

A Review and Analysis of Cognitive Strategy and STEM Success

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Abstract

This study is a review of the impact of learning style and/or cognitive strategy on math, science and higher order thinking skills needed for STEM success. A meta-analysis and descriptive statistics were performed. Important variables such as gender, ability level, anxiety, etc. were addressed. Suggestions for future research and diagnostic implications were mentioned as well as the need for remediation. The idea for further experimental control and identification of additional intervening variables was discussed.

Keywords: cognitive strategy, STEM, science, technology, math

A Review and Analysis of Cognitive Strategy and STEM Success

Present day concerns are mounting about math and science scores on standardized tests. With emphasis on STEM (science, technology, engineering, math), it has become necessary to seek solutions as American students fall behind world counterparts. In search of a silver bullet, many factors or variables have come under scrutiny. One such variable is cognitive strategy or learning style and the impact on math and science achievements, and higher order thinking skills.

Learning styles have been defined in very narrow terms as well as specific categories by educators. The educational emphasis is on the learning outcomes. However, some educators and psychologists point to the association between personality and achievement as a strong predictor. Personality differences have long been studied in terms of types. McClelland (1961) has identified a difference in types with regard to achievement, social, and power-oriented needs. Eysenck (1978) postulated 16 different personality types under the general umbrella of extroversion and introversion. More important for learning outcomes has been the differential aspect of field dependent and field independent types.

Halpern (n.d.) suggested a biological difference between the two types in favor of field independent individuals and math, science, achievement. Fiest (1998) believed there were conformity differences between the two types as well, favoring field independence. Brofennbrenner (2002) feels that those who are field dependent have a difficult time to separate the figure from the ground. Those who are field independent do so with ease. The basis of this comes from Lewin's field theory and results are confirmed by examination group embedded figures test (GEFT). This begs the question as to whether there are differences in problem solving strategies and whether this impacts those skills needed for STEM success. Many research

efforts may be categorized into the precise areas of math, science, technology, and mechanical ability. Gender differences and possibly anxiety are also considered.

Math, Science, Technology

Sriphal (2011) found that learning styles effect math achievement. In a study with 508 seventh graders, both boys and girls displayed a correlation with achievement and style. Cao (2006) in a comprehensive study of graphics and anatomy science with 238 undergraduate college students found field independent participants scored higher than field dependent students on a post test. Yumara (2013) in researching reflecting and impulsive cognitive style with 300 students found a reflective style associated with field independence performed better in math tests.

Onyekura (2015) investigated 320 subjects to determine if cognitive style affected career choice. It was determined that field independent subjects were higher in choosing science careers. Jantan (2014) studied math achievement in primary school. A positive correlation was found with cognitive strategy in favor of field independence. Tinajero and Paramo (1997) found similar results. Pithers (2002) also found a relationship to learning strategy and problem solving in favor of the field independent group. Likewise, Abiden et. al (2011) demonstrated differences with 317 upper secondary students favoring the field independents.

Entwhistle and Peterson (2004) suggested differences in studying habits between field independent and field dependent learners. Field independent learners were more “apt” to engage in elaboration while field dependent learners used note memorization. Musser (n.d.) suggested the same for field dependent learners in that there is more need for math rehearsal and repetition.

Carretta (1987) in an extensive study of Air Force affairs in flight training illustrated positive differences in favor of field independent learners. Azari et. al (2015) attempted to

control for anxiety and intelligence quotients which may be intervening variables. In this study with 100 female students cognitive style still predicted math achievement and problem solving. Karacom (2015) also found cognitive style affected direct circuit concept learning.

By contrast, Husch (2007) found no significant difference between calculus learners in secondary school and learning styles. Zonash and Naqiri (2011) found an association between learning style and extroversion. This study was conducted with 135 students, 18-25 years of age in math and fine arts. There was a positive correlation between mastery learners and introversion, with introverts having higher math scores. Wilkin and Goodenvugh (1976) found field independent learners worked problems alone, while field dependent learners made more use of information from others. Omodellefyle (2009) studied 57 field dependent and 46 field independent college students. It was determined that those who were aware of their styles or type performed better.

Gender Differences

Still others have investigated whether there may be gender differences to account for variation in achievement. Kyriakides (2005) studied 81 students from both rural and urban areas. Although thinking style was still a variable, boys achieved higher math scores than girls. Conversely, Onwumere and Reid (2012) discovered field independent students did outperform dependent students, but girls in the sample were more field independent.

Hargreaves et. al (n.d.) in a large sample of 500 students determined that girls performed as well as boys when subjects were matched on age and ability level. Azari et. al (2013) found cognitive style to be most relevant even when math anxiety and IQ were controlled.

Language and Reading Comprehension

With respect to language arts, Nozari and Siamian (2015) studied 305 high school students and found field independent learners scored higher on reading comprehension and learning English. Danilli and Reid (2006) also indicated there was a correlation between learning style and performance where language was a factor. There was 476 10th grade participants.

