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DEVELOPING AN INDEPENDENT LEARNER THROUGH SCIENTIFIC LITERACY

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Abstract

This is a case study of an educator's journey to implement early childhood science education to a group of three to four year old students from a nursery 2 class in a neighbourhood childcare centre. Difficulties faced and effective methods used during implementation are the focal points of this study. Traits of an independent learner were developed through the use of mediated learning experience (MLE), using science as a vehicle to teach these skills. From a social-constructivist perspective, learning is more likely to occur if adults or more competent peer mediate children's learning experiences. There is a growing consensus among early childhood professionals that the past success in improving basic skills in the "three Rs" (Reading, wRiting and aRithmetic) has not matched with the current demands of the twenty-first century. This study focuses on the role of the teacher in guiding preschool children's science learning while they play with everyday materials. Checklists were available to trace the development of fundamental areas such as process skills, thinking skills and scientific discourse. There is an increasing need to introduce early childhood science education into the local context as science involved the development of thinking skills and it also requires students to use appropriate tools and techniques essential in developing an independent learner. Creating an environment that is scientifically empowering and mediating children's experiences in this environment establishes the foundation of an independent learner.

1. Introduction

Valuing science, as knowledge of worth is vital for children's development of values and attitudes about science and technology. Scaffolding children's world with science help them understand everyday phenomena. As children develop their scientific ideas and thinking processes, they will find more meaning in their learning and will begin to take more responsibility for their own learning.

This paper reports findings from a case study of a nursery two classroom in a neighbourhood childcare centre. It focuses on an educator's journey to introduce the concept of buoyancy to a group of three to four year old children. In this paper, four areas will be examined. Firstly, a brief review of the theoretical underpinning linked to this research. The second area examined is a discussion of the approach used to teach buoyancy and the methods that was taken to monitor the development. The third section is a discussion of the difficulties associated with the teaching of science to young children. Finally, the findings from this study will be discussed and how this study is linked to the development of an independent learner.

2. Theoretical Underpinning: social-cultural theory and science learning

This study draws from sociocultural theory (Leontiev, 1978; Vygotsky, 1978) and research on science learning (Lemke, 1990). There are relevant factors involved in understanding student learning. This includes the ways that roles are established and positioned, the norms and expectations developed through the intervention activities and the mediating artifact.

Understanding human and symbolic mediation is considered central because the sociocultural study of learning science requires tracing how abstract-thinking skills are learned during the process of engagement with more "knowing others" such as a teacher (Tudge, 1990). A child's higher mental functioning is dependent upon mediating agents (human or symbolic) that the child comes into contact with during her or his interaction in social contexts (Vygotsky, 1978).

Students cognitive and physical skills are shaped and reshaped by human and symbolic mediators. Emphasis is placed on the ways knowledge is co-constructed by students and teachers within recurrent activity systems tied to mutual understandings about the who, when, why, what and how used to make sense of events that make up classroom time.

Psychological tools

According to sociocultural theory-once internalized and appropriated- psychological tools assist a person in mastering her or his own psychological functioning in the social as well as individual sense (Kozulin, 1998).

In the process of learning to appropriate internalized psychological tools, the individual develops metacognitive abilities that contributes to their own higher order cognitive functioning and how to interact with orders in a learning setting (Kozulin, 2003). Psychological tools need to be internalized and it can only be transmitted through social interactional processes, such tools are introduced by other people who have made use of the tools earlier. The internalization and appropriation of symbolic tools are construction and transmission processes that overwhelmingly occur during social interaction and not in solitude (Vygotsky & Luria, 1993).

The researcher has identified selected psychological tools to be shared with students that contributed to student learning across subject matter domains and specifically within the domain of science. The researcher/ teacher in this classroom was the primary human mediator of student science learning. This study highlights the systematic teaching practices employed by the teacher. Students in this nursery 2 classroom, not only learnt the psychological tools for thinking as scientists and about scientific concepts, they also had to understand the teachers' systematic use of psychological tools to guide their learning in her role of expert and their role as learner collaborators.

Why Mediated Learning Experience (MLE) approach?

From the early grades onwards, children are expected to know how to read, to know how to write, to know how to do elementary arithmetic, to know how to speak and how to behave. The emphasis is usually on how to do something, and only secondarily upon why and seldom on the logical or scientific basis underlying know-how. In MLE, a learner is involved in an experience while a mediator helps the learner to extract from that experience generalizations which will be useful in other contexts. A suitable vehicle for allowing the use of knowledge and skills in a problem solving process. An independent learner will emerge only when the learner is able to pose himself/herself certain questions when he/she is engaged in solving a certain kind of problem/situation.

