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The Relationship between Executive Functions and Self-Regulated Academic Learning Regarding the Mediating Role of Metacognition and Working Memory among University Students

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Abstract

Today, education experts mostly aim to detect significant causal variables leading to students' achievements in educational settings. The present study aimed to investigate the relationship between executive functions and self-regulated academic learning regarding the mediating role of metacognition and working memory among university students. This research was a correlational study using structural equation modeling. The statistical population included of all students of Shahid Chamran University of Ahvaz in the academic year 2018-2019. A total of 351 students were selected by multi-stage cluster random sampling. The research instrument included the Metacognitions Questionnaire (MCQ-30), Cognitive Abilities Questionnaire, the Self-Regulation Questionnaire (SRQ), and the Test of Information Processing Skills (TIPS). The collected data were analyzed using structural equation modeling. The findings revealed no significant and direct relationship between executive functions and self-regulated academic learning ($P>0.05$). However, there was a significant and direct relationship between executive functions with metacognition and working memory ($P<0.01$). Moreover, a significant relationship was observed between metacognition and working memory with academic self-regulated academic learning ($P<0.01$). In this regard, metacognition and working memory fully mediated the relationship between executive functions and self-regulated academic learning. The study findings provide university students and experts with an appropriate model since, as the theoretical foundations of the proposed model documented, academic achievement and well-being are mainly dependent on executive functions. Accordingly, metacognitive skills, including self-regulated academic learning, can be improved by promoting the executive functions among university students.

Keywords: Executive functions, metacognition, working memory, self-regulated learning

Introduction

Human brain has two functions: Rule-based functions controlling individuals' thoughts and performance (i.e. executive functions), and non- rule-based functions underpinned by emotions, desires, social cognition, and situational factors. Executive functions are defined as an ability to have cognitive flexibility, manage disturbing components in purposive behaviors, and predict performance outcomes (Ardila, Surloff & Mark, 2007). In other words, executive functions are purposeful neuroscientific processes providing the grounds for controlling and coordinating cognition and behaviors and make individuals be target-oriented, monitor their behaviors, and control inappropriate responses. In general, executive functions make individuals engage in planned, flexible, and forward-looking behaviors (Alvarez & Emory, 2006). Accordingly, the executive functions of human brain play a critical role in controlling and changing academic performance and complicated cognitive functions (Barkley, 2012).

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One of the propounded concepts in the education of the contemporary world is Self-Regulated Learning (SRL). Nowadays, SRL is considered one of the important domains of educations. Self-regulated learning is included in essential structures within the motivational discussions through which students can organize their learning. SRL is one of the most important predictive factors in academic achievement within the educational environment. Therefore, a study on the degree of educational SRL in learners has a privileged place. Educational SRL refers to a range of individual abilities that are involved in achieving various objectives, especially in the fields related to competition with others, such as educational and occupational scopes. This requires the maximum profiting from cognitive abilities and discipline. It includes self-evaluation, organization, goal orientation, help-seeking, environmental structures, and memory strategies (Magno, 2010). SRL is a cyclic process in which students make plans for a task, and their performance is under observation. Then, it reflects on the result. In the next step, the cycle is repeated and make the students able to use its reflection in adjusting and preparing for future tasks (Kun, 2019).

Self-regulated learning (SRL) is one of the self-regulated scopes. It is more arranged with educational objectives. SRL uses a process that deals with the control and evaluation of individual learning and behavior. Self-regulated learners are particularly aware of their academic strengths and weaknesses. They have a list of strategies that are appropriately used to face the daily challenges of the task within the college. Students who are not self-regulated learners may infrequently do their homework or completely forget their tasks. Students who practice SRL will ask questions, take notes, spend their time efficiently, and use the available resources (Cho, Yough & Levesque-Bristol, 2020).

Self-regulated learning is an extended structure encompassing the interactions among different control systems (namely cognition, attention, metacognition, emotion, motivation, and desire) (Boekaerts, 2011; Jafarkhani et al., 2019; Zimmerman & Schunk, 2011). Self-regulation involves a set of cognitive and emotional processes, all of which have a common feature, i.e. information processing and control coordination. The distinction between self-regulated learning and metacognition has played a remarkable role in research on educational psychology. Studies on self-regulated learning has been extended conceptually as there are now several self-regulated learning models. Possessing an integrated and coherent framework, these models provide the students with opportunities to be taught by more successful strategies and this facilitates their ability to monitor one's progress and achieve one's goals (Ghasemizad, Mohammadkhani & Saadatrad, 2019; Panadero, 2017). In this regard, structural models describe the main components, which are of significance in students' self-regulation, including content, cognitive strategies, cognitive regulatory strategies, metacognitive knowledge and motivational beliefs, motivational strategies, and motivational regulatory strategies. Each of the components represents a specific type of the other models and can be tailored to any research objective. All of these components focus on two main self-regulated learning mechanisms, i.e. cognitive and emotional / motivational self-regulation (Musso, Boekaerts, Segers & Cascallar, 2019). In the present study, executive function was examined as a predictive variable, and the mediating variables were metacognition and working memory.

