benefits of engaging educated and enthusiastic Singapore parents in supporting their children's science learning outside schools should not be overlooked. Essentially, parents can be a potential source of support in enhancing their children's science literacy and learning interest.

However, it has been observed that although many parents are generally enthusiastic in their children's science education, they often feel inadequate to guide their children in the learning of science. In fact, it is not uncommon to receive feedback from parents that "Science is more difficult to teach" as compared to English Language and Mathematics when they are guiding their children at home with their school assignments or projects. It is crucial that parents need to feel meaningful, competent and confident enough in order for them to participate actively and effectively in their children's science learning process. They need to be made aware that science learning is not "rocket science", but is something that they could do and be directly involved if they themselves are being appropriately guided and adequately supported.

The following section describes the development of a Primary Science Parent's Guide for parents in Singapore to guide their children in learning science outside

the formal classrooms.

Development of a Primary Science Parent's Guide to Empower Parents as Learning Facilitators in Informal Settings

Background

In the Singapore primary education context, science is taught as a subject in the mainstream primary schools, spanning over four years, from primary level 3 to 6. The current Singapore Primary Science Curriculum has an emphasis on 'science as an inquiry' which aims to develop the spirit of scientific inquiry among primary school children so that they will acquire science knowledge, process skills as well as science attitudes and values (Curriculum Planning & Development Division Ministry of Education Singapore, 2007). It is also the goal of the Primary Science Curriculum that students will enjoy science and value science as an important tool to help them explore their natural and physical world. In line with the broader vision of the Singapore education – *Thinking Schools*, *Learning Nation*, it also aims to prepare students to be effective citizens who are able to function in and contribute to an increasingly technologically-driven, globalised world (Curriculum Planning & Development Division Ministry of Education Singapore, 2007). In recognition that parents can play an important role in their children's science education, especially as facilitators of their children's science learning outside the formal classrooms, a Primary Science Parent's Guide which is in alignment with the Singapore Primary Science Curriculum is specially developed to guide parents to facilitate their children's science learning at home and in other informal settings (Lee, 2008, 2009).

A Sociocultural and Constructivist Framework

The Primary Science Parent's Guide adopts a sociocultural and constructivist framework in design (e.g., Falk & Dierking, 1997; Vygotsky, 1978) with the core belief that deep and meaningful learning is more likely to take place in children when they are guided by significant others and given opportunities to interact with their physical and social environments to construct their own meanings and make connections to the real world in their learning process (e.g., Glasersfeld, 1992; Falk & Dierking, 1997; Jaramillo, 1996; Martin, 2004; Palincsar, 1998; Roschelle, 1995;

Vygotsky, 1978). The sociocultural perspective of learning contends that meaningful learning occurs in the social context of the learner (Vygotsky, 1978) while the constructivist perspective of learning takes the notion that the learner does not passively absorb knowledge but rather constructs it from experiences (e.g., Chaille & Britain, 1991; Cobb, 1994) which is also a basis for 'science as an inquiry' in children's science learning. As noted by Cobb (1994), theories from the sociocultural perspective informs the conditions for the possibility of learning with the help of more knowledgeable others, whereas the constructivist perspective of learning focuses on what the individual learns and the cognitive processes by which he or she does so. Essentially, as an educational resource for parents, the activities in the Primary Science Parent's Guide are purposely designed to enable parents to provide learning opportunities in the everyday life contexts for their children to engage in meaningful learning and new knowledge construction when children make connections between science knowledge acquisition and real world applications. Therefore, a blend of both sociocultural and constructivist approaches in the development of the Primary Science Parent's Guide takes into account the interdependence of social as well as the individual processes in the construction of knowledge in children's science learning (e.g., Cobb, 1994; Hall, 2007; John-Steiner & Mahn, 1996).

Content and Format

With the aim of developing the Primary Science Parent's Guide as an educational resource to complement the Singapore Primary Science Curriculum for parents to guide their children's science learning outside the school, the development of the Parent's Guide thus takes into considerations the content requirements of the current Singapore Primary Science Syllabus (Primary levels 3 to 6) and the format structure of the current Primary Science textbooks (Lower Primary 3 & 4 and Upper Primary 5 & 6) in its design process. The Primary Science Parent's Guide consists of two booklets (Lower Primary 3 & 4 and Upper Primary 5 & 6) and its content structure and format are in alignment with the current Primary Science Syllabus and textbooks so as to allow easy reference and use by parents. The science tasks and scenarios provided in the Parent's Guide also cater to the five main themes in the Primary Science Syllabus and textbooks: *Diversity*, *Cycles*, *Systems*, *Interactions,* and *Energy*. These five themes are sub-divided into 23 chapters in the two booklets of the Parent's Guide (Lower Primary 3 & 4 and Upper Primary 5 & 6). Core science skills and processes as well

as science attitudes and values which are emphasised in the Primary Science Syllabus are also incorporated accordingly into the various science tasks in each chapter. (*Please refer to Appendix for a brief outline of the themes, chapters and activities in the Primary Science Parent's Guide.*)

In order to help parents to have a better understanding of how they could effectively facilitate their children's science learning, each chapter of the Parent's Guide is comprised of concise notes which serve as useful background information for parents, as well as simple hands-on activities, guiding questions and suggested answers. The provision of inquiry-based questioning prompts and suggested responses in the Parent's Guide aims to enable enthusiastic parents to feel more confident and become more competent to create meaningful learning opportunities and experiences for their children outside the formal classrooms. As the main purpose of the Primary Science Parent's Guide is to enable parents to directly use the activities or adapt the activities for use in facilitating their children's science learning process outside the school, most of the hands-on science activities are based on simple ideas and scenarios from the everyday lives by which the materials and equipment needed for conducting the activities are easily accessible by the parents and children. This means that the science activities in the Parent's Guide do not require sophisticated or complex laboratory equipment, but just simple objects and apparatuses which parents and children can easily obtain from home, supermarkets, gardens and other informal settings. Furthermore, suggested educational websites and internet resources are also included in the Parent's Guide to provide parents with more available resources to use when facilitating their children's science learning at home with the aid of information technology.

