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Predictors of Critical Thinking in Spanish University Students

Predictores del Pensamiento Crítico en Estudiantes Universitarios Españoles

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KEYWORDS:

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ABSTRACT:

Critical thinking (CT) is essential for the academic and professional success of university students, yet understanding its complexities remains challenging. This study examines the impact of various predictors on CT and its dimensions (argument analysis/evaluation and problem-solving) among Spanish university students. Using a hierarchical linear regression model with three levels, incorporating individual and contextual variables, data from a sample of 5,238 students across various Spanish universities were analysed. The results revealed significant effects of several predictors on CT and its dimensions, including gender (favouring males), year of study (favouring students in higher years), academic performance (favouring students with higher grades), type of degree (favouring students in double degree programs), and university ownership (favouring public universities). The study underscores the importance of addressing these predictors to enhance CT and promote academic and professional success. Recognising limitations, further research is needed to explore additional predictors, refine models, and deepen the understanding of CT in higher education.

DESCRIPTORES:

Pensamiento crítico

Siglo XXI

Educación superior

Evaluación educativa

Variables predictoras

RESUMEN:

El pensamiento crítico (PC) es esencial para el éxito académico y profesional del estudiantado universitario, pero entender sus complejidades supone un desafío. Este artículo tiene como objetivo analizar el efecto de diversos predictores en el PC y sus dimensiones (análisis/evaluación de argumentos y resolución de problemas) en el estudiantado universitario español. Para ello, se utilizó un modelo de regresión jerárquico-lineal (con tres niveles) que incorpora variables individuales y contextuales, contando con una muestra de 5.238 estudiantes de diversas universidades españolas. Los resultados revelaron un efecto significativo de varios predictores en el PC y sus dimensiones, entre otros: el género (con medias superiores a favor de los varones), el año de estudio (a favor de los estudiantes con mayor número de años en la universidad), el rendimiento académico (a favor de los estudiantes con mejores calificaciones), el tipo de grado (a favor de los estudiantes de doble grado) o la titularidad de la universidad (a favor de la titularidad pública). Se destaca la importancia de abordar estos predictores para mejorar el PC y promover el éxito académico y profesional. Reconociendo las limitaciones, se requiere más investigación para explorar predictores adicionales, refinar modelos y profundizar en la comprensión del PC en la educación superior.

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1. Introduction

Critical thinking is widely acknowledged as a vital competence for higher education students due to its impact on academic success (Akpur, 2020), employability (Indrašienė et al., 2021), and contributions to democratic societies (Aktoprak & Hursen, 2022). This cognitive ability enables individuals to engage in rational and ethical reasoning (Davies, 2015; Ennis, 1985; Paul & Elder, 2019; Siegel, 1988), evaluate information (Stoesz et al., 2022), make informed decisions (Ennis, 2018), analyse complex problems (Halpern, 2014), and develop creative solutions (Dwyer, 2017).

In recent years, numerous authors have made significant efforts to advance and assess critical thinking among students. Abrami et al. (2015) conducted a seminal meta-analysis, indicating that dialogue, exposure to authentic problems, and mentoring positively influence critical thinking skills. Onen (2020) highlighted faculty perceptions as a factor contributing to inadequate critical thinking development among students, while Avinante et al. (2023) found low self-perceived critical thinking levels among university students in the Philippines, underscoring the need for a more comprehensive approach to its cultivation.

In Spain, recent efforts, exemplified by the work of Rivas and Saiz (2023), aim to enhance critical thinking practices. Additionally, guidelines proposed by Gutiérrez-Ujaque and Gernández-Rodrígo (2021) advocate for a dialogic teaching approach, emphasising the reinforcement of critical thinking skills and the cultivation of social responsibility within educational settings.

Despite these efforts, a national-level study within Spanish universities to evaluate students' critical thinking and identify its predictors remains elusive. Identifying possible predictors of critical thinking is crucial for developing effective strategies to foster this competence in students, empowering educational institutions to design targeted interventions that enhance students' abilities to analyse, evaluate, and solve complex problems. Furthermore, understanding predictors of critical thinking skills enables institutions to evaluate the effectiveness of their programs and make evidence-based decisions for improvement (Hunter et al., 2014). Ultimately, gaining insights into the predictors of critical thinking has broader societal implications, enabling individuals and societies to thrive in an increasingly complex and interconnected world.

Critical thinking encompasses a multifaceted cognitive process involving the analysis of information to facilitate informed decision-making and actions (Dwyer, 2017; Ennis, 1985; Halpern, 2014). This cognitive ability requires the disciplined and methodical application of various cognitive skills (Gul & Akcay, 2020; Uslu, 2020). Analysing arguments from a logical-dialectical perspective relies on skills that detect, identify, and examine the components, relationships, and integrating principles of an argument. The primary objective is to understand the content and structure of the argument, with skills specific to this category including recognising the argument (Archila et al., 2022), distinguishing between facts and opinions (Heard et al., 2020), and identifying the logical relationship between premises and conclusions (Eemeren & Henkemans, 2016). This analysis enables the identification and interpretation of information, facilitating ethical and rational evaluation (Chatfield, 2022; Hatcher & Possin, 2020).

In contrast, the evaluation of arguments aims to assess the strength or weakness of premises in supporting conclusions, irrespective of one's level of agreement (Dwyer,

2017; Gul & Akcay, 2020). It involves detecting errors in reasoning (Heard et al., 2020), constructing counterarguments and alternative hypotheses (Liu & Stapleton, 2014), and questioning and identifying additional necessary information. Moreover, evaluating arguments from an ethical perspective involves rejecting statements that promote human rights violations, such as humiliation, discrimination, or offence. Skills specific to this category include assessing information credibility (Marttunen et al., 2021), identifying fallacies related to relevance (Da San Martino et al., 2020), and recognising false causal relationships (Cottrell, 2017).