Nowadays, education experts are to detect significant causal variables leading to students' achievements in educational settings, a majority of whom also focus on self-guided learning (Meltzer, Pollica & Barzillai, 2007). For example, self-regulated learning structures such as self-monitoring may promote performance for a variety of daily tasks that need a sequence or a forward-looking memory. In this regard, some public executive functions such as impulse control and organization may also have impacts on academic achievement. Studies have been carried out on the executive functions of clinical research (e.g., on patients suffering from autism, schizophrenia, bipolar disorder, attention deficit hyperactivity disorder, and traumatic brain injury) (Barkley, 2012; Busch, McBride, Glenn & Vanderploeg, 2005; Fisher & Happe, 2005; Klemm, Schmidt, Knappe & Blanz, 2006; Szoke et al., 2006); however, this issue has been less concerned among non-clinical population. In this regard, a more in-depth understanding of the relationship between executive functions and non-clinical structures, including academic self-regulation, would lead to better implications of executive functions (Garner, 2009).

A majority of studies confirm the relationship between executive functions and academic skills, including self-regulation. Aziziyan, Asadzadeh, Alizadeh, Dortag and Sadipour (2017), for example, claimed that teaching executive functions may significantly affect students' attention, inhibition, and working memory as well as the borderline intelligence of elementary school students. Follmer and Sperling (2016) also found out that executive function could predict metacognition and self-regulated learning. Saghafi, Esteki and Ashayeri (2012) reported that self-regulated students probably have more adaptive

cognition, stronger motivational outcomes, and higher academic achievements, in comparison to their peers who fail in self-regulation skills. Effeney, Carroll and Bahr (2013), also provided some evidence on the correlation between executive functions and self-regulated learning.

Some studies have also revealed that the relationship between executive functions and self-regulated learning in the educational sector might be complicated if some mediating variables are considered. As an example, Follmer and Sperling (2016), detected and supported the mediating role of metacognition in this relationship. Garner (2009), documented the correlation between executive functions and self-regulated learning with regard to the indirect measurement of executive functions. Accordingly, the executive functions significantly predict the usage of metacognitive strategies and promote diversity in academic self-regulation processes. It can thus be concluded that metacognition mediates the relationship between executive functions and self-regulated learning (Follmer & Sperling, 2016; Garner, 2009).

Given the findings of the previous studies in this field, metacognition and working memory were included in the present study as variables mediating the relationship between executive functions and self-regulated learning (Fakhary Nejad, Mojtabaie & Mirhashemi, 2019). Metacognition, a remarkable predictor of public progress, is operationally defined as awareness of an individual's cognitive process and its management at the time of necessity. This variable consists of two parts: metacognitive knowledge and metacognitive experiences. Roebers (2017), proposed a possible comprehensive framework of cognitive self-regulation to integrate executive function and metacognition. Accordingly, the present study was to investigate the relationship between executive functions and self-regulated learning with regard to the mediating role of metacognition and working memory among students at Shahid Chamran University of Ahvaz.

Method

This research was a correlational study using structural equation modeling.

Participants

The statistical population included of all students of Shahid Chamran University of Ahvaz in the academic year 2018-2019. The inclusion criteria were: student at Shahid Chamran University, no history of medical and psychiatric illnesses. To test the proposed model and research hypotheses with regard to the number of variables, a sample of 400 persons was selected using multistage cluster random sampling. The sample size was determined as the loss of the subjects, incomplete questionnaires, and missed data were also considered. After receiving the required permissions, the study samples were selected from six out of 12 faculties of Shahid Chamran University of Ahvaz, which had also been randomly selected. The participants received the consent forms and were ensured of information confidentiality. After removing incomplete and distorted questionnaires as well as outliers, 351 questionnaires underwent further analysis.

Instruments

The Metacognitions Questionnaire (MCQ-30): This 30-item questionnaire was developed based on the self-regulatory executive function (S-REF) proposed by Wells and Matthews (1996) to address emotional disorders and metacognitive patterns of anxiety disorder. A four-point Likert scale (1: I disagree to 4: I strongly agree) was used to score this questionnaire, and the minimum and maximum scores were 30 and 120, respectively. The validity of this questionnaire was evaluated and confirmed by Wells and Cartwright-Hatton (2004) and Shirinzadeh, Godarzi, Rahimi and Naziri, (2008). In the present study, the Cronbach's alpha coefficient was 0.74 for the questionnaire.

