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Relationship of IQ with Alternative Ideas of Primary School Students on the Concepts of Force and Weight

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ABSTRACT

This paper presents the results of the empirical research carried out on students in the Sixth grade of Primary School in the city of Ioannina, Greece, regarding the alternative ideas they have about the concepts of force and weight concerning the intelligence index of each student, which was measured with the WISC-III tool. The research results show a linear relationship between the IQ and the number of correct answers the student gave.

Keywords: alternative ideas, IQ, primary school, physics.

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I. Introduction

It is well known that students are fed in their daily lives with rules of thumb and ideas dictated by intuition, their sense organs, and common sense, as was done with the great scientists of the past up to the seventeenth century. Most students adopt them because they have been used, tested, and repeatedly confirmed in interpreting physical phenomena. Thus, they become firmly established in their minds and are carried to school. These alternative ideas are not irrational or characteristic of minority students. The child and the student can perceive natural phenomena, justify their existence, and predict their evolution. The process of prediction, and therefore of hypothesis, is inferential reasoning and is a high-level process where the student is asked to synthesize information from various concepts derived from the process of his ability to observe, the use of previously known evidence, and empirical experiences he has. The prediction leads to the derivation of conclusions and, essentially, the rules each student defines for interpreting natural phenomena. Essentially, this process requires the mental stages of analysis and synthesis and the ability to connect data with existing knowledge. These two components directly depend on the student's cognitive development and, consequently, his mental age, which is linked to IQ, so whether there is a relationship between the student's IQ and his alternative ideas about physics concepts.

A questionnaire for primary school students, which had been used in previous research, was used to record students' ideas. The internationally known WISC-III scale (Wechsler Intelligence Scale for Children–Third Edition) was used for the investigation and evaluation of the intelligence of the children in the present study, which was weighted and adapted in Greece in 1997 (Georgas *et al*., 1997). This test covers children from the age of 6 years to 16 years and 11 months. It consists of 12 tests. Six of these tests make up the verbal scale, and another six make up the performance scale. The child alternately faces verbal and performance tests.

The verbal scale consists of six oral activities (Information, Similarities, Arithmetic, Vocabulary, Comprehension, and Number Memory). It examines the child's verbal knowledge and understanding, the knowledge that is usually acquired through children's education, mainly at school. It also examines the child's ability to use this knowledge in a new situation.

The performance scale consists of six performance activities (Filling in pictures, Coding, Sorting pictures, photos, graphs, drawings, assembling pictures and mazes) and examines the child's ability to understand and organize visual stimuli within a limited time; the child's performance in this scale depends to a large extent on his ability to flexibly use various strategic methods to solve a new kind of problem.

The general intelligence quotient (IQ) results from the sum of the verbal and performance intelligence indices. According to Kaufman (1994), when the student's profile does not show significant differences between verbal and performance IQ, the general IQ can adequately describe the general mental functioning level. General intelligence is the most comprehensive, valid, and reliable indicator of a child's level of cognitive functioning provided by the WISC-III. A child's performance on an intelligence test has predictive value for several parameters. According to Research (Neisser *et al*., 1996, Greek translation edited by Euclid, 1997), the intelligence index allows a good prediction of school performance. It is considered by many

to be a general assessment of the child's mental abilities.

The Greek WISC-III also allows the examiner to express the child's performance in terms that indicate his developmental-mental age, which gives information on the level of development the child has achieved at any given age (Motti-Stefanidi, 1999).

