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Full Length Research paper

A gender study on predictive factors of mathematical performance of University students

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A large body of literature reports that there are gender differences in mathematical problem solving favoring males. Many variables including psychological and cognitive ability are revealed to contribute to gender differences in mathematical problem solving in some specific areas. This article investigates some of these variables to study why gender difference happens in mathematics performance. A sample of 109 university students including 34 girls and 75 boys were selected from Ferdowsi University of Mashhad to participant in this research. Results indicate that there is a little difference between male and female in math problem solving favoring male that occurs from different psychological and cognitive ability that female and males have.

Keywords: Gender difference, predictive factors, cognitive ability, math problem solving

INTRODUCTION

Researchers have repeatedly reported gender differences in mathematics performance (Gallagher, 1990, 1992; Gallagher and DeLisi, 1994; Hyde, Fennema, and Lamon, 1990; Royer, Tronsky, Chan, Jackson and Marchant, 1999; Halpern, 2000; Gonzales et al., 2004; Anglin, 2008). But, results from these studies are not consistent: Reports in favor of boys refer to advantages in general math performance (Lummis and Stevenson, 1990; Maccoby and Jacklin, 1974; Mau and Lynn, 2000); while additional findings reflect superior performance on only specific tasks (Casey et al., 1997; Casey et al., 2001; Gallagher et al., 2000; Geary and DeSoto, 2001). Meelissen and Luyten (2008) according the results of the Trends in Mathematics and Science Study of 2003 (TIMSS-2003) reported that as well as the participation rates of girls in (advanced) mathematics courses, show that in some countries, such as the Netherlands, gender equity in mathematics is still far from a reality. Sex differences in favor of girls are reported at younger ages through preadolescence (Ginsburg and Russell, 1981; Kaplan and Weisberg, 1987; Marshall and Smith, 1987). However, other studies have reported no significant sex differences in math abilities and achievement (Alyman and Peters, 1993; Geary,1994; Tate, 1997).

Zhu (2007) reported that "First-grade girls were more likely to use a manipulative strategy and first-grade boys were more likely to use a retrieval strategy to solve mathematics problems (Carr and Jessup, 1997). Fennema et al. (1998) suggested girls tended to use more concrete strategies and boys tended to use more abstract strategies and that elementary school boys tended to be more flexible in employing strategies on extension problems than elementary school girls. Their study also found girls chose to use more standard algorithms than boys at the end of Grade 3. Gender differences in strategy use were evident among secondary school students (Gallagher and Delisi's, 1994; Gallagher et al., 2000). Tartre's (1993) suggested that high school boys tended use a complement strategy to solve problems involving three-dimensional figure. High school girls tried to use more writing to solve problems requiring a written strategy." Anglin (2008) found that males performed better than females when mindful learning was not encouraged (absolute instruction), but males and females performed equally well when mindful learning was encouraged (conditional instruction). On the Speed of Processing Mathematical Information, Royer et al. (1999) showed that males were generally faster than females on math-fact retrieval tasks while there were no gender differences on simple retrieval tasks. However, females were slightly faster than males on verbal processing tasks. It was hypothesized that the automatic execution of math-fact retrieval, resulted in additional

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working memory capacity that could be used for problem representation and solution planning during problem solving; and males were more likely than females to develop the ability to retrieve basic mathematical facts rapidly and automatically.

Many factors were suggested by researchers to make a contribution to gender difference in mathematical problem solving. Researchers note that there is a relationship between the levels of student's abilities and strategy choice and efficiency. Higher ability students tended to solve problems by using more spatial processes, while the others tried to solve problem in a more analytical way. Also, researchers suggested that gender differences in mathematics can be explained by different learning style that boys and girls have (Zhu, 2007).

Kimball (1989) posited that females took a rote approach while males took an autonomous approach to learning mathematics. Females preferred to learn mathematics by using a conversational style, which fostered group consensus, encouraged collaboration, and contributed to constructing interrelationships of thoughts. Males, on the contrary, learned through argument and individual activity, which fostered independence and encouraged competition. But most classroom activities were organized to accommodate male learning styles (Ong, 1981)

Psychological factors such as mathematics anxiety, math attitude were found to contribute to gender difference in mathematics learning. So these cognitive ability and psychological factors consider investigating why gender difference happen in mathematical performance:

Math Anxiety and Gender Difference

Mathematics anxiety is one of the common attitudinal and emotional factors that have attached attention in recent years. Over the past thirty years, studies have shown mathematics anxiety is a highly prevalent problem for students (Baloglu and Koçak, 2006; Betz, 1978; Jain and Dowson, 2009; Ma and Xu, 2004; Rodarte-Luna and Sherry, 2008, Alamolhodaei, 2009).It has been directly or indirectly, affecting all aspects of mathematics education as one of the most commonly investigated constructs in mathematics education (Çatlıoğlu et al., 2009). In fact, math anxiety may be defined as a feeling of tension, apprehension, or fear that interferes with math performance (Richardson and Suinn, 1972). A number of studies have been carried out over the last few decades on math anxiety investigating its effects upon mathematical activities across all grade levels, k-college. They all revealed that math anxiety is often associated with low performance in mathematical activity and in particular solving math problems (Hembree,1990; Bessant, 1995; Ma, 1999, Mark and Woodard, 2004; Ma and Xu, 2004; Bologlu and Kocak,2006; Alamolhodaei, 2009).

Hembree's (1990) meta-analysis examining math anxiety found that female students consistently reported higher levels of math anxiety than their male counterparts. Whereas a number of studies have supported that women experience more mathematics anxiety than men (e.g., Pezeshki et al, 2011; Abed and Alkhateeb, 2001; Alexander and Martray, 1989; Bander and Betz, 1981; Benson, 1989; Cook, 1998; D'Ailly and Bergering, 1992; Hyde, Fennema et al., 1990; Lussier, 1996; Omoto, 1998), many others failed to confirm significant gender differences in mathematics anxiety (e.g., Coates, 1998; Cooper and Robinson, 1991; Fee-Fulkerson, 1983; Hummer,1998; Oropesa, 1993; Singer and Stake, 1986).

Miller and Bichsel (2004) found that gender was to moderate the relation between anxiety and math performance, and this moderating effect differed depending on the type of math performance. Math anxiety accounted for more of the variance in basic math performance for males than females. Conversely, math anxiety did not account for a significant amount of variance in applied math performance for males, while math anxiety did significantly account for the variance in applied math performance for females. Also Baloglu and Kocak (2006) showed multivariate differences in math anxiety between men and women. Female students showed significantly higher mathematics test anxiety, whereas male students were significantly higher in numerical task anxiety.

Math Attitude and Gender Difference

Many researchers report that, there is an assumption that positive mathematical beliefs, attitudes, and feelings will lead to increased mathematical achievement and while this seems like a reasonable proposition (Grootenboer, 2003a, Wilkins and Ma, 2003, Hassi and Laursen,2009). Attitudes to mathematics appear to be very important in relation to differences in achievement as well as in participation in mathematics courses. Research literature shows that attitude can predict achievement and that achievement, in turn, can predict attitude (Meelissen and Luyten, 2008). However, the relationship between attitudes and achievement is not clear and seems to be different for girls and boys. The results of a meta-analysis conducted by Hyde, Fennema et al. (1990) showed that the effect sizes of gender in relation to mathematics attitudes were just as small as the effect sizes of gender in relation to mathematics achievement. A more recent study (of pre-Grade 9) students showed that boys held higher competence beliefs in mathematics than girls, even though the girls outperformed these boys on mathematics tests (Crombie et al., 2005).The assumption here is that because societies generally regard mathematics as the domain of males, boys and girls receive different feedback on their mathematics achievement from people in their social environment, such as parents and teachers. Boys and girls learn to value mathematics differently. For instance, Li's (1999) meta-review of studies on the influence of teachers' beliefs on gender differences in mathematics achievement showed that teachers had different expectations of girls and boys. High achievement of boys in mathematics is usually attributed to their ability, while the high achievement of girls is often attributed to their effort (Li, 1999).Ma and Cartwright (2003), and Van Langen et al. (2006) show that the influence of affective factors on achievement or on course participation differs for boys and girls. In their longitudinal study of gender differences in affective outcomes in mathematics, Ma and Cartwright (2003) found that between-school variance in attitudes towards mathematics was larger for boys than it was for girls. Also McGraw, Lubienski and Strutchens (2006) and Pierce, Stacey and Barkatsas (2007) reported that female students' attitudes to mathematics and their self-concepts were more negative than those of males. Describing how attitudes to mathematics change from grades 6 to 9, Campos (2006) reports that while in grade 6 more girls than boys had positive attitudes towards mathematics, more boys than girls in grade 9 showed such positive attitudes. In addition, they found that both male and female teachers tended to consider mathematics a male domain and that boys were "naturally" better than girls at mathematics, noting that women have to work harder and make a greater effort in order to be successful in this subject.

