Appendix-8
Publication on Aptitude in Science

Aptitude in Science among the Upper Primary Students in Relation to Awareness of Environmental Pollution

**KEYWORDS**
Pro environmental behavior, Learning to live together, Aptitude in Science, Awareness of Environmental Pollution, Theoretical & Economic value

**ABSTRACT**
For study of the Aptitude in Science in relation to Awareness of Environmental Pollution the authors have drawn the similarity of such Awareness with human values enunciated by E. Spranger and the learning to live together emphasized by J. Delors. The authors have precisely described the techniques of construction of a standardized test in Aptitude in Science in relation to Environmental Pollution. They observed that Aptitude in Science varies due to change of sex of the students and pollution status in neighborhood of the school in WB. As an entry level behavior Aptitude has a very significant effect on the Awareness of Environmental Pollution (AEP) and related activity. Though continuous variable like Aptitude has significant effect on AEP, the discrete or categorical variables like sex or pollution status of the schools hardly has any effect on AEP. The related studies and the other studies of the authors exclusively showed that scientific concepts related to environment, attitude towards environment and different learning activities are very much are pro environmental. The authors strongly recommend the determination of construct validity/concurrent validity of such test in future.

INTRODUCTION:
Most of the environmental pollutants are manmade and such pollutants are causing attenuation of natural resources and continuous damage to the man and society. The causes of such environmental pollutions are largely attributed to the excessive craze of man for urban life, selfish activities, greed for unlimited wealth, indifference to on going developments in environment and utter disrespect for learning to live together (International Education Commiss -1996, UNO). German philosopher Spranger in his book "Types of Men" (1928) mentioned six "basic values of man" of which three are relevant here: Economic Utilitarian Value & Aesthetic value (of course, these two are diametrically opposite), the third one is Theoretical (Rational) value. Man having excessive economic values, often, damages environment indiscriminately for material gains but the second type of man devotes for better environment. The third type takes decision scientifically always caring for reason or cause and effect relationship. The last type has many characteristics very much common with one having Aptitude in Science and love and Awareness for Environment. The economic values existing in a person with high Rational Values are likely to be controlled or limited by his/her superior act of reasoning. This reasoning might also be expected from a man with higher Aptitude in Science.

Aptitude is treated as a certain specic ability of a person in addition to his intelligence, which helps to achieve success in specific activities. Aptitude is potential in a person to get success in specific works after suitable training (Patel, 2013). It is mostly predictive in nature. Aptitude is partly innate (arising due to heredity) and partly acquired from environment & culture (Bandele, 2004; Mangal, 2005). Gronbach (2002) stated that before 1965, Aptitude was treated as 'Object' but Binet & Piaget held it as process. He reiterated that 'Aptitude' of a person is detected by the level of performance while at work and the 'time spent for the work'. Performance level is influenced by the efficiency of the person which in turn influenced by nature of the task, immediate environment and goals of action.

Researches on 'Aptitude' in India were mainly confined to identifying the dimensions of aptitude test, preparation and standardization of the test. Using such tests Chatterjee, Mukhopadhyay & Mitra (1978) found the relation of science aptitude with achievement in Science. No research could be found on aptitude vis-à-vis awareness related to environment. Aptitude and more particularly science aptitude as an instrument for possible development of environmental pollution awareness does not remain in an individual (Nagappa and Subhane, 2010). Some researchers have shown that aptitude of individuals may vary due to sex difference, individual difference and nature of favorite subject of learning etc. Spelle Elizabeth (2000) observed that boys and male are more apt in mathematics and science in comparison to girls and female counterpart from lower to higher level of education including career choice due to different exposures from the beginning of life. Patel (2010) revealed the superiority of the boys over students and upper grade students in comparison to their counterparts in Aptitude Test in Chemistry.