Selected Activities from the Primary Science Parent's Guide

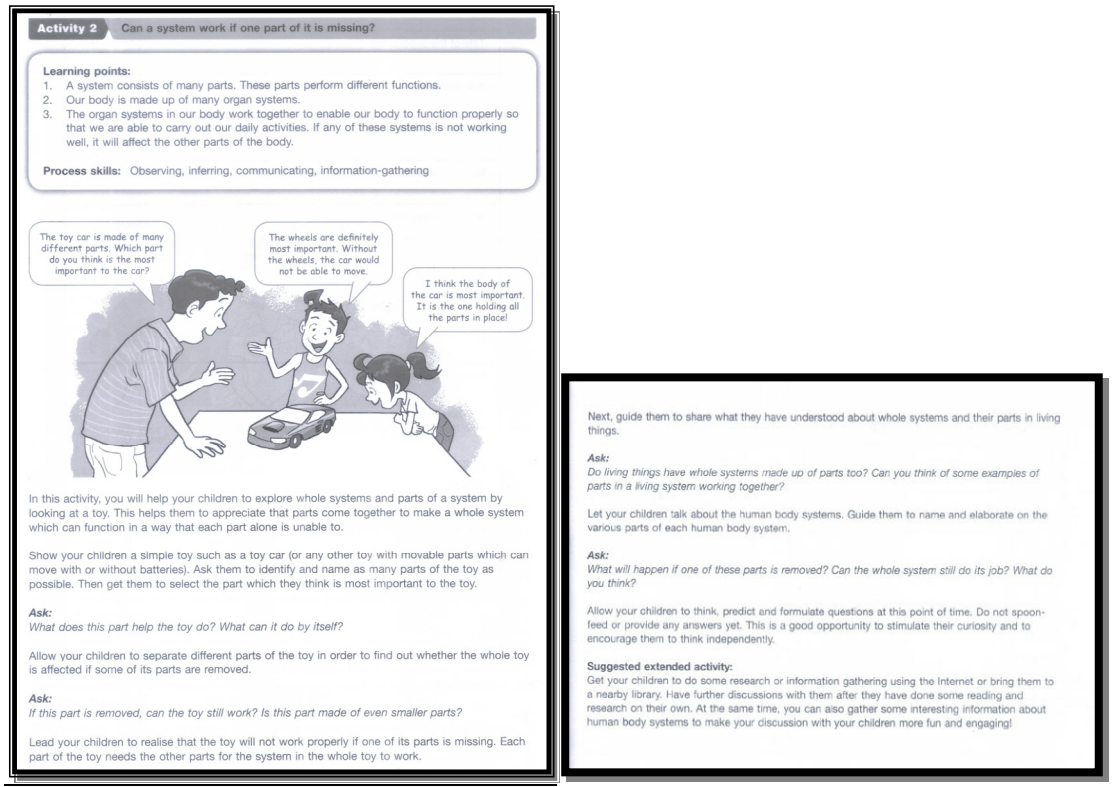
So, what kinds of tasks and activities could parents conduct at home and in other informal contexts to engage their children to learn science more effectively and meaningfully? Eight activities (specially designed with different learning rationale and objectives) are selected from the Parent's Guide (Primary 3 & 4 and Primary 5 & 6) and presented below to serve as examples to demonstrate how parents can make use of the inquiry-based leading questions and possible answers or responses to play the role of effective facilitators of science inquiry to their children at home and in other informal contexts.

Stimulate Children's Curiosity and Interest in Science

Science is in our everyday lives, and the basis for inquiry-based science learning is in fact learning-by-doing. Therefore, it is important that parents learn how to stimulate their children's curiosity and interest in science by seizing opportunities to 'talk' and 'do' science with children. Many of the children's familiar objects such as their toys, stationery, foods, or even electrical appliances or utensils in the kitchen can be used to design simple science tasks for children to explore how things work in their immediate environments. If parents are able to inject some fun and excitement such as by incorporating a magic trick or a simple game or even a demonstration using children's toys into the science activities, it will arouse the curiosity and interest of children towards the learning of science concepts even more (e.g., Gottfried, Fleming & Gottfried, 1998).

Example 1: Use of familiar objects of children (e.g., toys) to stimulate children's curiosity and interest in science

Figure 1. Taken from I-Science Parent's Guide Primary 5 & 6. Theme: Systems, Chapter 1: Systems in Living things, Activity 2: Can a system work if one part of it is missing? (Page 32-33) [Source: Lee, A. N. (2009)]



Activity 2 Can a system work if one part of it is missing?

Learning points:
1. A system consists of many parts. These parts perform different functions.
2. Our body is made up of many organ systems.
3. The organ systems in our body work together to enable our body to function properly so that we are able to carry out our daily activities. If any of these systems is not working well, it will affect the other parts of the body.

Process skills: Observing, inferring, communicating, information-gathering

In this activity, you will help your children to explore whole systems and parts of a system by looking at a toy. This helps them to appreciate that parts come together to make a whole system which can function in a way that each part alone is unable to.

Show your children a simple toy such as a toy car (or any other toy with movable parts which can move with or without batteries). Ask them to identify and name as many parts of the toy as possible. Then get them to select the part which they think is most important to the toy.

Ask:
What does this part help the toy do? What can it do by itself?

Allow your children to separate different parts of the toy in order to find out whether the whole toy is affected if some of its parts are removed.

Ask:
If this part is removed, can the toy still work? Is this part made of even smaller parts?

Lead your children to realise that the toy will not work properly if one of its parts is missing. Each part of the toy needs the other parts for the system in the whole toy to work.

Next, guide them to share what they have understood about whole systems and their parts in living things.

Ask:
Do living things have whole systems made up of parts too? Can you think of some examples of parts in a living system working together?

