Secondary mathematics teachers' filed dependency and its effects on their cognitive abilities

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Abstract: Teachers' Spatial ability, Numerical Reasoning, Abstract Reasoning and Verbal Critical Reasoning based on mathematics education literature seem to relate to teaching mathematics. As a relationship exist between the levels of individuals' abilities and strategy choice and efficiency in mathematics education and base on the important role of field dependencies in Science education, this study investigate the possible relationship between mathematics teachers' cognitive abilities and their cognitive style. The results of this study shown that mathematics secondary teachers with field dependent style have significantly lower Spatial ability, Numerical Reasoning, Abstract Reasoning and Verbal Critical Reasoning in contrast to mathematics teachers with Field intermediate and Field independent style. Recognizing teachers' field dependencies helps us to know which type of teachers need more in-service classes to developing their cognitive abilities and help them to teach mathematics in a more scientific way and provide opportunities for their students to make connections, explore mathematics ideas, and develop mathematical understanding.
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1. Introduction

Teachers are the front line of mathematics education, preparing students, parents, workers, and future teachers across the Commonwealth for the secondary grades, for college, and for careers that require increasingly demanding levels of mathematical skill and thinking. Along with some very engaged and skilled parents, a subset of our teachers laid the mathematical foundations for most of our current mathematicians, scientists, and engineers.

Over the last few decades, more emphasis has been placed on the role of mathematics teachers' plays in the learning process. Teachers organize and shape the learning context and therefore have enormous influence on what is being taught and learned. Based upon this fact, the mathematics education community began to invest more time and resources into teacher research. Specifically, mathematics education researchers, educational psychologists, and those involved in teacher education have become increasingly aware of the influence of teachers' beliefs on their pedagogical decisions and classroom practices (Cobb et al. 1991; Nespor, 1987; Pajares, 1992; Philipp, 2007; Philipp et al. 2007; Raymond, 1997; Thompson, 1992; Torff, 2005; Wilson and Cooney, 2002).

Teachers have the opportunity to leave an indelible impression on their students' lives. School experiences change, shape, and, can influence how children view themselves inside and outside of school. These school memories have the potential to last a lifetime in students' minds and can play a consequential role with present and future decisions. (Gourneau, 2005). In addition, Calderhead (1996), Pianta (1999), and Watson (2003) have described teaching as an intensely psychological process and believe a teacher's ability to maintain productive classroom environments, motivate students, and make decisions depends on her personal qualities and the ability to create personal relationships with her students. These effective attitudes and actions employed by teachers ultimately can make a positive difference on the lives of their students.

Mathematics education relies very heavily on the preparation that the teacher has, in her own understanding of mathematics, of the nature of mathematics, and in her bag of pedagogic techniques.

According to the important role of teachers in mathematics education, an exploratory position is taken in this study to examine the association between mathematics teachers' Cognitive style and their cognitive abilities (i.e. Spatial ability, Numerical Reasoning, Abstract Reasoning, Verbal Critical Reasoning). Therefore, researchers believe that cognitive abilities of mathematics teachers has a demanding influence on the way they teach mathematics and the decision they take in solving mathematics tasks for their students. It seems to be more beneficial to describe the historical background of these variables before introducing research framework.

Cognitive Style

One of the Cognitive dimensions which is widely used for purposes of analyzing human activities is Field Dependent (FD) and Field Independent (FI) introduced by Witkin and Fellows at year 1977. Field independence-dependence (FI-FD) is the ability to separate an element from an embedding context. Individuals adept at locating a simple figure within a larger complex figure are referred to as field independent, while those at the opposite end of the continuum are referred to as field dependent (Witkin and Goodenough, 1977).

Cognitive style differences influence the acquisition and demonstration of cognitive skills necessary for self formation such as differentiation, organization and integration. Witkin and Goodenough, (1981) Research shows that, in general, field dependent have a more social or interpersonal orientation than field independent people who prefer solitary situations to social ones (Coates et al., 1975; Ruble and Nakamura, 1972; Saracho, 1985a, 1985b, 1986,1989). Additional studies have found that, in contrast to FI individuals, FD people describe self and others more positively, have a greater preference for people oriented/ humanistic vocations learn social material more easily and demonstrate greater self-disclosure and cooperativeness (Oltman et al., 1975; Schleifer and Douglas, 1973; Sousa-Poza et al., 1973).

