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Singaporean Preschool Children Learning Science Through Play

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Abstract Play has an important role throughout childhood as children learn and develop through engaging in play. The aim of this study was to examine how purposeful play can be used to introduce and facilitate the learning of science ideas and scientific skills in young children in the Singapore context. Science activities were carried out with preschool children aged 5 to 6 through the use of purposeful play, and the video and audio recordings of the science activities were analysed using qualitative coding methods to identify the science learning that took place while engaging in purposeful play. The coded data were written into narratives to illustrate the process and learning outcomes of the science activities conducted using purposeful play. The findings of this study indicate that young children are able to display science process skills and learn science ideas through engaging in purposeful play.
Keywords: play; preschool; young children, science learning, Singapore

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Introduction

In the Singapore Ministry of Education (MOE) Kindergarten Curriculum Framework (MOE, 2012), purposeful play is emphasised as a way for children to learn in kindergartens because it is believed that young children learn when they play by themselves or with their friends and siblings. Purposeful play takes place when an activity, which has been planned by the teacher to include specific learning objectives, is fun and involves active participation by the children (MOE, 2012).

The MOE's kindergarten curriculum framework specified six learning areas that should be included in the curriculum, namely *aesthetics and creative expression, discovery of the world, language and literacy, motor skills development, numeracy, and social and emotional development* (MOE, 2012, pp. 67). The learning area *discovery of the world*, in particular, relates to science learning through experiencing the world around them. Hence, although science is not formally introduced in the curriculum in Singapore until Primary 3, the learning of science process skills is included in the early childhood curriculum framework. It is not a requirement for specific science concepts to be taught. However, one objective of this learning area is to afford opportunities for children to develop science process skills such as observing, comparing, and asking questions (MOE, 2012). With the MOE's focus on this as one of the learning areas, we therefore focus on the learning of science in our study. In line with this focus, we are interested to find out how science activities can be introduced to Singaporean preschool children through play.

Our study aimed to investigate how science learning occurred when young children in Singapore participate in science activities through purposeful play. It is the first known Singaporean study of science education on this group of learners. The findings in our study provided us with a picture of how learning could take place through play, which would be useful for teachers and curriculum planners when they plan a play-centred classroom activity. The research question that we wanted to address was:

How do Singaporean preschool children learn science through engaging in purposeful play?

This study was conducted in two preschool centres in Singapore. Science activities were carried out with the preschool children through purposeful play. The researchers and teachers designed, planned, and wrote lesson plans for the science activities such that the activities were children-centred, fun, open, catered to the children's abilities and interests, and related

to their everyday lives. In this way, the children could learn by harnessing on their personal interests and prior knowledge.

Theoretical Framework on Play

To date, there is no consensus on the definition of play. Diverse theories of play are provided between and within diverse research paradigm. Classical theories of play include Spencer's (1873) surplus energy theory, Lazarus's (1883) relaxation and recreation theory, Groos's (1896, 1901) practice theory of play, and Hall's (1920) recapitulation theory. To elaborate, Spencer's (1873) surplus energy theory states that children engage in play in order to release the excess energy that they have. On the other hand, the relaxation and recreation theory of play (Lazarus, 1883) states that children engage in play as it serves as an avenue for recreation and relaxation, which enables them to regain their energy. Groos's (1898, 1901) practice theory of play states that play allows the children to practise adult roles. The recapitulation theory of play (Hall, 1920) states that play is where children act out their evolutionary instincts.

Contemporary theories of play have been viewed as "more useful to the field" (Fleer, 2013, pp. 101). Fleer (2013) looked at some of the ways in which play has been defined in the early childhood literature, and found that they fall into three theories of play, namely developmental, cultural-historical, and critical or feminist poststructuralist.