Let your children talk about the human body systems. Guide them to name and elaborate on the various parts of each human body system.

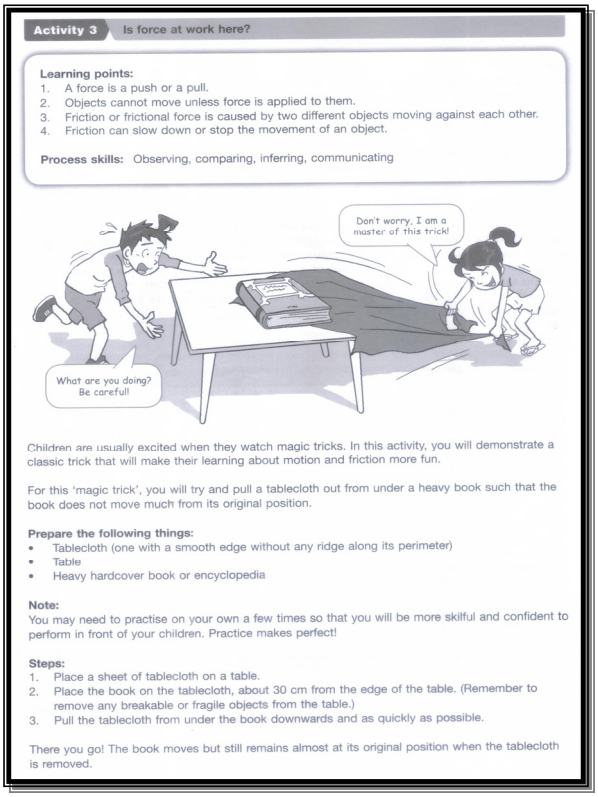
Ask:
What will happen if one of these parts is removed? Can the whole system still do its job? What do you think?

Allow your children to think, predict and formulate questions at this point of time. Do not spoon-feed or provide any answers yet. This is a good opportunity to stimulate their curiosity and to encourage them to think independently.

Suggested extended activity:
Get your children to do some research or information gathering using the Internet or bring them to a nearby library. Have further discussions with them after they have done some reading and research on their own. At the same time, you can also gather some interesting information about human body systems to make your discussion with your children more fun and engaging!

Example 2: Help children learn science through games and tricks

Figure 2. Taken from I-Science Parent's Guide Primary 5 & 6. Theme: Interactions, Chapter 1: Forces, Activity 3: Is force at work here? (Page 57-58) [Source: Lee, A. N. (2009)]



Activity 3 Is force at work here?

Learning points:
1. A force is a push or a pull.
2. Objects cannot move unless force is applied to them.
3. Friction or frictional force is caused by two different objects moving against each other.
4. Friction can slow down or stop the movement of an object.

Process skills: Observing, comparing, inferring, communicating

Children are usually excited when they watch magic tricks. In this activity, you will demonstrate a classic trick that will make their learning about motion and friction more fun.

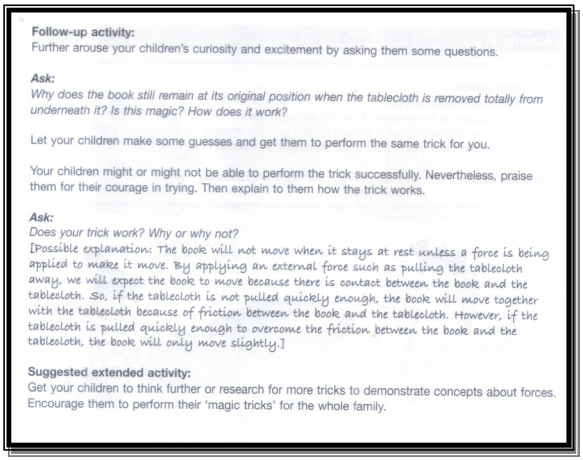
For this 'magic trick', you will try and pull a tablecloth out from under a heavy book such that the book does not move much from its original position.

Prepare the following things:
- Tablecloth (one with a smooth edge without any ridge along its perimeter)
- Table
- Heavy hardcover book or encyclopedia

Note:
You may need to practise on your own a few times so that you will be more skilful and confident to perform in front of your children. Practice makes perfect!

Steps:
1. Place a sheet of tablecloth on a table.
2. Place the book on the tablecloth, about 30 cm from the edge of the table. (Remember to remove any breakable or fragile objects from the table.)
3. Pull the tablecloth from under the book downwards and as quickly as possible.

There you go! The book moves but still remains almost at its original position when the tablecloth is removed.



Follow-up activity:
Further arouse your children's curiosity and excitement by asking them some questions.

Ask:
Why does the book still remain at its original position when the tablecloth is removed totally from underneath it? Is this magic? How does it work?

Let your children make some guesses and get them to perform the same trick for you.

Your children might or might not be able to perform the trick successfully. Nevertheless, praise them for their courage in trying. Then explain to them how the trick works.

Ask:
Does your trick work? Why or why not?
[Possible explanation: The book will not move when it stays at rest unless a force is being applied to make it move. By applying an external force such as pulling the tablecloth away, we will expect the book to move because there is contact between the book and the tablecloth. So, if the tablecloth is not pulled quickly enough, the book will move together with the tablecloth because of friction between the book and the tablecloth. However, if the tablecloth is pulled quickly enough to overcome the friction between the book and the tablecloth, the book will only move slightly.]

Suggested extended activity:
Get your children to think further or research for more tricks to demonstrate concepts about forces. Encourage them to perform their 'magic tricks' for the whole family.