The key difference between FD and FI individuals is visual perceptiveness. FD individuals who are asked to identify a simple geometric figure that is embedded in a complex figure will take longer to identify the simple figure than FI ones, or FD individuals may not be able to do it at all. FD person are, thus, not visually perceptive and have more difficulty in abstracting relevant information from visual (or even textual) instructional materials supporting more difficult learning tasks (Canelos, Taylor, & Gates, 1980; Liu & Reed, 1994; Lyons-Lawrence, 1994).Therefore, FD/I cognitive style appears important in learning science: problem-solving and conceptual understanding (Bahar & Hansell, 2000; Danili & Reid, 2006; Kang, Scharmann, Noh & Koh, 2005; Tsaparlis, 2005).

Several researchers have demonstrated the importance of field dependency in science education and mathematical problem solving (Witkin and Goodenough, 1981; Talbi, 1990; Johnstone and Al-Naeme, 1991, 1995; Alamolhodaei, 1996; Sirvastava, 1997; Ekbia and Alamolhodaei, 2000; Alamolhodaei, 2002, 2009). It was found that FI students tend to get higher results than FD students in calculus problem solving at university level. Moreover, school students with FI cognitive style achieved much better results than FD ones in mathematical problem solving, in particular word problems. Moreover, Teachers who score high field -dependence prefer frequent interactions with students, encourage active involvement of students in the management of learning, and create positive attitudes towards learning. Teachers who score high field -independence prefer more formal approaches to teaching, emphasizing their own standards and seeing their role as transmitting known factual information (Kagan, 1965; Hudson, 1966; Gregorc, 1979).

Abstract Reasoning

The Abstract Reasoning assesses persons' ability to identify patterns amongst abstract shapes. The items include irrelevant and distracting material which can lead the individual to unsatisfactory solutions. The non-critical person may remain satisfied with such solutions. The test, therefore, measures the ability to change track, critically evaluate and generate hypotheses which can be relevant in the development of new ideas and systems (Amani, Alamolhodaei & Radmehr, 2011).

Abstract reasoning ability is important in mathematical performance because it enables individuals to apply what they learn in complex ways. Many learners with learning disabilities have weaknesses in abstract reasoning and can benefit from direct instruction in math problem-solving skills. Individuals taking higher level of mathematics courses would benefit from training in abstract reasoning and problem solving, from computational practice, and from generally being more comfortable in working with numbers (Pallas and Alexander, 1983, Zhu, 2007).

Verbal Critical Reasoning

In general usage, verbal ability refers to a person's facility at putting ideas into words, both oral and written. This facility involves possessing not only a strong working vocabulary but also the ability to choose the right words to convey nuances of meaning to a chosen audience. Verbal ability also includes the ability to organize words in coherent ways. Verbal ability is a part of the traditional construct of intelligence, with most conventional intelligence tests measuring verbal ability, quantitative reasoning, and logical thinking. Verbal ability is usually demonstrated as the ability to write and speak well (Andrew, 2005).

Verbal critical reasoning tests are used to find out how well someone can assess verbal logic. They are usually in the form of a passage, or passages of prose, followed by a number of statements. Their task is based on deciding if the statements are "True", "False" or if they "Cannot tell" from the information provided. They are to assume that everything that is said in the passages is true.

Since many mathematical problems could be solved either by a spatial approach or by a verbal approach or by both of them, the discrepancy between spatial and verbal abilities would influence how students and teachers approach mathematical solutions (Krutetskii, 1976; Fennema and Tartre, 1985; Zhu, 2007). Battista, (1990) found that individuals with high spatial ability and low verbal ability might try to use more spatial strategies to solve mathematical problems, while those of high or low in both abilities might be more variable in strategy use. In addition, Verbal-logical abilities are regarded as being important to geometric problem solving for both genders (Battista, 1990; Krutetskii, 1976; Zhu, 2007).

Numerical Reasoning

Numerical Reasoning Test consists of information is provided that requires person to interpret it and then apply the appropriate logic to answer the questions. In other words, individual needs to work out how to get the answer rather than what calculations to apply. Sometimes the questions are designed to approximate the type of reasoning required in the workplace.

