Abstract—The overall project is an architectural response towards the problematic science education in Indonesia. A number of international tests in 2012 has shown the low performance of Indonesian primary and high school students in the subject of mathematics and science. The results show that, despite high academic qualifications, Indonesian students fail to develop their basic learning skills, which becomes critical during high school years. The condition is a result of too much emphasis being put towards cognitive learning objectives, ignoring affective and psychomotor aspects which are also crucial to a child’s learning development. ‘SciencePlay’ is designed to provide alternative science and technology learning for children ages 5-14 through the use of playful and intriguing spaces. The paper attempts to explain and discuss the underlying key factors contributing towards the design.

Keywords—Science, children, design, learning.

I. INTRODUCTION

Three sets of international education survey results were released at the end of 2012. Results for Indonesia were shocking. Trends in International Mathematics and Science Studies (TIMSS) 2011 noted a worrying fact in Indonesian students’ mathematics and science capabilities. Indonesia was ranked 38 out of 42 in mathematics, and ranked 40 out of 42 in science competencies. The evaluation was based on educational performances of junior high schools. This was followed by the Progress in International Reading Literacy Study (PIRLS) 2011 which noted Indonesian student’s literacy skills (still educationally related) at number 42 out of 45 countries. The most surprising, perhaps, is the Programme for International Student Assessment (PISA) results. The test not only measures educational competencies, but also capabilities on using educational knowledge to solve real-life problems. The evaluation had been conducted in the years 2003, 2006, and 2009. The results show that Indonesia ranked 60 out of the 65 countries observed.[1]

On the other hand, Indonesian students are among the highest-numbered science studiers, and are consistently involved in international educational Olympics, even producing winners in the field of mathematics and science. The results show that, despite high academic qualifications, Indonesian students fail to develop their basic learning skills, which becomes critical during high school years.
The situation is a major problem in a highly developing world heavily reliant on technology, which finds its roots in the continuous progress of science. Taking note of the problem, the author is challenged to respond to the problem architecturally. Architecture, as a means of creating a built environment may be key to creating an alternative hub towards science education, especially for children. The role that architecture can contribute towards the problem is by inducing new forms of science education aspects different to that of a schooling environment, with elements suited to children’s nature and levels of learning.

II. DISCUSSION

A. Best Practices in Learning Science

The most effective way of understanding science, is through experiencing science itself through the scientific method, which includes:

1. Forming a hypothesis
2. Discover variables
3. Making an observation
4. Doing an experiment
5. Collating data and results
6. Formulating an analysis
7. Arguing upon a formed theory
8. Reviewing and evaluating their own method

The statements are in line with Bloom’s taxonomy of learning objectives which states that in order to develop properly, children’s learning need to cover three major areas:

1. Cognitive: mental skills (knowledge)
2. Affective: growth in feelings or emotional areas (attitude or self)
3. Psychomotor: manual or physical skills (skills)

The taxonomy suggests that the development of all three learning domains to be balanced, in order for children to develop their learning properly.

In Indonesia, the practices are not effectively being implemented in schools. Lessons are carried out in class where experiments are rare and students spend more time studying and memorizing formulas. Science teaching in practice is heavily cognitive and lacks affective and psychomotor leaning. Therefore, if SciencePlay were to succeed, it needs to implement elements of affective and psychomotor leaning.

The content within science education is also an important factor to be noted. Science in Indonesia is being introduced as a general concept in primary school, and becoming categorized (differentiated into subjects of biology, chemistry and physics) throughout high schools.

To this extent, there is the question of which science subjects are exactly appropriate for children to study. "Taking Science to School: Learning and Teaching Science in Grades K–8" provides a thorough explanation on the topic. The book recommends the following subjects to be introduced to children:

1. Simple Physics; simple principles of Physics; properties of everyday objects and forces that affect the m
2. Naïve Psychology; relating to simple understanding of human emotions and behaviours