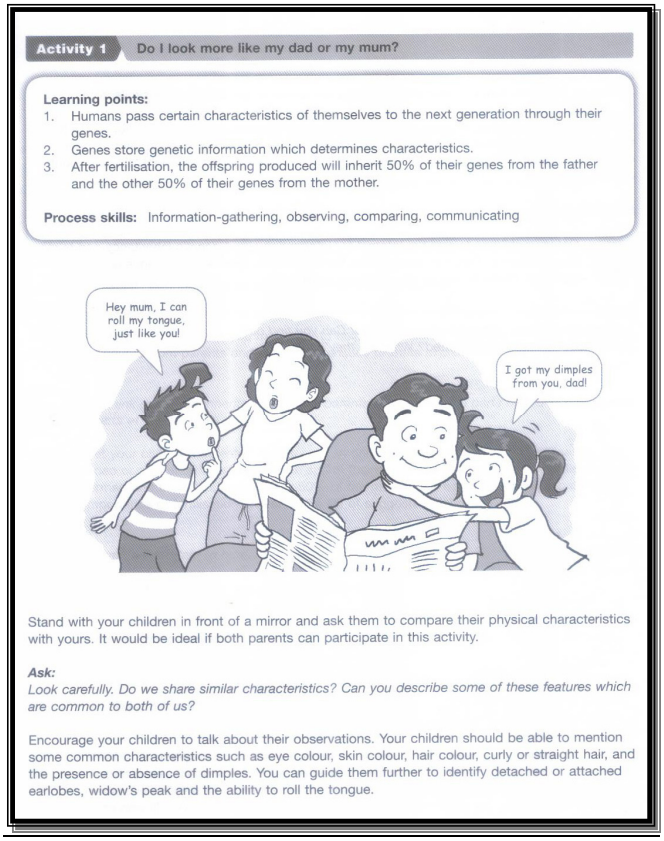
Infuse Science Thinking and Interest Through Meaningful Parent-child Conversations

Research has found that parent-child conversations when characterised by depth, richness, and variety, can allow learning to occur in contexts of great meaning to the child (e.g., Hall & Schaverien, 2001; Tizard & Hughes, 2002). As conversations are often triggered by the everyday events of life, parents can seize opportunities in daily life to talk about scientific and technological ideas with their children to nurture their child's interest in science and technology (Hall & Schaverien, 2001). In fact, opportunities for cognitive change often emerge spontaneously and frequently in parent-child interactions in informal settings, such as when parents and children engage in meaningful explanatory conversations during dinner table conversations, cooking projects, and other activities outside the school (e.g., Callanan & Jipson, 2001; Callanan & Oakes, 1992; Gleason & Schauble, 2000;

Shrager & Callanan, 1991; Snow & Kurland, 1996). As such, an advantage of the parents' role in their children's science learning in informal contexts is that they could facilitate the extension of science discourse beyond the formal classroom settings. If parents could initiate such learning opportunities for their children in parent-child daily conversations (e.g., Martin, 2004), they can help their children develop scientific concepts and make meaningful learning connections beyond their formal classrooms.

Example 3: Engage in meaningful parent-child conversations

Figure 3. Taken from I-Science Parent's Guide Primary 5 & 6. Theme: Cycles, Chapter 3: Sexual Reproduction in Humans, Activity 1: Do I look more like my dad or my mum? (Page 23) [Source: Lee, A. N. (2009)]



Activity 1 Do I look more like my dad or my mum?

Learning points:
1. Humans pass certain characteristics of themselves to the next generation through their genes.
2. Genes store genetic information which determines characteristics.
3. After fertilisation, the offspring produced will inherit 50% of their genes from the father and the other 50% of their genes from the mother.

Process skills: Information-gathering, observing, comparing, communicating

Stand with your children in front of a mirror and ask them to compare their physical characteristics with yours. It would be ideal if both parents can participate in this activity.

Ask:
Look carefully. Do we share similar characteristics? Can you describe some of these features which are common to both of us?

Encourage your children to talk about their observations. Your children should be able to mention some common characteristics such as eye colour, skin colour, hair colour, curly or straight hair, and the presence or absence of dimples. You can guide them further to identify detached or attached earlobes, widow's peak and the ability to roll the tongue.

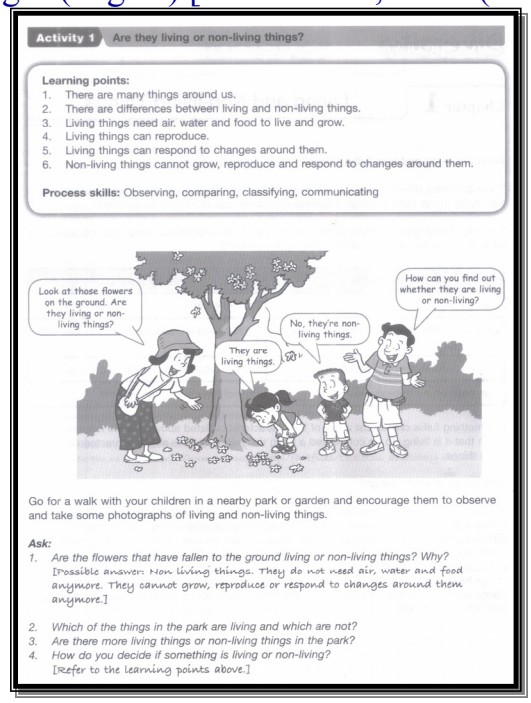
Provide Outdoor Experiential Experiences or Visits to Educational Learning Places

Experiential learning experiences cannot be directly provided by classroom textbooks and are seldom aptly provided by science lessons in the formal

classrooms. However, these concrete experiences are important for enhancing children's scientific thinking, curiosity and interest in science. To make learning more meaningful for children, parents could provide opportunities to allow their children to make connections between outdoor experiential learning experiences and classroom content (e.g., Bamberger & Tal, 2007; Hofstein & Rosenfeld, 1996; Rennie, Feher, Dierking, & Falk, 2003). Also, it has been reported that when parents act as learning partners or collaborators to their children by participating actively in informal learning activities together with them, the meaningful parent-child interactions could help to nurture responsible behaviours in children towards the society (e.g., Ostlund et al., 1985; Whiting & Whiting, 1975). Thus, if parents can seize teachable moments during outdoor learning opportunities to cultivate positive science attitudes and values (e.g., curiosity, perseverance, and care for the environment), they not only can make a difference in their children's science learning but also in their children's character development.

