

Article

Executive Functions and Problematic Internet Use among University Students: The Mediator Role of Self-Esteem

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Abstract: Information and communication technologies are transforming our daily lives in a wide variety of ways, such as the way we work, study, and interact with others. There are clear benefits to be gained from appropriate use, but a problem arises when addictive and problematic use of the Internet is experienced. In this sense, several predictive factors can be related to inappropriate or problematic Internet use. For this reason, the present study aimed to analyze whether inhibition, flexibility, emotional control (executive functions) and self-esteem directly influence all variables of problematic Internet use. Furthermore, it was examined whether executive functions, mediated by self-esteem, indirectly influence problematic Internet use. The study involved 514 university students who completed three scales, one for the assessment of problematic Internet use, one for self-esteem and one for executive functions. Mediation models showed that both executive functions and self-esteem had an influence on different problematic uses of the Internet. Specifically, it was found that flexibility and emotional control were the variables with the most direct effects, as they influenced all variables of problematic Internet use. However, when self-esteem was included as a mediator, inhibition was the variable with the most indirect effects.

Keywords: internet addiction; self-esteem; inhibition; flexibility; emotional control; executive functions; risk factor



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1. Introduction

Young [1] and Goldberg [2], in the late 1990s, were among the first authors to suggest that the internet can lead to addiction. Years later, Young defined problematic internet use as the inability of some people to control their own internet use, leading to disruption and impairment of their work, social and personal commitments [3]. Since then, several studies have been concerned with analyzing which variables may determine problematic Internet use [4–6].

Among some of these variables conceived as risk factors for problematic Internet use, self-esteem stands out, defined by Coopersmith as the individual's evaluation of themselves, including an attitude of approval or rejection. It is, therefore, a personal judgement of worth, expressed in attitudes that an individual has towards him/herself [7]. Self-esteem is an indispensable factor in the process of shaping personal identity, and given its importance, a negative development of self-esteem is more likely to lead to problematic Internet use [4,8]. People with low self-esteem may try to escape their own negative self-evaluation by spending more time online and attempting to compensate for their deficits by assuming a different identity and personality on dating, social networking, and gaming platforms. In addition, they are also more likely to compare themselves to other people online than those with high self-esteem. Reliance on online interaction as a means of achieving more positive self-evaluation could lead to problematic online habits [9]. Therefore, people who manifest low levels of self-esteem and, therefore, problems in their daily lives, may turn to the Internet in order to alleviate the psychological and emotional discomfort they feel. Along the same lines, those with low self-esteem are more likely to reject social relationships

with others and to show some preference for online social interaction. Evidence for this is derived from recent research by Sechi, Loi and Cabras, who argue that the Internet is an escape for people with low self-esteem, as well as a more comfortable alternative to face-to-face interaction [10].

Similarly, another variable that may be fundamental in the development of problematic Internet use is executive functions. Executive functions are a set of processes responsible for controlling, directing, and guiding behavior, cognitions, and emotions. Therefore, they are all the skills that enable people to have goals and to achieve them through the planning and control of thoughts, emotions and behaviors that interfere with their attainment [11]. Executive functions are divided into three main components: inhibitory control (defined as the ability to deliberately control thoughts, feelings, and behaviors), working memory (the ability to mentally operate representations) and cognitive flexibility (understood as the brain's ability to adapt behavior and thoughts to changing, novel and unexpected situations in the environment) [11–13]. Moreover, executive functions are not limited to cognitive control, but are also involved in emotional regulation and control [14]. Emotional control as an executive function refers to the ability to control emotions using a type of strategy, such as cognitive reappraisal, which, according to Andrés et al., is an emotional regulation strategy that involves re-signifying an event in order to change its emotional effect [15].

Although there are numerous studies related to problematic Internet use, there is little empirical research based on studying the relationship between problematic use and executive functions [16]. Despite this, some studies have established a relationship between problematic Internet use and the presence of a deficit in inhibitory control, especially in relation to online gaming addiction [5,6,17]. In other words, a significant relationship has been observed between problematic Internet use, highlighting deficient self-regulation due to compulsive Internet use, and inhibition, establishing that the greater the daily use of the Internet, the lesser the capacity to manage inhibitory control [18–20].

