New Perspectives in Science Education
International Conference
NEW PERSPECTIVES in SCIENCE EDUCATION


The Influence of Age, Gender and Subject Choice on Logical and Lateral Thinking Skills in Science Students at Secondary Level

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Abstract

One of the primary goals in education is the development of a student's cognitive structure on acquiring knowledge and understanding through thought processes, experiences and the senses. The mind's 'handling system' imposes a number of imperfections and lateral thinking, together with logical thinking, is one way to compensate for some disadvantages. Children must not passively receive content knowledge but engage as active learners in thinking independently by combining logic with creativity and intuition (Phillips, 2011).

A research study was carried out, aiming to provide a better insight into the development of thinking skills in Science students in Maltese secondary schools, and to outline – in particular – how the concept of lateral thinking and logical thinking skills may be used to enhance creative and analytical thinking in the classroom.

The study was conducted in two Church schools of different gender involving a total of 98 students (half attending a girls' school, and the rest a boys' school). Schools of a similar level, with a spectrum of different learning abilities, were chosen. Two different age groups were considered: Form II (c. 12 year old) students, exposed to the same level of Integrated Science, and two Form IV (c. 14 year old) classes with different subject choices. The latter were a class with the three Science subjects (Biology, Chemistry and Physics) and another class with only one (compulsory) Science subject. Some researchers claim that certain subjects require more problem solving skills than others, thus inducing better general thinking skills (Smith, 1981).

To measure the levels of creative thinking and logical ability, students were presented with a test including creative and analytical questions. The test consisted of 19 questions, divided in five categories. The participants' responses, from both gender schools, were analysed in order to compare and investigate any patterns with respect to age, gender and subject choice. The study revealed that students studying the three Science subjects, and particularly boys, tend to think more outside the box with respect to their peers.

1. Introduction

The present is one of constant change in which education at secondary level plays a vital role in the shaping of young minds, influencing the development of society. Due to the rapidly changing world we are living in, teachers are encouraged to mould their methods according to the needs of the modern world around us. The development of logical and creative thinking skills enables people to use their knowledge and apply it in a variety of different situations. Through education, individuals do not merely learn an accumulation of facts, but make sense of the world around them by conceptualizing, analyzing and evaluating data that is brought about through the observation of daily experiences and reasoning.

The main aim of this research is to investigate whether students can think creatively by solving lateral thinking puzzles, as well as logical solutions. Most innovators, scientists and engineers implement both lateral and logical thinking when formulating new ideas. The ability to generate new ideas does not merely depend on intelligence, but rather how one regularly exercises the mind into a particular route of thought. Such ideas should be instilled when students are being taught at secondary level, so as to further achieve the skills needed to make deliberate use of the rationalization of the mind.

2. Methodology

This study required a quantitative method, and the research tool chosen was that of a test. An account of key assumptions related to lateral and logical thinking was first formulated. Limitations and gaps in relevant literature were identified and taken into consideration during the planning stage. Prior to being

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used in the investigation, a pilot study was carried out on a representative group of subjects, to ensure the questions were appropriately chosen and the time provided was adequately planned. Questions were chosen from various sources, (Phillips C. 2011, Univeristy of Kent, 2015, Sloane & MacHale, 2005, Singh Negi, 2014, LearnDotTacomacc, 2016) to ensure variability and clarity. Davis (1950) insists that the constructed tests for an investigation are to be rigidly composed to ensure reliability and validity. Ackroyd and Hughes (1992) comment that "larger samples will increase precision, the less likely they are to vary from the population value, and the more confident we can be that our sample estimate of the population value is within a given range of accuracy" (p.72). The total number of participants taking part in this research was 98 students, half of which attend a girls' school, with the rest attending a boys' school. The test was consisted of 19 questions, divided in five categories as shown in Table 1.

Table 1: The Number of Questions within each Category

Category	Number of Questions per Category
Logical Reasoning	5
Technical Aptitudes	2
Lateral Thinking Solutions	6
Verbal Lateral Thinking	3
Visual & Spacial Puzzles	3

3. Interpretation of Results

3.1 Age influencing Cognitive Development

When a child develops, the process does not only involve the child's cultural experience, but also the cultural forms of reasoning (Vygotsky, 1987). The outcome of cognitive development, according to Bruner (1957), is the concept of habitual thinking. In having the mind relate from experience in order to form "generic coding systems that permit one to go beyond the data, to new and possibly fruitful predictions" (Bruner, 1957).

