Undergraduate Student Factors as Correlates of Scientific Literacy Levels in the University of the West Indies, Cave Hill Campus, Barbados

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Abstract: This study investigated the scientific literacy levels of a selected sample of non-science undergraduate students of the University of the West Indies, Cave Hill Campus, and Barbados. The study sought to determine if the scientific literacy levels of the students were satisfactory and also if there were statistically significant differences in the scientific literacy levels of the students based on their course of study (social sciences, humanities/education and law), level of study (levels 1, 2 and 3) and age. It further sought to determine the extent to which each of these three selected variables individually and jointly affected the undergraduate students’ scientific literacy levels. A sample of 314 students from three faculties participated in this study. Data were collected by means of ‘Scientific Literacy Test’ (SLT) and analyzed using means, standard deviations, and linear regression. The results of the study revealed that the mean score of the participants in the test was 49.21% which implies that an average non-science undergraduate student in the university was below average in his or her scientific literacy level. There were no statistically significant differences among the mean scores of the students’ scientific literacy based on course of study ($F_{(2,311)} = 1.169; p = 0.312$), and age ($F_{(6,300)} = 0.570; p = 0.754$). Moreover, the students’ course of study, level of study and age were not significant predictors of the scientific literacy scores. Also, the joint effect of the variables was not significant in predicting the scientific literacy scores of the undergraduate students ($F_{(3,310)} = 0.162; p = 0.922$). In this study, the best predictor of undergraduate students’ scientific literacy scores, though not statistically significant, was the age of the students.

Keywords: Scientific literacy, Undergraduate Students, Level of study, Sex, Age, Barbados, University of the West Indies.

Background
In modern societies, science is central to governance and democratic involvement. This is why industrialized democracies cannot survive unless their citizens are scientifically literate. The life’s blood of industrialized nations intertwines with science and technology (Salmon, 2007 and Hobson, 2008). Hobson particularly furthers that if an industrialized nation is democratic, its citizens must ultimately make the crucial choices about the uses of science and technology. Thus, a scientifically illiterate citizenry is a prescription for disaster. The truth is that if the world will turn from violence that we see every day and from extreme and unreasonable ideologies, toward peaceful co-existence, science and reason, scientific literacy, including critical thinking and an understanding of the processes of science should be embraced.

What is scientific literacy?
The term ‘scientific literacy’ was coined by Paul Hurd in the late 1950s and it was used to describe a comprehension of science and its applications to society (Laugksch, 2000). Presently, literature is replete of definitions of the concept of scientific literacy (SL). For instance, Durrant (1993) defines scientific literacy as what the general public ought to know about science, while Jenkins (1994) opines that it commonly applies to an appreciation of the nature, aims, and general limitations of science, coupled with some understanding of the more important scientific ideas. Recently, Brewer (2008) declares that scientific literacy is ‘being able to look at an article relating to science in a newspaper or in a magazine or listen to such commentary on a newscast or on TV and be able to understand what is being talked about and also being able to be skeptical’. He furthers that ‘it’s knowing enough about science to be able to judge if the story that you are being told is being told in a fair and accurate way’.

As an expert, American Association for the Advancement of Science (AAA) (1989) states that: Scientific literacy includes being familiar with the natural world and respecting its unity; being aware of some of the important ways in which mathematics, technology, and the sciences depend upon one another; understanding some of the key concepts and principles of science; having a capacity for scientific ways of thinking; knowing that science, mathematics, and technology are human enterprises, and knowing what that implies about their strengths and limitations; and being able to use scientific knowledge and ways of thinking for personal and social purposes. (pp. xvii-xviii)

This definition given by AAA lays emphasis on the fact a scientifically literate person is expected to be familiar with the knowledge of science, the interactions among mathematics, technology and the sciences as well as the ‘values, attitudes and thinking skills’ connected to those subjects. With the understanding that individuals may vary based on scientific literacy levels, Bybee, Powell and Trowbridge (2008: 92) present a framework of dimensions of scientific literacy (Fig. 1). The four-level framework is presented as a continuum from nominal scientific literacy to multidimensional scientific literacy in which an individual develops greater and more sophisticated understanding of science.
Nominal Scientific Literacy

- Identifies terms, questions, as scientific but demonstrates incorrect topics, issues, information, knowledge, or understanding.
- Has misconceptions of scientific concepts and processes.
- Gives inadequate and inappropriate explanations of scientific phenomena.
- Expresses scientific principles in a naïve manner

Functional Scientific Literacy

- Uses scientific vocabulary.
- Defines scientific terms correctly.
- Memorizes technical words

Conceptual and Procedural Scientific Literacy

- Understands conceptual schemes of science.
- Understands procedural knowledge and skills of science
- Understands relationships among the parts of a science discipline and the conceptual structure of the discipline.
- Understands organizing principles and processes of science

Multidimensional Scientific Literacy

- Understands the unique qualities of science.
- Differentiates science from other disciplines.
- Knows the history and nature of science disciplines.
- Understands science in a social context.