Example 4: Take a walk at the nearby parks or gardens

Figure 4. Taken from I-Science Parent's Guide Primary 3 & 4. Theme: Diversity, Chapter 1: Living and Non-living Things, Activity 1: Are they living or non-living things? (Page 2) [Source: Lee, A. N. (2008)]



Activity 1 Are they living or non-living things?

Learning points:
1. There are many things around us.
2. There are differences between living and non-living things.
3. Living things need air, water and food to live and grow.
4. Living things can reproduce.
5. Living things can respond to changes around them.
6. Non-living things cannot grow, reproduce and respond to changes around them.

Process skills: Observing, comparing, classifying, communicating

Go for a walk with your children in a nearby park or garden and encourage them to observe and take some photographs of living and non-living things.

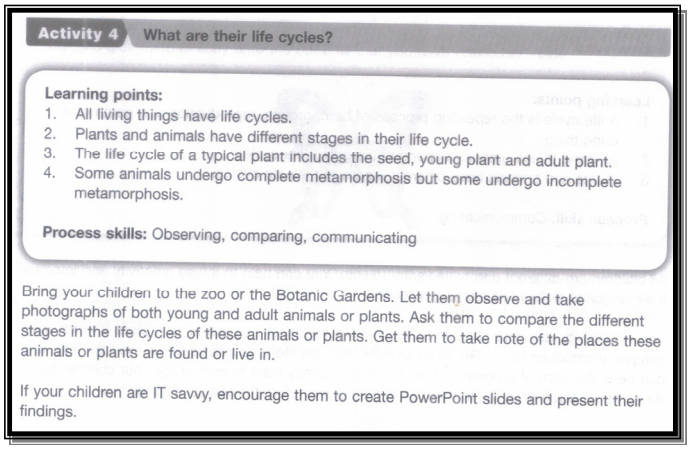
Ask:
1. *Are the flowers that have fallen to the ground living or non-living things? Why?*
   [Possible answer: Non living things. They do not need air, water and food anymore. They cannot grow, reproduce or respond to changes around them anymore.]
2. *Which of the things in the park are living and which are not?*
3. *Are there more living things or non-living things in the park?*
4. *How do you decide if something is living or non-living?*
   [Refer to the learning points above.]

It has been noted that one of the primary reasons for families to visit educational learning places is for recreational experiences where parents and children can

experience and learn together (e.g., Ostlund et al., 1985). Research has also found that learning experiences offered by educational learning places can constitute a dynamic, personally meaningful engagement with structured 'discovery learning' for children (e.g., Bruner, 1961; Callanan & Jipson, 2001; Rennie et al., 2003). Generally, children enjoy broader and deeper experiences when they visit educational learning places with parents (e.g., Dierking & Falk, 1994; Schauble & Bartlett, 1997; Crowley & Callanan, 1998). As such, besides the home, parents can bring their children to outdoor parks and gardens, farms or other educational learning places (e.g., zoos, farms, wetlands or botanic gardens) to enhance their children's exposures to different types of animals and plants in various habitats which they seldom encounter in their immediate surroundings.

Example 5: Excursions to educational learning places (e.g., zoo, science museum, botanic gardens)

Figure 5. Taken from I-Science Parent's Guide Primary 3 & 4. Theme: Cycles, Chapter 1: The Cycle of Life, Activity 4: What are their life cycles? (Page 40) [Source: Lee, A. N. (2008)]



Activity 4 What are their life cycles?

Learning points:
1. All living things have life cycles.
2. Plants and animals have different stages in their life cycle.
3. The life cycle of a typical plant includes the seed, young plant and adult plant.
4. Some animals undergo complete metamorphosis but some undergo incomplete metamorphosis.

Process skills: Observing, comparing, communicating

Bring your children to the zoo or the Botanic Gardens. Let them observe and take photographs of both young and adult animals or plants. Ask them to compare the different stages in the life cycles of these animals or plants. Get them to take note of the places these animals or plants are found or live in.

If your children are IT savvy, encourage them to create PowerPoint slides and present their findings.

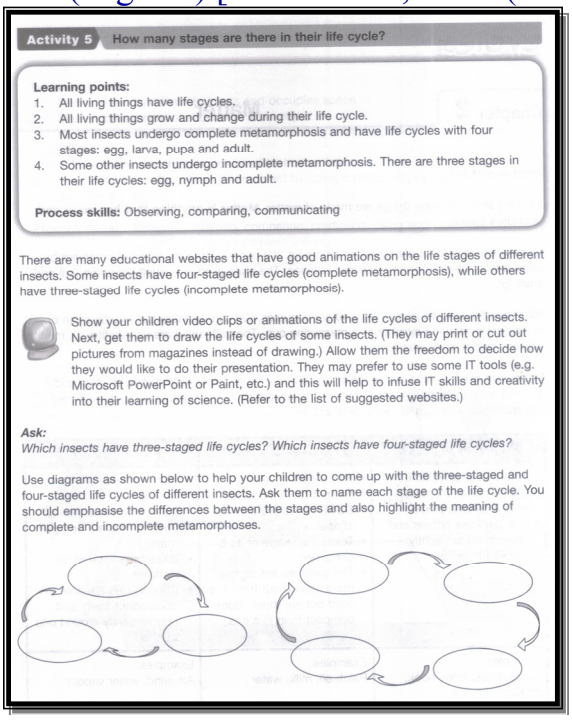
Leverage on Information Technology (IT) and Internet Resources for Science Learning

As more and more families nowadays own personal computers and other IT gadgets as an everyday lifestyle, parents could easily leverage on the internet or online educational resources to guide their children's learning at home (e.g., Plowman, McPake & Stephen, 2008). For instance, parents can make use of relevant video clips, animated demonstrations and other interactive visual aids to enhance children's understanding of more complex science concepts and

experiments. As noted by some researchers, technology frequently offers kinds of pedagogic structures and support (e.g., Scrimshaw, 1993; Sefton-Green, 2003) which parents can leverage on to provide meaningful science learning for their children. Thus, the use of IT tools and online educational resources can serve as 'scaffolds' (Vygotsky, 1978) to support children's understanding of abstract science concepts and also provide interactive learning experiences to enhance children's learning motivation (e.g., de Jong & van Joolingen, 1998). Studies have also found that when parents pursue inquiries together with their children by providing them with learning resources, conversing with them, and investigating collaboratively with them with the aid of informational technology, children's learning deepens (Hall & Schaverien, 2001).