II. Research

The population of the research is 79 students in the Sixth Grade from two Primary schools in the city of Ioannina. It was chosen to be students of the Sixth Grade because they have already been taught concepts of Physics both in the previous grade and in the Sixth. 48.1% are boys, and 51.9% are girls. It should be noted that from the research data, no statistical difference in the findings emerged regarding the gender of the sample subjects. The students individually answered a closed questionnaire of eight (8) questions to record their alternative ideas on the concepts of force and weight. We choose these basic concepts of force and weight because all the students have daily experiences in their daily life. On the other hand, there is much research about alternative ideas on these basic concepts of physics (Mohapatra & Bhattacharyya, 1989; Kruger *et al*., 1992; Halloun, I., 1998; Jimoyiannis, A., & Komis, V., 2003; Stylos *et al*., 2008). The questionnaire questions had been used in previous research on students of the same age (Kotsis & Kolovos, 2002; Kotsis & Vemis, 2002; Kotsis, 2011). Then each student, for about 60–80 minutes, was submitted to the WISC-III psychometric tool, from which their IQ was calculated.

III. Results

The data was processed with the statistical package SPSS 24. The student's answers to each question are presented in a table.

In question 1, students are asked when a force acts on a body. The results are shown in Table I.

TABLE I: Students' Answers to the Question:
"When Does a Force Act on a Body?"

Answer	Students (%)
When we push a body, it moves	50.6
When we stop a moving body	12.7
In both cases above	35.4

From the students' answers, it appears that the correct answer (in both cases above) is given by only 35.4%. At the same time, the well-known alternative idea prevails that force is only connected to the existence of movement (Driver, 1984; Galili & Bar, 1992; Enderstein & Spango, 1996; Bayraktar, 2009).

In the same context is question 2, which asks, "When does a football player exert force on a ball." Student responses are given in Table II.

In this question, most students give the correct answer (at the time of kicking the ball) at a rate of 73.4%.

TABLE II: Students' Answers to the Question:
"When Does a Soccer Player Exert Force on a Ball?"

Answer	Students (%)
The moment he kicks the ball	73.4
When the ball moves toward the net	10.1
In both cases above	10.1
In none of the above cases	5.1

Question 3 refers to an application of Newton's third law and reads as follows: "An insect is crushed against the windshield of a moving car because the windshield exerts a force on it. Does the insect exert a force on the glass?" The results of the student's responses are presented in Table III.

TABLE III: Student Responses to the Question:
"An Insect Is Crushed against the Windshield of a Moving Car because the Windshield Exerts a Force on It.
Does the Insect Exert a Force on the Glass?"

Answer	Students (%)
No, it doesn't	55.7
Yes, it does	43.0

More than half of the students (55.7%) answered incorrectly, connecting the existence of the force with its visible result. The rest of the students, i.e., 43%, answer correctly (Yes, it does).

Newton's third Law is also dealt with in question 4, which reads as follows: "A table pushes down on the ground. The ground likewise pushes up the table." The results of the student's responses are presented in Table IV.

TABLE IV: Student Responses to the Question
"A Table Pushes Down on the Ground.
The Ground Likewise Pushes Up the Table."

Answer	Students (%)
Correct	37.8
Wrong	60.8

Students answered 60.8% with the alternative idea (Brown, 1989; Sjober & Lie, 1981) without accepting the existence of the reaction, as in question 3, while only 37.8% gave the scientifically correct answer.

The remaining questions deal with the concept of weight, a force that the student is taught but also has experiential experiences. Question 5 is related to the nature of the concept of weight, and you have as follows: "The weight of a body is:" The students' answers are shown in Table V.

TABLE V: Students' Answers to the Question:
"The Weight of a Body Is:"

Answer	Students (%)
Force	12,7
A characteristic property of a body	22,8
Body mass	63,3

In the above question, the most significant percentage (63.3) of the students answer with the well-known alternative idea (Mullet & Gervais, 1990) that weight and mass are identical concepts. 22.8% answered with another alternative idea, namely that weight is a characteristic property of a body (Roggerio *et al*., 1985), while only 12.7% answered correctly, namely that weight is a force.

TABLE VI: STUDENTS'ANSWERS TO THE QUESTION: "A PERSON WEIGHTS BECAUSE:"

Answer	Students (%)
The air presses him to the earth	17.7
He is drawn to the earth	35.4
None of the above	45.6

The next question, question 6, has to do with the existence of their force of weight and is as follows: "A person weights because:" The students' answers are presented in Table VI.

