

## **CLUSTER ANALYSIS ON THE USE OF GENERATIVE AI TOOLS BY INDIVIDUALS IN EUROPEAN UNION COUNTRIES**

Marian ZAHARIA<sup>1</sup>

Camelia-Monica GHEORGHE<sup>2</sup>

Cristiana-Ştefania ANTONOVICI<sup>3</sup>

### **Abstract**

In recent times, artificial intelligence (AI) has gone beyond the stage of a tool, becoming for a fairly wide audience a consultant, a personal assistant with expertise in a variety of fields, from private to professional purposes, as well as, last but not least, in formal education. This attribute is underlined by the significant shares of the various categories of the population that use generative AI tools (GAIT). Considering this aspect, the paper presents the results of the analyses undertaken by the authors on the similarities and disparities between twenty-four EU member states regarding the shares of the use of GAIT by individuals according to the levels of education and the age groups they belong to, for private purposes (PP), professional purposes (WP) and educational purposes (FE). The results obtained highlight significant differences both between the different categories of individuals and between the states they belong to.

**Keywords:** Artificial Intelligence, AI tools, cluster analysis, hierarchic cluster methodology, private purpose, professional purpose, formal education

**JEL Classification:** C12, C18, C38, D19, I20

### **1. Introduction**

As artificial intelligence technologies evolve, more and more individuals and organizations are becoming users of AI [1] for a wide range of purposes, from private purposes to educational purposes, as well as in professional activities.

In professional activity, the use of generative AI tools (GAIT) has the role of automating, integrating and amplifying human creativity in work [2,3], being a factor in increasing productivity [4]. In these conditions, although managerial factors are interested in adopting AI in activities to optimize and increase their economic efficiency, it is necessary that the implementation of GAIT be based on ethics and produce people-centered results [5].

---

<sup>1</sup> PhD Professor, Oil and Gas University Ploiesti, Romania, marianzaharia53@gmail.com

<sup>2</sup> PhD Lecturer, Romanian-American University, Romania, camelia.gheorghe@rau.ro

<sup>3</sup> PhD Assistant, Romanian-American University, Romania, stefania.antonovici@rau.ro

Also, in the development of the educational level of individuals, in general, and especially in formal education, generative AI tools play an increasingly important role, with students showing a positive attitude towards them [6]. Their integration into course assignments improves student involvement, promoting dynamic learning environments, which can lead both to reducing the time needed to solve assignments, and to an increase in efficiency and creativity in solving them [7]. However, on the other hand, it can also generate risks related to the quality and authenticity of the works. In these conditions, the transformations brought by the use of AI require the reform of traditional educational systems [8], its responsible integration into educational processes [9], taking into account the ethical challenges associated with the large-scale adoption of AI in research and academia [130].

In addition to the advantages, the rapid and large-scale development of generative AI tools also brings a series of risks [11] regarding training and data validation issues, information leaks, intellectual property, privacy violations, misinformation, and amplification of prejudices, which imposes the need for innovative and inclusive approaches to ensure the development of GAIT in line with social values.

Individuals' willingness to use generative AI tools (GAIT), the intensity and frequency of their use, depend on the context [12], the diversity of socio-economic factors, certain attitudes and subjective norms [13], with a more intense use observed among individuals with higher education, as well as among younger people, especially students [14].

In this context, the objective of the paper was to analyse the similarities and disparities between the member states of the European Union regarding the shares of use of generative AI tools for private purposes, professional (work) purposes and formal education depending on the level of education and age groups of individuals, in the year 2025.

## **2. Research methodology**

Taking into account the main objective of the paper, two cluster analyses were carried out. The first of these aimed to identify similarities between EU member states regarding the shares of use of GAIT for private purposes (PP), work purpose (WP) and formal education purposes (FE) according to the educational attainment levels of the population aged 16 to 74 [15]: less than primary, primary and lower secondary (LPLS) education (levels 0-2), upper secondary and post-secondary non-tertiary (USNT) education (levels 3-4) and tertiary (TE) education (levels 5-8). The indicators included in this first analysis, regarding the relationship between educational level (EL) and GAIT used, are presented in Table 1

The second analysis is a refinement of the first analysis by including, along with the three levels of education (LPLS, USNT and TE), the segmentation of the population aged 16 to 74 into three age groups: 16 – 24 years, 25 – 54 years and 55 – 74 years.

Ind.	Signification	Units
IUPP	Individuals which use AI tools for private purposes	%
IUWP	Individuals which use AI tools for professional (work) purposes	%
IUFE	Individuals which use AI tools for formal education	%
PLPLSE	Population with LPLS education	%
PUSNTE	Population with USNT education	%
PTE	Population with TE education	%

Table 1 Indicators included in analysis of the relationship EL-AI tools

The main data sources were: Population in private households by educational attainment level [16] and Individuals - use of generative AI tools [17]. However, given that the data series for individuals aged 16-24 with tertiary education which uses GAIT, as well as for individuals aged 25-54 and 55-74 with LPLS education level which uses generative AI tools, show many discontinuities, these were not included in the analyses. Also, given that the data series for Hungary, Croatia and Malta show either discontinuities or low reliability, only the other twenty-four Member States of the European Union were included in the analyses. The indicators used are presented in Table 2.