Problem-solving entails the recognition and resolution of problems in a logical and systematic manner (Aktoprak & Hursen, 2022; Braun et al., 2020; Shavelson et al., 2019). It involves four phases: identifying and analysing the problem, determining strategies and alternatives, implementing actions guided by strategies, and conducting a final evaluation. Problem-solving skills include identifying fundamental elements of the problem (Dwyer, 2017), understanding its characteristics (Shanta & Wells, 2020), and recognising the knowledge requirements necessary for effective resolution (García Ruiz et al., 2020). Additionally, it encompasses the ability to select the most optimal alternative for a solution (Halpern, 2014), executing and implementing corrective actions when needed (OECD, 2017), and critically and constructively evaluating both the outcome and the process (Schoenfeld, 1980; Shavelson et al., 2019), among other essential abilities.

Recognising that critical thinking exists along a continuum with varying degrees of intensity, measuring this skill becomes essential for effective evaluation and teaching. Although breaking down the continuous thinking process into discrete skills may seem artificial, it aids in understanding, teaching, and evaluation of critical thinking (Halpern, 2014). Cultivating healthy scepticism, promoting adequate domain exposure, and developing ethical reasoning skills are crucial in nurturing critical thinking and enabling individuals to engage in rational and ethical decision-making (Heard et al., 2020; Paul & Elder, 2006).

By investigating the predictors of critical thinking and its dimensions, this study contributes to the broader understanding of this important competence. The insights gained from this research can inform educational practices and ultimately enhance individuals' ability to navigate complex challenges in a rapidly changing world. Specifically, the general objective of this paper is to analyse the simultaneous effect of a set of predictors on critical thinking skills and its constituent dimensions (argument analysis and evaluation, and problem-solving) among Spanish university students, for each data aggregation level (Level 1: Student, Level 2: University, and Level 3: Autonomous Community), by using hierarchical-linear modelling. Subsequently, the methodology employed will be described in detail, and the results will be thoroughly analysed and discussed. Additionally, the study will address the primary limitations and propose potential avenues for future research.

2. Method

To achieve the research objective of this study, a quantitative research approach was used, employing an exploratory cross-sectional design and a non-experimental expost facto approach.

Participants

A convenience non-probability sampling method was employed to obtain a sample of 5,238 voluntary student participants. With a 99% confidence level and a margin of

error of 1.78%, this sample represents a population size of 1,340,632 (Gobierno de España, 2022). The sample's characteristics provide insights into the demographics and academic profiles of the participants (Table 1). The age distribution reveals that most of the sample (85.53%) falls within the 17-24 age range, with the largest subgroup being 17-20-year-olds (50.17%). Most participants are women (60.15%), while 3.41% identify as non-binary. Table 1 provides a comprehensive description of the remaining variables considered in the study.

Table 1

Demographic profile of the sample based on sociodemographic variables

	N	%		N	%
Age			Late graduation		
17-20	2,628	50.17%	On time	4,753	90.74%
21-24	1,852	35.36%	1 year	405	7.71%
25-28	357	6.82%	2 years	100	1.49%
29-32	132	2.52%	Ownership		
+32	269	5.14%	Public university	4,959	94.67%
Gender			Private university	273	5.21%
Women	3,151	60.15%	Format		
Men	1,961	37.44%	Offline	5.080	96.98%
Non-binary	126	3.41%	Online	152	2.90%
Residency			Typology		
Familiar	3,331	63.59%	Own centres	5.042	96.26%
Non-familiar	1,907	36.39%	Affiliated centres	192	3.67%
Employment			Autonomous community		
No	3,796	72.47%	Madrid (Community of)	1,175	22.44%
Less than part-time	717	13.67%	Andalusia	841	16.06%
Part-time	381	7.27%	Valencian Community	617	11.78%
Full-time	344	6.57%	Catalonia	493	9.41%
Academic record grade			Galicia	384	7.33%
A	333	6.36%	Asturias (Principality of)	368	7.03%
B	2,221	42.40%	Castile and León	321	6.13%
C	1,007	19.22%	Basque Country	297	5.67%
D	84	1.60%	Balearic Islands	235	4.49%
F	15	0.29%	Canary Islands	221	4.22%
No data (1st-year students)	1,578	30.13%	Aragon	76	1.45%
Public financial aid			Castilla La-Mancha	70	1.34%
No	2,932	55.96%	Cantabria	52	0.99%
Yes	2306	44.02%	Region of Murcia	29	0.55%
Type of program			Chartered Community of Navarre	28	0.53%
Bachelor's Degree	4,714	90%	La Rioja	16	0.31%
Double Degree	524	10%	Extremadura	15	0.29%
Year					
1st	1,577	30.11%			
2nd	928	17.72%			
3rd	652	12.45%			
4th	1,848	35.28%			
5ºth	212	4.05%			
6th	21	0.4%			

Instrument

In this study, a four-stage instrument named *CritiTest* was developed for data collection purposes. Initially, a theoretical foundation for critical thinking was established, defining it as a comprehensive cognitive process aimed at exploring statements or problems to reach valid conclusions or select the alternative with the highest likelihood of success (Dwyer, 2017; Ennis, 1985; Halpern, 2014). This construct was then divided into two dimensions: analysis and evaluation of arguments, and problem-solving (see Annexes).

Attributes reflecting the construct were selected through a proposal of indicators evaluated by nine experts in argumentation, critical thinking, and measurement. Following this, item content was outlined based on previously identified indicators. To evaluate the argumentative dimension of critical thinking, current and socially controversial topics were recommended, leveraging data analysis from various sources such as social networks, media, and search engines. For the problem-solving dimension, areas where university students typically make decisions, such as family, studies, friendships, and travel, were identified. Next, a preliminary instrument was designed, comprising open-ended questions to maximise differences in individuals' constructs. To mitigate biases, the relationship between indicators and topics was randomised.