From the developmental view of play, play is seen to be something that children are intrinsically motivated to do and they naturally perform (Fleer, 2013). Fleer (2013) has stated that playful learning, as defined by Moyles (2010), is based on a developmental view of play:

[T]his relates to learning experiences that are child- or-adult-initiated or inspired, which engage the child in playful ways, and as near as possible, reflect the child's instinct to play. The adult's role is to be sensitive to children's playful learning modes, make planned provision, model, participate, interact, enhance vocabulary, to

perceive curriculum and learning intentions within the play and to observe and assess children's learning needs linking to planning (Moyles, 2010, pp. 21)

The cultural-historical view of play views play as an interaction between the children and their culture (Fleer, 2013). Hence, this is in contrast to the developmental theory of play, where people in different cultures are assumed to play in the same manner. Elkonin (2005) has argued that the play that children engaged in changed as their culture changes. In the early times, children are able to do what the adults do for survival due to the presence of the presence of simple tools. However, as societies developed, more sophisticated tools were used by adults, and children begin to be unable to enter adult life from a young age, resulting in a longer childhood period. As a result, children now pretend that they are participating in adult roles as they are no longer able to contribute to it. Therefore, it can be seen that play changes as the culture changes, in comparison to that of developmental theory.

From the critical or feminist poststructuralist view of play, the meaning of play is being challenged. As an example, Grieshaber and McArdle (2010) contested the notion that "play is natural, normal, innocent, fun, solely about development and learning, beneficial to all children, and a universal right for children" (pp. 1). Furthermore, they also pointed out that not all play are fair, and that power injustice may also reproduce itself in children's play (Grieshaber&McArdle, 2010).

In our study, we adopt the constructivist view of play. In MOE's kindergarten curriculum document, it defined purposeful play as being fun for the children, involves the active participation of children in "exploring, developing and applying knowledge and skills" (MOE, 2012, pp. 37), includes specific outcomes that the teacher wants to achieve by considering the level of competence of the children and whether the activity is of interest to the children, and involves teachers looking out for what the children have learnt and shape the activities to further the learning of the children. We underscore the importance of using

play as the platform for children to draw upon their funds of knowledge—or resources that they bring from their prior knowledge and experiences to the site of social interaction—to actively engage in learning with others (Gonzales & Moll, 2002).

Methods

Participants

Two preschools located in the southern part of Singapore were recruited for this study. Both preschools were located at the void decks of public housing. A total of twenty-eight preschool children, six pre-school teachers, and three researchers took part in this study. The preschool children were aged 5 – 6. One of the preschools (PS1, pseudo code) was a child care centre, at which the children stay from the morning till the late afternoon or evening when the parents pick them up. In this preschool, there was only one class of children in the K2 grade, and 11 children from this class participated in this study. The other preschool (PS2, pseudocode) operated for half-days, where children would go to the preschool at 8 am and leave by noon. In this preschool, there were three K2 classes totalling about 60 children, but we only recruited one class. Seventeen children from PS2 took part in our study. Six preschool teachers, including the childcare supervisor of PS1 and the centre principal of PS2, attended the curriculum meetings before the implementation of science activities. . During the science activities, only one preschool teacher from PS1 took part. The children of both preschools were separated into three groups of three to six children for the science activities. At PS1, the science activities were facilitated by two researchers and one preschool teacher. Each of them taught one group of children. At PS2, three researchers each taught one group.

Data Collection Methods

Curriculum meeting

The researchers in this study came up with the initial lesson plans for eight science activities. There were a total of two curriculum meetings at each preschool. At the first curriculum meeting, the researchers met with the preschool teachers to share with them the activity lesson plans. Each lesson plan describes the learning objectives, materials needed, and guiding questions to ask students. The preschool teachers were asked to look through the lesson plans and choose four activities for implementation at their centre. At the second curriculum meeting, the teachers shared with the researchers which were the activities that they have chosen to be implemented. They were also asked to elaborate on the concerns that they have regarding the implementation of each chosen activity, the prior knowledge that their preschool children have for each of the chosen activity, and changes that we should make to the activities. These feedbacks were obtained from the teachers as the teachers were in a better position to comment on whether the activities were suitable for the children in this study. Without placing any limits on the number of activities being chosen and without any discussion between the two preschools, the teachers from both preschools decided on the same four activities, suggesting that the four chosen activities were thought to be suitable for children of this age.

