NURTURING BUDDING SCIENTISTS THROUGH INQUIRY-BASED LESSONS
Foo Wei Tint Velicia, Chow Wai Har Genevieve, Noryati Bt Ab Rahaman, Stella Fernandez

Abstract:

This paper reports on an action research project “Budding Scientists” which involves the use of inquiry-based lessons to foster positive attitudes towards science and equip pupils with the skills involved in planning investigations. This approach which involves the teacher as a facilitator of learning is very different to the approach traditionally used which involves the teacher playing the role of knowledge dispenser or teaching facts from the textbook.

The project “Budding Scientists” was launched for the Primary 3 and 6. Teachers used a variety of methods such as concept cartoons, discrepant events, news articles and questioning techniques to generate productive dialogue to motivate students to generate scientifically-oriented questions and to challenge assumptions. Through the inquiry-based learning strategies, pupils were encouraged to write out, formulate their hypotheses to the questions raised by them. They were also encouraged to plan investigations to test their hypotheses. Teachers had to probe pupils further to think about materials or apparatus they would require and the steps they would take, and the observations or recordings that they have to make in their investigative science projects.

Pupils’ attitudes towards science and their skills involved in planning investigations and were assessed before and after their experience of the inquiry-based lessons which were conducted over a period of 10 weeks.

Objectives:

The objectives of this study are to address pupils’ weaknesses at PSLE, examine if inquiry-based learning will promote pupils’ positive attitudes (such as curiosity, creativity, integrity, objectivity, open-mindedness, perseverance and responsibility) towards science and enhance their ability to plan and carry out investigations to test their hypotheses. As stated in the PSLE Subject Report 2006, pupils show weaknesses in the following areas:

- Lack of understanding of certain experimental processes as evidenced in their inability to suggest an appropriate control for an experiment and to give a reason for the purpose of an experimental setup.
- Difficulty in applying concepts to a new situation.
- Difficulty making predictions based on their understanding of the data given and identifying related concepts linked to the data.

In addition, according to Rogers (1969), learning is facilitated when the pupils participate completely in the learning process and has control over its nature and direction. Hence, this study was done to measure the effectiveness and potential in implementing inquiry-based lessons in the classroom when introducing Science concepts to primary school pupils as compared to direct instructions.

Research Questions

The following research questions are proposed to further investigate this learning heuristic:

1. Do inquiry-based lessons help to improve pupils’ attitude toward science?
2. Do inquiry-based learning enhance pupils’ ability to plan investigations to test their hypotheses?
Background and Introduction

The current method of teaching science in primary school is often didactic. Without any opportunity to explore and construct discrete science concept, pupils may find it difficult to conceptualize as they do not have hands-on experience during the learning process. Neither are they engaged as the teacher may only be a dispenser of knowledge. According to Songer and Linn (1991), pupils tend to learn by rote, instead of understanding the science concepts which may be too abstract for them.

Historical Background – The Learning Cycle

Children take in information through their senses, but they ultimately learn by doing. First, they watch and listen to their teachers. Then, they try doing things on their own. This sparks their interest and generates their motivation to self-discovery.

According to Kolb (1984), learning is a four-step process. He represented these in the experiential learning circle as shown in Figure 1 below.

![Figure 1. Learning Cycle](image)

The learning circle can begin at any point in the circle and it is a continuous spiral. Kolb drew primarily on the works on Dewey (who emphasized the need for learning to be grounded in experience), Lewin (who stressed the importance of people being active in learning) and Piaget (who described intelligence as the result of the interaction of the person and the environment).

Kolb believed that learners who have immediate concrete experiences that allow them to reflect on new experiences are able to use these concepts which they have formed in new and complex situations.
Inquiry-based Learning

According to Bell, Smetana and Binns (2005), inquiry is an active learning process in which pupils answer research questions through data analysis. Thus, inquiry-based activities start with a scientific question. Inquiry is central to science learning. When engaging in inquiry, pupils describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. They identify their assumptions, use critical and logical thinking, and consider alternative explanations. In this way, pupils actively develop their understanding of science by combining scientific knowledge with reasoning and thinking skills (National Science Education Standards).

The inquiry-based lesson which involves the teacher as a facilitator of learning is very different from the tradition approach which involves the teacher playing the role of knowledge dispenser or teaching facts from the textbook.