If a child is engaged in a socially focuses problem-solving, the experience will be generalized and if the experience is transcended through mediated learning experience, the lessons can be used in other domains of life.

Children must learn these approaches to solving problems and the mental operations involved in solving these problems. They are not born with them. If the children do not find the activities they are learning meaningful or helpful to them, they will not learn much from the experience. When learning is properly mediated, it provides the basis of transcendence.

3. Approaches to the intervention activities

The main objective of the intervention activities was to integrate learning skills into the delivery of scientific content. As the researcher is also the mediator in this study, there were two areas she was concerned with. One area was to teach science with children's thinking in mind. This influenced her planning in which continuity of curriculum is designed for progression in the children's ideas. The term progression is applied to something that happens inside a learner's head: thinking about experiences and ideas, children develop their ideas. Some aspects of this learning may happen quite quickly and easily, whereas other aspects may happen in very small steps. The adult-child interaction conducted throughout the intervention programme, focused on extending the children's cognitive understanding of the materials they were manipulating. This was achieved through commencing explorations from within a socially meaningful context and moving to an abstract context and understanding. In this interaction, the facilitator uses many types of interactions such as questioning and procedural interaction. However, what was significantly different to most learning contexts was the greater emphasis placed on joint exploration and task completion and mediated instruction (during the abstract-based exploration with the materials).

During the implementation process, the researcher realized that young children construct better understanding on the complex physics concepts such as buoyancy through active discussion (pole bridging) with an adult acting as a mediator. Pole bridging is a deliberate attempt by children to verbalize their internal understanding using the appropriate language. Lemke (1990) demonstrated how content knowledge can be communicated and jointly constructed by teachers and students by introducing the useful concepts of the "thematic pattern". The most essential element in learning to talk science is mastery of the thematic patterns of each science topics.

These patterns of semantic relationship among scientific terms are inter-related. For example, the concept on “buoyancy” has a pattern of meaning expressed through such concepts and expressions as upthrust of water, density (mass and volume), surface tension, trapped air helping buoyancy.

In this study, the researcher encourages learning that fosters children’s construction of their own conceptualization in ways that make sense to them. She was more concern in the “valid” answers rather than the “right” ones. Buoyancy is a complex topic that requires much time for the child to comprehend completely. Children were shown the “big picture” and the unifying concepts leading to it along with the sub-concepts that scaffold children’s ideas of this “big picture”.

The other area the researcher was concerned with was the roles taken by mediators to ensure that the child’s learning process was scaffold properly and that the child understood the learning skills (principles) involved for each activity. Besides learning the content of the activities, a mediators’ role also involved the following objectives: (Marzano, 1992)

- Enable students to acquire and understand the core thinking skills and the processes involved in using them.
- Apply thinking skills in the learning of content subjects and in real life decision-making and problem-solving situations.
- Develop positive habits which would help them become critical, creative and self-regulated learners. These productive habits of mind is summed up in the following table

Critical thinking	Creative thinking	Self-regulated thinking
Being accurate and seeking accuracy	Persevering	Being aware of your own thinking
Being clear and seeking clarity	Pushing the limits of your knowledge and abilities	Evaluating the effectiveness of your actions
Being open-minded	Generating new ways of viewing a situation outside the boundaries of standard conventions	Being sensitive to feedback

As the focus in this study is the mediation of science processes in developing an independent learner, the researcher had to ensure that she engaged in the appropriate mediation processes to achieve this goal. The researcher used each videotaping session to analyze the lesson to ensure that as the mediator, her mediation skills are in-line with the mediation criteria.

4. Methodology

The Action Research methodology was adopted for this study. The cycle of Plan-Act-Observe-Reflect activities was adhered to. A case study approach was chosen, using action research as a way to examine this study systematically and carefully.

Data was collected through a reflective journal, audio and video recordings of students interviews during the duration of this study.

Design of study

This study was carried out in a neighbourhood childcare located at Chua Chu Kang, located at the northern part of Singapore. One of the nursery two class has been identified for this study because relatively little classroom-based research has been conducted for children of this age group . The pre-school level was selected because it provided an opportunity to investigate:

- (a) children's initial science understandings prior to extensive formal schooling.
- (b) emerging literacy abilities of very young children in context of their developing science understanding
- (c) social interactions between peers in the specific context of science experiences.

The children were observed in the course of 14 weeks from late June to early October 2006. The duration of each instructional period and data collection varied depending on the science concepts.