The ecosystem in the environment is naturally and scientifically maintained dynamic equilibrium in the environment. When that equilibrium is somehow lost pollution occurs in the environment. Understanding about pollution and its prevention or minimization requires knowledge of concept & process of science. So a student having aptitude in science is expected to develop more awareness about the environmental pollution. Here Aptitude might act as Enter ing behaviour in the process of development of ‘awareness of environmental pollution’. Person having scientific aptitude might view the environment from the standpoint of its structure, composition and process. Similarly, he might...
also recognize environmental pollution in terms of ‘cause and effect’, and in terms of ‘remedial measures’ to remove
the causes in order to minimize the pollution.

Hungerford & Volk (1990) stated that through Environmental
Education learners’ behavior can be changed. An envi-
ronmental study develops Environmental Awareness which
in turn develops Pollution Awareness. When proper atti-
tude develops the Pollution Awareness generates action to
restore pollutionless environment.

I) Env. Knowledge
II) Env. Awareness
III) Env. Pollution Aw.
IV) Action

IV) Action Fig 1: Behavioural Change System Through Envi-
ronmental Education

Pruneau (2006) has identified three factors in connection with
awareness or pro environmental behavior. These are
(a) cognitive (individual’s) own knowledge and action strate-
gies, affective and situational factors (mainly) economic
and demographic factors. He also attaches more weight
on cognitive factors for the development of environmental
awareness.

Emergence of the problem:

Narayana and Subane (2010) found negligible effect of
‘Aptitude in Science’ on ‘Environmental Awareness’ but
this result apparently contradicts our expectations on theo-
retical ground. It, therefore, requires further investigation
to verify whether science aptitude has at all any effect on
awareness for environment and hence for environmental
pollution. Furthermore the innate part of Aptitude may be
constant in case of an individual but the other part is
psychologically subjected to variation depending on the
following factors: Study skills, persistence of learning, mo-
tivation, and satisfaction derived from learning a subject,
Physical development, interests, attitudes etc. (Ediger &
Rao (2003)).

Aptitude of a person for a particular thing or practice is
also variable being subjected to the effect of educational
and environmental factors (Whitstone et. al. (1956)). Sci-
entific aptitude develops with the study of science as a
mentioned the impact of immediate environment on Ap-
titude. Patel (2010) studied Aptitude in Chemistry on the
basis of some categorical variables like sex, habitat, grade,
etc. However, these studies did not explicitly consider the
variables like Environmental Pollution Awareness, Envi-
ronmental Pollution in the vicinity of the schools the students
read in and the Aptitude in Science of the students. Again
these studies did not assign importance on Aptitude in
Science as an ‘entering behavior’ on Environmental Pollu-
tion Awareness. A study is therefore necessary to provide
answer to the following questions:

• Is there any effect of Aptitude in Science on the de-
velopment of Environmental Pollution Awareness of
the students?
• Does the Aptitude in Science of the students of
schools located at pollution and non-pollution zones
significantly differ?
• Does the Aptitude in Science of the students signifi-
cantly vary with sex of the students?
• The questions are also necessary from the standpoint
of sustainable development of the environment. So
the present study is designed.

II. DEFINITION OF TERMS:

1. Aptitude in Science:

Aptitude being an individual characteristic is mostly cog-
nitive. According to Freeman (1965) Aptitude is the state
of readiness and promise for training in a particular field.
Person’s aptitude gives him an added advantage of gain-
ing more success in a field: any performance or achieve-
ment. Intelligence tests and aptitude tests work in a similar
fashion in predicting achievement. Sometimes reasoning,
prima facie, works similar to Aptitude (Pal, 1992). Freeman
(1965) mentioned the Scientific (and Engineering) Aptitude
Test with the following dimensions: i) Experimental Bent,
ii) Clarity of definition, iii) Suspended vs snap judgment, iv)
Reasoning, v) Inconsistency, vi) Fallacies, vii) Induction,
Reduction, Generalization, viii) Caution and thoroughness, ix)
Discrimination of values in selecting and arranging Experi-
mental data, x) Accuracy of Interpretation & x) Accuracy of
observation.

2. Awareness of Environmental Pollution

Awareness of Environmental Pollution means to acquire
sensitivity to the total environment and its allied problems
and their implications.