Example 6: Leverage on IT and internet resources to enhance science learning

Figure 6. Taken from I-Science Parent's Guide Primary 3 & 4. Theme: Cycles, Chapter 1: The Cycle of Life, Activity 5: How many stages are there in their life cycles? (Page 41) [Source: Lee, A. N. (2008)]



Activity 5 How many stages are there in their life cycle?

Learning points:
1. All living things have life cycles.
2. All living things grow and change during their life cycle.
3. Most insects undergo complete metamorphosis and have life cycles with four stages: egg, larva, pupa and adult.
4. Some other insects undergo incomplete metamorphosis. There are three stages in their life cycles: egg, nymph and adult.

Process skills: Observing, comparing, communicating

There are many educational websites that have good animations on the life stages of different insects. Some insects have four-staged life cycles (complete metamorphosis), while others have three-staged life cycles (incomplete metamorphosis).

Show your children video clips or animations of the life cycles of different insects. Next, get them to draw the life cycles of some insects. (They may print or cut out pictures from magazines instead of drawing.) Allow them the freedom to decide how they would like to do their presentation. They may prefer to use some IT tools (e.g. Microsoft PowerPoint or Paint, etc.) and this will help to infuse IT skills and creativity into their learning of science. (Refer to the list of suggested websites.)

Ask:
Which insects have three-staged life cycles? Which insects have four-staged life cycles?

Use diagrams as shown below to help your children to come up with the three-staged and four-staged life cycles of different insects. Ask them to name each stage of the life cycle. You should emphasise the differences between the stages and also highlight the meaning of complete and incomplete metamorphoses.

Promote Interdisciplinary Learning and Creativity in Children

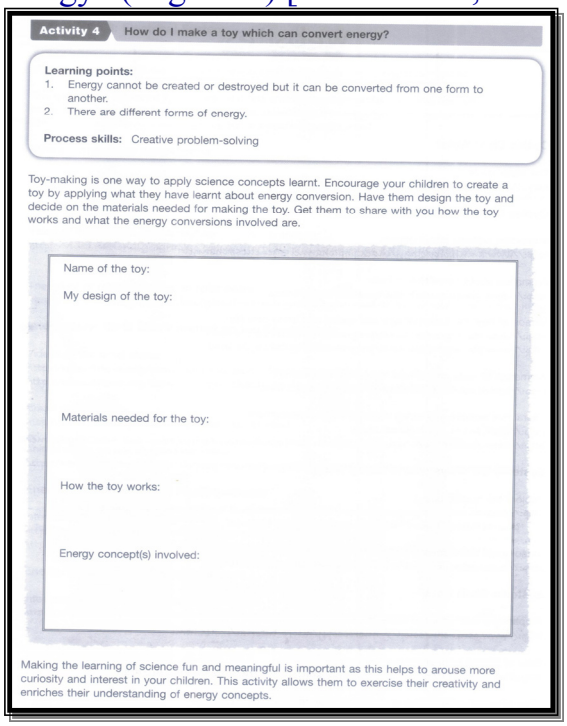
Informal learning environments are inherently multidisciplinary, and thus support authentic learning to take place. Unlike teaching and learning in the formal classroom by which subject matter or disciplines are usually compartmentalised

into fragmented teaching units which often diminishes holistic understanding of the issues explored (e.g., Foss & Pinchback, 1998), learning in informal contexts does not need to be restricted to only certain topics or specific subject discipline. As such, informal contexts can provide parents with the additional advantage and opportunities, which teachers in schools seldom have, to encourage children to go beyond specific topics and subject areas to think in a more interdisciplinary manner when solving real life problems. As noted by White (1985), real world problems seldom fit neatly into the confines of a single discipline. The integration of topics and subject matter content thus provides greater relevancy and authenticity in learning and understanding for the learner (e.g., Foss & Pinchback, 1998; White, 1985).

Therefore, some of the activities in the Parent's Guide have been purposely designed to provide opportunities for children to engage in interdisciplinary learning to encourage them to integrate knowledge and skills learnt from other science topics or subject areas (e.g. language arts, role-play, IT) into their problem-solving process. For example, parents can promote creative thinking and problem-solving skills in their children by providing opportunities for children to apply or integrate multiple science concepts in creating scientific toys or simple devices. Parents could also provide learning tasks for children to integrate science learning with language arts (e.g., creating a poem or writing a story) or with music and role-play. The incorporation of interdisciplinary learning into children's informal science learning process can thus provide children with the opportunities to apply their higher-order thinking skills and creativity as a form of integrated processes during their scientific investigations.

Example 7: Promote higher-order thinking and creativity through scientific toy-making

Figure 7. Taken from I-Science Parent's Guide Primary 5 & 6. Theme: Energy, Chapter 2: Energy Forms and Uses, Activity 4: How do I make a toy which can convert energy? (Page 101) [Source: Lee, A. N. (2009)]



Activity 4 How do I make a toy which can convert energy?

Learning points:
1. Energy cannot be created or destroyed but it can be converted from one form to another.
2. There are different forms of energy.