In addition, the inquiry-based lesson emphasizes on activities that investigate and analyze science questions, process skills and using the results of the experiments to make scientific arguments and explanations (Duschl, 2003).

The 5E Learning Cycle

The 5E’s Learning Cycle is a method of structuring a science lesson that is based upon constructivist learning theory, research-based best practices in science pedagogy and cognitive psychology. It is a recursive cycle of distinctive cognitive stages of learning that include: engage, explore, explain, extend, and evaluate. The science lesson often takes several days or weeks to complete.

The first stage is the "engage." This is the introduction to the lesson that motivates or hooks the pupils’ interest in the learning to follow. It can be a demonstration, a discussion, a reading or other activity used to tap into prior knowledge about the lesson and engage the pupils’ curiosity. It is used to uncover what pupils know and think about the concept or topic. This is followed with an "explore" activity that allows the pupils to have experiences with the concepts and ideas of the lesson. Pupils are encouraged to work together with guidance from the teacher. They observe,
question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.

The "explain" stage encourages pupils to explain concepts and definitions in their own words. Pupils are asked to justify and clarify their ideas.

The "extend" stage allows pupils to apply their explanations and skills in new, but similar situations. It often involves experimental inquiry, investigative projects, problem solving and decision making. Pupils proceeded to plan other investigation projects with minimal teacher guidance.

The "evaluate" stage assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies. Here, teachers bring a closure to the lesson by helping pupils summarise the relationship between the variable studied in the lesson and posing higher-order questions.

Even though the 5E’s were just described in a linear order, there are times when it is appropriate to loop back into the cycle before going forward. For example, several explore or explain loops may need to occur before pupils have the full ability to move forward into an extend session. Or, it may be that during the extend stage, the teacher may find pupils who need to revisit an engage activity. Evaluation is an ongoing process and is not generally left for the end activity. It is helpful to think of the 5E’s Learning Cycle as recursive and looping back on itself. It is also possible for a single E activity to have all of the other E’s embedded within it. For example, an extend session may well begin with engage, followed by brief explore/explain and be embedded with informal evaluations along the way. The idea of the 5E’s cycle being somewhat like a fractal with mini 5E’s building upon one another to create a 5E’s lesson can be an appropriate analogy.

**Effects of Inquiry-Based Lessons**

Science begins with the child asking questions. Children are naturally curious about their environment. They observe and openly seek to understand what they see. Thus, an inquiry-based lesson is a good vehicle for children to investigate their world and to acquire the skills and knowledge necessary to understand the world around them (Esler and Esler, 1996).

In many science curricula developed in recent years, it has been emphasized that acquisition of the science process skills should be one of the major goals of science instruction. Science as inquiry is basic to science education. Hence, students at all grades should have the opportunity to use scientific inquiry, including asking questions, planning and conducting investigations.

Investigations of inquiry based lessons have revealed that inquiry-based science lessons not only teach science process, but also enhance the curiosity of children and improve their attitudes towards science and school (Esler and Esler, 1996). Studies conducted by Freedman (1997) as well as Gibson & Chase (2002) have also proved that inquiry-based lessons improved pupils’ attitudes toward science.

Research has shown other positive effects upon children of learning science through an inquiry process. Wu and Hsieh (2006) examined the effect of inquiry-based lessons on sixth graders’ construction of explanations. The results showed that pupils demonstrated a significantly higher ability to identify causal relationships. They were also able to articulate the reasoning process and use data as evidence after they went through the inquiry-based lessons. The results indicated that the subjects in both treatment groups were identical statistically in logical thinking ability at the beginning of the treatment. Also, inquiry lessons help pupils develop critical thinking skills by gathering evidence to test their hypotheses, analyzing data quantitatively, and compiling explanations for conflicting results (Von Secker & Lissitz, 1999).
Research Method

Context of Study

A total of 117 Primary 3 pupils from 2 classes (3B and 3E) and 107 Primary 6 pupils from 3 classes (6C, 6D and 6F) of Marymount Convent School were involved in the study. 4 teachers who attended the Inquiry Science Thematic modules by the National Institute of Education had volunteered to implement the inquiry-based lessons in their classes.