Other studies, focusing on university students, also looked at the impairment of inhibitory control in excessive users of social networks. Along these lines, problematic Internet users reported a general impairment of inhibition, with this reduction in inhibitory control being conceived as a possible consequence of a tendency towards Internet and social network addiction [21].

Studies have also established a relationship between difficulties in emotional regulation, such as a poor ability to understand, control and manage negative emotions, and problematic Internet use in young students, specifically, a preference for online social interactions [22–24].

On the other hand, results derived from research by Tekin et al. indicate that individuals with problematic Internet use are more likely to develop cognitive disorders, such as attention problems and inability to control behavior, as well as impaired task flexibility in relation to Internet abuse [25]. This flexibility is necessary to meet new challenges and to seize opportunities when they arise unexpectedly. It also serves to avoid being carried away by what is prevailing in society and to look at reality from different points of view [12]. By improving cognitive flexibility, problems related to excessive and addictive use of the Internet and social media may be reduced [16,26]. In addition, the cognitive flexibility of subjects with Internet addiction disorder has also been related to inhibitory control during task switching, showing that subjects with this type of disorder show a lower capacity to switch attention during the performance of different tasks, as well as a significant deterioration in cognitive flexibility [27].

University students are the most at-risk group in terms of problematic Internet use [10] with six out of every one hundred university students experiencing problems with Internet use [28]. Brotóns et al. found that university students constituted a population at risk of problematic Internet use, due to the presence of a series of characteristics, the most notable being the justification of the amount of Internet use by conceiving it as one of the main tools in academic activities; the presence of very flexible study and work schedules

among university students; and the existence of low control and supervision of students' Internet activities by parents or legal guardians [17]. Although there are several studies on problematic Internet use that investigate university students [17,25,26], there is little research that focuses on university students who will be future teachers, educators, or social workers [29]. However, the analysis of this group of students may be important because they are the ones who will shape future students. Therefore, the analysis of this population could encourage the inclusion in the curricula of faculties of education of programs that train future educators on how they can promote healthy Internet use in themselves and their future students.

Considering the above, it has become evident that it is important to analyze the use of the Internet by university students, taking into consideration different variables that can act as risk factors, negatively affecting and causing the manifestation of a problematic use of the Internet.

However, although much research has found that executive functions and self-esteem play an essential role in problematic Internet use, fewer studies have examined whether these variables have a direct or indirect influence.

In addition, it is necessary to analyze the influence of cognitive and affective variables on Internet misuse problems in line with the I-PACE model (Interaction of Person-Affect-Cognition-Execution) suggested by Brand et al. [30]. An understanding the mechanisms behind these behaviors will facilitate the implementation of appropriate prevention and treatment actions.

In this I-PACE model, the authors include predisposing variables, affective and cognitive responses to external or internal stimuli, executive and inhibitory control, decision-making behavior that is important for the use of certain applications or Internet sites, and consequences of Internet use as the main components.

Moreover, this analysis is particularly relevant given that one of the goals of the 2030 Agenda for Sustainable Development focuses on promoting affordable and universal access to the Internet for the least developed countries. Knowledge of risk factors could facilitate the development of programs to prevent inappropriate use of the Internet and the consequences of such use.

In line with the above, this research aims to:

1. Analyze whether inhibition, flexibility and emotional control directly influence each of the variables of problematic Internet use analyzed.
2. Analyze whether self-esteem directly influences all variables of problematic Internet use.
3. Analyze whether inhibition, flexibility and emotional control have an indirect influence, mediated by self-esteem, on the variables of problematic Internet use.

2. Materials and Methods

2.1. Participants

A total of 514 participants, 466 females and 48 males formed the study population. The participation of a higher number of women than men is due to the fact that the selected master's and bachelor's degrees are mainly obtained by women. The age ranged from 17 to 52 years (mean age = 22.20 years; SD age = 3.86). Of the total number of participants, 93.6% were undergraduate students, and 6.4% were graduate students enrolled at a university in southeastern Spain. Of the undergraduate students, 71.4% were students of the Early Childhood Education degree, 5.6% of the Primary Education degree, 8.8% of the Social Education degree and 7.8% of the Social Work degree. Finally, 6.4% of postgraduate students were studying for their master's degree in Compulsory Secondary Education and Baccalaureate, Vocational Training and Language Teaching.