After expert review and revisions, administration procedures were developed. A pilot study involving 99 students analysed responses using Natural Language Processing (NLP) techniques, including Part of Speech Tagging (POS Tagging), Bag of Words (BOW), and a linguistic sentiment analysis model based on Transformers. These techniques were employed due to their capacity to streamline data analysis, extract meaningful insights, ensure objectivity in evaluation, facilitate scalability, and provide advanced analysis capabilities.

Based on these results, the final instrument was designed, consisting of 5-point Likert-type closed questions (see examples in Table 2). The instrument was organised into two major dimensions, namely analysis and evaluation of arguments (with 5 sub-dimensions) and problem-solving (with 4 sub-dimensions). Cronbach's alpha coefficient ensured good internal consistency (0.86 for the full scale, 0.81 for analysis and evaluation, and 0.76 for problem-solving).

Table 2

Examples of items for Analysis and evaluation of arguments, and Problem Solving

Item of Analysis and evaluation of arguments
AMAIA (TV presenter): Following a passionate debate on the topic of Monarchy versus Republic, 54% of the participating viewers have voiced their support for the Monarchy, while the remaining 46% favour the Republic. However, what's particularly intriguing is that 97% of all voters agree on the necessity of conducting a referendum for the populace to decide on the State model. Therefore, if we truly consider the desires of the Spanish people, we should proceed with a referendum. Please indicate your level of agreement with the following statements, on a scale from 1 to 5, where 1 represents "Strongly Disagree" and 5 represents "Strongly Agree": • Most Spaniards desire a referendum to determine the State model (reverse item). • The survey respondents accurately represent the Spanish population (reverse item).
Item of Problem solving
Your best friend is confronting a challenging situation (...). Following a heart-to-heart conversation, he reveals to you his severe cocaine addiction and seeks your assistance in locating a detox centre. After thorough research, you find yourself torn between two options:

1. The first centre is operated by a former addict from France, who is slightly older than your friend. Ninety percent of the individuals who underwent treatment for a year successfully detoxed from cocaine.
2. The second centre is overseen by a middle-aged German therapist who has never experimented with cocaine but possesses advanced training in the psychobiology of cocaine addiction. Only thirty percent of those enrolled in the treatment program managed to detox successfully.

Please indicate your level of agreement with the following statements, using a scale from 1 to 5, where 1 represents "Strongly Disagree" and 5 represents "Strongly Agree":

- The success rate should weigh more heavily than nationality when selecting the centre.

It is more probable to achieve recovery at the first centre (reverse item).

Variables

The present study focused on the dependent variables of critical thinking and its dimensions, specifically the analysis and evaluation of arguments, and problem-solving skills in participants. Critical thinking is a vital process for making informed decisions based on ethical and rational principles, both in beliefs and actions. Accordingly, the study evaluated Critical thinking through its two main dimensions, namely argument analysis and evaluation, and problem-solving.

Regarding the independent variables, a total of 23 predictors were selected for this study. For Level 1, which pertains to the student level, 12 covariates indicated in Table 3 were included. It is noteworthy that the values of these variables were recoded to suit the model, as presented in Table 3.

Table 3

Level 1 variables: Student

Variable name	Recoded values
Age	0= 17-20; 1=21-24; 2= 25-28; 3=39-32; 4= +32
Gender	0=Male; 1=Female
Residence at family home	0=Yes; 1=No
Employment during school year	0=No; 1=Yes, les tan half-time; 2= Yes, half -time; 3=Yes, full-time (40h/week)
Grade point average	0=No data (first-year students); 1=IN (0...4); 2=SU (5); 3=BI (6); 4=NT (7,8); 5=SB (9,10)
Public financial aid	0=No; 1=Yes
Critical thinking self-perception	[0-9]
Decision-making self-perception	[0-9]
Life satisfaction	[0-9]
Type of degree programme	0=Bachelor's; 1=Dual degree
Year	0=First; 1=Second; 2=Third; 3=Fourth; 4=Fifth; 5=Sixth
Late graduation	0=On-time graduation; 1=1 Year late graduation; 2=2 Years late graduation

For the Level 2: University, three variables have been selected as predictors, and their evaluated aspects and recoded values are displayed in Table 4.

Table 4

Level 2 variables: University

Name	Recorded values
Ownership	0=Public; 1=Private
Format	0=On-site; 1=Online
Typology	0=Own centre; 1=Affiliated centre

Finally, for Level 3: Autonomous community, the variables displayed in Table 5 have been taken into consideration.

Table 5

Level 3 Variables: Autonomous community

Name	Value range	Recoded values
Population	319,796 – 8,472,407	0 – 8,153,611
Number of universities	1 – 15	0 – 14
Gross domestic product per capita1	9,915 – 12,913	0 – 3,018
Public expenditure on education (% of GDP)2	2 – 5.3	0 – 3.3
Average number of students per educational group in: Early Childhood Education	15 – 17.6	0 – 2.6
Primary Education	22 – 24,1	0 – 2.1
Compulsory Secondary Education	26.7 – 28.5	0-1.8
Baccalaureate3	21.6 – 28.2	0 – 6.6

Note. The values have been recorded so that the minimum value is equal to 0.

Procedure

For the application of the instrument, contact was established with the main representatives of all Spanish universities, including rectors, vice-rectors, deans, vice-deans, faculty, and student representatives, soliciting their collaboration in data collection through an online platform. The virtual version of the instrument was provided to those expressing interest for distribution among their students.

Before completing the instrument, students were informed that participation was voluntary and that they could withdraw at any time without consequences. They were assured that their responses would remain anonymous and confidential, utilised solely for research purposes. Notification was provided regarding compliance with Regulation (EU) 2016/679 of the European Parliament and of the Council of April 27, 2016, as well as Organic Law 3/2018[4] of December 5, regarding data processing. Explicit acceptance for participation in the research was required for access to the instrument.