The topic, Plants, was chosen for Primary 3 while the topic, Environment, was chosen for Primary 6. The team planned the inquiry-based lessons for Primary 3 (Appendix A) and Primary 6 (Appendix B) respectively, using the 5E Learning Cycle. An Investigation Plan template (Appendix C) was designed around the use of guided-inquiry and investigation. The team met to concur on the implementation of the inquiry-based lessons, observations, video-taping and feedback sessions. The Investigation Plan template guided the pupils towards understanding and utilizing inquiry-based science instructions rather than relying on the standardized instructions found in their activity books. The observation sheet (Appendix D) and reflection log (Appendix E and F) were prepared and given to the pupils to reflect and record their learning points. For the Primary 3, a checklist (Appendix G) was given to each group to guide them in their preparation for presentation.

Instrumentation

The inquiry-based lessons for the experimental classes were crafted for pupils to carry out investigation projects in groups of four. Each group was given a scrap book to document their learning process. With the objective of nurturing budding scientists, the groups had to name themselves after a scientist. They had to research on the scientist they had selected and find out about their achievements, contributions and the positive values and attributes they possessed (Appendix H). Their findings of the scientists were to be recorded in the scrap books and presented to the class. Each group was then given the opportunity to present their findings and the teacher highlighted the important traits of a scientist such as having perseverance, courage to accept failures and challenging assumptions.

Learning Process of the Primary 3

1st stage : ENGAGE

An animated concept cartoon was used to arouse the interests of the pupils. A question was raised at the end of the cartoon, “Can seeds grow in the dark?” Majority of the pupils were convinced that seeds could not grow in the dark as they had observed plants withering when there was not enough sunlight. The teacher then challenged them to come up with an investigation to prove that seeds cannot grow in the dark. As it was the first time the Primary 3 pupils were learning Science, the teacher had to use questioning techniques to scaffold and lead them to see the aim of their investigation, the materials required, the steps to follow and the observations to make.

2nd Stage : Explore

The teacher then distributed the necessary materials and apparatus which included 2 plastic pots filled with equal amount of soil, a few bean seeds, few pieces of cotton wool and a small measuring beaker. Pupils placed an equal number of seeds in each pot. All the groups had one pot placed near the window where there was light and another pot placed in a dark place such as in the locker, in their uniform pocket, or in a shoebox.
The pupils showed enthusiasm and were eager to observe the seeds during Science lessons. Given the template, pupils recorded their observations by drawing the growth of the seeds in the template given. Some pupils even took photographs of their seeds daily and pasted them in the scrap books given to them.

3rd Stage : Explain

Based on their observations, the pupils also wrote short notes to describe and explain the change in the appearance of the seeds. The pupils were excited to share their findings with one another. They began to ask questions on the conditions necessary for seeds to grow. To facilitate independent learning, the teacher placed some books related to life cycle of plants in the Science Corner of the classroom.

After a week, the pupils were asked to compare the growth of their seeds. A few groups had forgotten to water the seeds and so their seeds died whilst the careful ones found that the seeds grew well when enough water was given daily. Yet a few others added too much water and found the young plants rotting and dying. Each group had to make an oral presentation of their findings which were documented in their scrap book.

4th Stage : Elaborate or Extend

Having completed their investigation projects, the teacher helped to extend the pupils’ skills and knowledge in another similar but new situation. As the next topic was “Fungi and Microorganisms”, the teacher showed the class a piece of bread with mould. To encourage pupils to generate their own inquiry questions, the teacher brought in some fruit specimens and gave them to each group. Pupils were asked to generate their inquiring questions about the conditions that support the growth of fungi and microorganisms. The following are questions generated by the pupils:

- Does the fruit rot faster with or without air?
- Does the fruit rot faster or slower in cold temperature?
- Will the fruit rot more quickly if the skin is peeled off?
- Will the fruit rot more quickly in bright or dark places?
- Will different types of fruits take the same period of time to rot?

With new questions generated, the teacher gave another template for each group to plan their investigations. The groups had to hand in their plans for the teacher to assess before they could carry out the next investigation project as an extension activity.