Video and audio recordings were collected during the curriculum meetings with the preschool teachers. The first curriculum meeting lasted for approximately 30 – 40 minutes in the two preschools, while the second curriculum meeting lasted for approximately 40 – 60 minutes. A total of approximately two hours of video recording and three hours of audio recording were obtained for the meetings at the two preschools. Following the modification of the science activities based on the teachers' suggestions, the activities were carried out with each preschool.

Science activities

Each activity lasts for approximately an hour and took place on different days as the preschool teachers have suggested that the attention span of the preschool children may not be long enough for us to conduct two activities in a day. The order of the activities were decided jointly by the teachers and the researchers, and were based on factors such as whether they believed that a particular activity could serve as a warm-up activity between the children and the researchers that they were seeing for the first time. The data collection methods include lesson video and audio recordings, photographs, and student artefacts. Video and audio recordings were collected as it provided us with the raw data to observe and code the science learning which has taken place. Photographs and student artefacts provided us with static images of how children went about doing the activity, and how the end product of each activity looked like. The amount of data that was collected is shown in Table 1 in Appendix A. Each science activity is briefly described below.

Activity 1: Hard or soft?

In this activity, students were provided with a variety of materials including wood, plastic, Styrofoam, and sponges, and were taught the concept of hard and soft by allowing them to feel the materials. In addition, children were allowed to play with Oobleck, which is a substance made from cornstarch and water. Oobleck can be both hard and soft depending on the way that it is being handled. For example, when one tries to hit the Oobleck, it will appear to be hard. However, it will also flow like a liquid. Hence, the young children learn that some materials exhibit hard and soft properties under different conditions.

Activity 2: Float or sink?

In this activity, children were given various objects such as ping pong balls, wooden ball, and marbles, and were asked to predict and test whether the item will float or sink. In addition, they were asked to think of ways to make a piece of plasticine float by moulding it

into appropriate shapes. After which, they tested out whose moulded plasticine were able to carry the highest number of paper clips before it sank.

Activity 3: Categorising different types of leaves

This activity took place in the Singapore Botanic Gardens. Children were first encouraged to pick up different types of fallen leaves. After which, children were encouraged to sort them according to categories, and to explain the categories to the researchers and teachers.

Activity 4: Magnets and art

In this activity, the children were first shown how magnets work. After the children were able to find out that magnets can work even with an object in between, the children chose the magnets and objects that were attracted to the magnets of their choice and were asked to make a painting with poster paints based on this concept. The children were encouraged to choose different objects attracted to the magnets as they will then produce different patterns on the drawing.

Data analysis

The data were analysed using the NViVo software. The video data was analysed first by coding for the episodes where aspects of purposeful play were seen. Microanalyses were then carried out on the episodes to find out what were the science process skills displayed and the science ideas learnt through engaging in the science activity through purposeful play.

Findings and Discussion

Narrative 1—“Inside is hard; outside is soft”

During the science lesson on the topic of “Hard and Soft”, Teacher Jamie quizzed the children “How do you know if something is hard or soft?” The group of children went silent, some children were seen thinking hard, and some sunk into their chairs. A minute went by. Teacher Jamie opened her ‘magic box’ and produced two objects in her hands (a wooden block in one hand, and a lump of plasticine in the other). Immediately, all the students sat up

and moved forward, towards the two objects shown and expressed interest in them. Teacher Jamie asked them what each object is and went on to probe which object is hard and which object is soft. She allowed the students to touch, to press and feel the items in her hands. The group became lively and started grabbing the objects from one another.

When Teacher Jamie posed the question “How do you know if something is hard or soft?” to the children and observed the children having difficulty answering the question, she produced objects which captures their interests, with the aim to lead/direct their learning. When she held the wooden block and a lump of plasticine in her out-stretched hands, instantaneously, she got all the children’s attention, as they were observed to sit up, moved forward and looked on the two objects shown with curiosity.

Teacher Jamie placed 2 balls in her hand and held them out towards the children. Again, she quizzed them, “Which is hard, and which is soft?” She allowed the children to feel, to touch, to squeeze the balls which she was holding in her hands. When one of the child, Jake said that depends on whether the ball bounces. Teacher Jamie proceeded to test both objects by bouncing them on the table (see Figure 1). The children saw that both balls bounced and started to suggest other ways to distinguish between the two objects.