Cognitive Abilities Questionnaire: The questionnaire was developed by Nejati (2013) and encompassed 30 items and seven factors of memory, inhibitory control and selective attention, decision making, planning, stable attention, social cognition, and cognitive flexibility. A five-point Likert scale (1: Almost never to 5: Almost always) was used to score this questionnaire, and the minimum and maximum scores were 36 and 180, respectively. Studies have reported the correlation between academic status and IQ. If we assume that cognitive abilities are the abilities to process and manipulate information, working memory exactly conforms with such an ability. Accordingly, working memory is known as the center of cognitive functions; however, some researchers have also considered it as general intelligence or non-social intelligence. Regarding the reliability of the questionnaire, the test-retest results confirmed the accepted replicability of the test. Cronbach's alpha also confirmed the internal consistency of the questionnaire. The reliability of this questionnaire, using Cronbach's Alpha coefficient, was reported as 0.83 by Nejati (2013). In the current study, the

reliability of the questionnaire was 0.84 using Cronbach's alpha coefficient.

The Self-Regulation Questionnaire (SRQ): This self-report scale contained 34 items and was developed and validated by Hong and O'Neil (2001). The participants responded the questionnaire using a four-point Likert scale ranging from 1 (almost never) to 4 (almost always). They reported the reliability of this questionnaire using Cronbach's alpha coefficients to be 0.76 for planning, 0.60 for self-assessment; 0.83 for perseverance, and 0.85 for self-efficiency. The validity of the structure was accepted by confirmatory factor analysis method. Furthermore, the total reliability of this 34-item questionnaire was 0.91 (Borjalilu, Mojtahedzadeh & Mohammadi, 2013). In the present study, the Cronbach's alpha coefficient was 0.82 for the questionnaire.

The Test of Information Processing Skills (TIPS): This test was a presentation on a computer, which exhibited trains with wagons of different colors entering from the left side of a station so that the train was not visible for a second, and then it appeared on the right side while some wagons had different colors. The task, done by pressing one or two specific keys, required the participants to detect whether or not the color of each wagon changed. The participants could watch the train for a while before entering the station. When the train arrived at the station and disappeared, they were also required to remember the color of the wagons. This is while some information about the remaining wagons, which had not appeared yet, should have been kept in the working memory. Each train had six wagons; hence, there were 84 wagons to be checked. A participant's score is equal to a percentage of his/her correct responses (Riding, 2000). The minimum and maximum scores of this test were zero and 84, respectively. Zahmatkesh, Hosseini-nasab and Saadati Shamir (2016), also estimated the reliability of this test using the pretest-posttest method with a three-week interval to be 0.79 for a group of 20 persons. In the present study, the Cronbach's alpha coefficient was 0.81 for the test.

Procedure

After selecting the participants and administrating the questionnaires, the analysis of the collected data was carried out using SPSS and AMOS software. The current study utilized descriptive statistical tests, including mean, standard deviation, and Pearson's correlation coefficient. Moreover, Cronbach's alpha coefficient was used for evaluating the reliability of the data collection tools. Moreover, in order to evaluate the fitness of the model, the indices including chi-square ($\chi 2$), the ratio of chi-square to degree of freedom (χ^2/df), Goodness of Fit Index (GFI), Normed Fit Index (NFI), Incremental Fit Index (IFI), Tucker-Lewis Index (TLI), and Root Mean Square Error of Approximation (RMSEA) were used. Furthermore, in order to evaluate the mediating role, the percentile bootstrap method and bias-corrected bootstrap method were used.

Findings

Table 1 presents the mean, standard deviation, minimum and maximum scores, and the number of participants for the research variables. The correlation coefficient matrix for the research variables was obtained, as shown in Table 2.