Math Attention and Gender Difference

Mathematics is a way of thinking and requires a great deal of attention, particularly when multiple steps are involved in problem solving process. However, attention is a controversial concept but its large scale treatments could be found in recent studies (Cowan et al., 2005).There has been demonstrated a close relation between attention and memory in the limit capacity system (Styles, 2005). At least two dimensions of attention may be considered, the attention control and its scope. These two dimensions of attention are not necessarily in conflict. Individuals who excel at controlling could be those who have the largest scope of attention (Cowan et al., 2005; Styles, 2005).

At the heart of math attention is the issue of how many tasks can be done at the same time to reach a solution. Alamolhodaei and Abbasi, (2010) found that mathematical attention is a cognitive functioning which allocates the math information and Z-demands (amount of information processing required by math task) of tasks to a different level of consciousness. The process of attention could help students with meaning level learning of mathematical activities. On the contrary, inattention is the most and widespread problem of learners. Inattention is a risk factor for poor mathematics achievement (Tannock, 2008).

Despite the fact that a large number of girls might be suffering from attention deficit hyperactivity disorder (ADHD), the scientific literature on ADHD is almost exclusively based on boys. Girls with ADHD were more likely than boys to have the predominantly inattentive type of ADHD, less likely to have a learning disability, and less likely to manifest problems in school or in their spare time. In addition, girls with ADHD were at less risk for co morbid major depression, conduct disorder, and oppositional defiant disorder than boys with ADHD. (Biederman et al., 2002)

Research literature doesn't show any gender study on math attention on ordinary students because this is a new term in mathematical education research.

Cognitive Style (FD/FI) And Gender Difference

Cognitive style differences influence the acquisition and demonstration of cognitive skills necessary for self-formation such as differentiation, organization and integration. 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). Witkin and Goodenough, (1981) Research shows that, in general, field dependent children and adults 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). Other research has shown that, in comparison to FD individuals, FI adolescents pay less attention to social cues and prefer vocations that require high autonomous functioning and analytic thinking (Eagle et al., 1969; Witkin and Goodenough, 1981; Witkin et al., 1977).

Several researchers have demonstrated the importance of field dependency in science education and mathematical problem solving, in particular word problems (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.

Attributes such as autonomy and analytic thinking may be more valued by society and, because they are traditionally masculine, may be more reinforced in males than females (Denmark et al., 1988; Newcombe et al.,1983; Reis, 1987; Tavris, 1992), whereas feminine characteristics associated with field dependence such as intuitive or global/holistic thinking may be more strongly reinforced among girls than boys. But no significant gender difference reported between female and male university students in cognitive style test (Zhang, 2004).

Working memory capacity and Gender difference

Working memory is the part of the brain where we hold information to work upon, organize, and shape it before storing in long-term memory for further use (Johnstone, 1984; Ribaupierre and Hitch, 1994). As Baddeley (1986, 1990) defined, it is a system for the temporary holding and manipulation of information during the performance of a range of cognitive tasks such as comprehension learning and reasoning. In fact, Baddeley's (1990) model of working memory has been particularly useful in explaining a variety of thinking phenomena (Niaz and Logie, 1993).

Working memory capacity (WMC) is essential for important cognitive abilities including reasoning, comprehension and problem solving (Engle, 2002). Although WMC is related to short-term memory capacity, WMC in addition reflects general "executive attention" ensuring that memory is maintained in spite of interference or distractions. This ability enables controlled attention capability in situations involving distraction during memory and cognitive control tasks (Engle, 2002; Mayers, 2011).

There are some considerable evidences suggesting that WM may be important for mathematics learning and problem solving. For instance, Adams and Hitch (1998) suggested that mental arithmetic performance relies on the recourses of working memory. Significant associations have been found between the phonological loop and mental arithmetic performance (Adams and Hitch, 1998; Javris and Gathercole, 2003; Holmes and Adams, 2006). Moreover, (Alamolhodaei, 2009; Farsad and Alamolhodaei, 2009 and Pezeshki et al., 2011) have found that the students with high WMC, are more capable of solving math word problems compared to those with low WMC.

