

Predicting FCI Gain with a Nonverbal Intelligence Test

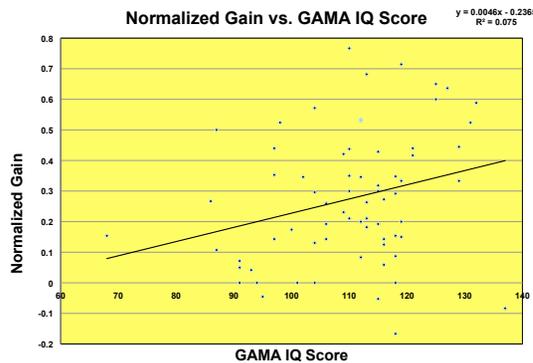
by

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Abstract: We have administered a commercial, nonverbal intelligence test (GAMA) to students in two introductory physics courses, one algebra-based and one calculus-based. We compare scores on that test with scores on Lawson's *Classroom Test of Scientific Reasoning* as predictors of gains on the *Force Concept Inventory*.

Introduction: The *Force Concept Inventory* (FCI) is widely used to assess student understanding of some of the fundamental concepts of classical mechanics. When used as a pre- and post-test, the gain students achieve on the FCI is usually interpreted as a measure of instructional efficacy. If a reliable way were found to predict such gains, our understanding of the learning process would benefit. Coletta and Phillips (2005) have advocated the use of Lawson's *Classroom Test of Scientific Reasoning* as such a predictor, and they found a significant correlation between scores on the Lawson test and FCI gain. The Lawson test is highly contextualized in that it deals with concepts frequently used in science. We investigated a test of logical reasoning that is abstract and devoid of any context, scientific or otherwise, to determine how it would compare to the Lawson Test as a predictor of FCI gain.

The GAMA: The test we used is the GAMA (General Ability Measure for Adults) by Naglieri and Bardos which is commercially available from Pearson Assessments. It is often used by psychologists to measure intellectual ability. Examples of the four types of questions posed on the GAMA are presented in the next column. The test itself consists of 66 similar items of increasing difficulty. Unlike the Lawson test the GAMA is timed (25 minutes), and no one is expected to finish it. A complex scoring rubric leads to a single number, the GAMA IQ score, which if measured for a large random population will have a mean of 100 and a standard deviation of 15.



The graph above compares normalized gains on the FCI with scores on the GAMA test for the 70 students for whom complete results were available. The correlation shown is positive but far from strong.

Matching Subtest

The Matching subtest requires the recognition of the spatial orientation of the designs and identification of the option with the same arrangement of shapes.

Sample A: Which answer (1, 2, 3, 4, 5, or 6) is the same as the first picture?

Analogies

Sample: Which answer (1, 2, 3, 4, 5, or 6) goes on the question mark?

Analogies require the recognition of the relationship(s) between the figures in the sample and identification of the option with the same conceptual relationship.

Sequences

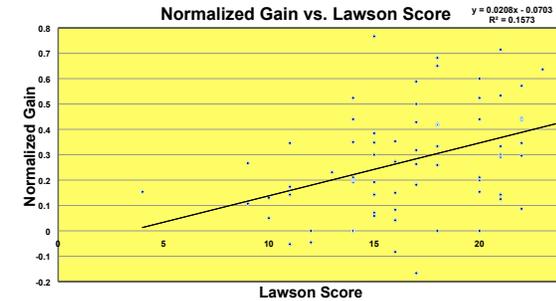
Sample: Which answer (1, 2, 3, 4, 5, or 6) goes on the question mark to complete the pattern?

Sequencing requires the recognition of the pattern of change in the sample and identification of the option with the same sequential pattern.

Construction

Sample: Which answer (1, 2, 3, 4, 5, or 6) can be made with the shapes in the top box?

Construction requires analysis and syntheses of the spatial characteristics of the shapes to mentally construct one of the options.



The graph above compares normalized gains on the FCI with scores on the Lawson test for the 70 students for whom complete results were available. The correlation shown is positive and slightly stronger than for the GAMA test.

Multiple Regression: As part of the administration of these tests a substantial amount of demographic information was collected from the students. The following twelve items of data were available to use as inputs to a stepwise linear regression: Lawson score, GAMA IQ score, completed college math, highest level of high school (HS) math, highest level of HS physics, years of HS science, years of HS life science, status as prospective teacher, age, gender, college major, and taking algebra- vs. calculus-based physics.

The stepwise multiple regression process will select the best predictors of a dependent variable (such as FCI gain) from among the set of twelve input variables. We find that the Lawson score and the GAMA IQ score are interchangeable in the analysis, and in the following the word "TEST" stands for either. The regression was performed for each of the dependent variables listed as headings in the table below. Under each heading, we list the best (more significant than 0.05) predictors in descending order of significance.

FCI Pre	FCI Post	Gain	Normalized Gain
Gender	Gender	TEST	TEST
HS Physics	TEST	---	Gender

Conclusion: We find that the GAMA test (expensive) is about as good as the Lawson test (free) as a predictor of gain on the FCI, and thus its use does not seem to be justified. The important role played by gender as a predictor of results has been noted by many investigators.