Data analysis

To accomplish the study's objective, hierarchical linear models were employed due to their capacity to capture the nested structure of data at multiple levels, namely, the individual student, institutional centre, and autonomous community. This methodology facilitates more precise identification of the effects ascribable to each of these levels. The software program MLwiN was used to conduct the data analysis.

[1] Gross Domestic Product (GDP) is the English equivalent of "PIB per capita" in Spanish, which is a measure of a country's economic output that considers its population size.

[2] "Public expenditure on education (% of GDP)" in English is the equivalent of "gasto público en educación (% sobre el PIB)" in Spanish. Both terms refer to the percentage of a country's gross domestic product that is spent on education by the government.

[3] "Bachillerato" in the Spanish education system refers to the last two years of secondary education, and it is a prerequisite for higher education. "Baccalaureate" is an English term that refers to a secondary education program that focuses on humanities and social sciences. Although the term "Baccalaureate" is not commonly used in the Spanish education system, it is sometimes used to refer to the Spanish "Bachillerato", especially in international or bilingual contexts.

[4] https://www.boe.es/buscar/doc.php?id=BOE-A-2018-16673

To examine the impact of various predictors on critical thinking and its constituent dimensions, namely argument analysis and evaluation and problem-solving, a hierarchical-linear regression model (HLM) is employed. This statistical approach accommodates the hierarchical structure of data by combining individual and contextual variables, effectively avoiding the pitfalls of atomistic and ecological fallacy (Gaviria & Castro, 2005). The study involves three univariate multilevel models that assess the influence of a set of predictors on Critical thinking, Argument analysis and evaluation, and Problem-solving, respectively. Additionally, a bivariate model was formulated to examine the concurrent effect of these predictors on Argument analysis and evaluation and Problem-solving, enabling the analysis of variable performance within the study phenomenon at the individual, collective, and cross-sectional levels.

The study utilises three univariate models, each with three levels (i.e., student, university, and autonomous community), and a multivariate model, also with three levels, which are jointly specified. In the multivariate model, scores on argument analysis and evaluation and problem-solving are nested within the student (level 1), who is aggregated into universities (level 2), which, in turn, are grouped into autonomous communities (level 3).

3. Results

In the following section, an overview of the modelling process used for the multilevel analysis is presented, encompassing both the null model and the final model. The final model serves as the foundation for the conclusive interpretation of the findings. The statistical procedures and assumptions underlying the models will be discussed to provide a clear and comprehensive description of the approach to the analysis of the data.

3.1. Estimation of null models

The estimation of the null model enables an evaluation of the suitability of MJL. Table 6 displays the results obtained after its estimation. The fixed parameters indicate the intercept's value, representing the average performance observed in *Critical thinking*, *Analysis and evaluation of arguments*, and *Problem solving* across the entire sample of 5,238 individuals. The average performance in *Critical thinking* is 145.786 points, in *Analysis and evaluation of arguments* it is 95.855 points, and in *Problem solving* it is 49.920 points.

The random component of the univariate models reveals that the residuals' variances at all three levels, except for the University level in *Problem solving*, are statistically significant[5]. The significance of these parameters justifies further model expansion, as it suggests that unexplained variance exists in two of the three levels for *Problem solving* and in all three levels for *Critical thinking* and *Analysis and evaluation of arguments*. This implies that the mean performance in *Critical thinking*, *Analysis and evaluation of arguments*, and *Problem solving* varies at the level of students and autonomous communities. Similarly, there are differences in the averages of *Critical thinking* and *Analysis and evaluation of arguments* at the university level.

[5] In accordance with the work of Gaviria and Castro (2004), a parameter is deemed significant (alpha=0.05) if the ratio between the parameter estimate and its standard error exceeds 1.96 (~2).

Table 6

Estimation of null models

FIXED EFFECTS		
Average performance in Critical thinking	β0	145.729 (0.256)
Average performance in Anal. and ev. of argum.	β1	95.802 (0.184)
Average performance in Problem solving	β2	49.910 (0.102)
RANDOM EFFECTS		
Level 1: Student		
Variance in Critical thinking	σu0	217.192 (6.023)
Variance in Analysis and evaluation of argument	Σu1	110.175 (3.079)
Variance in Problem solving	σu2	39.377 (0.982)
Covariance between Analysis and evaluation of arguments and Problem solving	Σu1u2	34.168 (1.358)
Level 2: University		
Variance in Critical thinking	σv0	21.455 (9.486)
Variance in Analysis and evaluation of arguments	Σv1	12.831 (4.982)
Variance in Problem solving	σv2	Not significant
Covariance between Analysis and evaluation of arguments and Problem solving	Σv1v2	7.636 (2.797)
Level 3: Autonomous community		
Variance in Critical thinking	σf0	22.785 (8.734)
Variance in Analysis and evaluation of arguments	Σf1	11.532 (4.562)
Variance in Problem solving	σf2	4.378 (0.783)
Covariance between Analysis and evaluation of arguments and problem solving	Σf1f2	7.636 (1.187)
Likelihood ratio		
Critical thinking		43.877.147
Analysis and evaluation of arguments		40.382.207
Problem solving		34.585.775
Number of parameters		
Critical thinking		4
Analysis and evaluation of arguments		4
Problem solving		3
N		5238

Note. Standard error is presented in parenthesis.

Moreover, the covariances between *Analysis and evaluation of arguments* and *Problem solving* at all three levels are found to be significant and positive. Thus, it is evident that students who perform better in *Analysis and evaluation of arguments* also exhibit better *Problem solving* skills. This trend is also observable at the university and autonomous community levels.

Lastly, the likelihood ratio indicates a value of 43,877.147 for a four-parameter model in the case of *Critical thinking*, 40,382.207 with four parameters in *Analysis and evaluation of argument*, and 34,858.011 with three parameters in *Problem solving*.