Robert and Savoie (2006) reported that "In a primary memory task analogous to word span tasks involving the phonological subsystem, men and women have displayed similar word recall (Herlitz et al., 1997). In another simple phonological storage task, the Digit Forward subtest of the Wechsler Intelligence Scale, some authors (Duff and Hampson, 2001; Orsini et al., 1986) have reported no significant gender differences, while others have observed a female advantage (Grossi et al., 1980).In the Digit Backward subtest, which asks for a more active involvement of the central executive, again men and women were not found to differ significantly (Duff and Hampson, 2001). With respect to visuospatial working memory, Corsi's test usually yields a male advantage (Capitani et al., 1991; Grossi et al., 1980; Orsini et al., 1986; Kessels et al., 2000; Postma et al., 2004). When the locations of random cells in series of two-dimensional grids need to be stored while further grids are shown, men also outdo women (Minor and Parks, 1999; Vecchi and Girelli, 1998). However, women's superiority has been established in locating pairs of coloured dots in a minimum of searches for individual dots concealed in an array (Duff and Hampson, 2001)."

Finally, result of Robert an Savoie (2006) investigation, showed men and women had no significant gender difference in any type of working memory save in the double-span task where women surpassed men.

Spatial Ability and Gender Difference

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 and 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).

Some aspects of mathematics have spatial component and correlations between math and visual spatial skills have been reported (Fias & Fischer, 2005, Lachance and Mazzocco, 2006; Zhu, 2007). Many researchers believe that substantial sex differences in spatial abilities do exist such as Maccoby and Jacklin 1974; Linn and Peterson 1985; Alexander 2005 and McNulty, 2007. Ginn and Pickens (2005) noted that previous research suggested that the male advantage on mental rotation tasks might be related to experience with spatial tasks. There is considerable evidence supporting the existence of gender differences in spatial abilities; however, researchers have only been able to make claims of sex differences in specific subdivisions of spatial ability. Moreover, many claims have been made about possible social and environmental causes of sex differences in spatial abilities. The shift toward male superiority in math, in higher grades, has been attributed in part to an increasing reliance on spatially based strategies, which boys are alleged to use more often

(Benbow, 1988; Casey et al., 2001; Maccoby and Jacklin, 1974).

While many researchers contend that substantial sex differences in spatial abilities exist, an equal number of researchers maintain that substantial gender differences in spatial abilities do not exist. Researchers who challenge the notion of sex differences argue that the current research on sex differences in spatial ability is inconsistent and flawed. The most well-known paper supporting that evidence for sex differences is unreliable was written in 1985 by Caplan and coworkers. Also, Lohman (1986) maintained that gender differences in spatial abilities can be eliminated with exposure and practice.

Verbal Critical Reasoning and Gender Difference

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

The different between spatial and verbal abilities also affected both females' and males' strategy use. 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 approached mathematical solutions (Krutetskii, 1976; Zhu, 2007). Battista (1990) found that, student with high spatial ability and low verbal ability might try to use more spatial strategies to solve mathematical problems, while students high or low in both abilities might be more variable in strategy use.

Hyde and Lynn (1988) found in their meta-analysis that females outperform males in overall verbal ability. Other studies reported that females outperform males in verbal fluency (Hines, 1990), synonym generation (Halpern and Wright, 1996), or reading comprehension (Hedges and Nowell, 1995). However, males outperform females in verbal analogies (Lim, 1994). Sex differences in verbal ability measures are not always favorable to females. Colom et al (2004) found that males outperform female in verbal reasoning task. However, sex differences in verbal reasoning turn to be non- significant when sex differences in dynamic spatial performance are statistically removed. Their finding is interpreted from the previously demonstrated fact that the verbal reasoning test requires spatial processing. Colom et al (2002) have demonstrated that performance in a test of verbal reasoning based on linear syllogisms or three-term series (John is better than Peter : Peter is better than Paul :: Who is worse?) is accurately predicted from a model of human information processing based on the mental transformation of the verbal information into a mental spatial diagram or a mental model.

Abstract Reasoning and Gender Difference

The Abstract Reasoning assesses students' 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 both an ability to change track, critically evaluate and generate hypotheses which can be relevant in the development of new ideas and systems.

Boys and girls mature at about the same rate up to the age of around 7 years; from the age of 8, girls begin a growth spurt in which there is an acceleration of their physical growth in respect of height, weight, and brain size; the growth rate of girls slows at the age of 14 and 15, while the growth of boys continues (Lynn and Irwing, 2004). The developmental theory states that intelligence follows the same trend. Evidence supporting the theory has been provided in Lynn (1994, 1998, 1999) and in Lynn and coworkers (2000). In regard to abstract reasoning ability, the theory as originally formulated in Lynn states that over the age range of around 9 through 12 years, girls have an advantage of approximately 1 IQ point; by the age of 16 years, this has changed to a small advantage in favor of boys and among adults the male advantage is 2.4 IQ points. These estimates were not derived from data on the progressive matrices but (in the case of adults) from the American standardization samples of the Differential Aptitude Test. In a subsequent compilation of studies, it was proposed that among adults the male advantage on abstract reasoning is approximately 5 IQ points (Lynn, 1999).