5th Stage : Evaluate

At this stage, the pupils realized that to make conclusions, they needed data to verify their findings and give supporting evidences to convince their friends. The teacher had to clarify with her pupils why some of the experiments worked while some with similar settings did not work out in the same way. Many possibilities were noted and the pupils showed a better understanding of carrying out a fair test. Pupils were rewarded for keeping good records and applauded for their effort and perseverance to study carefully and make accurate predictions and conclusions. The teacher then guided the pupils to use a concept map to link all the various factors that affect the germination of seeds.
Learning Process of the Primary 6

1st Stage : ENGAGE

To engage pupils in the topic on environmental impact on plant’s growth, two discrepant events were used. The first was a news article on the Brooklyn Botanic Cherry trees that blossom in early January this year (Appendix I). Cherry trees normally blossom in the summer when the temperature is higher. However, due to climatic change that resulted in a warmer winter, the cherry trees blossomed unexpectedly in winter time last year. The second article was about frozen oranges in Florida, United States (Appendix J). Despite the fact that South Florida enjoys a generally warm, subtropical climate, extremely cold temperatures are still possible. The extremely cold temperature can cause widespread damage to sensitive plants and crops.

2nd Stage : Explore

The class proceeded to investigate the truth of the statement “Environmental changes affect the growth of plants”. The teacher then elicited from pupils at least eight environmental factors that affect the growth of plants (e.g. temp of surrounding, amount of light, type of soil etc.)

In groups of four, each group had to plan an investigation using one of the 8 factors as an independent variable. Firstly, they generated a hypothesis related to the independent variable assigned to their group. Next, the groups started to plan their investigation. They had to state the aim of the experiment, materials needed, the steps involved in the experiment, how to record their results and conclude on what the group had found out.

The pupils recorded their observations daily in their scrap book – measuring the height of the plants as well as taking photographs of the plants. They were very eager to find out if their hypothesis were right.

3rd Stage : Explain

After three weeks of observation, each group presented their findings to their classmates. As the groups presented, the teacher checked if their conclusions (i.e. Environmental changes affect the growth of plants) were consistent. Then, the teacher led pupils to see that there is only one independent variable in a fair test and proceeded to explain how environmental factors can impact the survival of plants.

4th Stage : Elaborate or Extend

Pupils then went on to draft a proposal for the Shell Primary Science Fair 2007. The objectives of the Science Fair were:

- To provide pupils the opportunity to apply Science concepts, which they have learnt by conducting simple scientific projects, which in turn sharpen their Science process skills.
- To encourage pupils to look beyond their textbooks and to investigate further matter or phenomena that interests them.
- To provide the opportunity for pupils to use their creativity to solve problems based on Science concepts.
- To encourage team effort among pupils.
- To encourage pupils to share their findings and experience with others.

In line with the theme “Science and the Environment”, the pupils had to plan another investigation project in groups of four using the template provided (Appendix K). The teachers vetted the proposals and gave pupils feedback before they embarked on their next investigation projects. From amongst the 26 projects by the three Primary 6 experimental classes, two projects would be selected for submission to the SHELL Primary
Science Fair. The fair is held biennially by the Singapore Science Centre, Science Teachers Association of Singapore (STAS) and SHELL companies in Singapore and it provides a platform for pupils to showcase Science projects of a high standard.

5th Stage: Evaluate

The class recapitulated what they have learnt. The teacher brought a closure to the lesson by using questioning techniques to help children recall what they have found out in their investigations. Finally, the pupils created concept maps to link all the various environmental factors. This promoted collaborative learning among the pupils.

Summary of teachers’ feedback

The teachers were enthusiastic to be involved in this research study as they had attended the NIE Thematic modules and were keen to implement the inquiry-based lessons in their classrooms. Teachers involved were motivated to read up on literature on the benefits of inquiry-based teaching and learning. They were convinced that inquiry Science would impact pupils’ understanding which would then improve their performance in the subject.

However, the teachers were quite concern that this type of learning is very time-consuming and thus they may not be able to keep up with the pace of the syllabus. At the end of the study, feedback was positive and unanimous and the teachers felt that the 5E Learning cycle is a useful tool. It provides the platform for pupils to grasp scientific concepts through the discovery method where the pupils themselves were able to construct discrete science concepts as they journeyed through the process of questioning, exploring, predicting and discovering through the explanations using the information and data they collected to answer their assumptions and predictions.

The teachers noticed that the pupils were motivated during the lessons and this further spurred their own motivation to carry on with the teaching. Pupils became more engaged as they took ownership of their investigation. Using question techniques, the teachers acted more as facilitators than mere knowledge-givers.