Figure 1. Teacher Jamie released the ball to show if it could bounce.

While Teacher Jamie asked the children which object is hard and which is soft, she told them to touch, to press and feel the objects in her hands. The children were observed to gradually become lively and were seen to observe the objects intently, feel and touch them. Following Jake's suggestion to decide the hardness or softness of the rubber balls based on whether they bounced, Teacher Jamie went on to test out the hypothesis, instead of dismissing it, by bouncing the two rubber balls them on the table. The children witnessed that both rubber balls bounced and began to suggest other ways to determine which one was hard and which was soft. It is seen that children are given the opportunity to provide their ideas to test out during the activities, and learn that their initial ideas were not true and started coming up with new explanations.

A tray of Oobleck was presented to the children and Teacher Jamie invited the children to dip their fingers into the tray and drag it across. While they were exploring the Oobleck, she quizzed them if the Oobleck feels hard or soft. The children exclaimed that the Oobleck is "hard and soft". One said, "Inside is soft." Another said, "Inside is hard, outside is soft."

In the next activity, Teacher Jamie asked the children to grab a handful of Oobleck each in their palm, squeeze it, and slowly release it from their palm, demonstrating the process to the children. She encouraged the children to play with the Oobleck in their hands, squashing it, kneading it, feeling it. The children squeaked in delight as they worked their way through the Oobleck in their hands (see Figure 2).



Figure 2. Children working intently with the Oobleck

While they were playing with the Oobleck, Teacher Jamie posed the same question to the children, “Is the Oobleck hard or soft?” Some students replied “Hard”, while some said, “Soft”. She grabbed a handful of Oobleck with her palm, and asked the children “When you hold on to the Oobleck in your hand, how it feels?” The children observed and did the same. Holding on to the Oobleck in their palms, they chimed, “Hard”. She followed up with a question, “When you let go?” She released the Oobleck in her palm, they followed and chorused, “Soft”.

While the children were playing with the Oobleck, they were observed to be delighted and engrossed in playing with the Oobleck with their hands. When Teacher Jamie asked the question “Is the Oobleck hard or soft?” and observed that the children had different responses, she grabbed a handful of Oobleck with her palm, and asked the children how it felt. The children followed and did likewise and replied that it was hard. She then let go of the Oobleck in her palm and asked them how does it felt then. The children were witnessed to model after their teacher and shared that it felt soft. During this activity, the children were seen to be actively engaged with playing the Oobleck and learning about its properties.

Narrative 2—“They are different!”

During an excursion to the Singapore Botanic Garden, the children were tasked to pick up different kinds of leaves. After about 20 minutes of leaves picking, Teacher Jamie gave the

children an assignment. They were to sort the collected leaves by themselves into different groups, and tell her how they did it. All the children in team actively participated in the assignment (see Figure 3).



Figure 3. The children participated actively in sorting the leaves

Briskly, with little communication between them, the children started work, classifying the collected leaves amongst them (see Figure 4).



Figure 4. The children were sorting the leaves with little discussion on the criteria for the classification

Teacher Jamie went on to ask each student how they sorted the leaves. Dawn commented that they sorted the leaves according to “brown, yellow and green”. When Teacher Jamie asked Andy how the leaves were sorted, he said “They are dark green, green and brown.” Bernissa commented that the leaves were grouped according to “colour”.

Teacher Jamie proceeded to test the children “Are there other ways to sort the leaves?” One child said to sort “by type”. The teacher asked them, “What are the different types?” Andy held up two leaves and told Teacher Jamie that they are different. She asked him, “Why are they (the leaves) different?” Andy said, “Because, this one is like that (tracing the central vein of one leaf that runs from the edge of the leaf to the other), and this one is from the middle (pointing that the central vein of the other leaf runs from the centre of the leaf to its drip tip)” (see Figure 5).