Other research has documented that women tend to estimate their abstract reasoning ability lower than men do (Bennett, 2000; Furnham et al., 1999; Furnham et al., 1999; Rammstedt and Rammsayer, 2000, 2001, 2002). This finding bears no relation to their true level of ability and to the accuracy of their ability estimate (Holling and Preckel, 2005; Pallier, 2003). Similar results emerged when subjects had to estimate the ability of others (e.g., family members): Men regularly were judged more able than women in the domain of abstract reasoning (Rammstedt and Rammsayer, 2000). Thus, confidence ratings and estimates of one's own intellectual ability seem to be influenced by differences in self-perceptions that are caused by gender stereotypes (Beloff, 1992; Beyer, 1998; Pallier, 2003).

Numerical Reasoning and Gender Difference

Numerical Reasoning Test consist of information is provided that requires students to interpret it and then apply the appropriate logic to answer the questions. In other words, students need 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 Physics students. 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. While the study found a significant influence of quantitative ability on students' academic achievement, gender had no significant influence. 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 defined by an equation $\hat{y}=38.788+0.234x$ was obtained.

A useful source of data to examine for sex differences in abilities is the Differential Aptitude Test (DAT) (Bennett et al., 1982). This test consists of eight subtests, designated verbal reasoning (analogies), abstract reasoning (figural non-verbal reasoning), spelling, language usage (a test of grammar and punctuation), numerical ability (arithmetic), clerical speed and accuracy (perceptual speed), space relations (three- dimensional spatial visualization) and mechanical reasoning. The DAT has been standardized on four occasions in the United States on a total of 193,844 teenagers over the age range 13-18 years. The results have been analyzed for sex differences by Feingold (1988), who showed that females obtained higher means on spelling, language, and clerical speed and accuracy, males obtained higher means on mechanical reasoning and space relations, while there were no sex differences on verbal reasoning, abstract reasoning and numerical ability. But Lynn (1992) for British sample found that girls obtain higher means on the tests of clerical speed and accuracy and spelling and language, while boys obtain higher means on the remaining five tests in. Also Colom et al (1999) reported that Males scored higher in the DAT subscales Verbal Reasoning, Numerical Ability, Spatial Relations and Mechanical Reasoning between 1979 and 1995 in Spain.

Thus, the main question addressed here is: “Is there any gender difference in predictor factors of mathematical performance in university students?” So the first objective of this study was to discover whether there was a gender difference in students’ performance in Digit Span Backwards Test, Mathematics Anxiety Rating Scale, Cognitive style (FD/FI) Test, Modified Fennema-Sherman Attitude Scales, Mathematics Attention Test, Verbal Critical Reasoning Test, Numerical Reasoning Test, Spatial Ability Test and Abstract Reasoning Test. The second objective of the study was to test whether there was a gender difference between students’ mathematical performance.

MATERIALS AND METHODS

Participants

109 university students including 34 girls and 75 boys were selected from Ferdowsi University of Mashhad, faculty of mathematical science from Khorasan Razavi Province using random multistage stratified sampling design.

Procedures

The participants were required to take the following tests:
1. Digit Span Backwards Test (DBT)
2. Mathematics Anxiety Rating Scale (MARS)
3. Cognitive style (FD/FI) test
4. Modified Fennema-Sherman Attitude Scales
5. Mathematics Attention Test (MAT)
6. Verbal Critical Reasoning Test
7. Numerical Reasoning Test
8. Spatial Ability Test
9. Abstract Reasoning Test
10. Math Exam

After collecting data from students’, all the point was calculated from 100. Normality assumptions for exams were considered.

Digit Span Backwards Test (DBT)

For the measurement of the students’ working memory capacity (WMC), DBT has been quoted as the normal test (Case, 1974; Talbi, 1990; Alamolhodaei, 2009 and Pezeshki et al., 2011). The digits were read out by an expert and the students were asked to listen carefully, then turn the number over in their mind and write it down from left to right on their answer sheets. WMC was originally has seven plus or minus two storage unit as Pascual Leoni described.