Tables 1.
Descriptive Statistics Including Mean and Standard Deviation of Research Variables

Scale	Subscale	M	SD	Min.	Max.	n
Executive functions	Cognitive flexibility	13.66	3.10	10	15	351
	Active memory	19.67	6.22	14	22	
	Inhibitory control and selective attention	19.10	2.97	15	20	
	Decision making	15.59	4.73	11	18	
	Social cognition	11.41	2.81	8	14	
	Planning	9.63	3.95	6	12	
	Stable attention	11.27	3.01	9	13	
	Total score	100.25	15.69	81	119	
Self-regulated learning	Planning	2.88	0.38	2.33	3.67	
	Perseverance	3.05	0.43	2.33	3.75	
	Self-efficacy	2.71	0.42	2.38	3.63	
	Self-assessment	2.71	0.37	2.14	3.50	
	Total score	11.36	1.25	9.72	12.11	

Scale	Subscale	M	SD	Min.	Max.	n
Metacognition		75.55	15.12	60	89	
Working memory		63.32	12.51	53	76	

M*:* Mean; SD: Standard deviation; Min: Minimum; Max: Maximum

Table 2.
Pearson correlation coefficient between variables

Variables	1	2	3	4
1- Executive functions	1			
2- Working memory	0.26**	1		
3- Metacognition	0.32**	0.19**	1	
4- Self-regulated learning	0.29**	0.30**	0.32**	1

**=P<0.01

Table 2 indicates the simple correlations between the research variables, according to which all the research variables have significant correlations with each other. These correlation analyses provide a description of paired relationship between the research variables. Structural equation modeling was used to simultaneously test the notion of the relationships assumed in this study.

Before analyzing the data, structural equation modeling was first used to evaluate and confirm the assumptions of multivariate normal distribution, linearity, multi-linearity and error independence. Skewness and Kurtosis tests were used to assess the data normal distribution. Given that all research variables have absolute skewness coefficient values of <3 and absolute kurtosis coefficient value of <10, the data normal distribution was confirmed. Multi-linearity was also checked by tolerance statistics and Variance Inflation Factor (VIF). All the variables had VIF<10 and tolerance statistics >0.1; therefore, the assumption indicating non- multi-linearity was met. Durbin-Watson Test was also used to test the independence of errors, and its value in this study was 1.80. Since this value is in the range of 1.5-2.5, the assumption of error independence was also met.

The results revealed the linear relationships between all endogenous and exogenous variables as such the assumption indicating the linear relationship between these two types of variables was met. Since the assumptions were meth, the path coefficients and the fit of the proposed model can be evaluated with regard to fit indices. Table 3 shows the fit of the proposed test model with regard to fit indices. According to Table 3, the proposed model was well-fitted. Figure 1 presents the standard coefficients of the paths in the tested proposed model.

Table 3.
Proposed Model Fit Indicators

Fit indicators	χ^2	df	(χ^2/df)	IFI	TLI	GFI	NFI	RMSEA
Proposed model	358.76	124	2.89	0.91	0.94	0.96	0.90	0.07

χ^2: Chi-square; df: Degrees of freedom; IFI: Incremental Fit Index; TLI: Tucker-Lewis Index; GFI: Goodness of Fit Index; NFI: Normed Fit Index; RMSEA: Root Mean Square Error of Approximation.