Figure 5. Andy explaining to Teacher Jamie the difference between the two leaves which he observed

Teacher Jamie was thrilled with Andy’s explanation and gathered all the children together and shared with them Andy’s observation (see Figure 6). “Just now, Andy made a very good observation, do you see this, it goes through the centre of the leaf (she traced the central vein

of the leaf using her finger)?” “Now, look at this one, where is it?” she asked, pointing to the central vein of the leaf (the children have not been introduced to the terms used to describe the different parts of a leaf). A child observed and said “at the side.” Teacher Jamie went on and explained, “A lot of leaves, you see, this (pointing to the central vein of each leaf which she picks up) is at the centre.” She held up a couple of leaves and traced the central vein of each leaf and uttered, “All centre, right?” The children observed each leaf held up intently and exclaimed “Centre!” “Except for this one!” Teacher Jamie held up the unique leaf picked up by Andy for all to see. The children observed the unique leaf and goes “Wow!!!!”.



Figure 6. Teacher Jamie sharing with all the children the difference between the leaves as observed by Andy

Narrative 3 - “Magic, magic! It can’t go down!”

Teacher Melissa handed out an object to each child. She asked them if they know what the object is. The children started to observe the object, feel the object, some used the object to knock against the table.

Seeing what the students were doing, Teacher Melissa told one of the children to hold on to the object, while she placed the object which she was holding close to the one that the child is holding. The two objects moved towards each other and stick on to each other. The children exclaimed excitedly, “It is a magnet!” All the children started to place the object which they were holding in their hands next to the object which their peers were holding.

They were excitedly experimenting with the objects in their hands, with their peers. Steve attempted to spin his friend's magnet, from a distance (see Figure 7).



Figure 7. Steve trying to 'spin' his friend's magnet from a distance

As illustrated above, children were able to explore with objects hands-on during the activity. It can be observed that when the children realised the special characteristics/feature of the object which they have in their hands, they were very excited and tried to model what the teacher did by placing the magnet which they were holding in their hands next to the magnet which their friends were holding, to see the effects of two magnets attracting to each other. It is seen that through playing with the magnets, the children were starting to explore the idea that magnets can attract to each other.

Moments later, Teacher Melissa collected all the children's magnet, and placed one magnet at the centre of table, and hold another magnet closed to it. "How close do you think I can get to that magnet?" Teacher Melissa asked (see Figure 8). The children pondered and predicted, "Here!" "This close!" Teacher Melissa moved the magnet which she was holding closer to the one at the centre of the table, and "Woo La!" The two magnets moved towards each other and were stuck together.



Figure 8. Teacher Melissa asking the students to predict how close the magnet can get to the other one at the centre of the table.

The children were thrilled seeing that and squealed, “Can I play?” “Can I play?” Teacher Melissa promptly paired the students up and provided them with the magnets for them to explore and try out the new trick.

Moments later, Teacher Melissa passes some new magnets of different physical forms to the children. They immediately took to it and started playing with them, in the similar manner, amongst themselves (see Figure 9).



Figure 9. Children using a different set of magnet, but playing with them in a similar manner (placing one close to the other, observing that they attract each other)

It can be seen that the children were fascinated by the workings of the magnets when the children expressed their desire of playing with the magnets. Knowing that she had gotten the children interested in the activity, Teacher Melissa promptly paired the students up and provided them with the magnets for them to experiment with the new-found workings of the magnets.

While Young, Amelia and Katlyn were playing among themselves trying to attract one magnet to another, Steve was observed telling Ian, “I want to make your magnet moves!” He placed his magnet close to Ian’s magnet on the table, dragging it across the table. He then declared “I can make your magnet moves without touching!” He started to place his magnet below the table and manoeuvre Ian’s magnet which was placed on top of the table (see Figure 9).



Figure 9. Steve trying to move Ian’s magnet without touching, while Amelia and Katlyn look on

When Ian, Amelia and Katlyn saw what Steve had managed to do, they attempted to try out the new trick too, on their own (see Figure 10).