Mathematics Anxiety Rating Scale (MARS)

Level of anxiety was determined by the score attained on the Math Anxiety Rating Scale (MARS), which had been used recently in the Faculty of Mathematical Sciences, Ferdowsi University of Mashhad. The MARS for this research was newly designed by the researcher according to the inventory test of Ferguson (1986). It consists of 32 items, and each item presented an anxiety arousing situation. The students decided the degree of anxiety and abstraction anxiety aroused using a five rating scale ranging from very much to not at all (5–l). Cronbach's alpha, the degree of internal consistency of mathematics attention test items for this research was estimated to be 0.94

Cognitive Style (FD/FI) Test

The independent variables were cognitive style and the position of a learner on each of the learning style dimensions (FD and FI) was determined using the Group Embedded Figures Test (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. Students' cognitive styles were determined according to a criterion used by (Case, 1974; Johnstone et al., 1993; Alamolhodaei, 1996, 2009).

Modified Fennema-Sherman Attitude Scales

In an effort to study students' attitudes towards math, Elizabeth Fennema and Julia A. Sherman constructed the attitude scale in the early 1970's. The scale consists of four subscales: a confidence scale, a usefulness scale, a scale that measures mathematics as a male domain and a teacher perception scale. Each of these scales consists of 12 items. Six of them measure a positive attitude and six measure a negative attitude. This scale could give a teacher and individual student useful information about that particular student's attitude(s) towards math. Because this scale was originally written many years ago and the subtle meanings and connotations of words have changed in that time period so Doepken, Lawsky and Padwa were modified it. Researchers of this study was used this modified test. The URL below provides the Modified Fennema-Sherman Scale:
URL:http://www.woodrow.org/teachers/math/gender/08scale.html

Mathematics Attention Test (MAT)

Level of math attention was determined by math unpublished attention test which has been used in Faculty of Mathematical Sciences, Ferdowsi University of Mashhad in M.Sc project. In this task students respond to 25 questions which arranged according to Likert scale from very little to too much. Cronbach's alpha, the degree of internal consistency of mathematics attention test items for this research was estimated to be 0.86. Here are some typical questions of this exam:
How much attention do you have in each situation?

Question Number	Question
1	When the subjects are offered by teachers in the classroom.
2	When studying the math lessons that you have been learned
3	When the math teacher is teaching and you need to write and listen simultaneously
4	When you are studying and learning mathematics as a group
5	When the math course materials are to be tangible and concrete
6	When teacher directly monitors the process of your math problem solving.
7	When the math course materials are to be tangible and concrete.
8	When the math course materials were to abstract and you had no idea about it in your mind.

Verbal Critical Reasoning Test

Critical reasoning questions require students 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 students 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 students 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

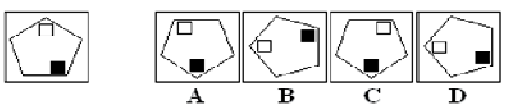
11	31
73	?

A	B	C	D	E
51	56	45	55	52

A B C D E

Spatial Ability Test

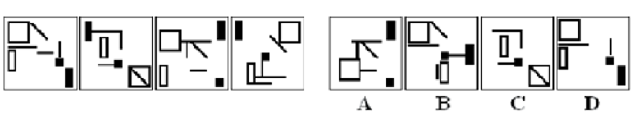
Spatial Ability Test consisted of 45 questions that students should answer as many questions as they can in 20 minutes. It has been created by Newton and Bristoll and available online from: http://www.psychometric – success.com. Here is a typical question of this exam:
Which figure is identical to the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



A B C D

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 students' general intellectual ability. Abstract Reasoning Test consisted of 25 questions that students 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?



A B C D

Math Exam

In the present study the students' scores on the mathematics test administered at the end of first term of 2010-2011 academic year were collected from Ferdowsi University records and served as the basis for judging students' math performance. This test is of utmost importance to the students.

RESULTS

The result of t-test for two groups of male and female students showed that they had significant difference in terms of mean scores obtained in Numerical Reasoning, Spatial ability, Math attention and cognitive style tests with these p-values 0.004, .046, .019, .010 respectively. Additionally it was shown that male students had more points in these tests (Numerical Reasoning, Spatial ability, cognitive style) And Female get higher points in math attention test.

The result of t-test for two groups of male and female students showed that they hadn't significant difference in terms of mean scores obtained in Mathematics Anxiety Rating Scale and math attitude test with p-value 0.706 and .651 respectively, nevertheless graph error bar shown that female students had more mathematics anxiety than male ones and male students had more positive attitude towards mathematics than females as shown in figure 2

The result of t-test for two groups of male and female students showed that they hadn't significant difference in terms of mean scores obtained in verbal and abstract reasoning test with p-value 0.056 and .770, respectively nevertheless graph error bar shown that female students had more verbal ability than male ones and male students had more abstract reasoning ability than females as shown in figure 2.