Summary of pupils’ feedback on lessons

Pupils were generally keen, enthusiastic and energetic when they were carrying out the investigative project. They were eager to test out their hypothesis and find out if their predictions are true. Thereafter, the pupils’ curiosity was further aroused and they were motivated to find out more about the topic on their own, thus becoming independent learners. Majority of the pupils showed a marked improvement in their ability to plan an investigation project when they did it the second time. For instance, two projects from the Primary 6 were shortlisted from amongst 211 proposals submitted by 96 schools, for showcasing at the SHELL Primary Science Fair. One of the teams even won the Most Comprehensive Report Award.

Through the qualitative data analysis, the findings showed that 93% of the experimental group indicated that they were more interested in Science after doing the project. 91% are now more curious to investigate and 95% feels that through the investigation, they are able to understand Science concepts better. 74% of pupils are now more confident to plan their own investigation.
Excerpts from Pupils’ Reflection Log

After doing the project…

1. I am more interested in science because…..

   “After the project, I found out that doing a project helps us understand something.”
   Victoria, Pri 3B

   “I learnt many things about plants which is not easy to understand.”
   Clarissa Faith, Pri 3B

   “I feel happy to take care of my plants and my friends and I get to work together as a team. We have learnt to cooperate. Though we argued, we listened to other people’s advice.”
   Min Si, Pri 3E

   “It interests me when I do “hands-on” and I can get to see the results myself.”
   Amanda Teo, Pri 6C

   “We can learn things in interesting ways and I like it.”
   Isabelle Dolor, Pri 6C

   “This project has captivated me and previously I was not interested in plants but this project has changed my thinking.”
   Viraj Desai, Pri 6F

2. I am now more curious to investigate because ……

   “I am curious to investigate because there is still more to learn about the things around us.”
   Keva Mohan, Pri 3B

   “Investigating is the answer to all your questions.”
   Neevetha, Pri 3B

   “It makes me want to know more and want to find out things that I do not know.”
   Geraldine Teo, Pri 6C

   “There have been many things I did not know. Although I learnt a lot after the project, new questions have not been answered. I am curious to investigate as there are many more answers I want.”
   Viraj Desai, Pri 6F

3. Through investigation, I am able to understand science concepts better because …..

   “The experiments are a fun way of learning.”
   Anastasia, Pri 3B

   “I get to observe and see what happens.”
   Dayna Siat, Pri 3B
“I see my plant change each day and I get to observe and record the changes and watch my plant reproduce.
Yu Yan, Pri 3E

“It gives me a clearer view of things.”
Rebecca Neo, Pri 6C

“I can learn better when I do the experiment myself.”
Venus Yap, Pri 6D

4. I am now more confident to plan my own investigation because .......

“We learnt to compare and realized that we can always ask the teacher when we are not sure, so that we do not have to carry out the experiment all over again.”
Shafiqah, Pri 3E

“This experiment has built up my confidence and patience as the plants need time to grow.”
Denise Goh, Pri 6C

“I have learnt that it is not easy to plan my own investigation but after going through the process, I now understand better and is more confident about planning.”
Lim Sherwynn, Pri 6C

“I have experienced the process of the investigation and am now more familiar with it.”
Viraj Desai, Pri 6F

“I know which variables to keep the same and which one to keep constant.”
Amalyn Aisyah, Pri 6F

Challenges of Implementing Inquiry

One major challenge facing teachers in teaching inquiry science in school is the lack of readily available instructional resources to enhance teaching and learning. Thus it becomes tedious and time consuming for teachers to prepare resources for each topic in the science syllabus. At the same time, teachers are also grappling with issues on how to apply the new and emerging technologies into their inquiry-based lessons.

Another main challenge is students’ assessment. In spite of this paradigm shift in the teaching of science, the final assessment is still heavily orientated toward content mastery -- mastery of "what we know" rather than a focus on "how we come to know." Thus, conceptual understandings, skills development, and nurtured habits of mind which are difficult to assess is superseded by traditional paper-pencil type assessments.

The support and involvement of parents to accept the changes in the education system is also a challenge in the implementation of inquiry-based lesson. Many parents have a fixed mindset that students should memorize and know content, do lots of homework (even though it might lack relevance), and do well in examinations. They also think that the focus on skills development is not important so there is a need to make these stakeholders aware of its importance.