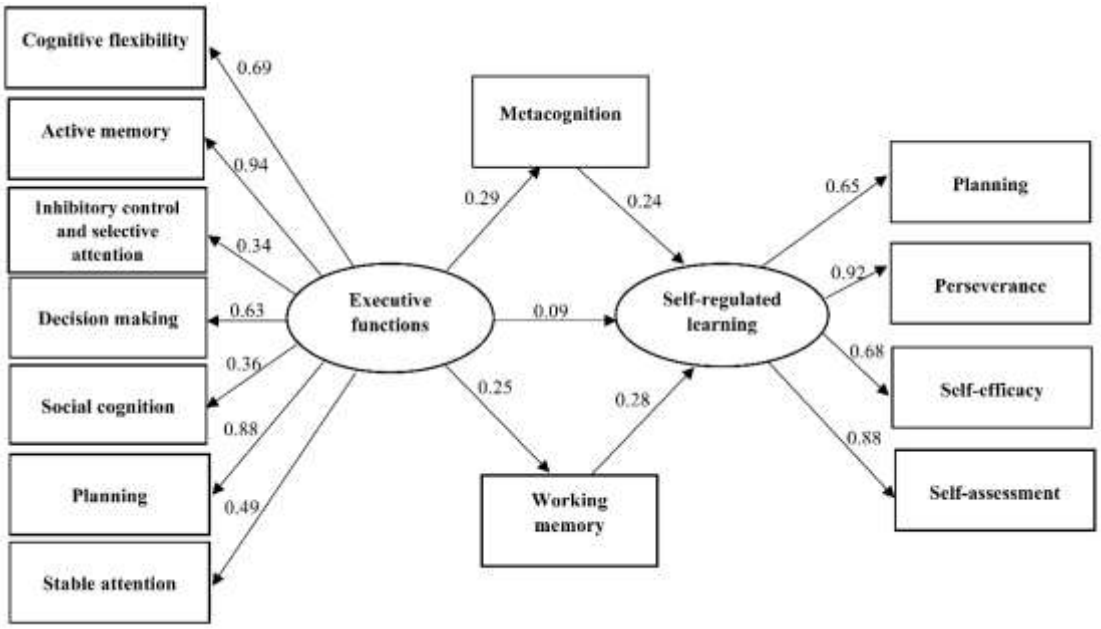

Figure 1.
Proposed Model of the Research

Regarding the coefficients of the standard parameter and the corresponding significance level in Table 4, the direct path of the predictor variable to the criterion variable was not significant; hence, it was removed from the model. Table 4 presents the structural model, paths, and their standard coefficients in the proposed model. As shown in Table 4, the path of executive functions to self-regulated learning in the proposed model was not significant (P>0.05) as such the path was removed from the model. With removing this path, although the proposed model was well-fitted, it was modified, and the fit of the final model was reevaluated using the fit indices. Table 5 presents the fit of the final tested model with regard to the fit indices. Table 5 reveals that the final model is well-fitted, and Figure 2 shows the standard coefficients of the paths in the final model.

Table 4.
Path Coefficients of Direct Effects between Research Variables in the Proposed Model

Path	β	P
Executive functions to self-regulated learning	0.09	0.13
Working memory to self-regulated learning	0.28	0.0001
Metacognition to self-regulated learning	0.24	0.0001
Executive functions to working memory	0.25	0.0001
Executive functions to metacognition	0.29	0.0001

Table 5.
Final Model Fit Indicators

Fit indicators	χ^2	df	(χ^2/df)	IFI	TLI	GFI	NFI	RMSEA
Final model	362.61	126	2.87	0.93	0.94	0.97	0.92	0.07

χ^2: Chi-square; df: Degrees of freedom; IFI: Incremental Fit Index; TLI: Tucker-Lewis Index; GFI: Goodness of Fit Index; NFI: Normed Fit Index; RMSEA: Root Mean Square Error of Approximation.

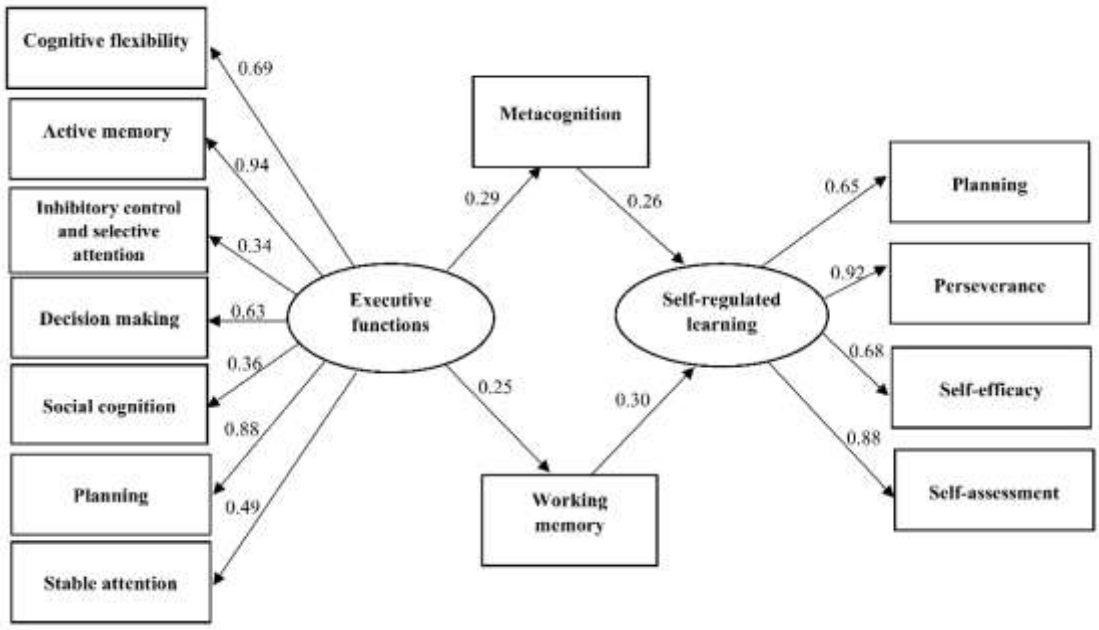

Figure 2.
Final Modified Model

Table 6 presents the structural model, paths, and their standard coefficients in the final model. With modifying the model, all the remaining paths in the final model were significant (P<0.01) (Table 6), and direct/positive and significant relationships were observed between working memory and self-regulated academic learning and between metacognition and self-regulated academic learning. In this regard, the direct relationships were also positive and significant between executive functions and working memory and between executive functions and metacognition (P<0.01).