The main goal of many schools today is to increase the
awareness because that is the only way to develop a more
sustainable world. Accordingly, pollution awareness should
begin with school education. A student having pollution
awareness is expected to have minimum working knowl-
edge about environmental degradation, factors causing
environmental degradations and concepts of sustainable
development, protection of environment. The Pollution
Awareness is preceded by Environmental Awareness and
succeeded by developmental Action.

A student having Pollution Awareness should have mini-
mum working knowledge about

• identification of sources of pollution,
• their effect on causing pollution,
• prevention of pollution,
• removal of pollution & development of environment.

ii) Polluted and non-polluted zones (locations):

Polluting zone, generally, means the area having high den-
sity of population and polluting industries with low density
of number of trees and plants. Moreover the absence of
lichen and moss on trees or old buildings (Santra, 2001)
has been taken as another indicator of such zones. Indus-
trial areas of WB (e.g. the Gangetic plateau of Howrah,
North 24 Parganas, Hooghly) come under this zone.

Non-Polluted Zone is conspicuous by the presence of
lichen and moss on trees or old buildings.

Delimitations:
The present study is limited to awareness about Air, Wa-
ter and Soil pollution only. However the identification of
polluted zone would be done on the basis of air pollution
only.

OBJECTIVES OF THE STUDY:

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1. To find the differences on aptitude in Science (AS) among the students on the basis of their gender and the pollution status of the locality of their schools.
2. To find the impact of Aptitude in Science (AS) on Awareness of Environmental Pollution (AEP).

HYPOTHESES TO BE TESTED:
On aptitude in science:
- \( H_0 \): The boys and girls of the schools do not differ in the mean scores on Aptitude in Science.
- \( H_1 \): The students of the schools located in polluted & non-polluting zones do not differ in the mean scores on Aptitude in Science.
- \( H_2 \): Boys and girls of the schools of non-polluting zones do not differ in the mean scores on Aptitude in Science.
- \( H_3 \): Boys of schools of non-polluting zone and non-polluting zones do not differ in the mean scores on Aptitude in science.
- \( H_4 \): Girls of schools of non-polluting zone and non-polluting zones do not differ in the mean scores on Aptitude in science.
- \( H_5 \): High and low score-Groups on aptitude in science test do not differ significantly in their mean scores on Awareness of Environmental Pollution.

III METHODOLOGY:
Population of the study:
Students passing VIII under WBEBSE in Bengali medium schools are considered for this study. Class VIII is the terminal stage of upper primary up to which students mostly learn about environment through activity and observation, and up to this stage science and environment education are interwoven and go together.

Sample of the study:
Sampling: Three polluted districts of WB were randomly selected. They were Howrah, Hooghly & North 24 Parganas. Similarly three non-polluted districts of North Bengal i.e. Malda, South Dinajpur & Jalpaiguri were selected. The schools of the concerned districts were selected randomly with the following restrictions: Schools were selected from polluted & non polluted zones, whose % of passes in first division in Secondary Final examinations was between 50 to 75% for the last three years. The distribution of schools of polluted and non-polluted zones is shown in Table-1 below:

<table>
<thead>
<tr>
<th>Zones of Schools</th>
<th>Boys’ schools</th>
<th>Girls’ schools</th>
<th>Total No. of schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>P zone</td>
<td>3</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>N/P zone</td>
<td>3</td>
<td>6</td>
<td>9</td>
</tr>
</tbody>
</table>

Total No. of schools = 18

In all 1063 students were selected from the schools (Table-2). The distribution of students of polluted and non-polluted zones is shown below:

<table>
<thead>
<tr>
<th>Zones of Schools</th>
<th>No. of Boys</th>
<th>Girls</th>
<th>Total No. of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>P zone</td>
<td>301</td>
<td>243</td>
<td>544</td>
</tr>
<tr>
<td>N/P zone</td>
<td>350</td>
<td>339</td>
<td>689</td>
</tr>
</tbody>
</table>