From the students' answers to the above question, it appears that only 35.4% answered correctly (the earth attracts him), while most, 45.6%, are unable to find the correct answer and connect weight with the force of gravity (Watts, 1982)

Students' inability to separate the concepts of weight and mass is dealt with in question 7, which reads: "When we diet, what do we lose?" Their answers are presented in Table VII.

TABLE VII: STUDENT RESPONSES TO THE QUESTION "WHEN WE DIET, WHAT DO WE LOSE?"

Answer	Students (%)
Weight	62.0
Mass	36.7

From the students' answers to the above question, it appears that the majority (62.0%) believe that dieting reduces weight, not distinguishing between the concepts of weight and mass (Mullet & Gervais, 1990), and 36.7% correctly believe that the mass is reduced first, which results in the weight also being reduced.

Finally, in question 8, it is established whether the students can perceive if the weight of a body is affected if it is in water. They were asked this: "When you swim, your weight:" The students' answers are shown in Table 8.

TABLE VIII: STUDENT RESPONSES TO THE QUESTION: "WHEN YOU SWIM YOUR WEIGHT:"

Answer	Students (%)
It gets bigger in water	17.7
It gets smaller in water	60.8
Does not change	20.3

The answers to this question show that a large percentage (60.8%) of the students answer according to their experiential experience (Stead & Osborne, 1980), and only 20.3% answer according to the scientific view, i.e., that the weight does not change.

From the application of the Greek version of the WISC-III scale, it emerged that the average IQ of the students of the present sample is 101.6±17.6, which corresponds to students with an average IQ. However, it should be noted that the IQ ranges for all students ranged from 88 to 135. The correct answers given by each student on the questionnaire were then counted and plotted against their IQ. The curve plotting the function of the students' IQ with the number of correct answers to the questionnaire is shown in the graph of figure 1.

Fig. 1 shows a range of IQ values for each number of correct answers. Students who gave two correct answers to a total of 8 questions have an IQ of around 90. Accordingly, students who gave six correct answers to 8 questions have an IQ of around 115. No one of the students gave eight correct answers. Overall, however, all the data presented in figure 1 can be attributed to a first approximation with a linear curve. As is noticed in Fig. 1, the value of R^2 is 0.9492, meaning that the linear curve describes the data from this research very well.