2.2. Instrument

The Generalized Problematic Internet Use Scale in its revised version (GPIUS2) [31], translated and adapted into Spanish by Gámez-Guadix, Orue and Calvete [32], was used

to assess problematic Internet use. This instrument consists of 15 items grouped into four subscales: preference for online social interaction ($\alpha = 0.84$), which refers to the belief that Internet relationships are safer, more comfortable and effective, and less threatening than face-to-face interaction (3 items, e.g., “I feel more comfortable communicating with other people online than face-to-face”); mood regulation through the Internet ($\alpha = 0.79$) refers to the use of the Internet to reduce feelings of isolation or emotional distress (3 items, e.g., “I have used the Internet to feel better when I have been sad”); negative consequences ($\alpha = 0.64$) assesses the extent to which an individual experiences personal, social, academic or work-related problems as a result of dysfunctional Internet use (3 items, e.g., “I have given up commitments or social activities because of my Internet use”); and deficient self-regulation ($\alpha = 0.86$) is conceptualized as a construct that includes cognitive preoccupation and compulsive Internet use. The cognitive preoccupation ($\alpha = 0.69$) includes obsessive thought patterns related to Internet use (3 items, e.g., “I would feel lost if I could not connect to the Internet”) while the compulsive Internet use component ($\alpha = 0.82$) refers to the inability to control or regulate Internet access (3 items, e.g., “I find it difficult to control my Internet use”). It consists of a Likert-type scale with 6 response possibilities ranging from 1 (strongly disagree) to 6 (strongly agree).

On the other hand, the EFECO questionnaire [33,34] was used to assess executive functions. This questionnaire consists of 6 Likert-type factors with four response options ranging from 0 (never) to 3 (very often). However, only the 23 items belonging to the following scales were used for the present research: inhibition, which assesses the ability to consciously control automatic behavioral and behavioral responses (10 items, e.g., “I act without thinking, doing the first thing that comes to my mind”); cognitive flexibility, which assesses the ability to use alternative strategies to reach a goal when the usual action does not work well (6 items, e.g., “I am disturbed by changes of plans”); and emotional regulation, which assesses the ability to control emotional reactions in accordance with the different contexts in which the individual develops (7 items, e.g., “when I get angry, I find it difficult to calm down easily”). The internal consistency index obtained in the present research for each of the scales is as follows: inhibition, $\alpha = 0.75$; cognitive flexibility, $\alpha = 0.70$; emotional regulation, $\alpha = 0.82$.

Finally, self-esteem was assessed using the Rosenberg self-esteem scale [35]. It is a Likert-type scale ranging from 1 (strongly agree) to 4 (strongly disagree). This scale is composed of 10 items (e.g., “I am convinced that I have good qualities”) and the internal consistency index obtained for this research is $\alpha = 0.88$.

2.3. Procedure

In order to carry out this research, different professors who teach in different bachelor’s and master’s degrees at the University of Granada were contacted and asked to collaborate in the completion of different questionnaires during their class time. In the classes of those teachers who agreed to collaborate, students were invited to participate in the study at the beginning of the class. To this end, a link was passed on to the students informing them about the title of the study; data protection; the importance of answering as honestly as possible, as the questionnaires were completely anonymously; and the possibility of leaving the study at any time without having to give any explanation. After reading the initial information, they were asked to tick a box if they agreed with the information read and gave their consent to participate in the research. To ensure confidentiality, and as there were some very personal questions, students were asked to sit far enough apart. Students who chose to participate, after ticking the informed consent box, completed questionnaires, and indicated other aspects such as their gender, age and education. Once the questionnaires had been completed and returned, they were entered anonymously into a database, analyzed and the research report was written.

2.4. Design and Statistical Analysis

This research study adopted an ex post-facto design, specifically, a prospective design, considering executive functions (inhibition, flexibility and emotional control) as independent variables, the different problematic uses of the Internet as dependent variables and self-esteem as a mediating variable.