In addition, teachers also need time to first educate themselves about the process and then help convince other teachers of its value. Teachers attempting inquiry-based lessons for the first time may not experience success. Thus, a teacher may need experience to ensure that the right condition is set in the classroom before a good inquiry-based lesson can take place in the classroom. Also, teachers have to help students...
develop skills to be good investigators and train them to be independent learners during the process of implementation.

Conclusion

To teach science as inquiry, a teacher has to allow children some ownership of the process which means giving the children opportunities to get connected with questions that are of interest to them, as well as to find ways to answer those questions. Engaging in inquiry provides opportunities to help children develop ways of understanding the world around them.

The positive impact of inquiry-based lessons on pupils cannot be denied. These lessons not only teach pupils’ process skills, they also enhanced children’s curiosity and improve their attitudes towards science and school.

The pupils in the experimental groups have shown that they were able to plan their own investigations to test their hypotheses and explain scientific concepts based on their observations. Inquiry-based lessons also helped them to apply these concepts to new situations during the elaborate or extend stage. Furthermore, the pupils have expressed a greater interest in science and are able to understand science concepts better after these inquiry-based lessons.

References


Appendix A: P3 Lesson Plan

5E LEARNING CYCLE INQUIRY-BASED LESSON PLAN

1. INQUIRY QUESTION

What are the conditions that enable seeds to grow?

2. SCIENTIFIC CONCEPT TO BE CONSTRUCTED

Plants reproduce to ensure continuity of their kind. Pupils will observe how some plants grow and develop during various stages of their life cycle.

In this topic, students will observe the germination and growth of seeds and record the critical conditions for seeds germination. The misconception that sunlight is needed for the germination of seeds will be addressed.

3. MOE CPDD SYLLABUS LEARNING OUTCOME (SKILLS & PROCESS)

To identify the factors that affect seed germination.

4. SCIENCE ATTITUDES TO NURTURE (CPDD LEARNING OUTCOME)

Show objectivity by using data and information to validate observations & explanations about the factors that affect the growth of a seed

5. MATERIALS NEEDED

• Seeds
• Pots
• Soil
• Measuring cylinder
• Scrap books

6. LESSON OUTLINE

<table>
<thead>
<tr>
<th>STAGE #</th>
<th>ACTIVITY / TASK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1: Engage (5 min)</td>
<td>(1) Purpose of the lesson To identify the conditions for seeds to germinate.</td>
</tr>
<tr>
<td></td>
<td>(2) Use a discrepant event to hook the students into learning by creating cognitive dissonance or disequilibrium (a) Show concept cartoons to students: Sunny Bean vs Sleepy Bean</td>
</tr>
<tr>
<td>Stage 2: Explore</td>
<td>(1) To investigate the truth of this statement: “Light affects the growth of a seed.” Teacher informs pupils that they will have an opportunity to observe the growth of a seed and see if light is needed for the seeds to germinate. (2) Student-centred activity to gather data: (a) In small groups of 4, each group plan an investigation to investigate the truth of the statement “Light affects the growth of a seed.”</td>
</tr>
</tbody>
</table>
(b) Groups generate a hypothesis related to the independent variable
(c) Groups to plan their investigation:
- Aim of the experiment
- Materials needed
- Steps in experiment
- How to record their results
- Conclude on what the group has found out

<table>
<thead>
<tr>
<th>Stage 3: Explain</th>
<th>Teacher-directed activity for concept development</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Teacher-directed activity for concept development.</td>
<td></td>
</tr>
<tr>
<td>- Each group shares their findings.</td>
<td></td>
</tr>
<tr>
<td>- Teacher checks if their conclusions (i.e. sunlight is not needed for the germination of seeds) are consistent</td>
<td></td>
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<tr>
<td>- Teacher consolidates concepts on the factors that affect the growth of seeds.</td>
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</tbody>
</table>

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<tr>
<th>Stage 4: Extend</th>
<th>Teacher-directed activity to reinforce the concept by extending and applying the evidence to new and real-world situations outside the classroom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan another investigation to find out what affects the growth of fungi on different kinds of fruits.</td>
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</tbody>
</table>

| Stage 5: Evaluate | Use concept map to link all the various factors that affect the germination of seeds. |
Appendix B: P6 Lesson Plan

5E LEARNING CYCLE INQUIRY-BASED LESSON PLAN

1. INQUIRY QUESTION

What are the conditions that enable seeds to grow?

