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www.msocialsciences.com**The Impact of Executive Functioning on Academic Performance of Students in Mathematics and Science****Alishba Hania<sup>1</sup>, Daisy Jance C. Orcullo<sup>1</sup>, Azlizamani Zubir Salim<sup>1</sup>**<sup>1</sup>Universiti Utara Malaysia

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**Abstract**

Present research investigated the impact of executive dysfunction on academic performance among students in their middle childhood. It was hypothesized that school teacher's rating of executive dysfunction in students can significantly predict their performance in Mathematics and Science subjects. The study used primary data which was collected from public schools of Lahore. An indigenized executive dysfunction inventory was constructed for this purpose and psychometric properties were established. It was postulated that student's performance in Science and Math will vary based on their executive dysfunction and the results attested to this hypothesis. Demographic properties were also evaluated through age, number of siblings, gender, family system, and mother profession. Statistical findings revealed that higher level of executive dysfunction is associated with lower level of science and math performance.

**Keywords:** executive functioning, executive dysfunction, academic performance

**Introduction**

Children in low- and middle-income countries experience several types of misfortunes and advancement barriers including inadequate cognitive stimulation, environmental toxins, micro and macronutrients, stunted growth and absolute poverty which negatively influence their cognitive development (Black et al., 2013). Majority of the children and students in these countries are unable to gain their cognitive potential and face difficulties in following even simple directions. Moreover, the mental function and cognitive issues are heavily underestimated in developing world (Gilbert, Patel, Farmer, & Lu, 2015). In Pakistan, students who do not perform well in science and math subjects, are forced to chose arts or related subject. Consequently, they develop further mental issues and suffer from a lower level of self-esteem through their lifespan.

Psychologists and behavioral scientists have proposed several solutions to enhance the academic performance of these students, however, most of the techniques are designed for developed countries. In developing countries like Pakistan, children are still compared through their Intellectual Quotient (IQ) to evaluate their mental ability. Nonetheless, self-regulatory mechanisms have criticized school psychologists for using IQ as a tool to measure mental well-being. Students who do not perform optimally in academics may perform efficiently in sports or extracurricular activities. Thus, self-regulatory approaches such as executive functioning are better than intelligence (Ursache, Blair, & Raver, 2012).

Executive functions (EF) is very essential to learn better and perform day to day activities adequately. Prefrontal Cortex of the brain executes these functions. Mainly these functions include inhibition, visual memory, working memory, emotional control, and planning. Inhibition is a process of suppressing and restraining the behavioral impulses, desire, and process. Individuals with a substantial level of inhibition function may get rid of the person they do not like. Lack of adequate executive functioning may also negatively influence visual memory. Visual memory helps a person to envisage certain steps in their mind to reach a specific goal while working memory allows an individual to recall a saved information to solve an issue. Emotional control is also one of the important functions which allow an individual to control unreasonable sentiments and emotions by using verbal and visual memory. Lastly, the problem-solving function makes an individual capable of proposing a plan to resolve an issue effectively using all other executive functions (Goldstein, & Naglieri, 2013).

According to previous literature in regards to executive functioning and self-regulation among internalizing or externalizing behavioral continuums, it is suggested that externalizing expressions possess high impulsivity and low inhibition while internalizing expressions are low in impulsivity but high in inhibition (Eisenberg, et al., 2001; Eisenberg & Spinrad, 2004). Such self-regulatory relationship of EF with internalizing and externalizing continuums are referred to under-regulated (externalizing) or over-regulated (internalizing). A wide range of studies has discussed the effect of executive functioning on individual behaviors (Bull & Lee, 2014; Leonard, Bernardi, Hill, & Henry, 2015). Nonetheless, in reference to children, the literature is inconsistent due to different types of complexities.

Researchers have argued that self-regulation and its association with internalizing/ externalizing behavioral continuum can influence academic performance. If identified and measured adequately, executive functioning of many students can be improved and psychologists can turn their failures into success (Duckworth & Seligman, 2005). Previous studies have considered updating, inhibition and task-switching the core elements of executive functioning and very important to investigate in children (Huizinga, Dolan, & van der Molen, 2006; van der Ven, Kroesbergen, Boom, & Leseman, 2013). Studies have also linked working memory, updating, task-switching, and inhibition with mathematics (Bull & Scerif, 2001; van der Ven, Kroesbergen, Boom, & Leseman, 2012; Cragg, Keeble, Richardson, Roome, & Gilmore, 2017).