For highlighting the similarities and disparities between the twenty-four states included in the analyses we used the hierarchical clustering analysis, founded by Johnson S.C. in 1967 [18] and D’Andrade in 1978 [19]. In applying the hierarchical clustering methodology, we started from matrices of the form  $Y = \left\| y_{ij} \right\|_{i=1, n, j=1, r}$ , where  $n = 24$  and represents the number of states included in the analysis, and  $r$  is the number of indicators according to the values of which the clusters are generated. In the first analysis  $r = 7$ , and in the second  $r = 24$ . Starting from these, squared Euclidian distance was used to generate the proximity matrix [20], and Ward’s method was used to generate the clusters [21].

To test the statistical significance of the membership of the variables in the clusters, as well as their means, the ANOVA method (variance analysis) was used, the applicability of which is conditional on verifying the homoscedasticity of the data series, and the Welch test (Robust Tests of Equality of Means).

To verify the homoscedasticity of the data series, the Levene test was used, with the null hypothesis ( $H_{01}$ ):

- $H_{01}$ : variance does not differ significantly (homoscedasticity), the condition of acceptance being:  $L < F_{(\alpha, r-1, n-r)}$  or  $Sig > \alpha$  where L is Levene statistic.

Ind.	Signification	Units
L16PP	Individuals aged 16-24 with PLSE which uses AI tools for PP	%
L16WP	Individuals aged 16-24 with PLSE which uses AI tools for WP	%
L16FE	Individuals aged 16-24 with PLSE which uses AI tools for FE	%
M16PP	Individuals aged 16-24 with USNTE which uses AI tools for PP	%
M16WP	Individuals aged 16-24 with USNTE which uses AI tools for WP	%
M16FE	Individuals aged 16-24 with USNTE which uses AI tools for FD	%
M25PP	Individuals aged 25-54 with USNTE which uses AI tools for PP	%
M25WP	Individuals aged 25-54 with USNTE which uses AI tools for WP	%
M25FE	Individuals aged 25-54 with USNTE which uses AI tools for FE	%
H25PP	Individuals aged 25-54 with TE which uses AI tools for PP	%
H25WP	Individuals aged 25-54 with TE which uses AI tools for WP	%
H25FE	Individuals aged 25-54 with TE which uses AI tools for FE	%
M55PP	Individuals aged 55-74 with USNTE which uses AI tools for PP	%
M55WP	Individuals aged 55-74 with USNTE which uses AI tools for WP	%
H55PP	Individuals aged 55-74 with TE which uses AI tools for PP	%
H55WP	Individuals aged 55-74 with TE which uses AI tools for WP	%

Table 2 Indicators included in analysis of the relationship EL-AG-AI tools,

If hypothesis  $H_{01}$  is accepted, to test the significance of the membership of the variables to the clusters, the ANOVA methodology (F test) can be used, with the null hypothesis  $H_{02}$ :

- $H_{02}$ : the membership of the variable to the clusters is not significant (the average values of the variable recorded at the cluster level do not differ significantly) the condition for accepting the hypothesis being  $F_{stat} < F_{\alpha, r-1, n-r}$  or  $Sig > \alpha$

If the hypothesis  $H_{01}$  is rejected, instead of the ANOVA methodology, Welch robust tests of equality of means can be used, the null hypothesis  $H_{03}$  being:

- $H_{03}$ : the mean values of the variable recorded at the cluster level do not differ significantly, the acceptance condition being  $W < F_{\alpha, r-1, df}$  or  $Sig > \alpha$ , where W is Welch statistic.

For testing the statistical hypotheses, the significance level used was 95% ( $\alpha = 0.05$ ).

### **3. Similarities and disparities regarding the relationship between the population's education level and AI tools used**

The analysis of similarities and disparities between the twenty-four EU member states included in the analysis was carried out according to six indicators (Table 1), three of which refer to the purpose of using generative AI tools (IUPP, IUWP and IUFE) and the other three to the level of education of users (PLPLSE, PUSNTE and PTE).

#### **3.1. Cluster generation and validation**

Following the analyses and tests carried out, depending on the values of variables recorded in 2025 at the level of the each state, a grouping into seven clusters resulted, including between two and six states. The dendrogram of cluster generation is illustrated in figure 1.

Clusters	Structure of clusters
A	Belgium, Greece, France, Netherlands, Austria, Finland
B	Bulgaria, Czechia, Poland, Slovakia
C	Denmark, Estonia, Sweden
D	Germany, Latvia, Lithuania, Slovenia
E	Ireland, Cyprus, Luxembourg
F	Spain, Portugal
G	Italy, Romania

Table 3 The structure of clusters generated based on EL-AI tools used relationships

Among the seven clusters (Table 3) the most numerous is cluster A which includes six states. Clusters B and D include four states, clusters C and E include three states, and clusters E and F include two states each.