Figure 10. Ian trying out the new trick which he learnt from Steve

It is observed that through exploring with the magnets, Steve has found a way in which he can manipulate a magnet without touching it by using another magnet. Steve was seen not only attempting to attract Ian's magnet (which was on the table), by placing his own magnet under the table, close to Ian's, but he was attempting to and he succeeded in dragging it across the table. Obviously Steve had observed the attraction that one magnet has for the other, and he was manipulating this working of the magnet to control its behaviour. After he had observed that he could attract and move Ian's magnet by placing his own magnet laterally on the table (close to Ian's), he then proceeded to experiment moving Ian's magnet by place his magnet below the table to manoeuvre Ian's magnet which was placed on top of the table. Steve conducted a series of tests by performing a series of actions and carefully observed their effects. He built on the prior observation and tried out new ways of manipulating the objects. All these actions and effects or tests were witnessed by Ian, Amelia and Katlyn, who then they attempted to model or try out the new tricks, on their own.

Moments later, Teacher Melissa placed some new objects on the table, she started with one paper clip for each child, then a dozen of paper clips and some magnetic cars. The children picked them up and included them in their play. Teacher Melissa encouraged the

children to try out what Steve did with the magnets, placing one under the table, to control the objects on the table (see Figure 11).



Figure 11. Ian and Steve trying to move the paper clips and magnet cars on the tables by using magnets placed under the table

Kathlyn did something unusual. She placed her magnet on her lap, and attempted to move a paper clip on the table. She alerted her friends, “See, I am moving the paper clips using my leg!” This prompted Steve to do something extra-ordinary. He climbed under the table, balanced his magnet on his head, and tried to move the paper clips on the table.

From manoeuvring objects on the table by holding a magnet in their hands, it can be observed that Kathlyn discovered a new way of achieving the same outcome using a different approach. She placed her magnet on her lap, brought it close to the table and started to manoeuvre the paper clip on the table. Amazed by her own discovery, she attempted to share her new magic trick of moving the magnet without touching to her teacher and friends. Looking at his friend’s new discovery, Steve attempted to apply the same principle and test out a new way of manipulating the magnet from beneath it, without using hands. He climbed under the table, placed his magnet on his head, and tried to move it, to manoeuvre the paper clip on the table.

Teacher Melissa collected all the children's magnets, placed a magnet at the centre of the table, and simply told the students to "just look". All the children looked at what she was about to do intently. She placed one object close to another one, the two objects moved towards each other and 'sticks' to each other. She then turned one of the object over to the other side and move the two objects towards each other, and they were now observed not moving towards each other. Teacher Melissa then asked the students to try. All the children started to play with the new objects in their hands. Amelia commented, "It is the same side, it sticks, but if it is the wrong side, it can't stick. It pushes away."

Hearing that, Teacher Melissa got the children's attention by getting them to help create the new object activity: using a stick and a ring magnet. Holding on to the stick, Teacher Melissa asked Amelia to place the ring magnet through the stick. As she got Young to drop the second ring magnet through the stick, she asked the students if the 2nd magnet will stick on to the first. The children chorused, "Yes!" Everyone watched intently as the Young dropped the ring magnet through the stick to check if their prediction is correct. The second magnet fell right on the first. "How about this one?" She asked as Steve gets ready to drop the third ring magnet through the stick. "Stick!" Looks of surprise when the children saw that the coin magnet stayed afloat the stick (see Figure 12).



Figure 12. Young attempted to 'correct' the mistake by turning the ring magnet to the other side and dropped it through the stick again

Teacher Melissa smiled. She removed the last two ring magnets from the sticks and dropped them through the stick. “Wow” The children were amazed to see the ring magnets floating on the sticks. Teacher Melissa asked one of the children to “try pushing” the ring magnet down. But they gasped that “It can’t go down!”



Figure 16. Teacher Melissa was getting the students to “try pushing” the ring magnet down the stick

In sum, we observed several science process skills being enacted in this series of activities. The children made observation, tested out their ideas using the objects which they were given, modelled their teachers’ and peers’ behaviour, and applied their learning from observing the objects or the behaviours of the objects.

Implications

Two major implications can be drawn from the findings of this study for preschool teachers and policy makers of preschool education. Firstly, the review of professional learning programme for preschool teachers, and secondly, the human resource deployment for the ministry in charge of preschool education. In the following section, we will elaborate upon each of these implications.