The result of t-test for two groups of male and female students showed that they hadn't significant difference in terms of mean scores obtained in math exam and Digit Backward test with theses p-values .287 and .157 respectively, nevertheless graph error bar shown that male students had more math performance and working memory capacity than female ones as shown in figure 3.

DISCUSSION

Gender differences in mathematical problem solving, which is believed to be an important factor that contributes to gender differences in mathematics performance, have been given increased attention by researchers in the last few decades. Research literature suggests that students' with different psychological factors and cognitive ability have different math performance. In other hand, mathematical education research shows that there is different between male and female in mathematical performance and strategies they have used in problem solving in some aspects. The aim of present study was to investigate the role of gender on predictive factor of mathematical performance on university students.

Results of present study, clarify Hyde et al. (1990) findings that there was very small gender difference

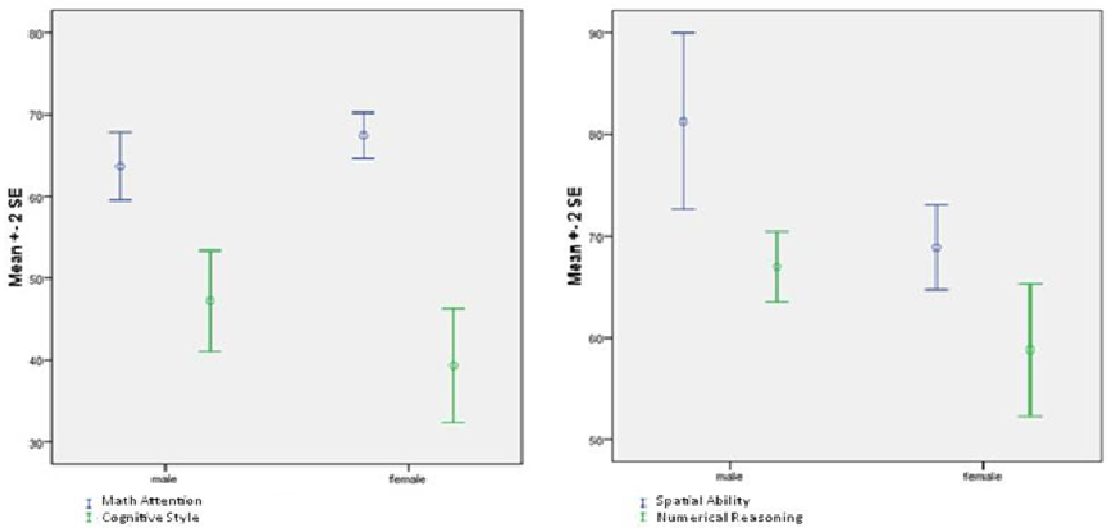


Figure 1. Math attention , cognitive style, spatial gender, numerical reasoning and gender difference

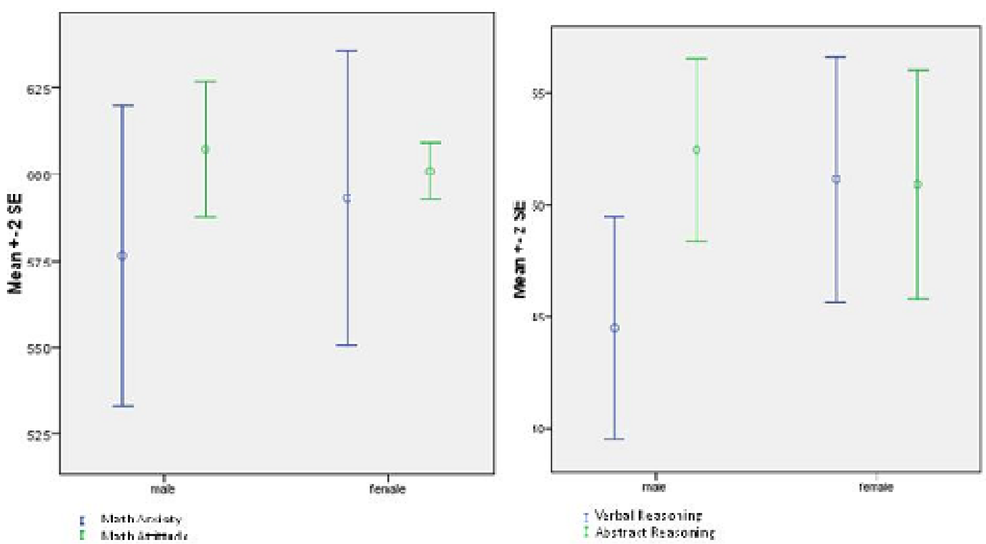
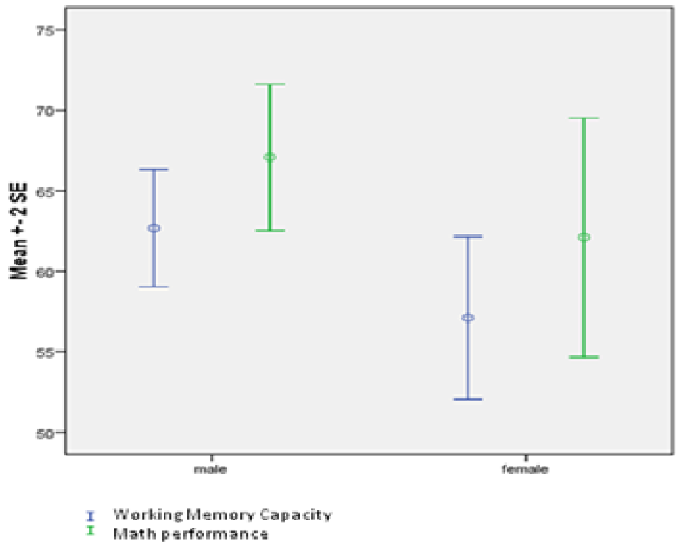