Fig. 1: Dimensions of Scientific Literacy

The four-level framework presented by Bybee, et al underscores the fact that scientific literacy can be explained as variations in the acquisition of knowledge and understanding of scientific concepts and principles required by individuals for making personal decisions, taking part in civic and cultural affairs, as well as contributing to societal economic productivity. Moreover, the framework clearly confirms the five components of scientific literacy earlier presented in the United States of America by the National Research Council (1996):

- Knowledge of significant scientific facts, concepts, principles and theories.
- Ability to apply relevant knowledge in everyday life;
- Ability to utilize the processes of scientific inquiry
- An understanding of general ideas about the characteristics of science and important interactions of science, technology and society;
- The possession of informed attitudes and interests related to science

However, broadly conceived but content-specific, Miller (2007) refers to two dimensions of scientific literacy. The first is a basic knowledge of key scientific concepts such as stem cell, molecule, nanometer, neuron, laser, DNA, nuclear power, continental drift, the cause of the seasons, biological evolution, and the greenhouse effect. The second dimension is an understanding of the process of science i.e. an understanding that science bases its conclusions on evidence and reason rather than emotion, ideology, ancient texts, authority figures, superstition, or religion. Therefore, scientifically literate people should thus understand what it means to study something scientifically, be able to define words like ‘experiment’ or ‘hypothesis’ and understand that astrology is not at all scientific. Twenty First Century Science (2008) agrees with Miller’s (2007) categorization of scientific literacy and consequently states that a scientifically literate person is expected to be able to:

- Appreciate and understand the impact of science and technology on everyday life;
- Take informed personal decisions about things that involve science, such as health, diet, use of energy resources, etc.;
- Read and understand the essential points of media reports about matters that involve science;
- Reflect critically on the information included in, and omitted from such reports;
- Take part confidentially in discussions with others about issues involving science

Conclusively, Miller (2007) defines scientific literacy as ‘the level of understanding of science and technology needed to function in a modern industrial society….which does not imply an ideal level of understanding, but rather a minimal threshold level’. Succinctly put, scientific literacy refers to an individual’s ability to understand and use basic knowledge of science for personal decision – making particularly in civics (public issues), aesthetics (laws of nature) and intellectual coherence. Therefore, scientific literacy is about using science and not about doing science.

Why is scientific literacy important?

Highlighting the importance of scientific literacy, Heller (2005) gave the following reasons for including scientific and technological competencies within the minimum standards for basic literacy:

- Employability: Competitiveness and employability are inextricably related to the capacity of individuals to participate actively and promote innovation in the workplace.
- Understanding of science-based activities: In the 21st century, science and technology have come to play an increasingly important role in many areas of society, including the development of leisure activities, arts, sports and recreation.
- Problem solving ability: Many of the greatest social problems of our time involve important scientific and technological components. To solve these problems, citizens must be able to participate in the discussions and decision-making processes with well-developed understanding of these scientific and technological aspects.
- Development of critical thinkers: The world is in need of citizens with critical thinking skills, people who are capable of questioning the foundations on which certain assertions are constructed, and who can independently search for information to build rational and well-supported opinions.

Researchers such as Hirsch (1987), Lewenstein (2003) and DeBoer (2000) raise some arguments to support the fact that scientific literacy is important and that we need to care about whether people understand science or not. The first argument is about civics which addresses the fact that we are all faced with public issues whose discussion requires some scientific background, and therefore we all should have some level of scientific literacy. For example an average citizen should have enough scientific background to discuss global warming, stem cells, common disease symptoms, etc. for the purpose of decision-making in voting and exercising civic responsibilities. The second argument is about aesthetics. According to this view, our world operates according to a few over-arching natural laws. Everything you do, everything you experience from the moment you wake up in the morning to the moment you go to bed at night, conforms to these laws of nature. Our scientific vision of the universe is exceedingly beautiful and elegant and it represents a crowning achievement of human civilization. Being scientifically literate gives everyone the opportunity to gain from the intellectual and aesthetic satisfaction to be gained from appreciating scientific processes and activities. On the other hand, a scientifically illiterate person is effectively cut off from an immensely enriching part of life, just as surely as a person who cannot read.