Process skills: Creative problem-solving

Toy-making is one way to apply science concepts learnt. Encourage your children to create a toy by applying what they have learnt about energy conversion. Have them design the toy and decide on the materials needed for making the toy. Get them to share with you how the toy works and what the energy conversions involved are.

Name of the toy:

My design of the toy:

Materials needed for the toy:

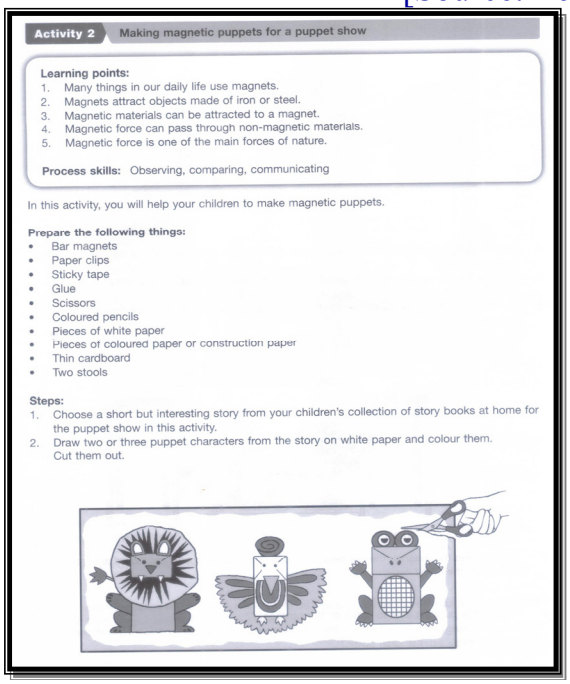
How the toy works:

Energy concept(s) involved:

Making the learning of science fun and meaningful is important as this helps to arouse more curiosity and interest in your children. This activity allows them to exercise their creativity and enriches their understanding of energy concepts.

Example 8: Foster creativity through interdisciplinary learning

Figure 8. Taken from I-Science Parent's Guide Primary 5 & 6. Theme: Interactions, Chapter 1: Forces, Activity 2: Making magnetic puppets for a puppet (Page 55-56) [Source: Lee, A. N. (2009)]



Activity 2 Making magnetic puppets for a puppet show

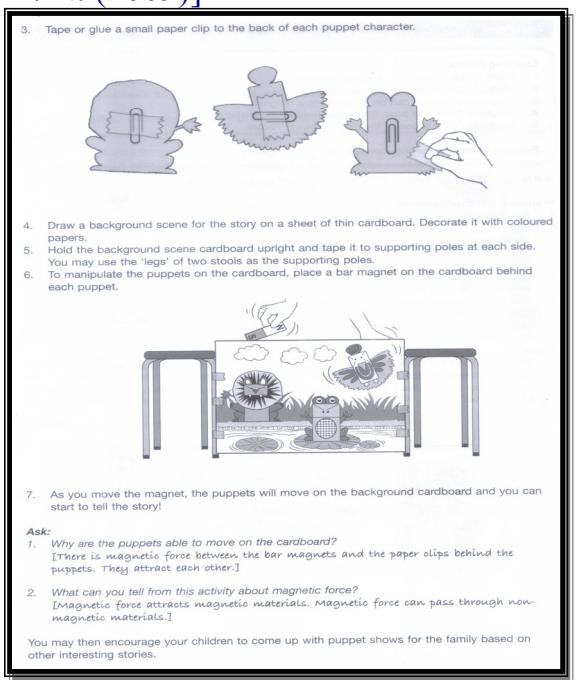
Learning points:
1. Many things in our daily life use magnets.
2. Magnets attract objects made of iron or steel.
3. Magnetic materials can be attracted to a magnet.
4. Magnetic force can pass through non-magnetic materials.
5. Magnetic force is one of the main forces of nature.

Process skills: Observing, comparing, communicating

In this activity, you will help your children to make magnetic puppets.

Prepare the following things:
- Bar magnets
- Paper clips
- Sticky tape
- Glue
- Scissors
- Coloured pencils
- Pieces of white paper
- Pieces of coloured paper or construction paper
- Thin cardboard
- Two stools

Steps:
1. Choose a short but interesting story from your children's collection of story books at home for the puppet show in this activity.
2. Draw two or three puppet characters from the story on white paper and colour them. Cut them out.



3. Tape or glue a small paper clip to the back of each puppet character.

4. Draw a background scene for the story on a sheet of thin cardboard. Decorate it with coloured papers.
5. Hold the background scene cardboard upright and tape it to supporting poles at each side. You may use the 'legs' of two stools as the supporting poles.
6. To manipulate the puppets on the cardboard, place a bar magnet on the cardboard behind each puppet.

7. As you move the magnet, the puppets will move on the background cardboard and you can start to tell the story!

Ask:
1. *Why are the puppets able to move on the cardboard?*
   [There is magnetic force between the bar magnets and the paper clips behind the puppets. They attract each other.]
2. *What can you tell from this activity about magnetic force?*
   [Magnetic force attracts magnetic materials. Magnetic force can pass through non-magnetic materials.]

You may then encourage your children to come up with puppet shows for the family based on other interesting stories.

Concluding Remarks

This paper discusses the importance and implications of parental involvement in children's science learning in informal contexts. It also describes the development of the Primary Science Parent's Guide based on the sociocultural and constructivist theories to propose how science activities can be designed and facilitated by parents to enhance their children's science learning at home or in other informal settings. However, this paper does not advocate that parents replace the science teachers' role in school. Instead, it contends that parents can play a complementary role to support the science teachers to enhance the science learning experience for their children at home and in other informal settings.

There are important implications for parents and children when they engage in science learning in informal settings. First, when parents provide their children with valuable experiential learning experiences outside the school, they can help their children recognise that science is meaningful because it is connected to their everyday lives in many ways. Second, when parents show enthusiasm and role-model as active learners by learning and doing science with their children, they not only can help their children acquire science knowledge and skills but can also cultivate in them the positive attitudes and values essential for their future learning as well as their character development. Last but not least, when parents and children share joy, laughter and fun during the process of learning and doing science, the quality time spent together not only promotes a collaborative parent-child relationship but also strengthens the family bond between parents and children.