Table 6.
Path coefficients of Direct Effects between Research Variables in the Final Model

Path	β	P
Working memory to self-regulated learning	0.30	0.0001
Metacognition to self-regulated learning	0.26	0.0001
Executive functions to working memory	0.25	0.0001
Executive functions to metacognition	0.29	0.0001

In this study, bootstrapping was performed to determine the indirect relationships among the variables and to examine the mediating roles of metacognition and working memory (Table 7). To this end, the overall effect of the predictor variable on the criterion variable was first assessed in the absence of the mediating variable, and a significant relationship was noticed between executive functions and self-regulated academic learning in the presence of no mediating variable. As Table 7 shows, although the indirect relationships are significant, the direct relationship between executive functions and self-regulated academic learning is not significant. In other terms, metacognition and working memory fully mediate these relationships.

Table 7.
Results of the Bootstrap Method for Investigating Indirect and Intermediary Paths

Predictor variable	Mediator Variable	Criterion variable	Direct Effect (t-Value)	Indirect Effect (t-Value)	Total Effect	Interpretation	Results
Executive functions	Metacognition and working memory	Self-regulated learning	0.32 (0.08)	0.14 (0.001)	0.26 (0.001)	Complete mediation	Accepted
Executive functions	Metacognition	Self-regulated learning	0.13 (0.11)	0.08 (0.002)	0.26 (0.001)	Complete mediation	Accepted
Executive functions	Working memory	Self-regulated learning	0.13 (0.09)	0.08 (0.005)	0.26 (0.001)	Complete mediation	Accepted

Discussion and Conclusion

The present study aimed to investigate the relationship between executive functions and self-regulated academic learning regarding the mediating role of metacognition and working memory among university students. According to the findings of this study, the direct path of executive functions to metacognition was significant this finding is consistent with the research results of Follmer and Sperling, (2016), Barkley, (2012), and Meltzer et al. (2007). In this case, it can be stated that monitoring and control are metacognitive components. It is also assumed that the repetitive information flow in both bottom-up (monitoring) and top-down (control) directions needs sufficient cognitive capacity, which is better absorbed by updated measures. In other words, a significant relationship is theoretically expected between a person's constant attention to the front and back during a task with executive functions and metacognitive processes. The significant relationship between executive functions and working memory may also be explained by the point that working memory and executive functions are not distinguishable and are considered as two main dimensions to reach a more in-depth understanding of the tasks associated with executive functions. Executive functions, as an umbrella term, represent cognitive processes that guide behaviors. In general, executive functions refer to a range of correlated capabilities and encompass activities ranging from a simple and conscious formation of a behavior and inhibitory activities to complex planning and problem-solving tasks. Accordingly, as the proposed model also indicates, the relationship between these two variables is inevitable and explainable with regard to the fact that working memory is one of the components of executive functions.

The findings also indicated a direct and significant relationship between metacognition and self-regulated learning. In this regard, when using different cognitive strategies, students with higher metacognition scores monitor their activities more completely and select the most efficient strategy tailored to the nature of the task. Moreover, they constantly review their performance and change their "strategy", if necessary, to reach their concerned goal (Follmer & Sperling, 2016). In other words, metacognition directs individuals' thought processes in learning situations as such it leads to the better formation of self-regulated learning.

The findings of this study revealed a significant relationship between working memory and self-regulated learning. This finding is consistent with the research results of Hofmann, Schmeichel and Baddeley (2012), as well as Schmeichel, Volokhov and Demaree (2008). In this regard, it is worth mentioning that working memory as a cold cognitive concept leads to warm cognitive processes, including self-regulated learning. Although no theoretical foundation reveals why working memory leads to better self-regulated learning, it can be inferred that working memory helps an individual detect when and how to use self-regulated behaviors in learning appropriately and efficiently (Hofmann Friese Schmeichel & Baddeley, 2011).

The present study examined the relationship between executive functions and self-regulated learning both directly and indirectly. Directly, this relationship was significant with no mediating variable being involved; however, the direct relationship was no further meaningful with the inclusion of mediating variables into the model. In terms of the mediating role

of the variables, it can be stated that the researcher seeks a variable in accordance with the theoretical foundations to mediate the relationship between the predictor and criterion variables. In this study, metacognition and working memory fully mediated this relationship. In other words, executive functions affected self-regulated learning with regard to the mediating roles of metacognition and working memory. No study has addressed the simultaneous mediation of these two variables in a model; hence, this is not in line or in contrast with previous research.