Need to improve scientific literacy

One conclusion from the international researches carried out so far is that global scientific literacy is shockingly low. For instance, Miller (1998) points out that, in a 1995 study, 12 percent of American adults qualified as well informed, or civic scientifically literate and approximately 25 percent qualified as moderately well informed. Another revelation from the study is that the estimated scientifically literacy rate of citizens globally ranged from 28% in the United States of America to 1% in Portugal. Conversely, 91% of the citizens in Portugal are not scientifically literate while 63% of Americans are not scientifically literate. This is truly shockingly low for the world that is growing rapidly in scientific and technological developments.

Moreover, Miller (2007) reveals that among the 34 nations tested in 2005, the scientific literacy rate rose above 30% in only one nation (Sweden, 35%). The United States was second with scientific literacy rate of 28%. Netherlands, Norway, Finland and Denmark were between 20% and 25%. In 15 European nations, including Germany, France, and the United Kingdom, the scientific literacy was between 10% and 19%. In 13 other countries, including Ireland, Japan, and Turkey, the rate was less than 10%. See Figure 2 below:
Miller (2007) also investigated the roles of age, gender, highest level of education, number of college science courses, number of children present in the household, use of informal science learning resources (museums, magazines, etc.) and whether their adult occupation is science-related. Miller found out that, over all these variables, the strongest predictor of adult scientific literacy was the number of college science courses taken; 75% of the variability in different people’s scientific literacy scores could be predicted simply from this number. Thus, the college experience is a strong determinant of scientific literacy in the United States. Unfortunately, as important as these studies and findings are, no Caribbean nation participated in the two studies (Miller, 1998; 2007) and there is also a dearth of research efforts on scientific literacy among science educators and researchers in the Caribbean. It is against this background that the problem of this study is posited.

This study, therefore, investigates the scientific literacy levels of a selected sample of non-science undergraduate students of the University of the West Indies, Cave Hill Campus, Barbados. The study seeks to determine if there are statistically significant differences in the scientific literacy levels of the students based on their course of study (social sciences, humanities/education and law), level of study (levels 1, 2 and 3) and age. It also seeks to determine the extent to which each of these three selected variables individually and
jointly affect the non-science undergraduate students’ scientific literacy levels.

Research Questions

The following research questions are formulated and answered in the study:

1. Is the level of scientific literacy of the selected undergraduate non-science students in the University of the West Indies, Cave Hill Campus satisfactory?

2. Are there any significant differences in the students’ scientific literacy levels based on course of study (social sciences, humanities and education and law), level of study (levels 1, 2 and 3) and age?

3. To what extent does the combination of students’ course of study (social sciences, humanities and education and law), level of study (levels 1, 2, and 3) and age jointly predict their scientific literacy levels?

4. To what extent does each of the students’ variables (course of study, level of study and age) individually predict their scientific literacy levels?

Methodology

Design

This study employed ex post facto research design in which the existing status of the independent and dependent variables were only determined during data collection without any manipulation of any of the variables under study by the researcher.

Sample

All 314 non-science undergraduate students who registered for a University Foundation Course titled ‘Medicine, Science and Society’ in 2012/2013 session (second semester) participated in this study. The sample consisted of 227, 49, and 38 students from the Faculties of Social Sciences, Law and Humanities & Education respectively. In all there were 234 females and 80 males with their ages ranging from 16 to 61 years old. Moreover, 272 of the students were in level 1, 32 were in level 2 while only 10 were in level 3.

Instrumentation

Results

Research Question 1:

1. Is the level of scientific literacy of the selected undergraduate non-science students in the University of the West Indies, Cave Hill Campus satisfactory?

Table 1: Mean Percentage Score of Scientific Literacy of Non-science Students

One validated questionnaire named ‘The Internet Infidels Test of Scientific Literacy (TITSL)’ constructed by Carrier (2001) was modified by the authors and used for collection of data for the study. The questionnaire TITSL has two sections. Section A elicited responses from the participants on their personal information such as age, course of study/faculty, and level of study. Section B has 24 items to which participants were required to answer true or false. Examples of the type of items in section B are: (a) Science only produces tentative conclusions that can change. (b) Scientific theories only change when new information becomes available and (c) A scientific law will not change because it has been proven true. Students were not asked to indicate their names on the questionnaires so as to make the responses anonymous.