2. SCIENTIFIC CONCEPT TO BE CONSTRUCTED

Pupils should observe and record the changes in a particular plant when grown from seeds. Environmental issues such as global warming, depletion of natural resources and pollution are concern in the world community. As part of this community, students need to be instilled with environmental consciousness.

In this topic, students are introduced to basic concepts of conservation of natural resources. They will also learn about pollution and its impact. They are also encouraged to take an active role in protecting and maintaining the environment.

3. MOE CPDD SYLLABUS LEARNING OUTCOME (SKILLS & PROCESS)

To identify factors that affect the survival of an organism e.g. physical characteristics of the environment

4. SCIENCE ATTITUDES TO NURTURE (CPDD LEARNING OUTCOME)

Show objectivity by using data and information to validate observations & explanations about the factors that affect the growth of a seed

5. MATERIALS NEEDED

- Seeds
- Pots
- Soil
- Measuring cylinder
- Scrap books

6. LESSON OUTLINE

<table>
<thead>
<tr>
<th>STAGE #</th>
<th>ACTIVITY / TASK</th>
</tr>
</thead>
</table>
| Stage 1: Engage (5 min) | (1) Purpose of the lesson
To identify the factor that affects the survival of an organism (e.g. physical characteristic of the environment)

(2) Use a discrepant event to hook the students into learning by creating cognitive dissonance or disequilibrium
(a) Show students news articles on Cherry Blossoms blooming in winter
http://cbs2.com/national/topstories_story_002194213.html

(b) Show students news article of frozen oranges
http://www.srh.noaa.gov/mfl/hazards/info/about_cold.php |

Stage 2: | (1) To investigate the truth of this statement: |
<table>
<thead>
<tr>
<th>Explore</th>
<th>“Environmental changes affect the growth of plants.” Teacher elicits from pupils at least 8 environmental factors that affect the growth of plants (e.g. temp of surrounding, amount of light, type of soil etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>(2) Student-centred activity to gather data:</strong> (a) In small groups of 4, each group plan an investigation using one of the 8 factors as an independent variable. (b) Group generate a hypothesis related to the independent variable assigned to their group (c) Groups to plan their investigation: - Aim of the experiment - Materials needed - Steps in experiment - How to record their results - Conclude on what the group has found out</td>
</tr>
<tr>
<td>Stage 3: Explain</td>
<td><strong>Teacher-directed activity for concept development</strong> (a) Ask each group to share their findings and check if their conclusions (i.e. Environmental changes affect the growth of plants) are consistent (b) Teacher lead pupils to see that there is only one independent variable in a fair test (c) Teacher explains how environmental factors can impact the survival of plants</td>
</tr>
<tr>
<td>Stage 4: Extend</td>
<td><strong>Teacher-directed activity to reinforce the concept by extending and applying the evidence to new and real-world situations outside the classroom</strong> (a) Students to draft a proposal for the Shell Primary Science Fair 2007.</td>
</tr>
<tr>
<td>Stage 5: Evaluate</td>
<td><strong>Use concept map to link all the various environmental factors</strong></td>
</tr>
</tbody>
</table>
INVESTIGATION PLAN

Group Name : ________________________
Group Members :
(1) _____________________
(2) _____________________
(3) _____________________
(4) _____________________
(5) _____________________

Aim :
_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________

Materials :
(1) 

(2) 

(3) 

(4) 

(5) 

Procedures :
(1) 

(2) 

(3) 

(4) 

(5) 

Conclusion :
_____________________________________________________________________________________
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### Appendix D: Recording Template

**Group Name**: ___________________

**Observations**: :

<table>
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<tr>
<th>Day 1</th>
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<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
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<th>Day 11</th>
<th>Day 12</th>
<th>Day 13</th>
<th>Day 14</th>
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</table>
Appendix E: Reflection Log 1

Dear Diary,

During the experiment, I found out that ...

At the end of the experiment, I found out that ...

By doing this experiment, I have learnt that ...

After doing this experiment, I feel that ...