Although a wide range of previous studies have found a direct link between executive functioning and academic performance; however, their results are less conclusive (Bailey, Andrzejewski, Greif, Svingos, & Heaton, 2018; Bull & Lee, 2014; Gordon, Smith-Spark, Henry, & Newton, 2018; Samuels, Tournaki, Blackman, & Zilinski, 2016). Especially, in the context of Pakistan, there is scanty of literature which explores the association of executive functioning with academic performance in adolescents. For instance, Zafar, Kausar, and Pallesen (2018) evaluate the relationship between executive functioning and academic performance in young adults. Their results reveal that time management, planning, flexibility, working memory, and retroactive flexibility is significantly associated with CGPA of students. On the other hand, Hussain and Ali (2014) focused on adolescents but did not find any link between academic achievement (arithmetic, spelling, and reading) and executive functioning.

According to our best knowledge, there are no previous studies in the context of Pakistan which evaluate the association of executive functioning with the academic performance of science and math students simultaneously. Thus, it is expected that this study will contribute to the academic literature and helps school psychologists in developing a strategy to enhance the academic performance of students through better executive functioning. The main objective of this study is to investigate the effect of executive functioning on the science and math performance of the students. Additionally, this study is interested in evaluating the effect of demographics (age, gender, number of siblings, father education, mother education, mother profession, and family system) on executive functioning and academic performance.

## Methodology

### *Population and Sample*

This study has focused the students of public sector schools in Pakistan. Students in private schools usually have better academic performance, better infrastructure and preferred medium of instruction while the opposite is true for public schools in Pakistan. Thus, the issues related to executive functioning could be more prevalent in public schools. However, owing to the excessive fees in private schools, lower class or lower middle-class families cannot get admission in these schools. According to Pakistan Education Statistics report 2016-2017, there are total 19.35 million children enrolled in primary schools of Pakistan from which 61 percent (11.90 million) are attending public schools. According to Krejcie and Morgan (1970) criteria for determining sample size, a final sample of 394 children was selected. Out of 394 students, 103 did not complete the survey; hence, the response rate was 74 percent. Description of selected sample's demographics is given in Table 1.

Table 1: Demographics of the Study Sample

Characteristics	F(%)	M(S.D.)
Age		11.08(1.44)
Number of Siblings		4.77(1.75)
Gender		
Male	145(49.9)	
Female	146(50.1)	
Family System		
Nuclear	227(78)	
Joint	64(22)	
Mother Profession		
Housewife	255(87.5)	
Working Women	36(12.5)	

Table 1 shows that the average age of students is 11 years while the average number of siblings is 5. Our sample comprised of 49.9 percent male students while 50.1 female students. Most of the students are living in a nuclear family system (78 percent) and the majority of the mothers are housewives (87.5 percent).

### *Measures*

Owing to the fact that most of the questionnaires/scales to measure executive functioning are developed for the western population. Western countries are developed countries and their measurements cannot be generalized on underdeveloped or developing countries. Thus, we developed a scale specifically in the context of Pakistan to measure executive functioning. The questionnaire measured executive functioning of students through perspective of teachers. Questionnaires used teacher's view of challenges in student's executive functioning. Executive Dysfunction Inventory measured the responses on a three-point Likert scale ranging from (1) Never to (3) Often. Higher scores on our scale meant higher level of executive dysfunction. On the other hand, academic performance is measured through the outcomes of the student's final examinations.

### *Data Collection Procedure*

We have collected the data from public sector schools of Lahore. Lahore is the second largest city of Pakistan; thus, the responses can be generalized on other major cities. Since the inventory was indigenously developed, permission of using the instrument was not required. In order to collect the data, researcher took permission from the principles of respective schools. Questionnaires were

distributed during the parent-teacher meeting to record the responses of parents, teachers, and students. In order to collect the data of academic performance, we requested administration of schools to provide the relevant data.

**Diagnostic Tests and Operational Model**

In accordance with our study’s objectives, we have developed three regression models. Ordinary least square (OLS) regression is utilized as it is a powerful tool when used in conjunction with data transformation or dummy variable coding. However, there are certain assumptions of OLS regression which should be fulfilled in order to evaluate robust estimates. Firstly, normality is ensured using skewness and kurtosis values. Values for all variables were between -2 to +2. Secondly, we also did not find any issue of autocorrelation as Durbin Watson statistic for all models was close to 2. Thirdly, no issue of multicollinearity was detected as VIF values of all predictors were less than 10. Lastly, we ensure the homogeneity of data using scatter plots. All plots were scattered and they were not following any specific pattern. After assuring that there are no anomalies in the data, we test our results using the following regression models.