Participants

There were twelve participants from the nursery two class, ranging between three to four years old. Of these twelve students, 5 were boys while 7 were girls. Phase 1 was the observation stage

and this lasted for 4 weeks. Phase 2 was the implementation period of the intervention project and this lasted for 10 weeks.

Instructional methods

This research emphasizes the development of children's language skills through an explicit, teacher-directed approach and an exploratory, child-centered approach to acquiring science knowledge. There were two phases involved in this study. The lessons were crafted out after about four weeks of observation. It was designed based on a few guiding principles. Young children have a natural tendency to explore. There will definitely be some "science" in children's current daily playtime activities. Science education in school unites cognitive development and children's prior knowledge and experience with intuitive scientific theories to formulate new ideas. Rather than looking at isolated science concepts, science for early childhood education is intended to show children the "big picture." This study also adopts the interactive analytic approach whereby children are encouraged to describe, communicate their ideas as they make sense of their own learning, drawing prior knowledge and asking questions to acquire information.

Developmentally appropriate practices are being adopted in this program. They provide standards for identifying high-quality early childhood education program. Appropriate opportunities for learning are further supported by providing an environment that cultivates receptive and expressive language and cognitive development.

Problem solving is a way of life. Even the youngest of children face problems in their daily activities. Children should be presented with teaching models that require them to demonstrate various characteristics of effective problem-solving skills, methods, and strategies such as persistence, tolerance of ambiguity, use of related knowledge, use of logical reasoning, finding patterns, trial and error, dealing with data, planning a solution, solving a challenge, analyzing and evaluating solutions and working cooperatively.

In the development of process skills, the researcher used checklists to trace the development of conceptual development and process skills as a tool to assist in the process of scaffolding children's thinking towards a more accurate level of understanding (Rogoff, 1990; Vygotsky, 1991).

Data analysis

Three levels of analyses were conducted:

- (a) video analysis of classroom life
- (b) discourse analysis of interaction
- (c) artifact analysis of students' products.

These analyses were conducted to provide case study evidences that were gathered throughout the study and to exemplify science teaching and learning within an activity system. Triangulation will be ensured through the use of multiple data sources and methods of data collection, and through the analysis of the data.

5. Problems encountered

Throughout the course of study, the researcher stumbled across several difficulties mainly due to the deficit in language and mathematical logical skills. The table below briefly states the problems encountered.

Learning Outcomes	Difficulties encountered
Students experiment to clearly understand the concept of floating and sinking.	Children are still confused with the terms 'float' and 'sink' Most of them prefer to use their terms to explain the concept by stating 'on water' and 'in water'.
Students test a variety of items based on size.(same material/same shape)	Children lack the concept of size. Although they know what is big or small, they tend to relate increasing mass to increasing size. (Children tend to predict that the ping pong will sink because it is larger than the marble s o it is heavier than the marble) What is heavy, what is light? What does heavier than means?
Students test a variety of items based on shape.(same material/same size (mass))	Children have great difficulty associating shape to buoyancy. Some could grasp the concept that a boat-like shape tends to float better
Students test a variety of items based on	Children do not know the different types of

material.(same material/same size (mass))	materials. Due to time constrain, this concept was removed in the post assessment
Students learnt the effects of air on buoyancy	Children do not have the concept of air being a matter. They were not even sure what air is. This led to lessons addressing the concepts about air

One major difficulty the researcher faced lies in the failure to recognize the centrality of language and literacy to science education. These difficulties associated with the everyday use of the words as compared with its specific meaning in science. For example, the children in this study, associated the word “air” to wind. Wind is usually associated to the fan. Thus, these children tend to believe that air is only available in the presence of a fan. This confusion was easily dealt with in the teaching sequence through carefully constructed adult-child interaction. The teacher encouraged the children to explore the concept of “air” through manipulating of materials such as balloons, rubber tubes, empty cups etc (see appendix 1 for details of the lesson on air).

Gallas(1995) argues that students, together with the teacher, need to move towards “an inclusive kind of talk about science where everyone is allowed the appropriation of a science discourse”. The mediator needed to establish a set of scientific terms that have the same meaning to both the children and the mediator. This is important in order to establish a clear communication and to assist children in their need to verbalize their ideas on the concepts.

6. Findings

This study confirmed the possibility of enhancing the independent attitude of young children by ensuring a positive, healthy, social-emotional adjustment through the application of a science intervention programme, designed to enhance the quality of mediation provided to the children.

One of the most important factors observed in a mediator’s interaction with their students in relation to attachment, was the frequency of her responding to the students’ initiatives, especially when their responses appeared together with behaviours which conveyed acceptance and mediated competence to the young children.