On the relationship between executive functions and self-regulated learning, it should be mentioned that executive functions are purposeful neurocognitive processes facilitating the control and coordination of cognition and behaviors and make individuals be target-oriented, monitor their behaviors, and control inappropriate responses. In general, executive functions make individuals engage in planned, flexible, and forward-looking behaviors (Alvarez & Emory, 2006). The literature mostly has focused on the relationship between executive functions and academic performance and achievement (Fuhs, Nesbitt, Farran & Dong, 2014). However, it is of paramount importance to detect how executive functions affect academic achievement. Among the factors forming and promoting self-regulated behaviors, as one of the main cognitive and life skills, the cognitive capacities of the neuro-cognitive executive functions should also be concerned. This is because metacognitive skills, including self-management, cognitive flexibility, organization, reconstruction, and problem solving, and changes of cognitive arrays, better lead a person to adopt a scientific and evaluative approach to various phenomena and events. Furthermore, such skills make individuals use deep processing strategies in their learning as such they would enjoy a better organization and greater achievements. To explain the mediating role of working memory and metacognition, given that these two mediating variables have included in the model simultaneously and in parallel, we can mention that executive functions pose their effect by improving metacognitive skills and working memory, as one of the main components of executive functions.

The findings of the present study provide students and experts with an appropriate model since the theoretical foundations of the proposed model support that academic achievements and well-being are largely dependent on executive functions. Accordingly, metacognitive skills, including self-regulated academic learning, can be improved by promoting the executive functions among university students. It is worth noting that the findings of the present study need to be interpreted and generalized with regard to the limitations. Given that brain executive functions have been usually examined in communities such as late learners and or individuals with a specific type of disorder, the exclusive use of self-report instruments instead of studying the behaviors and the existence of research gaps or at least the gaps reported within the framework of research variables and the research community, i.e. university students, are some of the limitations of the present study as such the interpretation and generalization of the findings should be done with caution. It is also suggested to conduct further studies using experimental and causal-comparative methods and considering gender as a control variable.

Conflict of interest

The authors declared no competing interests.

References

Alvarez, J. A., & Emory, E. (2006). Executive function and the frontal lobes: a meta-analytic review. *Neuropsychology Review, 16*(1), 17-42.

Ardila, A., Surloff, C., & Mark, V. W. (2007). Dysexecutive syndromes. *San Diego: Medlink Neurology, 116*, 653-63.

Aziziyan, M., Asadzadeh, H., Alizadeh, H., Dortag, F., & Sadipour, E. (2017). Developing and implementing an educational package for training executive functions and its effectiveness on underachiever pupils' academic achievement. *Biquarterly Journal of Cognitive Strategies in Learning, 5*(8), 113-137.

Barkley, R. A. (2012). *Barkley deficits in executive functioning scale – children and adolescents*. New York, NY: The Guilford Press.

Boekaerts, M. (2011). Emotions, emotion regulation, and self-regulation of learning. *Handbook of Self-regulation of Learning and Performance, 5*, 408-425.

Borjalilu, S., Mojtahedzadeh, R., & Mohammadi, A. (2013). Exploring the validity, reliability and factor analysis of self-regulation scale for medical students. *Journal of Medical Education and Development, 9*(2), 25-35.

Busch, R. M., McBride, A., Glenn, C., & Vanderploeg, R. D. (2005). The components of executive functioning in traumatic brain injury. *Journal of Clinical and Experimental Neuropsychology, 27*, 1022-1032.

Cho, H. J., Yough, M., & Levesque-Bristol, C. (2020). Relationships between beliefs about assessment and self-regulated learning in second language learning. *International Journal of Educational Research, 99*, 10-25.

Effeney, G., Carroll, A., & Bahr, N. (2013). Self-regulated learning: Key strategies and their sources in a sample

of adolescent males. *Australian Journal of Educational & Developmental Psychology, 13*, 58-74.

Fakhary Nejad, S., Mojtabaie, M., & Mirhashemi, M. (2019). Comparison of the effectiveness of yoga training with emotion regulation training on students' working memory and cognitive flexibility. *Iranian journal of Learning and Memory, 2*(7), 33-41.

Fisher, N., & Happe, F. (2005). A training study of theory of mind and executive function in children with autistic spectrum disorders. *Journal of Autism and Developmental Disorders, 35*(6), 757-771.

Follmer, D. J., & Sperling, R. A. (2016). The mediating role of metacognition in the relationship between executive function and self-regulated learning. *British Journal of Educational Psychology, 86*(4), 559-575.

Fuhs, M. W., Nesbitt, K. T., Farran, D. C., & Dong, N. (2014). Longitudinal associations between executive functioning and academic skills across content areas. *Developmental Psychology, 50*(6), 1698.