In terms of validity and reliability of the instrument, Carrier (2001) who is the original author of The Internet Infidels Test of Scientific Literacy (TITSL) did not indicate any information. Therefore to establish the validity of the instrument for the present study, some experts were consulted to subject the items to rational logical analysis and they offered their suggestions and comments. They were all in agreement with the items, thus the 24 items were retained. Carrier (2001) also indicated explanatory notes for clarity in interpreting each of the items. On the other hand, to establish the reliability of the instrument, 35 non-science undergraduate students responded to the items and Crombach alpha reliability coefficient of 0.61 was obtained. This confers sufficient reliability on the instrument.

Procedure

The researchers sought the consent of the course lecturers and the students that took part in the study, by explaining to them the purpose of the study and they all consented. Having adopted the instrument and established its psychometric properties which confirmed that the instruments were valid and reliable, the researchers with the course lecturers administered the instrument on the students who voluntarily took part in the study. The instrument was collected back immediately.

Data Analysis

Data were analyzed using mean and standard deviation for research question 1, One-Way Analysis of Variance (ANOVA) for research question 2, regression analysis for research questions 3 and 4. All research questions were answered at 0.05 level of confidence using a two-tailed test.
Table 1 indicates that the students’ scientific literacy mean score is 49.21. This implies that most of the students are averagely scientifically literate. This is not satisfactory because although it is close to 50%, the mean score is still lower than 50%. Moreover, the minimum score of 13% is obviously too low. Fig. 1 (below) shows the distribution of the scientific literacy scores and provides a clear picture of the scientific literacy of the university students clustering slightly below the middle.

### Table 1: Scientific Literacy Scores

<table>
<thead>
<tr>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>314</td>
<td>13.00</td>
<td>92.00</td>
<td>49.21</td>
<td>11.23</td>
</tr>
</tbody>
</table>

Table 2 shows that although males outperformed females in the scientific literacy test, the difference is found to be insignificant.

### Table 2: Difference between scientific literacy levels of females and males

<table>
<thead>
<tr>
<th>Sex</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>Df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLAP</td>
<td>Female</td>
<td>234</td>
<td>48.64</td>
<td>11.427</td>
<td>312</td>
<td>.747</td>
</tr>
<tr>
<td>SLAP</td>
<td>Male</td>
<td>80</td>
<td>50.90</td>
<td>10.497</td>
<td></td>
<td>.174</td>
</tr>
</tbody>
</table>

- **NS** = Not Significant (p>0.05)

However, Table 2 shows that although males outperformed females in the scientific literacy test, the difference is found to be insignificant.

**Research Question 2:**
Are there any significant differences in the students’ scientific literacy levels based on course of study (social sciences, humanities and education and law), level of study (levels 1, 2 and 3) and age?

### Table 3: Differences in the students’ scientific literacy levels based on course of study

<table>
<thead>
<tr>
<th>SLAPercent</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sum of Squares</td>
</tr>
<tr>
<td>Between Groups</td>
<td>294.174</td>
</tr>
<tr>
<td>Within Groups</td>
<td>39140.530</td>
</tr>
<tr>
<td>Total</td>
<td>39434.704</td>
</tr>
</tbody>
</table>

NS = Not Significant (p>0.05)

### Table 4: Differences in the students’ scientific literacy levels based on level of study

<table>
<thead>
<tr>
<th>SLAPercent</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sum of Squares</td>
</tr>
<tr>
<td>Between Groups</td>
<td>11.421</td>
</tr>
<tr>
<td>Within Groups</td>
<td>39423.283</td>
</tr>
<tr>
<td>Total</td>
<td>39434.704</td>
</tr>
</tbody>
</table>

NS = Not Significant (p>0.05)

### Table 5: Differences in the students’ scientific literacy levels based on age.

<table>
<thead>
<tr>
<th>SLAPercent</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sum of Squares</td>
</tr>
<tr>
<td>Between Groups</td>
<td>434.596</td>
</tr>
<tr>
<td>Within Groups</td>
<td>39000.108</td>
</tr>
<tr>
<td>Total</td>
<td>39434.704</td>
</tr>
</tbody>
</table>

NS = Not Significant (p>0.05)

Tables 3 to 5 reveal that there were no statistically significant differences in students’ scientific literacy levels based on their course of study ($F_{(2, 311)} = 1.169; P > 0.05$), level of study ($F_{(2, 311)} = 0.045; P > 0.05$), and age ($F_{(2, 311)} = 0.570; P > 0.05$). This implies that irrespective of course of study, level of study and age of the students, their scientific literacy levels remain almost the same.