Wintergerst (2001) studied learning style performance with ELL (English language learners). Field independent learners performed better. Soureshjari (2012) examined test results from 95 undergraduate college students and also found field independent learners to excel more in language arts.

It does appear that some relationship or association exists between personality types or cognitive style and various aspects of achievement. Further investigation appears warranted and necessary. This is especially crucial since emphasis on test standardization has come to attention. Students today are compared to an arbitrary level by teachers. (Reynolds et. al 2009), yet standardized tests compare them to a norm.

Method

Subjects

There were 879 participants from research studies. Gender, age, and ability level were heterogeneous as well as grade level.

Instruments

The instruments were achievement tests in math science, etc. The initial screening device that was used was the GEIFT.

Procedure

A meta-analysis was conducted as well as a descriptive analysis.

Results

The n was 879. A mean and standard deviation was computed, and the effect size. In addition, some percentages were compiled for further illustration. The effect size was calculated according to Cohen's (1998) D formula and guidelines. It resulted in .188 only a slight difference and as such appears negligible.

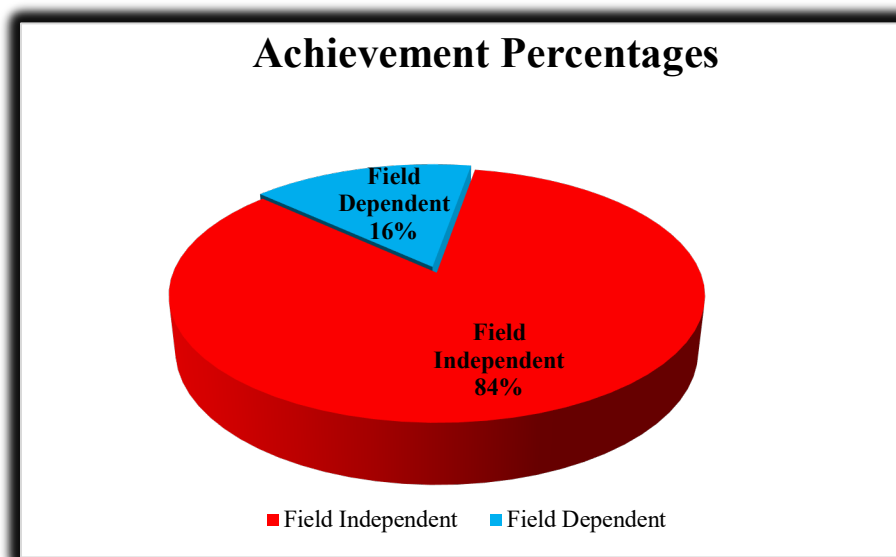
TABLE I: Overall mean scores on achievement for field independent and field dependent subjects.

Mean Scores for Achievement	
Subjects	Mean
Field Independent	120.07
Field Dependent	116.11

TABLE II: Overall standard deviation for field independent and field dependent subjects on achievement.

Standard Deviation for Achievement	
Subjects	Standard Deviation
Field Independent	4.87
Field Dependent	3.57

FIGURE I: Percentage of achievement for field independent versus dependent learners.



Discussion

A plethora of studies indicate a difference based on cognitive strategy. However, the implications for STEM success are still more generalized than specific. Many of the studies are based on correlation coefficients that indicate a relationship or association, but not a direct cause and effect (Mills et. al 2016), (Frankel et. al 2015), and (Babbi 2009).

In addition, research seems not to be horned into one area. Rather, learning style is designed to encompass many facets (i.e.- introversion, extroversion, visual, auditory, etc.). Although more studies addressed the issue of field independence and dependent types, many intervening variables need yet to be controlled. Most of the control was related to gender, ability level etc.

Other questions should be considered. Payne (2003) looks to socio-economic status or poverty as a predictive factor. Even age, grade level, school, and school district need correlation as does other moderator variables. Green (1990) also points to teacher involvement.

The crux of the matter appears to be with the ability to perform higher order thinking and critical thinking skills. Educators have long relied on Bloom's taxonomy to develop lesson plans, teach, and strategies to enhance these skills Psychologists approach learning from a different perspective. While these concepts may seem narrow, they are multifaceted. Educators desire intrinsic rewards and have criticized programs emphasizing external ones (psychological in nature). The amalgamation of these differences may lead to programs that attack the problem at hand. Piaget (1963), for instance, feels math should not be taught until the age of abstract reasoning, which about 11-12 years old. Zhang and Huang (2006) feel that thinking styles and personality traits overlap. Moreover, (Miller et. al.) feels that students' performance has made

educators more accountable. Stotsky (2014) questioned whether even common core will lead to problem resolution

In summary, more research is needed using the experimental method with adequate control of variables deemed to intervene. Many studies have had rather small samples, lack control because of design type and overall are somewhat inconclusive. More rigorous attempts may lead to identifying predictor variables needed for diagnosis and better programs for remediation. This could entail the designed silver bullet for the future.

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