Emeke and Adegoke (2001) examined the effect of test response mode, students' numerical ability and gender on the cognitive achievement of senior secondary school. The study revealed that the higher the numerical ability of students, the better their performance in the Physics achievement test. Adu (2002) tested the influence of quantitative ability and gender among other independent variables on students' academic achievement in Economics. The study found a significant influence of quantitative ability on students' academic achievement. Eleanor Ursos and Bauyot (2006) showed that a moderate correlation exists between Numerical Ability Test and Achievement Test in College Algebra. Using least squares method, a mathematical model was defined by the equation $\hat{y}=38.788+0.234x$.

Spatial Ability

The concept of "spatial ability" is not easily defined. Generally spatial abilities entail visual problems or tasks that require individuals to estimate, predict, or judge the relationships among figures or objects in different contexts (Elliot & Smith, 1983). More specifically, spatial abilities have to do with individuals' abilities to search the visual field, apprehend forms, shapes, and positions of objects as visually perceived, form mental representations of those forms, shapes, and positions, and manipulate such representations mentally (Carroll, 1993). In addition, spatial skills involve the ability to think and reason using mental pictures rather than words (Nuttall, Casey, and Pezaris, 2005, p.122).

Researchers have demonstrated that there exists a relationship between the levels of individuals' abilities and strategy choice and efficiency. Individuals of higher ability tend to solve problems by using more spatial processes, while the others try to solve problem in a more analytical way (Zhu, 2007). Generally spatial abilities entail visual problems or tasks that require individuals to estimate, predict, or judge the relationships among figures or objects in different contexts (Elliot & Smith, 1983). They are believed as one important component of mathematical thought during mathematical problem solving (Battista, 1990; Casey, 2003; Halpern, 2000).

Also others indicate that some aspects of mathematics have spatial components and correlations between math and visual spatial skills have been reported (Fias & Fischer, 2005, Lachance & Mazzocco, 2006; Zhu, 2007). Individuals with low spatial ability are more directed to the semantic content. If the semantic content of the interface is low, individuals of high spatial ability have a performance advantage compared to individuals of low spatial ability. In these situations individuals of low spatial ability derive comparatively greater benefit from the provision of additional non-spatial semantic information (Westerman, 1995). In addition, one of the desired suggestions to develop mathematical skills is to suitably emphasize and develop primary abilities such as spatial ability instead of just teaching mathematics (Bishop, 1980). Spatial ability was considered to be one of the primary abilities that seem especially important in learning and doing mathematics (Battista & Wheatley, 1989). Spatial abilities are claimed to be powerful tools for understanding and solving mathematics problems (Hodgson, 1996). Also Geddes (1993) claimed that studying geometry, in other words developing spatial sense, provided opportunities for divergent thinking and creative problem solving while developing students' logical thinking abilities.

All these studies highlight the importance of spatial ability. Therefore, the development of spatial ability has been a primary problem for the researchers, educators and teachers for many years.
Various studies insisted that spatial ability could be improved by education. For example, Burns (1984) expressed that, appropriate geometry experiences were useful for developing reasoning processes which in turn support problem solving skills children needed to understand arithmetic as well as geometric concepts.

Research frameworks

Teachers' Spatial ability, Numerical Reasoning, Abstract Reasoning and Verbal Critical Reasoning based on mathematics education literature seem to be related to teaching mathematics. As a relationship exist between the levels of individuals' abilities and strategy choice and efficiency in mathematics education and base on the important role of field dependencies in Science education, this study investigate the possible relationship between mathematics teachers' cognitive abilities and their cognitive style. Therefore, our research question is: ''Is there any interaction between mathematics teachers' FD/FI cognitive styles and their cognitive abilities (i.e. Spatial ability, Numerical Reasoning, Abstract Reasoning, Verbal Critical Reasoning)?"

In an attempt to answer this question the following objectives were sought:

The first objective of the study was to determine whether there is significant difference in math teachers' Abstract Reasoning among teachers who have different cognitive style (i.e. FD/Fint (field-intermediate)/FI).

The second objective of the study was to discover if there is significant difference in math teachers' Verbal critical Reasoning between teachers who have different cognitive style (i.e. FD/Fint/FI).

The third objective of the study was to explore if there is significant difference in math teachers' Numerical Reasoning abilities among teachers who have different cognitive style (i.e. FD/Fint/FI).