Research Question 3: To what extent does the combination of students’ course of study (social sciences, humanities and education and law), level of study (levels 1, 2, and 3) and age jointly predict their scientific literacy levels?

Table 6 shows that the combination of the three variables accounted for 0.20% (R square = 0.002, P > 0.05) of the total variance in the students’ scientific literacy scores and this was found to be insignificant [$F_{(3, 310)} = 0.162; P > 0.05$]

Research Question 4: To what extent does each of the students’ variables (course of study, level of study and age) individually predict their scientific literacy levels?
Table 7: Relative contributions of course of study, level of study and age to students’ scientific literacy levels

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>T</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>(Constant)</td>
<td>48.655</td>
<td>3.193</td>
<td>15.238</td>
</tr>
<tr>
<td>Faculty</td>
<td>.313</td>
<td>1.016</td>
<td>.019</td>
<td>.308</td>
</tr>
<tr>
<td>Level</td>
<td>.299</td>
<td>1.576</td>
<td>.012</td>
<td>.190</td>
</tr>
<tr>
<td>Age</td>
<td>-.255</td>
<td>.461</td>
<td>-.032</td>
<td>-.553</td>
</tr>
</tbody>
</table>

Table 7 shows the decreasing order of contributions of the independent variables thus: Age > Course of study > Level of study. Another important revelation here is that none of the independent variables is found to be significant in its contribution to variations in students’ scientific literacy scores.

Discussion

The major findings of this study are:

- The students’ mean scientific literacy score is 49.21% which is below 50%. Also, the minimum score of 13% is something to worry about. Males have higher scientific literacy level than females. However, the difference is not significant.
- There were no statistically significant differences in students’ scientific literacy levels based on their course of study \( F(2, 311) = 1.169; P > 0.05 \), level of study \( F(2, 311) = 0.045; P > 0.05 \), and age \( F(2, 311) = 0.570; P > 0.05 \).
- The decreasing order of contributions of the independent variables is thus: Age > Course of study > Level of study.
- The combination of the three variables accounted for 0.20% (R square = 0.002, P > 0.05) of the total variance in the students’ scientific literacy scores and this was found to be insignificant \( F(3, 310) = 0.162; P > 0.05 \). This implies that there is need to keep searching for more variables to improve the scientific literacy of the students.

This study found out that there were no significant differences in the scientific literacy levels of students based on their sex, course of study, level of study as well as age among different groups of individuals. The implication is that the general trend of poor performance among males and females, types of courses they are pursuing as well as number of years they have been in the university is yet to be put under control. However, according to Hobson (2008), adult scientific literacy has been rising in most countries. For example, he furthered that the United States of America’s scientific literacy rate rose steadily from 10% in 1998 to 28% in 2005.

It is interesting to note that although this study did not find any of the three variables instigated to be significant either as individuals or jointly, the results of Miller (2005) were said to be striking in that he found out that the strongest predictor of adult scientific literacy was the number of college science courses taken. According to him, the total effect of this variable on scientific literacy was 75%, meaning roughly that 75% of the variability in different people’s scientific literacy scores could be predicted simply from the number of college science courses they had taken.

Conclusion

The results reported in this study underscore the need for science educators, scientists and government agencies in charge of science and technology in the Caribbean to accept the reality of the poor level of scientific literacy levels of non-science students in the University of the West Indies where this study was carried out. If this is the reality among undergraduate students, what will be the situation with the general public? It is a reality that a scientifically illiterate citizenry is a prescription for disaster. All hands have to be on deck to produce citizens who can understand and use science for the purpose of making personal decisions on health-related matters, what side of debates when such issues as climate change, stem cells, ozone layer, use of drones, nuclear weapons, etc. are being debated, as well as to decide on political leaders to vote for having understood the leaders’ positions on critical issues. Finally, it is also a truism that most national and global problems cannot be solved without a scientifically literate citizenry.
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