Educators are more likely to be aware of educational goals related to teaching children new skills or ideas and are less conscious of mediated feelings, directly as well as indirectly through mediation commonly associated with cognitive enhancement. It is through these fine body language that the child develops their self esteem and this will lead to a child more willing to learn.

These children are very young, between the ages of three to four years old. With the emergence of the child's language skills, the mediator expanded on the reliance of words to bring forward the conceptual development through mediation processes such as explaining, labeling and associating.

With this mediation processes in place during the intervention program, the researcher saw a distinct improvement in these 3 areas:

- (1) Children have developed in their ability to provide higher-order explanation to their answers or observations. This reflects that deep learning has taken place.

Nature of explanation	
Higher-order explanation (Deep approach of learning)	Lower-order explanation (Surface approach of learning)
Describing unobservable entity <i>"Air in the glass bottle helps it to float"</i> Cause and effect relationship <i>- "If I put many marbles in this boat, it will sink"</i> <i>- "If I put this clay ball on this boat, it can now float"</i> <i>- "If I leave this aluminum foil flat, water comes up and it will sink, but if I make it into a bowl, it can float and even carry this clay ball!"</i> More detailed and elaborate, incorporating examples, analogies, real-life experiences. <i>- "If I take out the cap of this glass bottle, there got bubble, air come out, glass bottle sink"</i> <i>- "I go to the beach, I use the buoy, got hole in</i>	Vague and non-specific Cannot relate to the cause and effect. Look at it as discreet items/events Usually given when solicited. Requires much probing and scaffolding to produce a more complete explanation

<i>buoy, air come out, I cannot float with the buoy anymore, must blow some more, buoy bigger than I can float"</i> More forthcoming. (ie. Spontaneously generated requiring little or no prompting")	
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(2) They have developed in their ability in making predictions and justifications.

After lessons	Before lessons
Tend to give prediction almost spontaneously	Tend to be apprehensive about making prediction as they fear it might be wrong
All predictions are supported by explanation (explanation might not be the "right" answers but they are "valid" answers as they have a logically reasoning behind it)	Have difficulty supporting their prediction. Done at random. T: "What will happen to this object when I release it to the water" C: Sink T: "Why" C: Dunno

**C refers to the child's talking while T refers to the teacher/mediator talking

(3) They are starting to ask questions that reflect deep level learning
(higher-order questions)

Asking questions	
Deep approach	Surface approach
<ul style="list-style-type: none"> Focus on explanations and causes Willing to make predictions Reflect curiosity and puzzlement C: "This aluminum foil boat floats but this folded one sink. Why?" C: "Her boat float, mine sink. How to	<ul style="list-style-type: none"> Focus on factual recall of information C: "This toy, sink or float" C: "Oh, sink, ok."

make my boat float like hers?"	
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The mediated learning experience approach in this study, also nurtures children's social and emotional development. The socio-cultural forces is able to shape the situation of a child to becoming an independent learner. One of the key features of the intervention program in this study is the opportunity for children to work collaboratively, not only with their class-mates and the mediator, but at times, incidentally, the Kindergarten 2 children, who are sharing the same area during free play, provide assistance to these young children. Through their informal discussions, children who participated in this study was able to raise their level of understanding in buoyancy. These kindergarten 2 children were older and more matured and they are able to understand the idea of buoyancy faster than the younger ones. What was intriguing was how they use this knowledge to explain their younger peers in simple terms to enable these young children to have a better understanding of the concepts. Furthermore, the participants of this study look up to their older peers and took these children's enthusiasm as a form of role-modeling.

7. Discussion

Throughout the intervention program, children were given information that moved them from concrete to abstract. These information, sharing sessions were repeated in different context to emphasize the concepts. It was clear that children are more receptive to learning experiences which help them to understand everyday phenomena, no matter how difficult the concepts are perceived to be by the adult world. The process of an adult and child working together moves the child through to its zone of proximal development (the distance between the actual development level as determined through collaboration with a more capable peer) (Wertsch, 1985:67-68). This approach to learning has been labeled by Burner and Haste (1987) as scaffolding. It was evident that there was a gradual release of responsibility on the part of the mediator as the child is reaching the end of the intervention program. The child has internalized some of the required "tools" to take over the responsibility of learning.

As educators, we have a tendency of focusing on cognition at the expense of other equally important factors such as motivation. We believe that science enhances pupils' motivation as it relates to their daily life and involves hands-on materials. Early childhood experiences that are

pleasurable, is crucial for intrinsic motivation to occur. During these experiences, children are allowed to explore materials and situations that lead to deeper understanding.