3.2. Expanded models

To explain the maximum possible amount of variance, the models incorporate predictors from all three levels for *Critical thinking* and *Analysis and evaluation of argument*, in both the fixed and random components. Likewise, the predictors from the corresponding two levels are incorporated for *Problem solving*. The analysis of each of these models is presented below.

3.2.1. Expanded model of critical thinking

Initially, first-level variables were introduced, excluding those that did not exhibit significant parameters. Subsequently, this process was repeated with second and third-level variables. Table 7 displays that 12 variables exhibit significant parameters: 10 at the first level, one at the second level, and one at the third level.

Table 7

Final model of critical thinking

FIXED EFFECTS		
Constant	β0	145.656 (0.240)
Gender	β0.1	-2.422 (0.440)
Residence at family home	β0.2	1.122 (0.444)
Grade point average	β0.3	0.851 (0.192)
Public financial aid	β0.4	-1.312 (0.425)
Critical thinking self-perception	β0.5	1.886 (0.157)
Decision-making self-perception	β0.6	0.660 (0.178)
Life satisfaction	β0.7	0.279 (0.130)
Type of degree programme	β0.8	2.617 (0.737)
Year	β0.9	1.500 (0.268)
Late graduation	β0.10	-1.329 (0.631)
Ownership	β0.11	-3.415 (1.012)
Average number of students in early childhood education	β0.12	-2.238 (0.367)
RANDOM EFFECTS		
Level 1: Student		
Variance in critical thinking	σ2u0	202.574 (5.508)
Level 2: University		
Variance in critical thinking	σ2v0	15.642 (8.230)
Level 3: Autonomous community		
Variance in critical thinking	σ2f0	17.499 (7.527)
Likelihood ratio		43.347.091
Number of parameters		16
N		5238

Note. Standard error is reported in parentheses.

Considering the parameters of the fixed part of the model, the average performance has now increased to 145.656 points. Based on the operalisation of the variables, these values correspond to the estimated average performance in *Critical thinking* for male students who reside in the family home during the school year, are in their first year of a degree program at a public university, do not receive public financial aid for studying, belong to an autonomous community with an average of 15 students per educational group in early childhood education, and perceive both their critical thinking and decision-making ability, and life satisfaction to be low.

The results indicate the significance of certain explanatory variables that have previously been identified as possible predictors in prior research. Regarding student characteristics, the mean performance is anticipated to be 2.422 points lower for female students. Similarly, the average performance of students receiving public financial aid for studying decreases by 1.312 points. Conversely, students not residing in the family home during the school year exhibit an increase in mean performance by 1.122 points, and for every higher level of academic transcript, the average student performance increases by 0.851 points.

Concerning the perception of critical thinking, for each degree increase in the student's level of perception regarding this concept, the mean performance rises by 1.88 points. Likewise, for every degree increase in the student's level of decision-making and life satisfaction perception, the mean performance increases by 0.660 and 0.279 points, respectively.

For predictors related to individual studies, for every higher course level, the mean performance increases by 1.500 points. Similarly, students studying a double degree exhibit an increase in mean performance by 2.617 points, and for every level of late graduation, the mean performance decreases by 1.329 points. The rest of the student-related variables (age, participation in collective extracurricular activities, and work during the school year) failed to exhibit significant values.

Regarding third-level variables related to university characteristics, ownership has been discovered to be significant, with a 3.451-point decrease in the mean critical thinking score for students in private institutions. The other variables related to the institution's format and typology did not exhibit significant values.

Of the variables considered at the autonomous community level, solely the average number of students per educational group in early childhood education has been identified as a significant predictor in the model, with each additional student leading to a 2.238-point decrease in the mean critical thinking score. It is important to note that while the values of the random parameters have reduced compared to the initial values of the model, unexplained variance still exists in critical thinking performance at all three levels. To determine which model (null or expanded) best suits the data for each dependent variable, the likelihood ratio test compares the null model to the final model. With a deviation difference of 530.056, 16 degrees of freedom, and an associated probability of 0.000, the superiority of the final model over the null model is confirmed.

Lastly, a comparison between the parameter values of the final and null models through the R^2 coefficient enables the analysis of the proportion of variance associated with each level. Concerning critical thinking, the predictors included in the model identify almost 7% of the differences among students (R^2=0.067), approximately 27% of the differences among universities (R^2=0.270), and slightly over 23% of the differences among autonomous

3.2.2. Expanded models for analysis and evaluation of arguments

The present section introduces an expanded model for analysing and evaluating arguments, as presented in Table 8, which includes both fixed and random parts. This model considers the impact of individual and contextual characteristics, such as university and autonomous community, on student performance, with the parameter values and their corresponding standard errors presented in parentheses. It should be noted that variables with non-significant parameters were excluded from the analysis.

The fixed part of the model reveals that the mean performance for male students residing at home during the school year, in their first year of a degree program, without public financial aid, and reporting low levels of critical thinking perception and decision-making satisfaction, is 95.744 points. Meanwhile, the random part of the model shows that unexplained variance remains across all three levels, although the values of the random parameters have decreased in comparison to the null model. Further investigation into this issue will be explored later.