$$SCI = \alpha + \beta_1 EXED + \beta_2 AGE + \beta_3 GEND + \beta_4 SIBL + \beta_5 FEDU + \beta_6 MEDU + \beta_7 MPRF + \beta_8 FAMS + \varepsilon \dots\dots\dots (eq. 1)$$

$$MATH = \alpha + \beta_1 EXED + \beta_2 AGE + \beta_3 GEND + \beta_4 SIBL + \beta_5 FEDU + \beta_6 MEDU + \beta_7 MPRF + \beta_8 FAMS + \varepsilon \dots\dots\dots (eq. 2)$$

$$EXED = \alpha + \beta_1 AGE + \beta_2 GEND + \beta_3 SIBL + \beta_4 FEDU + \beta_5 MEDU + \beta_6 MPRF + \beta_7 FAMS + \varepsilon \dots\dots\dots (eq. 3)$$

Where SCI = Science scores, EXED = Executive Dysfunction, AGE = Age of student, GEND = Gender of student, SIBL = Number of siblings, FEDU = Father’s education, MEDU = Mother’s education, MPRF = Mother’s profession, FAMS = Family system, ε = error term

**Results and Discussion**

The present study tests three regression models and their results are reported in Table 2. The results show that higher level of executive dysfunction is associated with lower level of science (β = -0.34, p < 0.01) and math performance (β = -0.40, p < 0.01). These results are consistent with prior related studies (Bailey et al., 2018; Cragg et al., 2017; Gordon et al., 2018; van der Ven et al., 2012). A higher level of executive functioning is essential for scoring better in science and math subjects. It is also revealed that the science performance of children also decreases with the increase in age (β = -0.068, p < 0.1). However, this evidence is contrary to the results of Navarro, García-Rubio, and Olivares (2015) who found the positive influence of age on academic performance due to the involvement of maturation.

Table 2: Regression Results

Predictor Variables	Dependent Variables		
	Science Performance	Math Performance	Executive Dysfunction
Executive dysfunction	-0.337(0.000)***	-0.400(0.000)***	
Age	-0.068(0.050)*	-0.039(0.242)	0.037(0.308)
Gender	-0.047(0.170)	-0.071(0.033)**	0.016(0.660)
Siblings	-0.018(0.602)	0.048(0.161)	-0.072(0.054)*
Father Education	0.006(0.890)	-0.031(0.483)	-0.031(0.526)

Mother Education	-0.006(0.863)	0.108(0.017)**	-0.111(0.024)**
Mother Profession	-0.034(0.329)	-0.034(0.307)	0.024(0.506)
Family System	-0.006(0.863)	0.005(0.869)	0.002(0.947)
Constant	-0.786(0.000)***	0.907(0.000)***	154.073(0.000)***
Goodness of Fit (R <sup>2</sup> )	12.30%	18.70%	2.10%

Note: Values in parentheses are the estimated p-values. \*, \*\*, and \*\*\* indicate significance at the 10%, 5% and 1% levels, respectively.

Regression results also asserted that male students perform better as compared to female students in case of mathematics ( $\beta = -0.071$ ,  $p < 0.05$ ). A previous study by Guiso, Monte, Sapienza, and Zingales (2008) argued that differences in math scores between males and females exist in the presence of less social equality in a country. Thus, it is purported that female students in Pakistan face gender discrimination and gap due to which they may not perform well in their math exams.

Mother education also plays a vital role in improving math performance of the students ( $\beta = 0.108$ ,  $p < 0.05$ ). This evidence can be supported by the study of Tang, Davis-Kean, Chen, and Sexton (2016) who also asserted that mother education is one of the important determinants of a child's academic performance. In the third model, executive dysfunction is considered as a dependent variable. Results show that a greater number of siblings may lead to a lower level of executive dysfunction ( $\beta = -0.072$ ,  $p < 0.1$ ). Rolan, Schmitt, Purpura, and Nichols (2018) argued that siblings offer a unique context for practicing skills such as executive function (EF). Further, siblings are influential agents in parenting practices, which may, in turn, be related to EF. Our results also posited that mother education is also one of the important determinants of executive dysfunction. There is a lower level of executive dysfunction in a child if the mother is more educated ( $\beta = -0.111$ ,  $p < 0.05$ ). Susic-Vasic et al. (2017) also tried to link the executive functioning with mother's education but they did not find any statistically significant association between these two variables. Rest of the relationships was insignificant which can be observed in Table 2.

## Conclusion

It has been a tradition that school psychologists use IQ scores on psychometric tests as a mean of defining potential for competence in academics. Rather than using such IQ scores and a predefined percentile of capability for academics, present study has attempted to explain competence as typical characteristics that are possessed by successful students. Conversely, students who are unsuccessful possess significantly less characteristics of such kind. In present study those characters were attributed as executive functions that are commonly shared by students who perform high in Science and Math subjects specifically. This perspective originate hope and optimism for further education endeavors that aim to help underachieving students because it is established that competence is not a fixed trait but a characteristic that can be remediated. Findings of present study suggest that educators can design individualized intervention plans to enhance self-regulation among underachieving children in order to increase their executive functioning.

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