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Table 4: Descriptive Statistics of Aptitude in Science test:

<table>
<thead>
<tr>
<th>Source</th>
<th>Type II SS</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>375.380</td>
<td>1</td>
<td>375.380</td>
<td>8.513</td>
<td>0.004(p&lt;0.05)</td>
</tr>
<tr>
<td>Loc</td>
<td>637.280</td>
<td>1</td>
<td>637.280</td>
<td>10.479</td>
<td>0.001(p&lt;0.05)</td>
</tr>
<tr>
<td>Sex x Loc</td>
<td>397.620</td>
<td>1</td>
<td>397.620</td>
<td>0.003</td>
<td>0.997(p&gt;0.05)</td>
</tr>
<tr>
<td>Error</td>
<td>1842.920</td>
<td>196</td>
<td>44.097</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3075.000</td>
<td>198</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Analysis:

To find the main effects of ‘Location’ of schools involving pollution and ‘Sex’ and their interaction, ANOVA was designed for 50 scores selected randomly from each of the 4 (four) cells: Boys, Girls, Polluted and Non-polluted locations of schools.

Table 6: t-test for aptitude in science between different groups sex-wise & location-wise

<table>
<thead>
<tr>
<th>Groups</th>
<th>Mean</th>
<th>SD</th>
<th>t</th>
<th>df</th>
<th>p-value</th>
<th>Significance Relevance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Boys of Pollution Zones</td>
<td>23.11</td>
<td>7.112</td>
<td>3.19</td>
<td>98</td>
<td>0.000(p&lt;0.01)</td>
<td>Significant</td>
</tr>
<tr>
<td>Boys of Non Pollution Zones</td>
<td>17.24</td>
<td>4.039</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Girls of Pollution Zones</td>
<td>17.54</td>
<td>4.518</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls of Non Pollution Zones</td>
<td>17.32</td>
<td>3.002</td>
<td></td>
<td></td>
<td>0.165</td>
<td>Not significant</td>
</tr>
</tbody>
</table>

Table 7: Descriptive Statistics of the Scores on Awareness of Environmental Pollution (AEP)

<table>
<thead>
<tr>
<th>Groups</th>
<th>Mean Score on AEP</th>
<th>SD</th>
<th>SE of Mean</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>23.10</td>
<td>7.112</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>17.24</td>
<td>4.039</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Boys of Pollution Zones</td>
<td>17.54</td>
<td>4.518</td>
<td></td>
<td>1.4018</td>
<td>0.055(p&lt;0.05)</td>
</tr>
<tr>
<td>4. Boys of Non Pollution Zones</td>
<td>17.32</td>
<td>3.002</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>17.32</td>
<td>3.002</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Analysis and Interpretation of the tables:

1.0 Table 5 indicates that:

1.1 Boys and girls differ significantly (p<0.01) in the aptitude in science. So hypothesis H0 is rejected.

1.2 Students of schools located in pollution & pollution zones differ significantly (p<0.05) in their aptitude in science. So the hypothesis H0 is rejected.

2.0 t-tests of Table 6 show:

2.1 Boys & Girls of Pollution zones significantly (p<0.01) differ in their Aptitude in Science. So Hypothesis H0 is rejected.

2.2 Boys and Girls of Non Pollution Zones do not significantly (p>0.01) differ in their Aptitude in Science. So Hypothesis H0 is rejected.

2.3 Boys of Pollution and Non Pollution Zones significantly (p<0.01) differ in their Aptitude in Science. So Hypothesis H0 is rejected.

2.4 Girls of Pollution and Non Pollution Zones do not significantly (p>0.01) differ in their Aptitude in Science. So Hypothesis H0 is rejected.

3.0 Table 7 shows that high and low scores in Aptitude in Science significantly differ in their mean scores in Environmental Pollution Awareness. Hence H0 is rejected.