And the last objective of this study was to find out whether there is significant difference in math teachers' Spatial ability between teachers who have different cognitive style (i.e. FD/Fint/FI).

2. Material and Methods

Participants

A total of 68 female secondary mathematics teachers from Mashhad (Khorasan Razavi Province, Iran) provided responses for this study. The ages of the teachers ranged from 20 to 50 years, with 47% of them 30 years or less, another 39% between 31 and 40 years inclusive and 13% over 40 years old. 7.35% have associated degree in mathematics while 80.88% have bachelor degree and others (11.77%) have master degree in mathematics or mathematics education.

Procedures

The research instruments were:

1- Cognitive style (FD/FI) test
2- Abstract Reasoning Test
3- Verbal Critical Reasoning Test
4- Numerical Reasoning Test
5- Spatial Ability Test

Cognitive styles measure

The independent variables were cognitive style and the position of a teacher on each of the learning style dimensions (FD, Fint and FI) was determined using the GEFT (Oltman et al. 1971). On the test, subjects are required to disembed a simple figure in each complex figure. There are 8 simple and 18 complex figures, which make up the GEFT. Each of the simple figures is embedded in several different complex ones. Teachers' cognitive styles were determined according to a criterion used by (Scardamalia, 1977; Case, 1974; Case and Globerson, 1974; Johnstone et al. 1993; Alamolhodaei, 1996, 2009; Amani, Alamolhodaei, Radmehr, 2011). Teacher who had a score less than 1/4 standard deviation (SD) below the mean were classified as field dependent (FD).In order to create the category of field independence, teachers had to score at least 1/4 SD above the mean for the sample population and between (Mean ± 1/4 4 SD) were those who may be located between the above two styles (FD & Fl) who were labeled as field-intermediate (FInt) learners. Table 1 shows the number of teachers in each of three dimensions (FD/FInt/FI) in this sample.

Table 1. The distribution of mathematics teachers in each of three dimensions (FD/FInt/FI) over the sample

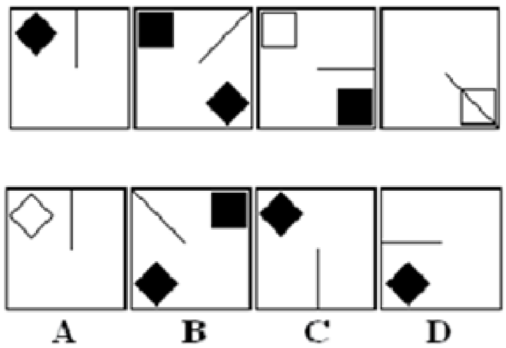
Group	FD	Fint	FI
Total	n = 22	n = 16	n=30
n = 68	32.4%	23.5%	44.1%

Abstract Reasoning Test

Abstract reasoning tests use diagrams, symbols or shapes instead of words or numbers. They involve identifying the underlying logic of a pattern and then determining the solution. Because they are visual questions and are independent of language and mathematical ability, they are considered to be an accurate indicator of individuals' general intellectual ability.

Abstract Reasoning Test consisted of 25 questions that persons should answer as many questions as they can in 20 minutes. It has been created by Newton and Bristoll and available online from: http://www.psychometric – success.com. Here is a typical question of this exam:

Which figure completes the series?



Verbal Critical Reasoning Test

Critical reasoning questions require persons to demonstrate their ability to make logical decisions and even to recognize that insufficient data has been provided for a definitive answer to be reached, as would be the case in many real-life situations. This verbal Critical reasoning test consisted of 8 questions that math teacher should answer as many questions as they can in 20 minutes. It has been created by Newton and Bristoll and available online from: http://www.psychometric – success.com.

Here is a typical question of this exam:

Pedro goes either hunting or fishing every day. If it is snowing and windy then Pedro goes hunting. If it is sunny and not windy then Pedro goes fishing. Sometimes it can be snowing and sunny.

Which of the following statements must be true?