Another aspect of this science intervention programme that leads to independent learning is the role of the teachers as mediators. Close identification with adults, who may accompany a youngster as he or she broaches a new domain is essential to enhance the child motivation. Youngsters crave the approval of adults whom they love, and these adults can acclimate pupils to the world of science in a fun way. Preschool is the best time to learn science because the children are learning for sheer interest or pleasure. Both teachers and pupils do not have to be answerable to any imminent exams, and this gives pupils more time to acquire the knowledge at their own pace.

8. What is the implication of scientific literacy to independent learning?

The following are findings that derived from this study.

Mixed-age groupings

One of the key features of this intervention program is the opportunity for children to work collaborative, not only with their class-mates and the mediator but at times, incidentally, the Kindergarten 2 children who are sharing the same area during free play, give assistance to these young children, thus raising their zone of proximal development. Through the discussions, children acquire their scientific vocabulary in a more meaningful way. As these children mature in their ability to communicate, they will also develop their scientific knowledge on scientific discourse on the topic on buoyancy.

The early childhood educational institutions in Singapore are still giving too much weight to specific age experience. The age at which children begin to contribute activities is strongly related to the social constrain offered by their community (Rogoff, 2003, p17). Development is viewed as the relationship between the child and society, it flourishes within a particular community where cultural diversity exists.

We propose building in structures that encourage collaboration across the different levels. A buddy support system whereby the older children guide the younger children during exploratory activities is one way to encourage collaboration among different age groups.

Talking science

Pole bridging is one type of “talking science” that requires the child to notice what he or she is doing. It requires children to pay attention to phenomena and comment aloud on the process they observed. It encourages observation of detail, classification, reflection and speculation. All these are actually powerful tools that are required to develop higher levels of thinking skills.

When a child does this at a very early age, he lays down discreet neural pathways, connecting language sites with other “poles” within the brain

The role of teachers as mediators

The importance of the mediator’s role in guiding children’s scientific learning and their ability to sieve “alternative framework” are essential to enable this approach to succeed. The teachers would require to equip themselves with the skills needed by mediators to use the proper scientific language to guide children’s progress in their conceptual understanding and to also use the proper scientific language to guide children’s progress in their conceptual understanding and to also monitor children’s progressive learning sequence to bridge the naïve understanding with the mature scientific understanding. In good teaching, there is a great deal of repetition, use of examples, and implicit use of terms and of principles across a variety of context (Lemke, 1990). Teachers must be aware of their role as mediators in a mediated learning experience. Teachers must be available to interact with children, even during free play, as they listen to their conceptions, preconceptions, and misconceptions. Teachers can encourage “talking aloud” about how a child arrived at his or her answer and encourage listening skills as children nearby explain their solutions (Sperry Smith, 2001). Questioning and guidance by teachers can lead children to the next level of learning.

The possible role played in early childhood science in children’s thinking processes

This study suggests that learning science at an early stage may yield positive consequences to the thinking processes and other cognitive domains. This study requires extensive replication, however, it suggests that certain activities may assume privileged roles in early childhood experiences

The crucial role played by emotional coding in early childhood learning

The formative role of emotions in learning is being increasingly recognized. Experiences that have emotional consequences are likely to be retained and utilized subsequently. In science

lessons, rich experiences are savoured and preserved, not primarily for practical reasons, but rather because there is inherent value in probing everyday experiences, making these experiences their own. The cultivation and elaboration of multiple representations, multiple intelligences, is crucial in developing an independent learner. Approaching science in a manner whereby children are invited to explore, in multiple, comfortable ways, the physical world, the biological world and the social world, allow children to self-regulated their learning

Future plans

To develop independent learners, the process of learning self-regulatory skills need to become self-sustaining. Certain self-regulatory components such as cognitive-strategy acquisition could be taught explicitly through scientific discussion in “pole-bridging” and when children are asked to justify their predictions or observations. The science activities exposed to young children need to be crafted such that they allow children to make decisions and choices about the course of their own learning . Only with such a “curriculum” can acquiring science literacy lead to children acquiring the “knowledge” (eg concepts, vocabulary etc), “skills”(eg manipulating objects, etc), “disposition”(habits of mind or tendencies to respond to situations in certain ways such as curiosity) and feelings (eg feeling of competence).

In the future, the goal of scientific literacy will be more than analyzing situations, but it also need to include guiding individuals to make the right decisions. The ultimate goal for scientific literacy for young children, is to serve as pillars for them to maintain a sense of responsibility, civility, and morality in a world full of harsh realities.

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