Table 8

Final model of analysis and evaluation of arguments

FIXED EFFECTS		
Constant	β1	95.744 (0.173)
Gender	β1.1	-2.768 (0.314)
Residence at family home	β1.2	0.869 (0.317)
Grade point average	β1.3	0.683 (0.136)
Public financial aid	β1.4	-0.925 (0.302)
Critical thinking self-perception	β1.5	1.348 (0.117)
Decision-making self-perception	β1.6	0.461 (0.127)
Life satisfaction	β1.7	0.209 (0.093)
Type of degree programme	β1.8	2.276 (0.526)
Year	β1.9	0.897 (0.183)
RANDOM EFFECTS		
Level 1: Student		
Variance in Analysis and evaluation of arguments	σ2u1	100.387 (2.928)
Cov. between Argument analysis and evaluation, and Problem solving	σ2u1u2	31.477 (1.265)
Level 2: University		
Variance in Analysis and evaluation of arguments	σ2v1	9.604 (4.311)
Critical thinking self-perception	σ2v1.1	0.895 (0.455)
Level 3: Autonomous community		
Variance in Analysis and evaluation of arguments	σ2f1	8.834 (3.915)
Cov. between Argument analysis and evaluation, and Problem solving	σ2f1f2	6.250 (1.053)
Likelihood ratio		39853.759
Number of parameters		13
N		5238

Note. Standard error is reported in parentheses.

Although there is still unexplained variance in the performance of analysis and evaluation of arguments at all three levels, the random component of the model has lower parameter values compared to the null model. Further analysis of this issue will be conducted later.

The results indicate the significance of certain predictors. For instance, female students have a mean performance that is 2.768 points lower than male students. Similarly, students who receive public financial aid to study have a mean performance that is 0.925 points lower than those who do not receive such aid. Conversely, students who do not live in their family home during the school year have a mean performance that is 0.869 points higher, and for each higher level of grade point average, the mean student performance increases by 0.683 points.

Concerning the perception of critical thinking, for every degree that the student's level of perception increases, the mean performance increases by 1.348 points. Likewise, for every degree that the student's level of perception of decision-making and satisfaction with life increases, the mean performance increases by 0.461 and 0.209 points, respectively.

For variables related to the student's field of study, the mean performance increases by 2.276 points for each higher course level, and for students who are enrolled in a double degree program. None of the level 1 variables related to the student (age, participation in collective extracurricular activities, work during the school year, and

late graduation), or level 2 and 3 variables (university and autonomous community) have shown to be significant predictors.

The likelihood ratio between the null model and the extended model is 528.448, with 13 degrees of freedom and an associated probability of 0.000. This confirms that the final model has a significantly better fit compared to the null model.

In summary, the analysed predictors explain approximately 9% of the differences among students (R^2=0.0889), just over 25% of the differences among universities (R^2=0.2515), and 23.4% of the differences among autonomous communities (R^2=0.2324). The total explained variance is 11.68% (R^2=0.1168).

3.2.3. Expanded model of problem solving

Table 9 displays the fixed and random parts of the final model of problem solving, which incorporates the effects of individual and contextual characteristics, including autonomous community, on students' problem-solving ability. The table presents parameter values and typical errors in parentheses. Variables that did not demonstrate significant parameters were excluded from the model.

Table 9

1Final model of problem solving

FIXED EFFECTS		
Constant	β2	49.881 (0.099)
Employment during school year	β2.1	-0.343 (0.114)
Critical thinking self-perception	β2.2	0.550 (0.071)
Decision-making self-perception	β2.3	0.241 (0.063)
Year	β2.4	0.762 (0.071)
Late graduation	β2.5	-0.649 (0.268)
Average number of students in early childhood education	β2.6	-0.534 (0.147)
RANDOM EFFECTS		
Level 1: Student		
Variance in Problem solving	σ2u2	35.695 (0.978)
Cov. between Argument analysis and evaluation, and Problem solving	σ2u1u2	31.477 (1.265)
Level 3: Autonomous community		
Variance in Problem solving	σ2f2	3.40 (0.713)
Variance in employment during school year	σ2f2.1	1.364 (0.513)
Variance in Critical thinking self-perception	σ2f2.2	0.628 (0.179)
Cov. between Argument analysis and evaluation, and Problem solving	σ2f1f2	6.250 (1.053)
Likelihood ratio		34309.590
Number of parameters		9
N		5238

Note. Standard error is reported in parentheses.

The fixed part of the model indicates that the estimated average performance for students who do not work during the school year, are in the first year, and belong to an autonomous community where there are an average of 15 students per educational group in early childhood education is 49.881 points. This value is derived from the parameters of the fixed part of the model. In the random part of the model, unexplained variance in problem-solving performance still exists at both levels. However, the values of the random parameters have decreased compared to those of the null model. This matter will be further examined later.

The results show that some predictors are significant. At level 1, variables related to Student Characteristics indicate that being a worker is linked to lower problem-solving performance, with the mean decreasing by 0.343 points for each higher level (working less than half a day, half, or full day). In terms of critical thinking perception, for each degree that the student's level increases concerning this perception, the mean performance improves by 0.550 points. Similarly, for each degree that the student's level of life satisfaction increases, the mean performance increases by 0.241 points.

Regarding predictors related to individual studies, for each higher grade, the mean performance increases by 0.762 points, while for each level of late graduation, the mean performance decreases by 0.649 points. The remaining variables related to the student (age, gender, participation in collective extracurricular activities, average grade point average, etc.) do not have significant values.

At level 3 (autonomous community), the only significant predictor is the average number of students per educational group in early childhood education. For each additional student, the mean performance in problem-solving decreases by 0.534 points.

Moreover, the difference in the likelihood ratio of the null and extended models is 274.185, with 9 degrees of freedom and an associated probability of 0.000. This confirms that the final model provides a better fit than the null model. Overall, the predictors analysed explain just over 9% of the differences among students (R^2=0.0936) and almost 17% of the differences among Autonomous Communities (R^2=0.1686), with the total explained variance being 10.10% (R^2=0.1010).

4. Discussion and conclusions

The present study aimed to examine the effect of various predictors on critical thinking and its constituent dimensions, namely argument analysis and evaluation, and problem-solving, among Spanish university students. Through the utilisation of hierarchical linear regression models, the study provides valuable insights into the critical thinking skills exhibited by Spanish students.