IV. Findings:

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In the Aptitude in Science Test the following groups

significantly differ:
1. Boys and Girls
2. Students of schools located in pollution & non-pollution zones
3. Boys and pollution and non-pollution zones
4. Boys and Girls of pollution zones
5. In the Aptitude in Science Test the following groups

do not significantly differ:
1. Girls of Pollution and non-Pollution Zones
2. Boys and Girls of non-Pollution Zones

Impact of Aptitude in Science on Awareness of Environmental Pollution

7. Aptitude in Science has significant effect on Awareness of Environmental Pollution

V. Limitations of the study:
- The identification of pollution status of a locality is a difficult task. In these days of scientific and technological advancements no habitat is entirely free from all types of pollution.
- In the present research the degree of pollution could not be precisely defined.
- In the identification of polluted habitats emphasis has not been given on air pollution.
- Tests on Awareness of Environmental Pollution & Aptitude in Science in this research relate to Air, Water & Soil pollution only.
- Industrial areas of some districts have been identified as polluted zones. Furthermore nonexistence of Lichens is also an additional indicator of environmental pollution in terms of air.
- In this research categorical variables have been chosen as sex and location of schools. Other relevant categorical variables could have been used for impact analysis.

Discussion:
The present study on aptitude in science bears some common aims with the studies of the authors Bhat (2014a) and Bhat (2014b) on the same set of sample regarding effect of concepts in science on the awareness of environmental pollution of the students (ii) a study on contribution of scientific aptitude and attitude on environmentally sensitive practices (Narayana & Subhani, 2010). The combined views might be presented in the following ways:

Firstly:
The present research shows that Aptitude of the students in science differ significantly due to difference of sex as also due to difference of the factor ‘Environmental Pollution’ surrounding the schools of the students. It was further observed that the impact of environmental pollution on aptitude in science is more in the case of boys. The voluntary participation of the students in different environment related games, activities and behavior might indicate the level of Environmental Awareness & Aptitude in Science of the students (Narayana & Subhani, 2010).

Secondly:
In search of factors contributing to Pollution awareness it was observed from the present study that Aptitude of the students in science has significant effect on Pollution Awareness of the students. It was found from the study of Bhat et al. (2014a) that concepts in science has also significant effect on Pollution Awareness of the students. Higher aptitude in science enables a student to participate in different pro environmental activities which may ultimately develop higher Environmental Pollution Awareness. Narayana & Subhani’s findings were somewhat different. They observed that Aptitude of the students in science has limited effect on the pollution awareness. Aptitude owing to its component ‘reasoning’ dominates at certain points but scientific attitude of the students has more dominating and lasting effects on pollution awareness.

Awareness is a value laden concept. Its development depends much on Aptitude in Science & Scientific Attitude in a sequence as shown in the following diagram. Here Aptitude in science is in no way inferior (Aptitude in Science, Scientific Attitude Awareness).

Thirdly:
In another study on the same sample Bhat, De & Sen (2014b) found the effect of some categorical variables on environmental pollution awareness. It was found that sex of the students and pollution characteristics of the surrounding area of the schools have almost no effect on the environmental pollution awareness of the students.

Arranged hierarchically, the effects of the factors on the environmental pollution awareness are: Scientific Concepts related to Environment, Scientific Attitude, Scientific Aptitude, and Sex of the students & Pollution Characteristics surrounding the schools.

For awareness activities students having higher Aptitude in Science (AS) are preferred because AS is pre learning/ entry level behaviour. However, the ultimate aim of teaching Environmental Studies is to develop pro environmental attitude of the students.

VI. Conclusion:
Environmental Pollution Awareness depends more on the continuous variables like scientific concepts and aptitude in science related to environment in comparison to discrete or categorical variables. So in the development of environmental practices leadership may be bestowed on the children having higher scientific concepts and aptitude.

Suggestions for Further Research on Aptitude in Science:
1) Impact of different grades, casts, parents’ academic status, economic status of family of the students may be considered as categorical variables to study their impacts on Aptitude in Science related to Environment.
2) It is better to find concurrent and/orconstruct validity of the aptitude in science test over and above finding the content validity of the test or inter raters’ agreement on the test.