Garner, J. K. (2009). Conceptualizing the relations between executive functions and self-regulated learning. *The Journal of Psychology, 143*(4), 405-426.

Ghasemizad, A., Mohammadkhani, K., & Saadatrad, F. (2019). The mediating role of critical thinking in relation to higher education students' meta-cognition and self-efficacy. *Iranian journal of Learning and Memory, 2*(7), 7-15.

Hofmann, W., Friese, M., Schmeichel, B. J., & Baddeley, A. D. (2011). Working memory and self-regulation. *Handbook of self-regulation: Research, Theory, and Applications, 2*, 204-225.

Hofmann, W., Schmeichel, B. J., & Baddeley, A. D. (2012). Executive functions and self-regulation. *Trends in Cognitive Sciences, 16*(3), 174-180.

Hong, E., & O'Neil, H. F. (2001). Construct validation of a trait self-regulation model. *International Journal of Psychology, 36*(3), 186-194.

Jafarkhani, Z., Manzari Tavakoli, A., Manzari Tavakoli, H., Razavi, V. (2019). The mediating role of study habits in the relationship between the motivation of progress with self-regulation learning of students. *Iranian Journal of Learning and Memory, 1*(4), 33-38.

Klemm, S., Schmidt, B., Knappe, S., & Blanz, B. (2006). Impaired working speed and executive functions as frontal lobe dysfunctions in young first-degree relatives of schizophrenic patients. *European Child & Adolescent Psychiatry, 15*(7), 400-408.

Kun, L. (2019). MOOC learners' demographics, self-regulated learning strategy, perceived learning and satisfaction: A structural equation modeling approach. *Computers & Education, 132*, 16-30.

Magno, C. (2010). Assessing academic self-regulated learning among filipino college students: The factor structure and item fit. *The international Journal of Educational and Psychology Assessment, 5*(1), 61-76.

Meltzer, L., Pollica, L. S., & Barzillai, M. (2007). Executive function in the classroom. *Executive Function in Education: From Theory to Practice*, 165-193.

Musso, M. F., Boekaerts, M., Segers, M., & Cascallar, E. C. (2019). Individual differences in basic cognitive processes and self-regulated learning: their interaction effects on math performance. *Learning and Individual Differences, 71*, 58-70.

Nejati, V. (2013). Cognitive abilities questionnaire: Development and evaluation of psychometric properties. *Advances in Cognitive Sciences, 15*(2), 11-19.

Panadero, E. (2017). A review of self-regulated learning: Six models and four directions for research. *Frontiers in Psychology, 8*, 422-444.

Riding, R. J. (2000). *Information processing index*. Birmingham: Learning and Training Technology.

Roebers, C. M. (2017). Executive function and metacognition: Towards a unifying framework of cognitive self-regulation. *Developmental Review, 45*, 31-51.

Saghafi, M., Esteki, M., & Ashayeri, H. (2012). Executive functions in students with nonverbal learning disorders and students with dyslexia. *Journal of Exceptional Children, 12*(2), 27-36.

Schmeichel, B. J., Volokhov, R. N., & Demaree, H. A. (2008). Working memory capacity and the self-regulation of emotional expression and experience. *Journal of Personality and Social Psychology, 95*(6), 1526-1540.

Shirinzadeh, S., Godarzi M. A., Rahimi, C. H., & Naziri, G. (2008). Factor structure, reliability and validity of The Metacognitions Questionnaire (MCQ-30). *Journal of Psychology, 12*(4), 445- 461.

Szoke, A., Schürhoff, F., Golmard, J. L., Alter, C., Roy, I., Méary, A., & Leboyer, M. (2006). Familial resemblance for executive functions in families of schizophrenic and bipolar patients. *Psychiatry Research, 144*(2-3), 131-138.

Wells, A., & Cartwright-Hatton, S. (2004). A short form of the metacognition's questionnaire: properties of the MCQ-30. *Behaviour Research and Therapy, 42*(4), 385-396.

Wells, A., & Matthews, G. (1996). Modelling cognition in emotional disorder: The S-REF model. *Behaviour Research and Therapy, 34*(11), 881-888.

Zahmatkesh, Z., Hosseini-nasab, S., & Saadati Shamir, A. (2016). Examining the relationship between working memory and intelligence with female students` academic achievement in monolingual and bilingual high school of Tehran. *Journal of Instruction and Evaluation, 8*(32), 111-134.

Zimmerman, B. J., & Schunk, D. H. (2011). *Handbook of self-regulation of learning and performance*. Routledge/Taylor & Francis Group.