Findings from the study shows young children aged 5-6 are able to engage the diverse science process skills through purposeful play. The children clearly demonstrated the science process skills of making observation, making prediction, recognising patterns and causality,

drawing inferences, negotiating ideas, planning and carrying out investigations, constructing explanation and drawing inferences, as seen in the narratives above. In addition, the children show that science ideas may be learnt through play. A more intriguing question would be to identify the factors that made the above possible.

Firstly, we need to consider the distinct components that formed the makeup of purposeful play; namely, the provision of learning experiences that engage the child, in playful ways and secondly, the inclusion of “perceived curriculum and learning intention within play” (Moyles, 2010, as cited in Fleer, 2013).

Playful learning gives the children the space to discover and explore the world. Structuring learning in ways aligned to the natural instincts of human being is an approach set for success. A scan on the few existing studies reveals that the use of purposeful play produce positive outcomes amongst children including higher motivation towards school, better memory, increased creativity, and academic results (see review by Weisberg, Hirsch-Pasek, & Golinkoff, 2013). Like any other learning processes involving learners of all ages, it is not the act of defining the learning outcome of the activity, nor the crafting of a detailed and rigorous intended curriculum that determines the success of a learning activity. The crux lies in the enacted curriculum where the teacher’s role is momentous.

In our study, we observed that during playful learning, the teacher played the role of a facilitator; in initiating and leading children in their ‘play’ down the path towards the intended specific outcome; in modelling and interacting with the children in their process of ‘play’; in observing and assessing the children’s prior knowledge and understanding of ideas and concepts, in shaping and providing experiences which supports their construction of knowledge. Instead of operationalizing the teaching protocol as stipulated by the curriculum planners, the teachers were vigilant for moments where they ‘hook’ onto to the questions, comments or behaviour of the students, and lead them on a journey of deeper exploration and

discovery. These 'learning/exploratory hooks' serve to deepen the learning experiences of the children, and acts as natural progression of learning experiences which are student initiated or inspired. For instance, as highlighted in narrative 1, upon hearing one of the children's comments, that one way to find out if a ball is hard or soft is by bouncing the ball, instead of dismissing the child's answer, and moving on to her intended instruction, the teacher picked it up and turned it to a student-directed activity, where the children test out the hypothesis of the child. This is a diversion from the intended curriculum but a powerful teaching moment where teacher demonstrate very science process skills of experimentation and testing of hypothesis.

In narrative 3, children were given the space to experiment and explore the workings of magnets by themselves and with their peers. We witnessed guided play where the teacher modelled specific working of the objects (magnets) and children followed. More importantly, we observed that while the teacher participated in play with a child/a couple of children, she is keeping a close eye observing the play of the other children, assessing their comprehension and mastery of the working of the magnets, before modelling the next action. It is the teacher's perceptiveness of the children's prior knowledge, experience, and their comprehension that determines the former's instructions, that constitutes the children's learnt curriculum. The masterful teacher of purposeful play weaves together the tapestry of knowledge and experiences that the children brings with them to the class, to construct a learning journey of relevance and appropriate to the children.

The study observed the teachers of purposeful play demonstrating fluidity within the overarching structure of the lesson. The skilful teachers have an oversight of the intended learning objectives of the lesson and the designed lesson activities, and yet allow the flow of the lesson to take its form and momentum by taking clue from the participants of this learning experience. These children's assumptions and (mis)conception of ideas and concepts, the way

they talk science, and their level of comprehension of concepts illustrated by the teacher, direct and shape the pedagogical construct of the lesson. And these could only be discerned through effective questioning tactics, sharp observation skills and strong conceptual understanding of the subject discipline. As such, professional learning programme of pre-service and in-service preschool teachers needs to take on a new dimension.