Figure 2. Math anxiety , math attitude, verbal reasoning, abstract reasoning and gender difference

favored to males in mathematics performance (D=.23). As can be inferred from the results of the present study there is a gender difference in numerical reasoning and spatial ability as previous studies mentioned earlier (For Spatial ability, Maccoby and Jacklin, 1974; Linn and Peterson, 1985 ; Alexander, 2005 and McNulty, 2007) (For Numerical reasoning : Lynn,1992 and Colom et al., 1999).

Also for university sample from the result of this study, it can be seen that male student had better performance on cognitive style (FD/FI) test. It means that they tend to be field independent more than girls; that support Denmark et al (1988), Newcombe et al (1983), Reis (1987) and Tavris (1992) findings. Another significant gender difference find from this study was in math attention favoring girls. This term is a new one in math educational research and more focus should be done on it. There is no gender study on this variable to compare to the result of this study.



The table gives the means of the boys and girls, the standard deviation for both sexes combined and the D (the effect size, i.e. the sex difference in standard deviation units).

Table1. Effect sizes for gender group

	Male	Female	SD	D
Math performance	66.66	62.09	19.70	.23
Math Anxiety	58.40	59.49	12.36	-.09
Math Attitude	60.70	60.19	4.60	.11
Math attention	61.84	67.79	11.46	-.52
Working memory capacity	62.84	58.46	14.91	.29
Cognitive style	49.69	39.06	18.48	.58
Spatial ability	80.91	68.66	27.71	.44
Verbal reasoning	43.97	51.14	17.14	-.42
Abstract reasoning	51.85	50.91	14.56	.06
Numerical reasoning	67.81	57.57	15.08	.68

Minus signs indicate that girls obtain higher means than boys.

Male university students had a more math attitude (D=.11) and less math anxiety (D=-.09) compare to females ones that can clarify previous studies while the effect size (D) in this study was less than previous researches. A gender study on working memory capacity was done by Duff and Hampson (2001) that no gender difference was found in it. This result was repeated in present study but effect size was a little favored to male students as shown in table 1. And finally no significant gender difference found in abstract reasoning test (D=.06) that wasn't support previous studies. The effect size of sex difference in abstract reasoning in previous studies are more favored to male than what researchers of this study obtained in university sample and result showed that may be this gap had been minimized in university students.

In conclusion as a mathematics educators we should minimize gender difference in mathematical performance and making necessary opportunity for girls to perform as the same as boys in mathematical courses in university. For investigating why this gender differences were happened, mathematics educators should pay more attention to predictive factors of mathematical performance. Male students significantly better performed on numerical (D=.68), spatial (D=.44) and cognitive style (D=.58) test according to the results of this study and also they had more positive attitude (D=.11) toward math and less math anxiety (D=-.09) compare to female students also they have a slight more working memory capacity (D=.29) than female ones. In other hand female students better performed on math attention (D=-.52) and verbal reasoning test (D=-.42). Higher math attention that females have, compare to male students, can minimize the gender difference that exist in math performance if female have more positive attitude toward math and they can control they anxiety toward mathematics. This can be done by the help of math teachers and hard working of female students.

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