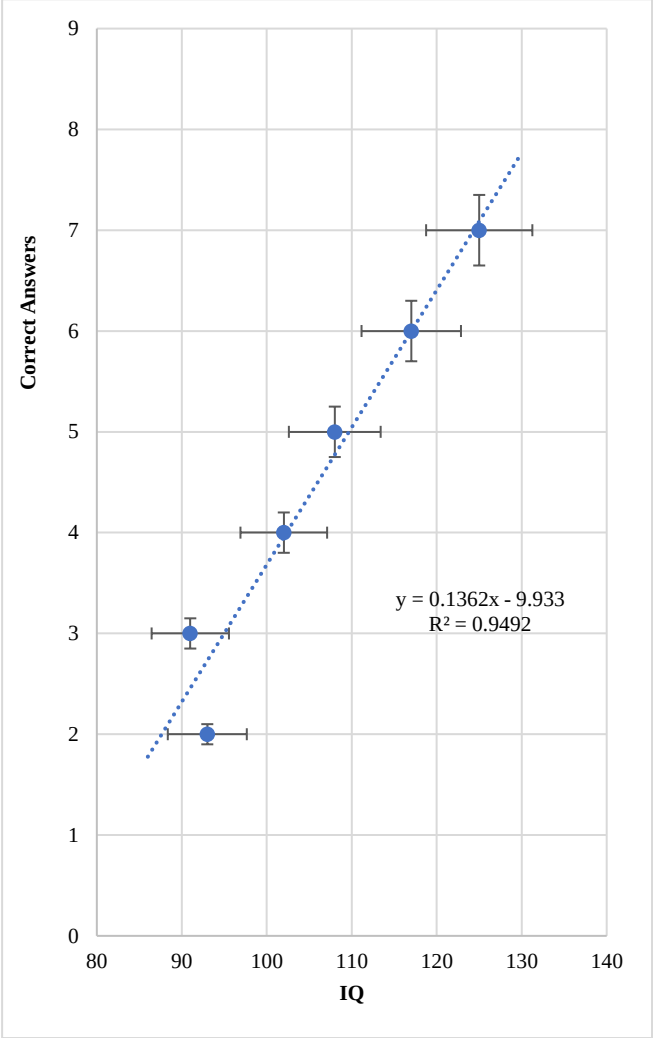

Fig. 1. The function of students' IQ with the number of correct answers to the questionnaire.

The linear relationship between the correct answers and the IQ means that the higher the IQ of a student, the greater the number of correct answers he gave to the specific questionnaire.

IV. CONCLUSION

The present research findings show a relationship between the student's IQ and the number of correct answers in the questionnaire on concepts of force and weight. This relationship is linear and states that the higher the IQ of a student, the better he can perceive some physical phenomena related to the concepts of force and weight. This conclusion cannot be generalized as a rule for all concepts of Physics, but as a finding, it is essential. That there is a range of IQ values for each correct answer may be because the most appropriate psychometric instrument for measuring IQ was not used. Even a closed questionnaire may not be

appropriate for this research. Using an interview would be more appropriate but particularly tiring for students since the administration of the WISC-III alone required about one hour for each student.

Finally, it is worth mentioning that the analysis of the data at the level of each question separately did not show anything that can be generalized as a rule, even at the level of this research. The data showed that a student with a low IQ answered a question correctly, while another with a much higher IQ answered the same question incorrectly, based on his alternative idea. That is, it is impossible to draw any conclusions about the students' answers or their IQ at the level of a question. Further in-depth research is undoubtedly needed to capture the relationship of IQ with students' responses to Mechanics concepts.

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REFERENCES

Bayraktar, S., (2009). Misconceptions of Turkish pre-service teachers about force and motion. *International Journal of Science and Mathematical Education*, 7(2), 273–291.

Brown, D., (1989). Students' concept of force: the importance of understanding Newton's third law. *Physics Education*, 24, 353.

Driver, R. (1984). Cognitive psychology and pupil's frameworks in mechanics, in Lijnse, P. (ed.), The many faces of teaching and learning mechanics in secondary end early tertiary education. *Proceedings of the conference on physics education, August, Utrecht*; GIPERS/SVO/UNESCO, WCC, Utrecht, 1985, 227.

Enderstein, L. G., & Spango, P. E., (1996). Beliefs regarding force and motion: a longitudinal and cross-cultural study of South African school pupils. *International Journal of Science Education*, 18(4), 479–492.

Galili, I., & Bar, V., (1992). Motion implies force: where to expect vestiges of the misconception? *International Journal of Science Education*, 14(1), 63–81

Georgas, D., Paraskevopoulos I., Mpezevegkis, H, & Giannitsas N.D., (1997). *Ελληνικό WISC-III: Οδηγός εξεταστή, Αθήνα*, [Greek WISC-III: Examiner's Guide]. *Ελληνικά Γράμματα (Ellinika Grammata)*.

Halloun, I., (1998). Schematic concepts for schematic models of the real world: the Newtonian concepts of force. *Science Education*, 82(2), 239–263.

Jimoyiannis, A., & Komis, V., (2003). Investigating Greek Students' Ideas about Forces and Motion. *Res Sci Educ*, 33, 375–392

Kaufman, S. (1994). *Intelligent testing with the WISC-III*. New York: Wiley

Kotsis K.T. (2011). *Ερευνητική Προσέγγιση του διαχρονικού χαρακτήρα των εναλλακτικών ιδεών στη διδακτική της φυσικής, Εκδόσεις Πανεπιστημίου Ιωαννίνων, Ιωάννινα*. [Empirical research to the timeless character of alternative ideas in the Didactics of Physics]. Book, University of Ioannina.