Overall, among the students who sat for the tests, Form IV students performed significantly better than Form II students. The younger group of students still performed relatively well in most of the category questions. Students achieved comparable scores in logical thinking, which was based on mathematical and analytical questions. This might be the result of similar content matter acquired in the different schools. Questions based on lateral thinking in the third category gave notably similar percentage average scores for boys, for the Form II and Form IV students.

Form II Girls decreased the percentage difference by outperforming boys in categories such as technical aptitudes, verbal lateral thinking and visual-spatial puzzles. Girls scored well in lateral thinking questions, indicating that they can be more creative than their male counterparts, while boys got a higher final percentage due to better averages in logical and analytical thinking.

3.2 Gender Differences

"Gender differences in subject choices within secondary education remain evident across Western societies." (Smyth & Darmody, 2009). With respect to occupations, adolescents undergo conflicts and complex developments, an aspect which is more evident in girls rather than boys. Even though girls managed to surpass boys in the PISA examination (OECD, PISA 2009), boys performed better than girls in the logical and lateral thinking test, in both the Form II and the Form IV final score.

An interesting feature that has been noticed in this study was that, even though males in general acquired higher scores when compared to females, there was also significantly large group of low-

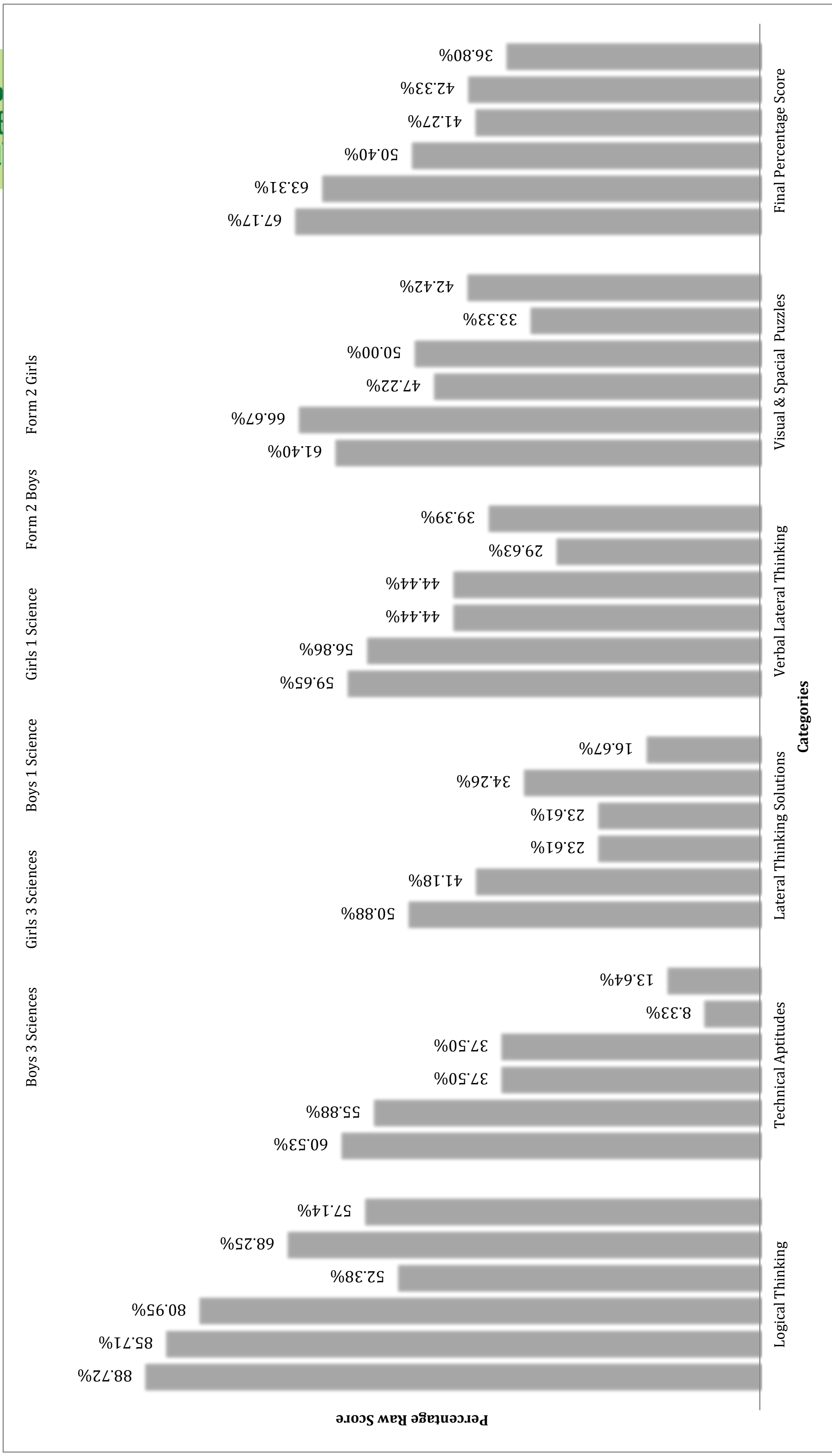
Percentage Raw Score
Categories
Logical Thinking
Technical Aptitudes
Lateral Thinking Solutions
Verbal Lateral Thinking
Visual & Spacial Puzzles
Final Percentage Score
Boys 3 Sciences
Girls 3 Sciences
Boys 1 Science
Girls 1 Science
Form 2 Boys
Form 2 Girls
88.72%
85.71%
80.95%
52.38%
68.25%
57.14%
60.53%
55.88%
37.50%
37.50%
8.33%
13.64%
50.88%
41.18%
23.61%
23.61%
34.26%
16.67%
59.65%
56.86%
44.44%
44.44%
29.63%
39.39%
61.40%
66.67%
47.22%
50.00%
33.33%
42.42%
67.17%
63.31%
50.40%
41.27%
42.33%
36.80%