Professional learning programme of preschool teachers needs to provide a heavier emphasis and focus on deepening the subject knowledge of teachers; their understanding of scientific concepts and learning, and in strengthening the teachers' mastery of scientific inquiry. While it was essential and will continue to be imperative for preschool teachers to learn to design and craft lesson plans and acquire a range of pedagogical tools, the characteristics and nature of purposeful play demands that the teachers customised the delivery of the lesson according to the participants of the learning activity. This customisation is not accomplished by completing a needs assessment of the students' level of understanding at the beginning of the year, or at the beginning of the lesson. This assessment of the children's learning is a continuous process throughout the lesson itself. Through effective questioning tactics and sharp observation skills, teachers engaged in purposeful play discerned and guided the children's learning experience to help them construct an understanding of scientific concepts. It is only with a deep strong conceptual understanding of the subject discipline, could teachers be able to guide the children's play, towards the construction of the intended scientific concept and understanding. It is only with an in-depth scientific knowledge would the teachers be able to discern the misconceptions that children possess and/or help them relate the different scientific concepts. For instance, more curriculum conversations should be conducted amongst the teachers, not just on the 'how' of teaching but the 'what'. The engagement of purposeful play to teach science means that the teachers' view of the curriculum needs to be shifted; we should no longer view curriculum as

one that needs to be implemented but one that is to be interpreted, which is very much dependent on the subject competency of the teacher.

The second implication that can be drawn from our study concerns the human resource deployment for preschool classes. Findings from the study shows that in purposeful play, for the teachers to observe and assess the learning needs of the children, in determining the next learning activity, and for the teacher to construct learning experiences that are child initiated or inspired requires a practical teacher-student ratio. Purposeful play entails the role of teacher to be “sensitive to children’s playful learning modes, make planned provision, model, participate, interact, enhance vocabulary, to perceive curriculum and learning intentions within the play and to observe and assess children’s learning needs linking to planning” (Moyles, 2010). It also involves the children as active co-constructors of scientific knowledge and understanding. All this is only probable with a manageable size per play group. Furthermore, purposeful play demands the teachers to tap on the students’ initiatives to lead and shape the group activities to further the learning of the children. Without doubt, science learning through purposeful play takes place more effectively in a small play group setting.

Conclusions

Our study revealed how Singaporean preschool children aged 5-6 enacted science process skills through purposeful play. The children were seen making observation and prediction, recognising patterns and causality, drawing inferences, negotiating ideas, planning and carrying out investigations, constructing explanation and drawing inferences. In addition to the enactment of science process skills, the children also show the learning of science ideas, such as the use of magnets, through participating in the activity. In determining how science learning takes place with purposeful play, we observed that the teacher is the major determinant in the enacted and the learnt curriculum. We suggested a review of the

professional learning programme for the preschool teachers to deepen their subject competency; in their understanding of scientific concepts and their mastery of scientific inquiry, as we believe this would help create rich learning experiences where children participate as co-constructors of scientific knowledge. . A review of the human resource deployment was also suggested to facilitate the forming of small play group setting which is supportive of the enactment of purposeful play in its totality. We believe that through purposeful play, the children's natural curiosity and instinct to play facilitate their construction of knowledge and learning of their environment. This natural learning process would go a long way to develop our young to be the life-long learners of the 21st century.

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Appendix A

Table 1: Summary of the data collected at the two preschools

Science activity	PS1		PS2	
	Type of data	Quantity	Type of data	Quantity
Hard or Soft?	Small group lesson videos	3 videos x 50min = 150min	Small group lesson videos	1 video x 20min = 20min 2 videos x 45min = 90min
	Audio recordings	3 audio recordings x 50min = 150min	Audio recordings	3 audio recordings x 45min = 135min
Float or Sink?	Small group lesson videos	3 videos x 80min = 240min	Small group lesson videos	3 videos x 60min = 180min
	Audio recordings	5 audio recordings x 80min = 400min	Audio recordings	3 audio recordings x 60min = 180min

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			Photo artefacts	3
Categorizing different types of leaves	Small group lesson videos	3 videos x 60 min = 180min	Small group lesson videos	3 videos x 60min = 180min
	Audio recordings	6 audio recordings x 60min = 360min	Audio recordings	6 audio recordings x 60min = 360min
	Photo artefacts	20	Photo artefacts	22
Magnets and Art	Small group lesson videos	3 videos x 45min = 135min	Small group lesson videos	3 videos x 45min = 135min
	Audio recordings	3 audio recordings x 45min = 135min	Audio recordings	4 audio recordings x 45min = 135min
	Photo artefacts	15	Photo artefacts	18