A. If it is not sunny and it is snowing then Pedro goes hunting.

B. If it is windy and Pedro does not go hunting then it is not snowing.

C. If it is windy and not sunny then Pedro goes hunting.

D. If it is windy and sunny then Pedro goes hunting.

E. If it is snowing and sunny then Pedro goes hunting.

Numerical Reasoning Test

Numerical Reasoning Test consisted of 22 questions that math teacher should answer as many questions as they can in 20 minutes. It has been created by Newton and Bristoll and available online from: http://www.psychometric –success.com. Here are two typical question of this exam:

1) Identify the missing number at the end of the series. 662, 645, 624, 599

A	B	C	D	E
587	566	589	575	570

2) Identify the missing number

4	14
35	26

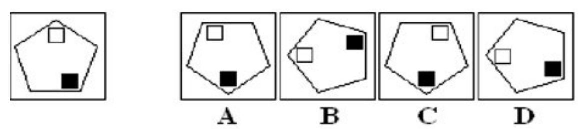
11	31
73	?

A	B	C	D	E
51	56	45	55	52

Spatial Ability Test

Spatial Ability Test consisted of 45 questions that math teacher should answer as many questions as they can in 20 minutes. It has been created by Newton and Bristoll and available online from: http://www.psychometric – success.com. Here is a typical question of this exam:

Which figure is identical to the first?



The descriptive statistics concern to these four abilities provided in Table 2.

3. Results

As to the first objective of this study, a one-way ANOVA was conducted to determine if there is statistically significant difference in mathematics teachers' Abstract Reasoning who has different cognitive style. The result of one-way ANOVA for three groups of cognitive Style showed that there was significant difference between mathematics teachers' Abstract Reasoning at p-value less than 0.001which indicated by Table 3.

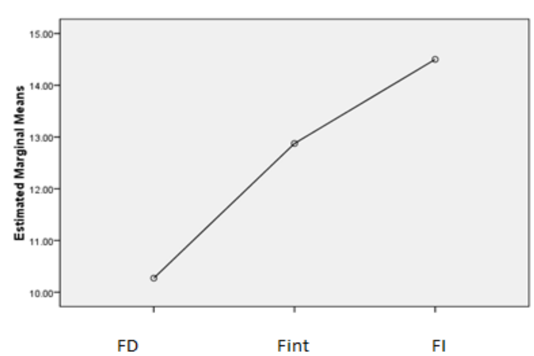


Figure 1. Abstract Reasoning and FD/FI cognitive style

Table 2. The descriptive statistics of math teachers' cognitive abilities over the sample

Cognitive Abilities	N	Minimum	Maximum	Mean	Std. Deviation
Abstract Reasoning	68	4	22	12.75	3.93
Verbal Critical Reasoning Test	68	0	7	3.58	1.54
Numerical Reasoning Test	68	2	22	13.04	4.15
Spatial Ability	68	6	40	27.63	7.47

Table 3. Univariate Analysis of Variance for math teachers' cognitive abilities and cognitive style over the sample

Cognitive Abilities	FD mean	Std. Deviation	Fint mean	Std. Deviation	FI mean	Std. Deviation	P-value	R-square
Abstract Reasoning	10.27	2.54	12.87	4.5	14.5	3.56	Less than 0.001	.219
Verbal Critical Reasoning	2.86	1.48	3.93	1.12	3.93	1.63	0.026	.106
Numerical Reasoning	10.18	4.37	13.25	3.25	15.03	3.18	Less than 0.001	.259
Spatial Ability	24.31	7.36	26.56	5.72	30.63	7.37	.007	.142

According to Duncan Multiple Range Test at 0.05 levels, FD teachers had significantly lower abstract reasoning in comparison to Fint and FI ones. But there was no significant difference between Fint and FI teachers in term of mean score obtained at Abstract reasoning test. In addition, according to Univariate Analysis of Variance field dependency explains 0.219 of the variance (R squared) of mathematics teachers' Abstract Reasoning. Figure 1 shown the performance of mathematics teachers in this test for three groups of cognitive style (FD, Fint, FI).

Concern to Verbal Critical Reasoning the result of one-way ANOVA for three groups of cognitive Style showed that there was significant difference between mathematics teachers' Verbal Critical Reasoning at p-value 0.026.

According to Duncan Multiple Range Test at 0.05 levels, FD teachers had significantly lower Verbal Critical Reasoning in contrast to Fint and FI ones. But there was no significant difference between Fint and FI teachers in term of mean score obtained at Verbal Critical Reasoning test. In addition, according to Univariate Analysis of Variance cognitive style explains 0. 106 of the variance (R squared) of mathematics teachers' Verbal Critical Reasoning. Figure 2 shown the performance of mathematics teachers in this test.

