

AI AND INTERNET USE AND THEIR ASSOCIATION WITH MEMORY AND COGNITIVE AUTONOMY IN PRE-UNIVERSITY EDUCATION IN ROMANIA

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Abstract

This paper examines the relationship between the use of the internet and artificial intelligence (AI) and cognitive processes related to memory, critical thinking, and cognitive autonomy in the context of pre-university education in Romania. The motivation for this research stems from the rapid expansion of digital technologies, which, while optimizing access to information and educational processes, may reshape users' cognitive strategies, particularly through memory externalization and reduced engagement in deep information processing. The study combines a theoretical review of recent literature with an empirical component conducted between December 2025 and January 2026, based on a sample of 313 respondents (students and teachers) from the counties of Dâmbovița, Ilfov, and Cluj. Data were collected through an online questionnaire and analyzed using quantitative methods, including hierarchical clustering (Ward.D2 method, Euclidean distance) and inferential statistical tests (ANOVA, Chi-square, Wilcoxon), in order to identify distinct cognitive and behavioral patterns. The results reveal the existence of three differentiated cognitive profiles: (1) an adaptive profile, characterized by moderate use of AI and relatively high cognitive autonomy; (2) a profile predominantly associated with teachers, marked by critical use of technology and high cognitive autonomy; and (3) a profile specific to students, characterized by a high tendency toward memory externalization and lower cognitive autonomy. Statistical analyses indicate significant differences between clusters in terms of cognitive autonomy ($p < .001$), while age does not significantly explain cluster membership ($p > .05$), suggesting that cognitive strategies and attitudes toward technology are more relevant than demographic factors. The findings should be interpreted in light of methodological limitations, including the use of self-reported data and the cross-sectional nature of the study, which does not allow for causal inferences. Nevertheless, the study provides a relevant contribution to understanding how AI use is associated with transformations in cognitive strategies in education and highlights the need for AI literacy, critical thinking development, and differentiated educational interventions.

Keywords: *Artificial Intelligence, memory, cognitive autonomy, education, learning.*

1. Introduction

Digital transformation has significantly reshaped educational environments, with artificial intelligence (AI) and internet-based technologies playing an increasingly central role in how students access, process, and retain information. The integration of AI in education has been widely discussed in recent studies (Degni, 2024). While these technologies enhance efficiency and accessibility, they are also associated with shifts in cognitive strategies, particularly regarding memory use and independent reasoning.

Recent studies highlight the tendency of users to externalize memory processes to digital tools. Bai, Liu, and Su (2023) describe this phenomenon as cognitive externalization, where individuals remember where to find information rather than the information itself. This shift may influence long-term retention and cognitive engagement, especially among younger learners.

At the same time, research by Ng et al. (2025) shows that teachers generally perceive generative AI positively, particularly for content generation and assessment support. However, concerns remain regarding overreliance on technology, ethical risks, and the absence of clear institutional policies. Similarly, Yim & Su (2025) emphasize the importance of early AI literacy, showing that interactive and project-based approaches can enhance cognitive autonomy and critical thinking.

In this context, the present study aims to examine how the use of AI and the internet is associated with memory strategies, cognitive autonomy, and attitudes toward critical thinking among students and teachers in Romanian pre-university education.

2. Methodology

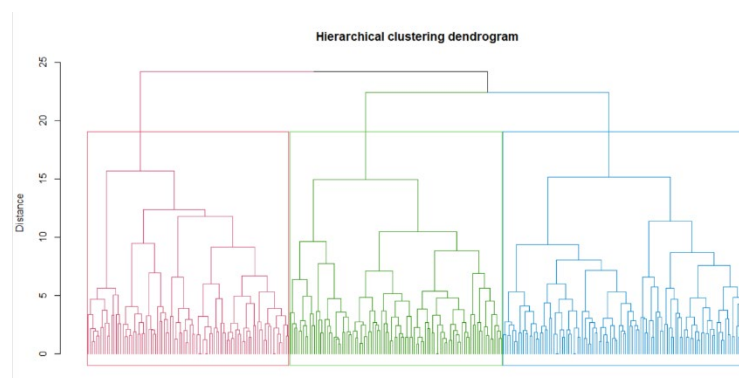
The study was conducted between December 2025 and January 2026 using an online questionnaire administered to students and teachers from Dâmbovița, Ilfov, and Cluj counties. A total of 313 valid responses were collected.

The questionnaire included items measuring: frequency of AI and internet use, perceived memory capacity, memory externalization, cognitive autonomy, trust in AI, attitudes toward critical thinking.

Cognitive autonomy and memory externalization were operationalized as composite scores derived from Likert-scale items (1–5). Autonomy reflected confidence in independent thinking, while externalization captured reliance on digital tools.