First, statistical analyses were carried out to determine the reliability of the data and to calculate the descriptive statistics and correlations among the variables. Second, the mediation model for each of the executive functions (dependent variables) was tested using PROCESS, as recommended by Muller et al. [36]. The mediating effect was assessed using bootstrapping approach ($n = 5000$ bootstrap sample) estimates based on 95% bias-corrected confidence intervals. Estimates of indirect effects were considered significant when zero was not contained in the confidence interval [37].

Mediation was calculated via a regression model by determining the significance of the indirect effect; that is, the total effect (c) of an independent variable (IV) on a dependent variable (DV) comprises a direct effect (c') of the IV on the DV and an indirect effect ($a \times b$) of the IV on the DV through the mediator (M). Here, 'a' is the effect of the M on the IV, and 'b' is the effect of the M on the DV, when controlling for the effect of the IV. In analyses involving multiple mediators, estimates for specific indirect effects (each individual M) and the total indirect effect (sum of the specific indirect effects) are estimated [38].

Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 24 running the PROCESS version 3.5 script, model 4 [39].

3. Results

Table 1 shows the mean scores and Pearson's correlation coefficients between the study variables. It is observed that the highest mean scores correspond to the mood regulation through the Internet and compulsive Internet use scales. In contrast, the lowest mean scores are observed for the preference for online social interaction and negative consequences scales. Moreover, data from the correlation analysis indicate that all problematic Internet use variables correlated significantly and negatively with all executive function variables, except the preference for online social interaction variable, which did not correlate with inhibition. Similarly, all variables of problematic Internet use correlated significantly and negatively with self-esteem. In addition, significant and positive correlations were found between all executive function variables and self-esteem.

Table 1. Descriptive data and Pearson correlation coefficients between study variables.

	1	2	3	4	5	6	7	8	9
1. POSI	1								
2. MR	0.335 **	1							
3. CP	0.343 **	0.427 **	1						
4. CIU	0.278 **	0.399 **	0.728 **	1					
5. NO	0.352 **	0.333 **	0.512 **	0.597 **	1				
6. IN	−0.084	−0.118 **	−0.187 **	−0.194 **	−0.208 **	1			
7. FL	−0.171 **	−0.121 **	−0.228 **	−0.215 **	−0.196 **	0.304 **	1		
8. EC	−0.155 **	−0.200 **	−0.191 **	−0.179 **	−0.183 **	−0.349 **	0.318 **	1	
9. SE	−0.203 **	−0.145 **	−0.127 **	−0.140 **	−0.229 **	0.183 **	0.193 **	0.259 **	1
M	5.12	10.03	7.27	8.29	5.23	24.87	14.84	16.16	32.08
SD	2.84	3.98	3.06	3.65	2.36	2.70	1.99	2.95	5.83
Min.	3	3	3	3	2	12	7	0	11
Max.	18	18	17	18	15	30	18	21	40

Notes. POSI = preference for online social interaction. MR = mood regulation through the Internet. CP = cognitive preoccupation. CIU = compulsive Internet use. NO = negative consequences. IN = inhibition. FL = flexibility. EC = emotional control. SE = self-esteem. M = media. SD = standard deviation. Min. = minimum. Max. = maximum. ** $p < 0.01$

In the mediation analyses carried out, self-esteem was considered as the mediating variable (M) between the executive functions, included in the model as independent

variables (IV) and the different variables of problematic Internet use as dependent variables (DV). The model and the effects analyzed are shown in Figure 1.

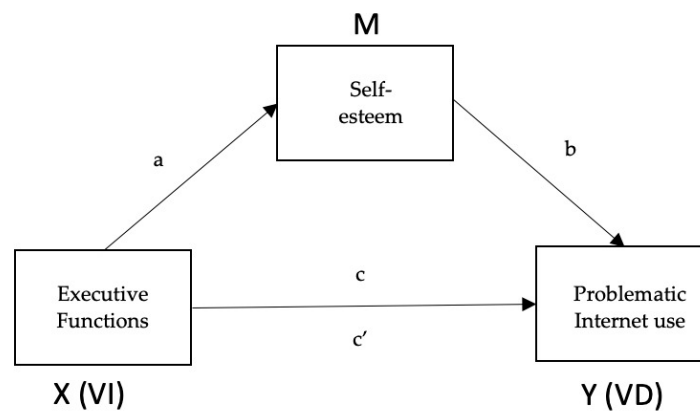


Figure 1. Representation of the mediation model.