Kotsis K.T. and Kolovos C, (2002). Οι εναλλακτικές αντιλήψεις των παιδιών, η εννοιολογική αλλαγή και η διάρκεια γνώσης από την διδασκαλία στο Δημοτικό στην έννοια της δύναμης, στο Μαργετουσάκη Αθ. &. Μιχαηλίδης Π.Γ (επ.) Πρακτικά 3ου Πανελλήνιου Συνεδρίου για την «Διδακτική των Φυσικών Επιστημών και των Νέων Τεχνολογιών στην Εκπαίδευση», Ρέθυμνο, 250–256. [Children's alternative perceptions, conceptual change, and duration of knowledge from primary school teaching in the concept of power]. *Procceding of the 3rd Conference for Didactics of Sciences and New Technologies in Education*.

Kotsis K.T. and Vemis K., (2002). Οι εναλλακτικές αντιλήψεις των παιδιών, η εννοιολογική αλλαγή και η διάρκεια γνώσης από την διδασκαλία στο Δημοτικό για φαινόμενα που στηρίζονται στον τρίτο νόμο του Νεύτωνα, στο Μαργετουσάκη Αθ. &. Μιχαηλίδης Π.Γ (επ.) Πρακτικά 3ου Πανελλήνιου Συνεδρίου για την «Διδακτική των Φυσικών Επιστημών και των Νέων Τεχνολογιών στην Εκπαίδευση», Ρέθυμνο, 257-262. [Children's alternative perceptions, conceptual change and duration of knowledge from primary school teaching about phenomena based on Newton's third law]. *Procceding of the 3rd Conference for Didactics of Sciences and New Technologies in Education*.

Kruger, C., Palacio, D., Summers, M. (1992). Surveys of English primary teachers' conceptions of force, energy, and materials. *Science Education*, 76(4), 339–351.

Mohapatra, J. K., & Bhattacharyya, S (1989). Pupils, teachers, induced incorrect generalization and the concept of "force." *International Journal of Science Education*, 11, 429–436.

Motti-Stefanidi F., (1999)., Αξιολόγηση της Νοημοσύνης παιδιών σχολικής ηλικίας και εφήβων. Εγχειρίδιο για ψυχολόγους. Αθήνα: Ελληνικά Γράμματα [Assessment of the Intelligence of school children and adolescents]. Handbook for psychologists. Book, Athens.

Mullet E., and Gervais H., (1990). Distinction between the concepts of weight and mass in high school students. *International Journal of Science Education*, 12(2), 217–226

Neisser, U., Boodo, G., Bouchard, T.J.,Jr.,Boykin, A.W., Brody,N., Ceci, S.J., Halpern, D.F., Loehlin, J.C., Perloff, R.,Sternberg, R.J.,& Urbina,S. (1996), Νοημοσύνη: Τι είναι γνωστό και τι δεν είναι, (Επιμέλεια ελληνικής μετάφρασης, Α. Ευκλείδη 1997) [Intelligence: What is known and what is not]. *Ψυχολογία,* 4 (1), 48–93

Roggerio S, Cartielli A., Dupre F., and Vicentini-Missoni M., (1985). Weight, gravity and air pressure; mental representations by Italian middle-school pupils. *European Journal of Science Education*, 7(2), 181–194.

Sjobery S. and Lie S., (1981). *Ideas about force and movement among Norwegian pupils and students*. Institute of Physics Report Series: Report 81-11, University of Oslo.

Stead K. and Osborne R., (1980). *Gravity*, [LISP Working Paper 20, Science Education Research Unit, University of Waikato, Hamilton, New Zealand].

Stylos, G., Evangelakis G. A., and Kotsis, K. T., (2008). Misconceptions on classical mechanics by freshman university students: A case study in a Physics Department in Greece, *Themes in Science and Technology Education*, 1, (2), 157–177.

Watts D.M., (1982). Gravity–do not take it for granted. *Physics Education*, 17, 116–121.

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