Data analysis combined hierarchical clustering (Ward.D2, Euclidean distance) and K-means validation. Data processing approaches are aligned with common practices in data science (Wickham & Grolemund, 2023). The selection of three clusters was based on dendrogram inspection, interpretability, and elbow method criteria. Statistical differences between clusters were tested using ANOVA, Chi-square, and Wilcoxon tests.

Figure 1. Hierarchical clustering dendrogram (Ward.D2 method).



The selection of three clusters was based on dendrogram inspection, interpretability, and consistency with the elbow method applied in K-means clustering.

The methodological approach is consistent with statistical practices described in previous studies (Diez et al., 2019; Navarro, 2019). The use of hierarchical clustering follows established approaches in data analysis (Murtagh & Legendre, 2014).

2.1. Operationalization of variables

Cognitive autonomy and memory externalization were measured using composite scores derived from Likert-scale items (1–5). Cognitive autonomy included items assessing confidence in independent problem-solving and reliance on internal reasoning processes. Memory externalization was measured through items evaluating the frequency of using digital tools (internet, AI systems) for storing and retrieving information. Although the scales were constructed based on existing literature, the study relies on self-reported measures, which may introduce subjective bias.

3. Data analysis and results

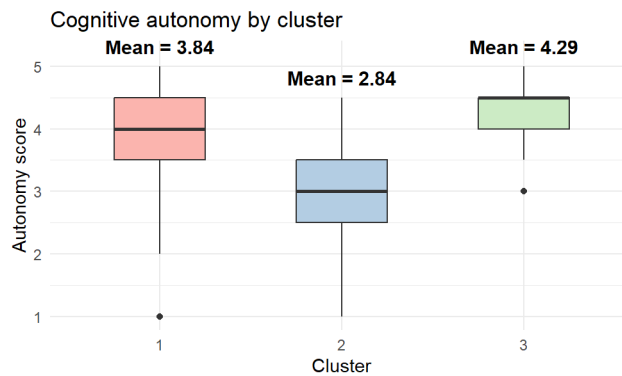
The cluster analysis identified three distinct cognitive profiles, reflecting different patterns of interaction with artificial intelligence and digital resources.

No statistically significant association was found between age and cluster membership ($\chi^2 = 1.86$, $p = 0.3944$), suggesting that cognitive profiles are not primarily determined by demographic factors, but rather by individual learning strategies and attitudes toward technology.

Memory externalization shows a moderate variation across age groups, with respondents under 25 reporting slightly higher levels ($M = 3.48$) compared to those over 25 ($M = 3.12$). However, this difference remains limited and does not appear to be a dominant factor in explaining cognitive profiles.

In contrast, cognitive autonomy differs substantially across clusters. Cluster 2 exhibits the highest level of autonomy (Mean = 4.10), followed by Cluster 1 (Mean = 3.62), while Cluster 3 shows the lowest level (Mean = 2.95). These differences are statistically significant (ANOVA: $F(2, 301) = 134$, $p < .001$; Kruskal-Wallis: $\chi^2 = 153.35$, $p < .001$), indicating that the identified clusters represent meaningful distinctions in cognitive functioning.

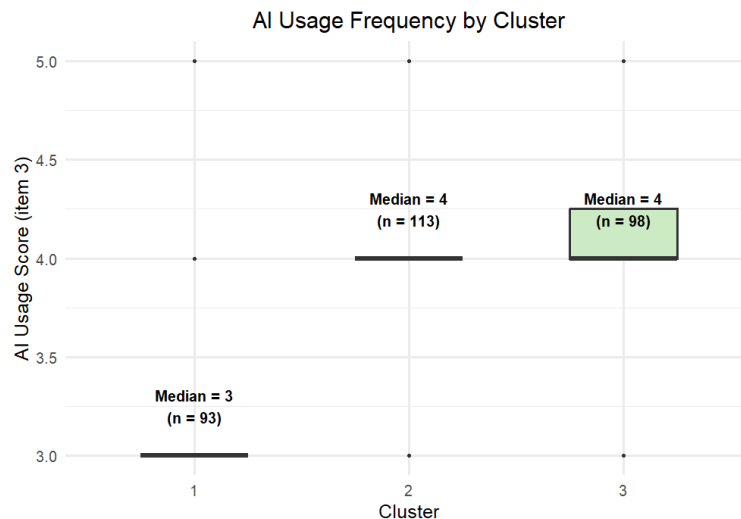
Figure 2. Cognitive Autonomy by Cluster.



These differences are visually represented in Figure 2, which highlights the clear separation between clusters in terms of cognitive autonomy.