In the first mediation model analyzed, considering inhibition as an independent variable (see Table 2), a positive and significant direct effect of inhibition on self-esteem was observed (a). The effects of self-esteem (M) on all dependent variables (b) were negative and significant.

Table 2. Summary of the coefficients mediating self-esteem (M) between the independent variable inhibition (VI) and the dependent variable problematic Internet use (DV).

Dependent Variable	Effect of IV on M (a)	Effect of M on DV (b)	Direct Effect (c')	Total Effect (c)	Indirect Effect (a × b)	Bootstrap IC 95%	
						Lower	Upper
Preference for online social interaction	0.39 ***	−0.09 ***	−0.05	−0.09	−0.04 *	−0.066	−0.016
Mood regulation through the Internet	0.39 ***	−0.09 **	−0.14 *	−0.17 **	−0.03 *	−0.068	−0.009
Cognitive preoccupation	0.39 ***	−0.05 *	−0.19 ***	−0.21 **	−0.02 *	−0.044	−0.001
Compulsive Internet use	0.39 ***	−0.07 *	−0.24 ***	−0.26 **	−0.03 *	−0.056	−0.005
Negative consequences	0.39 ***	−0.08 ***	−0.15 ***	−0.18 **	−0.03 *	−0.055	−0.013

Notes. (a) = effect of IV on M; (b) = effect of M on DV; (c') = direct effect; (c) = total effect; (a × b) = indirect effect. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

Likewise, significant negative direct effects of Inhibition were found for the following dependent variables (c'): mood regulation through the Internet; cognitive preoccupation; compulsive Internet use; and negative consequences. In contrast, no significant effects were found with preference for online social interaction.

In terms of the total effects (c) of inhibition on each of the variables of problematic Internet use, it was found that there are negative and significant effects with mood regulation through the Internet, cognitive preoccupation, compulsive Internet use and negative consequences. In contrast, the total effect of inhibition with a preference for online social interaction was not significant.

As for the indirect effects (a × b), considering self-esteem as a mediating variable, the results showed negative and significant indirect effects of inhibition with all the variables of problematic use analyzed, as zero was not included in the Bootstrap IC.

The coefficients of the second model analyzed in which flexibility (VI) and its effects on the variables of problematic Internet use (DV) are considered, considering self-esteem as a moderating variable, are presented in Table 3. The results of the mediation model show a positive and significant effect between flexibility (IV) and self-esteem (M). Regarding the effects of self-esteem (M) on the dependent variables (b), the data show negative and

significant effects with a preference for online social interaction, mood regulation through the Internet, cognitive preoccupation, compulsive Internet use and negative consequences.

Table 3. Summary of the coefficients mediating self-esteem (M) between the independent variable, flexibility (VI), and the dependent variable, problematic Internet use (DV).

Dependent Variable	Effect of IV on M (a)	Effect of M on DV (b)	Direct Effect (c')	Total Effect (c)	Indirect Effect (a × b)	Bootstrap IC 95%	
						Lower	Upper
Preference for online social interaction	0.56 ***	−0.09 ***	−0.20 **	−0.24 ***	−0.05 *	−0.085	−0.020
Mood regulation through the Internet	0.56 ***	−0.09 **	−0.19 *	−0.24 **	−0.05 *	−0.092	−0.013
Cognitive preoccupation	0.56 ***	−0.04 *	−0.32 ***	−0.35 ***	−0.03	−0.058	0.000
Compulsive Internet use	0.56 ***	−0.06 *	−0.36 ***	−0.39 ***	−0.04 *	−0.077	−0.004
Negative consequences	0.56 ***	−0.08 ***	−0.19 ***	−0.23 ***	−0.05 *	−0.075	−0.020

Notes. (a) = effect of IV on M; (b) = effect of M on DV; (c') = direct effect; (c) = total effect; (a × b) = indirect effect. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

Significant negative direct effects are also observed between the independent variable and the dependent variables (c'): preference for online social interaction; mood regulation through the Internet, cognitive preoccupation, compulsive Internet use and negative consequences. We also found negative and statistically significant total effects (c) of flexibility on each of the variables of problematic Internet use: preference for online social interaction; mood regulation through the Internet; cognitive preoccupation; compulsive Internet use; and negative consequences.