<table>
<thead>
<tr>
<th>No.</th>
<th>Type</th>
<th>Level of Interactivity</th>
<th>Information Depicted</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Display walls</td>
<td>Low</td>
<td>multiple objects surrounding a particular theme</td>
</tr>
<tr>
<td>2</td>
<td>Multimedia exhibits</td>
<td>Medium</td>
<td>additional in-depth information or media quiz/games, especially for older audience</td>
</tr>
<tr>
<td>3</td>
<td>Info panels</td>
<td>Medium</td>
<td>series of information, visual presentations</td>
</tr>
<tr>
<td>4</td>
<td>Hands-on elements</td>
<td>High</td>
<td>Demonstration of particular actions and consequences; more interactivity is achieved if it covers various dimensions of space around it</td>
</tr>
<tr>
<td>5</td>
<td>Themed areas</td>
<td>High</td>
<td>Settings of a particular time and place and a variety of information relating to it</td>
</tr>
<tr>
<td>6</td>
<td>Simulators</td>
<td>Very High</td>
<td>Demonstrate real-life (although subdued) phenomenas which can be felt by audiences</td>
</tr>
</tbody>
</table>
3. Biology/Natural World; understanding of organisms and natural phenomena
4. Materials and their properties; differentiating between different types of materials, elements of which they are comprised of and the properties they hold
5. Energy; a current issue in today’s world, with an emphasis on renewable energy and renewable sources of energy

B. Children’s Behaviour Relating to Play

A natural way of developing children’s affective and psychomotor aspects is through playing. Playing is a natural mechanism embedded in children to learn about their surrounding environment. There are five types of play experienced by children[6]:

1. **Physical games:** games which test their ability in action and movement, as well as balance and coordination, including jumping, running, cycling, crawling, climbing, sliding.

2. **Social games:** social or relational games including hiding, chaging and role-playing

3. **Creative games:** modelling and transforming physical properties of certain materials, requiring the use of imagination and creativity

4. **Sensorial games:** playing by stimulating the senses through elements of touch, auditory, visual and olfactory (smells).

5. **Peace-and-quiet games:** concentrating, focusing on certain play elements and enjoy an individual activity.

Children of 5-12 years are at their most active and at the peak of learning[6]. There are several important characteristics which may be attributed to this age group:

1. Socially aware
2. Enjoy playing things which represent something else (abstract elements)
3. Enjoy games with movement and action
4. Enjoy testing their dexterity
5. Able to play structured games in teams
6. Like to demonstrate balance and coordination
7. Like to group together without adult supervision

There are, however, specific interests between different age ranges. Broto divides into three major categories:

1. 3-6 years: playing in groups and playing with abstract elements
2. 6-8 years: games with movement and action and complex motor responses
3. 8-10 years and upwards: structured games and games demonstrating powers of balance.

C. Forms of Science Displays

To understand how principles of science are displayed engagingly, observations have been made to two different science centers; Taman Pintar in Yogyakarta, Indonesia and

<table>
<thead>
<tr>
<th>Exhibition Theme</th>
<th>Sub-Theme and Representation</th>
<th>Age Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple Physics</td>
<td><strong>E1:</strong> Light&lt;br&gt;A prism in a dark room that splits a ray of light along the length of the room</td>
<td>5-8</td>
</tr>
<tr>
<td><strong>E2:</strong> Gravity &amp; Movement&lt;br&gt;A climber set</td>
<td>5-8</td>
<td></td>
</tr>
<tr>
<td><strong>E3:</strong> Sound &amp; Speech&lt;br&gt;Rhythmical walls</td>
<td>5-8</td>
<td></td>
</tr>
<tr>
<td><strong>E4:</strong> Electromagnetics&lt;br&gt;Spaces placed in zig-zag order at particular lengths to demonstrate representation of the electromagnetic spectrum.</td>
<td>9-10</td>
<td></td>
</tr>
<tr>
<td><strong>E12:</strong> Solids, Gas &amp; Liquids&lt;br&gt;&quot;Under the microscope&quot;</td>
<td>11-14</td>
<td></td>
</tr>
<tr>
<td>Natural World</td>
<td><strong>E5:</strong> Land, Flora &amp; Fauna&lt;br&gt;Hunting to animal caves</td>
<td>9-10</td>
</tr>
<tr>
<td><strong>E6:</strong> Sky &amp; Space&lt;br&gt;Under a sky dome</td>
<td>9-10</td>
<td></td>
</tr>
<tr>
<td><strong>E7:</strong> Ocean &amp; Underwater&lt;br&gt;Descending underwater tunnel</td>
<td>9-10</td>
<td></td>
</tr>
<tr>
<td><strong>E9:</strong> Human Body&lt;br&gt;Inside the rib cage</td>
<td>11-14</td>
<td></td>
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</tbody>
</table>
Science Center in Singapore. Observations include noting down different types of display and what types of information they are used to convey, as well as the level of interactivity they provide. The results can be viewed in the Table I.