The perceived importance of internal memory does not differ significantly between age groups (Wilcoxon: $W = 11826.5$, $p = 0.3975$), with both groups showing a median value of 3. Similarly, no significant differences are observed between individuals with high and low levels of memory externalization, suggesting that externalization is generally perceived as a complementary strategy rather than a replacement for internal memory.

Figure 3. AI Usage Frequency by Cluster.



AI usage frequency varies across clusters and provides further differentiation between cognitive profiles. Cluster 3 shows the highest frequency of AI use (median = 4), followed by Cluster 2, while Cluster 1 shows lower usage (median = 3). These patterns are illustrated in Figure 3, indicating that AI use is associated with cognitive profiles rather than age alone.

Table 1. Cognitive profiles identified through cluster analysis.

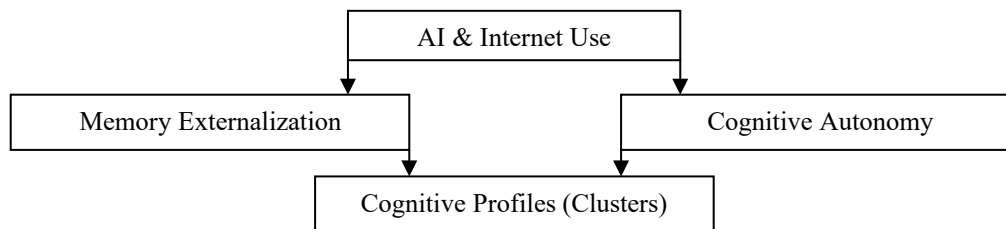
Cluster	AI Usage	Cognitive Autonomy	Memory Externalization	Profile Type
Cluster 1	Moderate	Medium-High	Medium	Adaptive
Cluster 2	Moderate	High	Low	Critical users (teachers)
Cluster 3	High	Low	High	Dependent users (students)

The identified clusters can be summarized into distinct cognitive profiles based on AI usage, cognitive autonomy, and memory externalization (Table 1). This representation highlights the differences between adaptive, critical, and dependent patterns of technology use.

4. Discussion

The findings support existing literature on cognitive externalization (Bai et al., 2023) and overreliance on AI systems (Buçinca et al., 2021). The identification of distinct cognitive profiles suggests that users interact with technology in fundamentally different ways.

Figure 4. Conceptual model illustrating the relationship between AI use, memory externalization, and cognitive autonomy.



Based on these findings, a conceptual model is proposed to illustrate the relationship between AI use, memory externalization, and cognitive autonomy, and their role in shaping distinct cognitive profiles (Figure 4). This model integrates the empirical results and provides a framework for understanding how different patterns of technology use are associated with variations in cognitive functioning. It highlights how AI usage influences cognitive processes both directly and indirectly through memory externalization.

Importantly, the results indicate that cognitive strategies and attitudes toward technology are more relevant than age in explaining differences between users. This highlights the need for educational approaches that focus on cognitive development rather than demographic categorization.

The presence of a cluster with high autonomy and balanced AI use suggests that technology can support learning when used critically. Conversely, high externalization combined with low autonomy may indicate a risk of passive learning behaviors.

These findings are consistent with previous research on cognitive externalization (Bai et al., 2023), which suggests that increased reliance on digital tools may reduce internal memory engagement. Similarly, the results align with Buçinca et al. (2021), who highlight the risks of overreliance on AI in decision-making contexts.

These findings also suggest that the increasing use of AI tools may contribute to a shift from knowledge retention toward information access strategies. While this may enhance efficiency, it raises concerns regarding the development of deep learning and independent reasoning skills in educational contexts.

5. Limitations

This study has several limitations. First, the use of self-reported data may introduce response bias. Second, the cross-sectional design does not allow causal interpretations, but only identifies statistical associations. Third, the sample is limited to specific regions in Romania, which restricts the generalizability of the findings.

In addition, the use of an online questionnaire limits control over the response environment, and differences in interpretation between students and teachers may affect the consistency of responses. Furthermore, the absence of objective cognitive measures limits the ability to validate self-reported perceptions. Future research should include experimental designs and longitudinal data to better capture changes over time.

6. Conclusions

The study shows that the use of AI and digital technologies is associated with distinct cognitive profiles rather than uniform effects across users. The results highlight the importance of promoting critical thinking, cognitive autonomy, and AI literacy in education.

Future research should explore longitudinal designs and experimental approaches to better understand causal relationships and to support the development of adaptive educational systems.

These results support the need for balanced integration of AI in education, ensuring that technological support does not replace essential cognitive processes. Previous research highlights the growing role of AI in educational evaluation and learning systems (Ma, 2024; Pang & Ma, 2025).

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