The indirect effects (a × b) when considering self-esteem as a moderating variable were significant in preference for online social interaction, mood regulation through the Internet, compulsive Internet use and negative consequences. However, as can be seen in Table 3, the Bootstrap IC in cognitive preoccupation includes zero and, therefore, no indirect effects of flexibility with this variable can be considered to exist ($\beta = -0.03$, IC -0.058 0.000).

The coefficients of the prediction model in which emotional control is included as an independent variable are presented in Table 4. The results show a positive and significant effect between emotional control (IV) and self-esteem (M). The effects of the mediating variable (self-esteem) with the dependent variables (b) were negative and significant in preference for online social interaction, mood regulation through the Internet, compulsive Internet use, and negative consequences. However, a non-significant negative effect is observed with cognitive preoccupation.

Table 4. Summary of the mediation coefficients of self-esteem (M) between the independent variable, emotional control, (VI) and the dependent variable, problematic Internet use (DV).

Dependent Variable	Effect of IV on M (a)	Effect of M on DV (b)	Direct Effect (c')	Total Effect (c)	Indirect Effect (a × b)	Bootstrap IC 95%	
						Lower	Upper
Preference for online social interaction	0.56 ***	−0.09 ***	−0.20 **	−0.24 ***	−0.05 *	−0.085	−0.020
Mood regulation through the Internet	0.56 ***	−0.09 **	−0.19 *	−0.24 **	−0.05 *	−0.092	−0.013
Cognitive preoccupation	0.56 ***	−0.04 *	−0.32 ***	−0.35 ***	−0.03	−0.058	0.000
Compulsive Internet use	0.56 ***	−0.06 *	−0.36 ***	−0.39 ***	−0.04 *	−0.077	−0.004
Negative consequences	0.56 ***	−0.08 ***	−0.19 ***	−0.23 ***	−0.05 *	−0.075	−0.020

Notes. (a) = effect of IV on M; (b) = effect of M on DV; (c') = direct effect; (c) = total effect; (a × b) = indirect effect. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

On the other hand, significant negative direct effects (c') of emotional control are observed with all negative Internet use variables: preference for online social interaction; mood regulation through the Internet; cognitive preoccupation; compulsive Internet use; and negative consequences. The total effects (c) are equally negative and significant with

all dependent variables: preference for online social interaction; mood regulation through the Internet; cognitive preoccupation; compulsive Internet use; and negative consequences.

The indirect effects ($a \times b$) were negative and significant in preference for online social interaction, mood regulation through the Internet, compulsive Internet use and negative consequences. No indirect effects of emotional control are observed with cognitive preoccupation ($\beta = -0.02$, IC -0.016 0.001) as zero is included in the Bootstrap IC.

4. Discussion

Considering the negative consequences that problematic Internet use has on the personal and professional lives of individuals, it is appropriate to investigate possible variables that act as predictors of such use, to better understand its origin and facilitate preventive intervention from an early age. For this reason, the present research aimed to analyze whether inhibition, flexibility and emotional control directly influence all variables of problematic Internet use. In addition, we examined whether self-esteem directly influences problematic Internet use and whether executive functions, mediated by self-esteem, indirectly influence problematic Internet use.

To this end, we analyzed whether executive functions, considered as independent variables, had not only direct effects on the different problematic uses of the Internet but also indirect effects, as these cognitive functions were mediated by self-esteem. In this way, it could be considered that inappropriate Internet use is not only affected by cognitive variables, but that this cognitive assessment made by the person is determined, in part, by a more emotional or affective variable, such as self-esteem. We also examined whether executive functions had direct effects on self-esteem and whether self-esteem, in turn, has a direct influence on problematic Internet use.