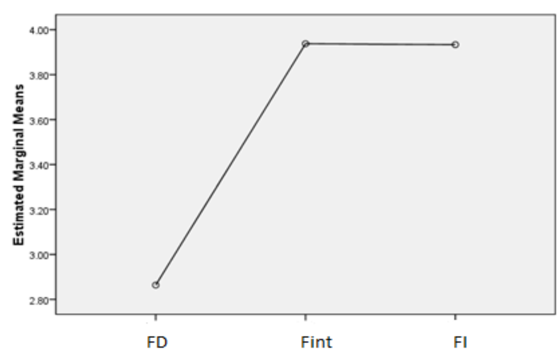


Figure 2. Verbal Critical Reasoning and FD/FI cognitive style

The third objective of the study was to explore if there is significant difference in math teachers' Numerical Reasoning abilities among teachers who have different cognitive style (i.e. FD/Fint/FI). The result of one-way ANOVA for three groups of cognitive Style showed that there was significant difference between mathematics teachers' Numerical Reasoning at p-value less than 0.001.

According to Duncan Multiple Range Test at 0.05 levels, FD teachers had significantly lower

Numerical Reasoning in comparison to Fint and FI ones. But there was no significant difference between Fint and FI teachers in term of mean score obtained at Numerical Reasoning test. In addition, concern to Univariate Analysis of Variance field dependency explains 0.259 of the variance (R squared) of mathematics teachers' Numerical Reasoning. Figure 3 shown the performance of mathematics teachers in this test for three groups of cognitive style (FD, Fint, FI).

Finally as to the last objective of this study, a one-way ANOVA was conducted to determine if there is statistically significant difference in mathematics teachers' Spatial ability who have different cognitive style. The result of one-way ANOVA for three groups of cognitive Style showed that there was significant difference between mathematics teachers' Spatial ability at p-value less than 0.007.

According to Duncan Multiple Range Test at 0.05 levels, FD teachers had significantly lower Spatial ability in contrast to Fint and FI ones. Similarly to other situations there was no significant difference between Fint and FI teachers in term of mean score obtained at Spatial ability test. In addition, according to Univariate Analysis of Variance field dependency explains 0.142 of the variance (R squared) of mathematics teachers' Spatial ability. Figure 4 shown the performance of mathematics teachers in this test.

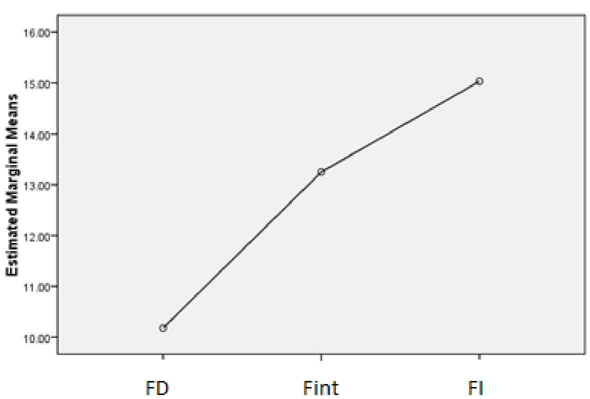


Figure 3. Numerical Reasoning and FD/FI cognitive style

4. Discussions

Two decades ago, the National Council of Teacher of Mathematics (NCTM) unveiled standards for the teaching and learning of mathematics, proclaiming the importance of mathematical thinking, reasoning, and understanding in the lives and futures of students and portraying a vision of the type of mathematics teaching necessary to attain this goal (NCTM 1989, 1991). In this vision, teachers serve as facilitators of students' learning by providing opportunities for students to engage with rich mathematical tasks, develop connections between mathematical ideas and between different representations of mathematical ideas, and collaboratively construct and communicate their mathematical thinking. USA assessment of mathematics teaching conducted by Horizon Research indicated that only 15 % of the 300 observed mathematics lessons provided students with opportunities to make connections, explore mathematics ideas, and develop mathematical understanding (Weiss et al., 2003). Similarly, results from the 1999 TIMSS video study identified several disheartening features of mathematics instruction in US classrooms: lack of coherence in mathematical ideas, low cognitive demands in 83 % of the mathematical tasks presented to students, and virtually no opportunities for students to make mathematical connections through a lesson (Stigler and Hiebert, 2004 in Boston, 2012).