III. OUTPUTS

A. SciencePlay Description

SciencePlay is a place for children to learn science and technology informally, or in a playful way.

SciencePlay is typologically a science museum. However, this main function is disguised by its appearance as more as a play arena for children, which incorporates science and technology exhibitions. The architectural structure is also an object of play. Through exploring the space, children are encouraged to learn about basic, everyday science and technology principles.

The object must serve as a delight for children and families to play its role. It does so by offering a scientific and also high-technology environment which provides a playful, interactive social climate. Behaviour of the users are modified to promote curiosity and all-round learning. It contains activities of learning, disguised as games or objects of play in a series of exhibitions.

B. SciencePlay Curriculum

The design of SciencePlay incorporates Taking Science to School: Learning and Teaching Science in Grades K-8 as a basic curriculum for all the exhibitions within, but each topic has been expanded into different types of exhibition. The result is 14 different exhibition spaces. Each space is intended for a specific type of audience, which is based on an evaluation of children’s learning processes and their behaviour in play. Each space is represented by a dominant exhibitional display relating to its theme. The representation should also comply to the issue of interactivity within the space (Table II).

C. Overall Design: Space Programming

Spaces containing exhibitions are programmed per age group. Each age group is defined by a different building mass. Each building mass contains a minimum of three exhibitions, each with a minimum area of 60m²:

1. Building A: ages 5-8, containing simple physics
2. Building B: ages 9-10, containing natural world exhibitions and one simple physics of electromagnetics
3. Building C: ages 11-14, containing naïve psychology and additional multi-purpose room for communal activities
4. Building D: ages 11-14, containing more advanced physics and communal spaces; temporary exhibition and library
5. Building E: ages 11-14, indicate the ‘highest peak’ of learning in SciencePlay, devoted towards energy topics.

<table>
<thead>
<tr>
<th>Exhibition Theme</th>
<th>Sub-Theme and Representation</th>
<th>Age Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naïve Psychology</td>
<td>E10: Human Emotions</td>
<td>11-14</td>
</tr>
<tr>
<td></td>
<td>3D Puzzles of human emotions</td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td>E13: Geothermal Energy</td>
<td>11-14</td>
</tr>
<tr>
<td></td>
<td>Journey to the center of the earth</td>
<td></td>
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<tr>
<td></td>
<td>E14: Electricity</td>
<td>11-14</td>
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<td></td>
<td>Tesla Coil</td>
<td></td>
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<tr>
<td></td>
<td>E15: Solar Energy</td>
<td>11-14</td>
</tr>
<tr>
<td></td>
<td>‘Into the sun’</td>
<td></td>
</tr>
</tbody>
</table>

Image 3. Overhead view of SciencePlay, consisting of five building masses.
Each building mass has its own entrance which also serves as an exit. Each building mass contains a minimum of three exhibitions, each one bearing a minimum area of 60m², which are connected in a two-way relation towards each other.

Spaces are arranged in a circular route, to give the impression of space flexibility throughout the building. Utilities including toilets, lift, panel room and Air Handling Unit spaces are located in the middle and accessible through the main area of the building.

Development of spaces are implemented according to their theme and space representations. Developments are implemented towards the ceiling, walls, and main area. In some locations, different floor levels are used to enhance playfulness of the building.

Furthermore, design is perfected by taking into account the following aspects important in children’s design:
1. Accessibility; in and out of site and in and out of building
2. Health and Safety; includes the presence of emergency areas and a first-aid room
3. Climate Suitability; the use of suitable materials and climate-suited elements of design

IV. CONCLUSION

An alternative science learning environment is a possible solution for the problem of science education in Indonesia. The ideal model for a particular science learning environment not only holds comprehensive, yet simple science topics suitable for children, but also combines it with elements of interactivity in affective and psychomotor learning domains to balance the cognitive aspects of learning at school.

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