In this study, 12 examined variables exhibited statistical significance within the critical thinking, argument analysis and evaluation, and problem-solving models. Among these variables, 10 were categorised at the first level, including gender, place of residence, average academic grades, financial aid, self-perceived critical thinking, self-perceived decision-making, life satisfaction, type of study, year, and late graduation. One variable belonged to the second level (ownership of the institution), and another to the third level (average number of students in early childhood education).

In the argument analysis and evaluation model, nine variables with significant parameters were observed, all falling within the first level. These variables included gender, place of residence, average academic grades, financial aid, self-perceived critical thinking, self-perceived decision-making, life satisfaction, type of study, and year.

Regarding the problem-solving model, six significant variables were identified. Among these, five were situated at the first level (employment, self-perceived critical thinking, self-perceived decision-making, year, and late graduation), while one variable belonged to the third level (average number of students in early childhood education).

Regarding critical thinking, the predictors incorporated in the model explained approximately 7% of the variations among students, 27% among universities, and slightly over 23% among autonomous communities, resulting in a total explained

variance of 9.8%. Concerning argument analysis and evaluation, the examined predictors accounted for approximately 9% of the variations among students, just over 25% among universities, and 23.4% among autonomous communities, with a total explained variance of 11.68%. Finally, concerning problem-solving, the analysed predictors accounted for just over 9% of the variations among students and almost 17% among autonomous communities, resulting in a total explained variance of 10.10%

Regarding Student Variables (Level 1), several significant predictors were identified:

- *Gender* was found to be a significant predictor of critical thinking and argument analysis and evaluation, with males achieving higher average scores. These findings align with previous studies such as Liu et al. (2019) and Vong and Kaewurai (2017). Similarly, the results of the pre- and post-tests in the study by Howard et al. (2015) indicate that males outperform females in the pre-test but show no differences in the post-test. According to the authors, this may be attributed to the greater commitment of females towards academic work. This variation could potentially be ascribed to the influence of gender on neurophysiological mechanisms, as noted by Nanova et al. (2022). Their findings suggest that gender disparities in certain cognitive processes may stem from overarching and non-material-specific effects of gender on sensory processing mechanisms. Moreover, research by Sladek et al. (2010) indicates that men tend to exhibit a greater inclination towards rational processing, while women lean more towards experiential processing. Given these observations, it becomes imperative to delve deeper into the gender-based distinctions in critical thinking and elucidate the underlying factors, including the potential impact of societal stereotypes on these cognitive differences. The educational implications of these findings underscore the importance of considering gender-sensitive pedagogical approaches that accommodate diverse cognitive styles and foster equitable learning outcomes for all students.

- *Year* was identified as a significant predictor of critical thinking, argument analysis and evaluation, and problem-solving, with higher-level students achieving higher average scores. This conclusion is consistent with meta-analyses conducted by Abrami et al. (2015) and Huber and Kuncel (2016), which highlight the positive effect of university experience on students' levels of critical thinking. However, as emphasised by Ennis (2018) and Roohr et al. (2019), although university experience appears to have a positive effect on the development of critical thinking, these gains may be insufficient. Critical thinking is an intellectual rigorous competency, demanding dedicated time for its development (Archila et al., 2022), explicit teaching and ongoing practice (Abrami et al., 2015), assessment (Dwyer, 2017), facilitation of transferability (Tiruneh et al., 2017), and active intellectual engagement (Paul & Elder, 2019). While teachers increasingly seem willing to assume this responsibility, showing growing interest in incorporating critical thinking instruction into their teaching practice (Bellaera et al., 2021), several factors conspire to undermine learning environments that promote critical thinking. These include insufficient resources, time limitations, implementation challenges, preconceived ideas, and lack of training (Magrabi et al., 2018; Veliz & Veliz-Campos, 2019), all of which hinder students from having optimal conditions to develop this competence. Educators and policymakers must therefore address these obstacles to ensure that students have the necessary support and opportunities to cultivate critical thinking effectively.

- Likewise, *average academic grades* serve as a significant predictor of critical thinking and argument analysis and evaluation, with students with higher grades achieving higher average scores. This correlation between critical thinking and academic performance is well-documented in the literature, with numerous studies highlighting a positive relationship between the two (D'Alessio et al., 2019; Kanwal & Butt, 2021). Possible reasons for this association could include the development of analytical skills through rigorous academic engagement, as well as the application of critical thinking abilities in academic tasks, leading to improved performance. These findings underscore the importance of fostering critical thinking in educational settings, not only for intellectual development but also for academic success and lifelong learning.

- Additionally, *late graduation* was found to be a significant predictor of critical thinking and problem-solving, with students graduating within the expected timeframe achieving higher average scores. Late graduation may be indicative of various underlying factors, including academic challenges and setbacks, which could impede students' overall performance, including critical thinking abilities. Lower average academic grades, often associated with late graduation, may reflect difficulties in mastering course material or meeting academic requirements, further hindering the cultivation of critical thinking skills. Moreover, students with lower grades may require remedial coursework or additional support, prolonging their time to graduation. To address these challenges, institutions should consider implementing targeted interventions and support mechanisms aimed at promoting timely graduation and enhancing critical thinking outcomes for all students.

- The *type of study* was also identified as a significant predictor of critical thinking and argument analysis and evaluation, with students enrolled in double degree programs achieving higher average scores. Economic factors may explain this difference, as double degree programs tend to attract students with higher admission grades from families with better economic situations (Fernández-Mellizo & Salvo, 2019). This suggests that socioeconomic status plays a role in shaping opportunities for academic enrichment, potentially impacting critical thinking outcomes.

- Similarly, the receipt of *public financial aid for studying* was found to be a significant predictor of critical thinking and argument analysis and evaluation, with students not receiving public financial aid achieving higher average scores. This finding is consistent with previous studies that highlight the influence of family socioeconomic status on critical thinking development (Huang et al., 2019; Kleemola et al., 2022). The influence that family socioeconomic status may have on critical thinking development, therefore, underscores the importance of equitable access to education sources and support. It is imperative for educational institutions and policymakers to prioritise initiatives aimed at reducing socioeconomic disparities in education to ensure that all students have equal opportunities to develop critical thinking skills and succeed academically.