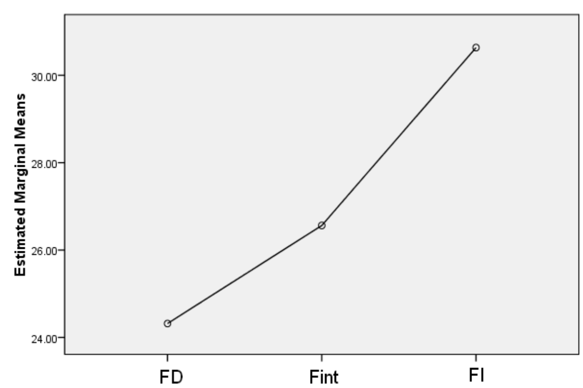


Figure 4. Spatial ability and FD/FI cognitive style

Teachers' cognitive abilities based on mathematics education literature seem to relate to teaching mathematics. As a relationship exist between the levels of individuals' abilities and strategy choice and efficiency in mathematics education and base on the important role of field dependencies in Science education, this study investigate the possible relationship between mathematics teachers' cognitive abilities and their cognitive style.

Abstract reasoning questions are seen to be a good measure of general intelligence, as they test participants' ability to perceive relationships and then to work out any co-relationships without you requiring any knowledge of language or mathematics.

This test consists of visual questions and is independent of language and mathematical ability so it can be considered as an accurate indicator of teachers' intellectual ability. Also mathematics teachers need Verbal Critical reasoning to have this ability to make logical decisions and even to recognize that sufficient mathematics data has been provided for a definitive answer to be reached. Verbal Critical reasoning is needful for interpreting and analyzing mathematics questions for individuals. In addition, High Numerical Reasoning ability is needed for mathematics teachers to have this ability to interpret mathematics data as soon as possible and then apply the appropriate logic to answer the mathematics questions. Finally concern to Spatial Ability, If mathematics teachers have a high level of this ability they have more options to teach mathematics to their students. Researchers have demonstrated that there exists a relationship between the levels of individuals' abilities and strategy choice and efficiency (See Zhu, 2007). Individuals of higher ability tend to solve problems by using more spatial processes, while the others try to solve problem in a more analytical way. This type of teachers has this ability to solve mathematics questions in both analytical and spatial ways.

The results of this study shown that mathematics secondary teachers with FD style have significantly lower Spatial ability, Numerical Reasoning, Abstract Reasoning and Verbal Critical Reasoning in contrast to mathematics teachers with Fint and FI style. According to previous studies (Kagan, 1965; Hudson, 1966; Gregorc, 1979) FD teachers prefer frequent interactions with students, encourage active involvement of students in the management of learning, create positive attitudes towards learning but concern to teaching mathematics, cognitive abilities (i.e. Spatial ability, Numerical Reasoning, Abstract Reasoning and Verbal Critical Reasoning) of mathematics teachers have a important and challenging role.

Teachers usually avoid to present math problems in class which aren't mastery on them. Teachers with FI style and high cognitive abilities usually could understand mathematics problems which are more demanding and have complex structure. But teachers with low cognitive abilities think that this kind of questions isn't necessary to being introduced in math classes.Since they have some problems for understanding this type of questions they think that their students may have similar problems when we introduce these questions to them. Therefore, they avoid presenting high demanding questions in the math class. In other hand, math teachers with low cognitive abilities solve mathematics questions in the simplest way for their students and may not introduce more demanding solutions for math questions while teachers with high cognitive abilities introduce different solutions for each mathematics problems(Even if alternative solution has a complex procedure).

Recognizing teachers' field dependencies helps us to know which type of teachers need more in-service classes to developing their cognitive abilities and help them to teach mathematics in a more scientific way and provide opportunities for their students to make connections, explore mathematics ideas, and develop mathematical understanding.

If FD math teachers can develop their cognitive abilities, their students have this chance to face mathematics problems which are more challenging and demanding since their teachers have this ability to interact with them and tend to introduce these types of questions in mathematics classes and solved mathematics questions in different way for their students as well as teachers with high cognitive abilities.

We should mention that the findings of this study are based on female teachers' samples. Consequently, further research is necessary perhaps under more specific conditions for finding more information, in particular for male mathematics teachers.

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