In this sense, inhibition, cognitive flexibility, and emotional control were found to positively influence self-esteem. Thus, higher scores on inhibition, cognitive flexibility, and emotional control led to higher scores on self-esteem. Therefore, people who were able to control their behavior, thoughts, and emotions and who were able to use alternative strategies to achieve a goal tended to rate themselves more positively. In this line, and in the case of flexibility, Chen, He and Fan [40] considered that cognitive flexibility is related to openness to new experiences, which favored getting involved in more creative tasks and at the same time improving their self-esteem. Similarly, with university students, Miller, Davis, and Hayes [41] found a positive relationship between flexibility and self-esteem, although in their case, they analyzed only interpersonal flexibility, that is, the processes by which an individual changes his or her behavior according to the demands of an interpersonal nature, which the situation requires of him or her.

Although more research is needed on the bidirectional influence between executive functions and self-esteem, it seems that the results found in the present research may indicate that the ability to control thoughts and feelings could reduce the likelihood of people having negative thoughts or feelings about themselves. Similarly, more cognitively flexible people may seek alternative solutions and thoughts when they feel negatively about themselves.

On the other hand, the results showed that flexibility and emotional control had a significant and negative direct effect on all variables of problematic Internet use. Thus, students who were less able to control their emotional reactions depending on the context and who were less flexible preferred online interactions because they perceived them as safer, more comfortable, effective, and less threatening than face-to-face interaction. In addition, they seemed to use the Internet to reduce their negative emotions and ability to regulate Internet access, and increased their obsessive thoughts, and social, academic, and personal problems, resulting from excessive Internet use.

These results have also been found by other studies. For example, Yu et al. indicated that low cognitive flexibility may cause failures in self-regulation (particularly difficulties with emotional regulation), which may further increase the likelihood of Internet addiction [26]. In addition, Dong et al. found that people with an Internet addiction disorder

showed impaired cognitive flexibility compared to people without Internet addiction [27]. This impairment in cognitive flexibility can also be observed in people with other types of addictions. For example, some studies have shown problems in cognitive flexibility in people with gambling problems [42,43] or with food [44].

In addition, Babaei et al. found that emotional regulation was related to different addictions, such as Internet addiction, food addiction and opioid addiction [22]. Similarly, Trumello et al. argued that excessive Internet use may be an attempt by people to avoid dealing with negative emotions as it allows instant emotional avoidance, as well as distraction and disconnection [23]. Thus, the ability to manage and regulate social-emotional competence may be related to an individual's ability to manage Internet use. Those who were aware of their emotional states and were able to manage them, without allowing these feelings to affect and interfere deeply with their interpersonal relationships, were likely to be able to better extend this ability to manage their time, Internet access or content [24].

Similarly, inhibition had a significant negative direct effect on mood regulation through the Internet, negative consequences, cognitive preoccupation, and compulsive Internet use. However, no direct effect was found between inhibition and preference for online social interaction. Therefore, students who were unable to control their automatic and impulsive behaviors used the Internet to regulate their emotional state, had various personal problems resulting from excessive Internet use, had obsessive thoughts and were unable to control their Internet use. In this line, Wu et al. found, in a sample of 267 young people, that those who were more impulsive spent more time on social networks exhibiting addictive tendencies [19]. Along these lines, Dieter et al. conducted a study involving 51 people with Internet addiction and 44 people without Internet addiction. These authors found that people with Internet addiction were more impulsive than non-addicted people [20].

Finally, the present research found an indirect influence, mediated by the self-esteem variable, of inhibitory control on all variables of problematic Internet use. Therefore, participants who had high inhibition and high self-esteem had less problematic Internet use. Thus, having high inhibitory control and high self-esteem was associated with a preference for face-to-face interactions over online; less use of the Internet to reduce feelings of isolation or emotional distress; fewer personal, social, academic, or work-related problems as a result of dysfunctional Internet use; fewer obsessive thoughts related to Internet use; and a greater ability to regulate time spent online. In a paper by Grao et al., although in this case, through a moderated mediation analysis, it was found that high self-control or inhibition enhanced the effect of self-esteem against anxiety generated by the addictive use of smartphones. This study concluded that an increase in self-esteem alone would not prevent addictive smartphone use [45].