Sign off,

_______________________
Name:
Date:
<table>
<thead>
<tr>
<th>+  PLUS  +</th>
<th>-  MINUS  -</th>
<th>😊 INTERESTING 😊</th>
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## Appendix G: Checklist for P3 Presentation

### CHECKLIST

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<th>No.</th>
<th>Items.</th>
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<tr>
<td></td>
<td><strong>EXPERIMENT</strong></td>
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</tr>
<tr>
<td>01</td>
<td>Aim of experiment</td>
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</tr>
<tr>
<td>02</td>
<td>Findings</td>
<td></td>
</tr>
<tr>
<td>03</td>
<td>+ / - / Interesting</td>
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<tr>
<td></td>
<td><strong>INFORMATION ON SEED</strong></td>
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<tr>
<td>04</td>
<td>Name of seed</td>
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<tr>
<td>05</td>
<td>Scientific name of seed</td>
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<tr>
<td>06</td>
<td>Picture of seed</td>
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</tr>
<tr>
<td>07</td>
<td>Where it comes from (originate)</td>
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</tr>
<tr>
<td>08</td>
<td>Procedures to grow a seed</td>
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</tr>
<tr>
<td>09</td>
<td>Ideal condition to grow a seed</td>
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<td>10</td>
<td>Reflection by group members (1 line per member)</td>
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### ROLES OF GROUP MEMBERS

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<thead>
<tr>
<th>Name</th>
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What to research on?

- Name of scientist
- Photograph
- Biography
- His works
- Prizes won (if any)
- What qualities and values does the Scientist have?
Appendix I: Discrepant Event 1

Cherry Jubilee

January 2007

Prunus 'Fudan-Zakura' (Photo by Kate Blumm, Courtesy of Brooklyn Botanic Garden)

What better way to appreciate the unusual warmth of this winter than to view Brooklyn Botanic Garden's "cherry jubilee"? Presently, there are five everblooming cherries (Prunus 'Fudan-Zakura') in flower at Brooklyn Botanic Garden, bringing an extra touch of magic to an already exceptional winter season. Though the everblooming cherries are expected to flower in late November, the amount of blossoms on the cherry trees at this time has astounded visitors to the Japanese Hill-and-Pond Garden. The trees are boasting thousands of flowers—instead of the couple of hundred that usually appear during the November bloom—thanks to the mild weather of the past several weeks.

Despite this extraordinary blossoming, the everblooming cherries will bloom again in the spring per their "regular" schedule, making this event a rare preview of New York's rite of spring, Hanami—the Japanese tradition of viewing and cherishing each moment of the cherry blossom season. During Hanami, visitors can witness the breathtaking cycle of flowering cherry trees—from the first buds to the brilliant blossoms to the petals falling like pink snow—and celebrate Sakura Matsuri, a two-day celebration of Japanese culture with over 60 events and performances.
Appendix J: Discrepant Event 2

Cold Weather Hazards: Freezes and Wind Chill

Source: http://www.srh.noaa.gov/mfl/hazards/info/about_cold.php

Despite the fact that South Florida enjoys a generally warm, sub-tropical climate, extremely cold temperatures are still possible.

A recent study revealed that from 1979 to 1999, 124 people in Florida died from the cold, not including those who have perished in house fires started by space heaters, or from other secondary causes. Numerous deaths usually occur during brief cold snaps, such as in December 1989 when 26 Floridians died from hypothermia.

Freezing Temperatures. Because of normally mild temperatures, Florida homes often lack adequate heating and insulation. Also, the Florida outdoor lifestyle can lead to danger for those not prepared for freezing temperatures. In addition, freezing temperatures in South Florida can cause widespread damage to sensitive plants and crops. Fortunately, overnight temperatures rarely drop below freezing in South Florida, especially along the coasts. Inland areas are more susceptible to below freezing temperatures, primarily during the middle part of January. In addition, inland sections of the metropolitan areas are more likely to experience freezing temperatures than coastal areas.
INVESTIGATIVE PROJECT PROPOSAL (CATEGORY A)

1. What do you want to find out? What questions do you want to answer? (PROBLEM)

2. What materials do you need to use? (MATERIALS)

3. What will you do to find out? (PROCEDURE)

4. What do you think will happen? (HYPOTHESIS)

5. What did you learn from this experience? (LEARNING POINTS)

PROJECT AREA (Please circle one):
BIOLOGY / CHEMISTRY / PHYSICS / MATHEMATICS / GENERAL