Figure 1: Comparing test results under the influence of Age, Gender and Subject Choice

scoring males. Research shows that the overall performance of (Sternberg R. J., 1985) (Sternberg & Williams, 2010) (Sternberg & Williams, 2010) males is much more variable (Lubinski & Benbow, 2007). This means that males' scores are more widely distributed in contrast to the clustered scores of female candidates. Feingold (1992) reviewed statistical reports on quantitative and spatial ability test scores, and found that males score higher in such tests, while females score higher in tests of verbal ability.

All in all, gender seems to have no effect on skill and performance. However, another mechanism, which may enhance differences, could be anxiety. A Maltese study by Chetcuti (2009) points out that girls are more meticulous in their work and this instigates that the difference in results may be a result of behavioural differences, rather than cognitive or intellectual factors. Students should be exposed to essential problem-solving skills in conjunction with computation, which will not only help them in other Science and Engineering areas, but will even help students who opt for other subject areas and in their every day lives.

3.1 The Influence of Subject Choice

The formulated logical and lateral thinking tests were distributed to both males and females in Form II and IV, half of which study one Science subject, with the other half studying two or more Science subjects. This was done in order to obtain a broader view and to investigate if students' thinking patterns is affected by their subject choice at secondary school. As seen in Figure 1, both genders studying all the three Sciences performed and achieved significantly higher scores than their respective peers opting for one Science subject only.

Gardner (1999) defined intelligence as "the ability to solve problems or fashion products that are of consequence in a particular cultural setting or community". Whereas Gardner's theory of multiple intelligences emphasises the dependent modular structures, Robert Sternberg's (1985) triarchic theory of human intelligence is composed of three relatively distinct processes, which consist of analytical, creative and practical abilities.

The different intelligences of students may have influenced their thinking pathways throughout the course of the test, possibly even favouring some students over others. Students with a superior sensitivity towards linguistics would have performed better in understanding words and different functions of language in the fourth category, whereas the logical and mathematically oriented would have been able to discern logical or numerical patterns in the first and second category more easily, by handling long chains of reasoning. Students with a higher capacity in perceiving visual-spatial transformations would have been more creative than their peers in lateral thinking questions and visual and spacial puzzles. Having said this, an important characteristic of the multiple intelligences theory is that people do not just have one single intelligence, but have all intelligences at different levels, with some being more dominant over others. (Armstrong, 2000; Gardner, 2004).

4. Conclusion

These test results are in line with other studies (Bunch & Hutchinson, 1993), indicating that students studying Sciences, exercise the development of ideas and concepts more frequently than students having one Science only, thus developing their cognitive reasoning to a higher level. All three-Science students might have performed better also due to the nature of the test, containing questions based on patterns and abstract concepts, in having a higher ability to visualise and reason formally being able to achieve higher scores. According to Fowler and Watford (2000), the development of formal reasoning is not only related to scientific subjects but also to academic achievement in general.

Following these theories, teachers in different subjects need to reach the needs of individual learners. Horn (2009) affirms that teaching should be more learner-centred and, similarly, Mitchell (2008) emphasises that visual teaching methodologies should be used in classrooms. These methodologies enhance learning by catering for the needs of various intelligence combinations.

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