As noted by Crowley et al. (2001), "the most important outcome of everyday parent-child scientific thinking may be that children develop an early interest in science, value science as a cultural practice, and form an identity as someone who is competent in science." With the guidance and support from their parents through purposely designed learning activities, children can develop understandings of how science works in their everyday lives when they make meaningful connections between their prior knowledge and experiences in their construction of new knowledge.

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Appendix

An Outline of the Themes, Chapters, and Activities in the I-Science Parent's Guide (Lower Primary 3 & 4 and Upper Primary 5 & 6)

I-Science Parent's Guide Booklet 1 (Lower Primary 3 & 4)		
Themes	Chapters	Activities
Diversity	Chapter 1: Living and Non-living things	Activity 1: Are they living or non-living things?
		Activity 2: Are the things at home living or non-living?
		Activity 3: How do we know whether it is living or non-living?
		Activity 4: What can living things do?
	Chapter 2: Diversity of Living Things	Activity 1: Which animal groups do they belong to?
		Activity 2: What does my pet need?
		Activity 3: Are vegetables plants?
		Activity 4: Are seeds living or non-living things?
		Activity 5: What are fruits?
	Chapter 3: Diversity of Materials	Activity 1: Which materials is it made of?
		Activity 2: Is it transparent, translucent or opaque?
		Activity 3: Which material absorbs water the fastest?
		Activity 4: Does it float or sink?
		Activity 5: Will it get scratched easily?
Cycles	Chapter 1: The Cycle of Life	Activity 1: What are seeds?
		Activity 2: Making a butterfly life cycle mobile
		Activity 3: What is your life story?
		Activity 4: What are their life cycles?
		Activity 5: How many stages are there in their life cycle?
	Chapter 2: Matter	Activity 1: How do we measure mass and volume?
		Activity 2: What is a matter?

		Activity 3: How do we classify matter?
		Activity 4: Can you smell that?
Systems	Chapter 1: Plant System	Activity 1: What do the parts in a part do?
		Activity 2: Making a leaf press
		Activity 3: How do we classify leaves?
		Activity 4: How does water travel in a plant?
	Chapter 2: Human System	Activity 1: What happens to your food?
		Activity 2: Making a lung model
		Activity 3: Does your pulse rate change?
		Activity 4: How much do you know about your skeleton?
Interactions	Chapter 1: Magnets	Activity 1: Guess which objects are magnetic?
		Activity 2: Making my own magnet by the stroking method
		Activity 3: Is the strength of a magnet uniform throughout?
		Activity 4: Making a magnetic toy
Energy	Chapter 1: Light	Activity 1: Mirror and reflection
		Activity 2: Can these objects form shadows?
		Activity 3: Can shadows change?
		Activity 4: Making a pinhole camera
	Chapter 2: Heat and Temperature	Activity 1: Hot or cold?
		Activity 2: What are heat conductors and insulators?
		Activity 3: Does air expand and contract?
		Activity 4: What is my body temperature?
		Activity 5: What is the temperature today?
		Activity 6: Which coloured material is warmer – black or white?
I-Science Parent's Guide Booklet 2 (Lower Primary 5 & 6)		
Themes	Chapters	Activities
Cycles	Chapter 1: Water	Activity 1: How does water change to solid and back to liquid again?
		Activity 2: How does water change to a gas

		and back to a liquid again?
		Activity 3: How is rain formed?
		Activity 4: Why do we need reservoirs?
		Activity 5: How can we reduce water pollution?
	Chapter 2: Reproduction in Plants	Activity 1: How is a flower pollinated?
		Activity 2: Why do seeds need to be dispersed?
		Activity 3: Why do angsana fruits have wing-like structures?
		Activity 4: What helps a seed to germinate?
	Chapter 3: Sexual Reproduction in Humans	Activity 1: Do I look more like my dad or my mum?
		Activity 2: How does the developing baby grow?
Systems	Chapter 1: Systems in Living Things	Activity 1: Does breathing rate depend on a person's age?
		Activity 2: Can a system work if one part of it is missing?
		Activity 3: Why do we need our body systems?
	Chapter 2: Cells	Activity 1: What is in a cell?
		Activity 2: Making a jelly cell
	Chapter 3: Electrical System	Activity 1: What makes up a simple circuit?
		Activity 2: Which circuit is better?
		Activity 3: Is this a conductor or an insulator of electricity?
		Activity 4: Which electrical appliance uses more energy?
Interactions	Chapter 1: Forces	Activity 1: Am I pushing or pulling?
		Activity 2: Making magnetic puppets for a puppet show
		Activity 3: Is force at work here?
		Activity 4: Friction – helpful or not helpful?
	Chapter 2: Environment	Activity 1: What are the factors that affect

		the organisms in a garden community?
		Activity 2: What communities can I find?
		Activity 3: Making a garden in a bottle
	Chapter 3: Web of Life	Activity 1: Exploring an open field community
		Activity 2: How can we form food webs from food chains?
	Chapter 4: Adaptations	Activity 1: How do animals adapt themselves to their environments?
		Activity 2: What adaptations do marine organisms have?
		Activity 3: What adaptations does a polar bear have?
	Chapter 5: Man's Impact on the Environment	Activity 1: How does water pollution affect aquatic organisms?
		Activity 2: How do we use recycled materials creatively?
		Activity 3: How is yeast used in biotechnology?
Energy	Chapter 1: Energy and Photosynthesis	Activity 1: Where does our food come from?
		Activity 2: How do plants make food?
		Activity 3: Is starch present?
	Chapter 2: Energy Forms and Uses	Activity 1: What is energy?
		Activity 2: How do my toys convert energy?
		Activity 3: Making a jumping frog
		Activity 4: How do I make a toy which can convert energy?