- The *student's place of residence* was also found to be a significant predictor of critical thinking and argument analysis and evaluation, with students not residing in their family home during the school year achieving higher average scores. While economic factors may contribute to this finding, further studies

are needed to explore this aspect. One possible explanation for the difference could be the experiences of students who move away from their family home. These experiences may foster independence and responsibility, providing opportunities for the development of critical thinking skills through decision-making and problem-solving. Further research in this area can provide valuable insights into how environment factors shape individuals' cognitive abilities and inform strategies to promote critical thinking in diverse learning contexts.

- *Working during the school year* was identified as a significant predictor of problem-solving, with students not working achieving higher average scores. While there is limited research on this specific topic for further comparison, it is reasonable to consider that economic factors may contribute to this finding. Understanding the impact of employment during the school year on problem-solving abilities is important for educators and policymakers in designing supportive environments that balance academic responsibilities with students' practical experiences.

- Additionally, *self-perceived critical thinking and decision-making* were significant predictors of critical thinking, argument analysis and evaluation, and problem-solving, with students having higher levels of self-perception in these areas achieving higher average scores. This aligns with previous works that emphasise the connection between critical thinking and decision-making (Dwyer, 2017; Halpern, 2014; Hill, 2002). It is possible that students' self-perceptions accurately reflect their actual abilities in these cognitive domains, indicating a degree of self-awareness and metacognitive insight. Understanding the relationship between self-perceived skills and actual performance is vital for educators in tailoring interventions to enhance students' cognitive development effectively. Further exploration of this relationship can provide valuable insights into the role of metacognition in academic success and critical thinking proficiency.

- Furthermore, *life satisfaction* was found to be a significant predictor of critical thinking and argument analysis and evaluation, with students reporting higher levels of life satisfaction achieving higher average scores. This relationship is in line with previous studies and suggests that individuals who perceive themselves as critical thinkers and good decision-makers are likely to be more satisfied with their lives (Celik, 2016). This conclusion holds significant implications in educational contexts, as it underscores the interconnectedness between cognitive abilities and overall well-being. Understanding this relationship can inform educational practices aimed at fostering not only academic success but also students' holistic development and satisfaction with life. Thus, educators should consider incorporating strategies that promote critical thinking skills alongside initiatives to enhance students' overall quality of life and happiness.

Regarding level 2 variables, University:

- The *ownership of the institution* is a significant predictor of critical thinking, with students from public universities achieving the highest average scores. Differences in the understanding of critical thinking among university faculty based on the ownership of the institution (Bezanilla et al., 2018) may explain this finding. According to the authors, faculty at private universities tend to associate critical thinking with evaluation, while those at public universities link it with decision-making and action. As a result, teachers' efforts to foster

critical thinking among their students are likely guided by these differing conceptualisations. Thus, faculty at private institutions may emphasise the evaluative aspect of critical thinking, whereas those at public institutions may focus on decision-making, representing a more holistic understanding. Understanding these institutional differences in approaches to critical thinking promotion is crucial for designing effective pedagogical interventions tailored to the unique contexts of different types of universities.

Regarding level 3 variables, Autonomous community:

- The *average number of students per educational group in early childhood education* is a significant predictor of critical thinking and problem-solving, with students from Autonomous Communities with a lower average number of students per educational group in early childhood education achieving higher average scores. The impact of student-to-teacher ratio on performance has been well-researched, with higher ratios leading to lower performance (Koc & Celik, 2015; Kweon et al., 2017). High student-to-teacher ratios pose challenges in providing personalised support and feedback, crucial for fostering optimal development of critical thinking (Abrami et al., 2015). In larger class sizes, it becomes increasingly difficult to address students' individual needs effectively, potentially compromising the quality of instruction provided. Recognising the importance of class size in shaping students' cognitive development underscores the need for policies aimed at reducing student-to-teacher ratios in early childhood education settings.

In summary, this study investigated various predictors and their impact on critical thinking, argument analysis and evaluation, and problem-solving among Spanish university students. Significant predictors provided valuable insights into the factors influencing these skills. However, the presence of unexplained variance suggests the existence of other influential factors not accounted for in the models, warranting further research to explore and refine these aspects.

Nevertheless, this study contributes significantly to understanding critical thinking skills and underscores the importance of continuous support and promotion of this competence in the Spanish education system. It is essential to recognise that while some students may naturally exhibit intellectual curiosity, critical thinking is not an innate ability, but rather a learned competence that requires training and continuous practice. Students who score lower in critical thinking may not necessarily lack the capability; rather, it could be attributed to a deficiency in attitude, knowledge, or limited opportunities to cultivate it effectively. This underscores the responsibility of educators to create optimal conditions, including explicit instruction in critical thinking, adequate time allocation for activities that foster critical thinking, integration of critical thinking assessment into evaluations, contextualised teaching to enhance transferability, and promotion of intellectual engagement among students. These efforts are essential for all students to develop this indispensable competency in today's society.

Acknowledging the limitations of this study, such as the use of a non-probability sampling method, a restricted range of predictors, and the absence of a qualitative dimension, the findings still offer valuable insights for educators and policymakers aiming to foster critical thinking skills among university students. Therefore, universities should strive to further enhance the already advanced critical thinking skills of their students.

In conclusion, the findings of this study provide evidence-based insights that can inform decision-making and positively influence the development of critical thinking skills among university students. Educators and policymakers must utilise these findings to drive positive change and advance the cultivation of critical thinking in higher education. The importance of nurturing critical thinking in higher education cannot be overstated, and applying these findings can contribute to the development of more informed, analytical, and solution-oriented graduates.

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