Moreover, the results of the study showed that cognitive flexibility and emotional control, mediated by self-esteem, indirectly influenced almost all variables of problematic Internet use. Specifically, high cognitive flexibility and high emotional control, mediated by high self-esteem, scores were found to influence low scores on the preference for online social interaction, less use of the Internet for mood regulation, reduced negative consequences of problematic Internet use, and a lower likelihood of compulsive Internet use. However, no mediation effect of self-esteem between cognitive flexibility and cognitive worry was found. Similarly, no indirect relationships were found between emotional control, when measured by self-esteem, and cognitive worry. These results would be in line with the cognitive-behavioral model of pathological Internet use, which stated that inappropriate Internet use stems from maladaptive behavioral habits and cognitive patterns, which are, at the same time, determined by pathological traits and situational cues related to the Internet [46].

In the results obtained, self-esteem not only showed itself to be a mediator between executive functions and problematic Internet use, but also become a variable that directly influenced this inappropriate use. Along these lines, there is extensive research that establishes that low self-esteem plays a key role in problematic Internet use. For example, Moral and Dominguez conducted a study with 240 young people aged 15–22 and found

that low self-esteem predicts problematic Internet use [47]. Similarly, Sechi et al. conducted a study with Italian university students and found that self-esteem had a direct protective effect on Internet addictive behaviors [10]. These results are also comparable with the research carried out by Herrera et al., who state that the low security and confidence of people with low self-esteem was a trigger for their addiction to the Internet and their preference for online social interactions through this medium [48]. According to Niemz et al., the fact that a person had a low opinion of him/herself hindered his/her ability to socialize, conceiving the Internet as an efficient alternative to face-to-face interaction [49]. In fact, the Internet and its possibility of anonymity allows its users to interact with others using a “false self-image”, which favors pleasant experiences, such as making friends online [30]. On the other hand, Pérez, Monje and León’s review of problematic mobile phone use concluded that the personality trait most consistently associated with problematic use was low self-esteem [50].

Therefore, the present research showed that both executive functions and self-esteem could directly influence problematic Internet use. Furthermore, it was found that the relationship between executive functions and problematic Internet use could be mediated by self-esteem. These results suggested the need for prevention and intervention programs to reduce problematic Internet use. It is important that these programs work on executive functions and self-esteem to help future teachers to improve their self-image and self-esteem, which will lead to an improvement in their ability to control and self-regulate their behavior. Moreover, future teachers and educators will be responsible for educating future generations, and if they themselves are not able to make healthy use of the Internet, it will be difficult for them to help their students in this area.

Limitations

Although the results found in this research are promising, there are some relevant limitations that need to be considered. First, this study was conducted with a Spanish population and involved only university students from the University of Granada (Spain), so interpretations should be made with some caution as problematic Internet use may differ according to age and country of residence. Therefore, these results may not be generalizable to other countries. Another limitation of the study was related to gender, as the sample consisted mainly of women, which could bias the results found. For this reason, future lines of research could test whether problematic Internet use varies according to variables such as nationality, age, or gender.

Second, the cross-sectional design does not allow any directional relationship to be tested. Future research should adopt longitudinal and experimental methods to investigate the effect of the causal relationship between executive functions and inappropriate Internet use on both these cognitive variables and self-esteem, in order to guide more efficient interventions to prevent or reduce this type of behavior from an early age. On the other hand, only two variables that could be related to problematic Internet use (self-esteem and executive functions) were analyzed in this study. It would be necessary to include other variables that may increase the predictive value of problematic Internet use, such as social skills, parenting styles, age, gender, or culture. In addition, problematic Internet use was analyzed in a generic way, not specifying its purpose (e.g., playing video games, chatting, and online shopping) or the media used (e.g., mobile phone and computer) or the time students spend online. It would be interesting for future studies to qualify these aspects.

5. Conclusions

It could be concluded that executive functions and self-esteem have direct effects on problematic Internet use. Specifically, flexibility and emotional control were the variables with the most direct effects, as they influenced all variables of problematic Internet use. However, when self-esteem was included as a mediator, inhibition was the variable with the most indirect effects, influencing all variables of problematic Internet use.

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