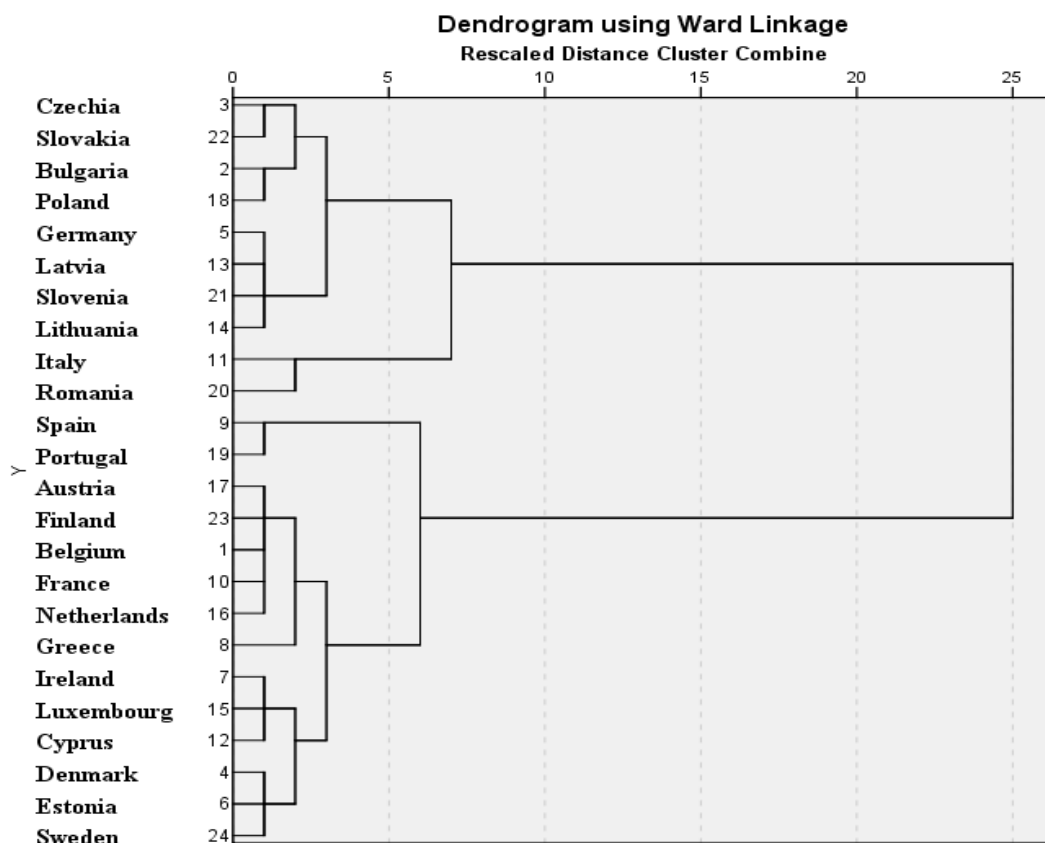


Figure 1. Dendrogram of cluster generation based on EL-GAIT used relationships

The Levene test (Test of Homogeneity of Variance) was used to test the homogeneity of variances of the data series. The results obtained (Table 4a) highlight the fact that, for the variables PLPLSE and PUSNTE, for which  $Sig < 0.050$ , the null hypothesis  $H_{01}$  is rejected and, consequently, the ANOVA methodology cannot be used to test the statistical significance of the variables belonging to clusters. Under these conditions, the Welch test (Robust Test of Equality of Means) was used to verify the statistical significance of the mean values of the variables, recorded at the cluster level. Considering that in this case all

the values Sig<0.050 (Table 4b), the null hypothesis H<sub>03</sub> is rejected. All the mean values of the variables recorded at the cluster level are statistically significant.

<b>a. Test of Homogeneity of Variances</b>					<b>b. Robust Test of Equality of Means</b>				
	Levene Statistic	df1 r-1	df2 n-r	Sig.		Welch Statistic	df1 r-1	df2	Sig.
IUPP	1,151	6	17	,376	IUPP	26,767	6	5,937	,000
IUWP	1,040	6	17	,434	IUWP	18,297	6	5,620	,002
IUFE	1,113	6	17	,395	IUFE	10,292	6	5,286	,009
PLPLSE	4,086	6	17	,010	PLPLSE	13,157	6	5,112	,006
PUSNTE	9,278	6	17	,000	PUSNTE	17,338	6	5,099	,003
PTE	1,500	6	17	,237	PTE	28,144	6	5,311	,001

Table 4 Results of Levene (A) and Welch (B) statistical tests

### 3.2. Similarities and disparities between EU member countries regarding the relationships between users' education level and GAIT used by individuals

The results of the cluster analysis on the relationships between the level of education of users (EL) and GAIT used by individuals highlight both similarities and disparities between the twenty-four EU member states included in the analysis, leading to their grouping into seven clusters.

Variables	Clusters						
	A	B	C	D	E	F	G
IUPP	32,02	23,28	35,32	29,33	36,63	31,71	13,83
IUWP	21,37	10,33	24,43	16,14	23,32	18,94	6,62
IUFE	11,88	6,80	18,09	8,00	13,06	15,36	4,87
PLPLSE	22,92	13,98	20,53	16,33	21,10	42,45	31,75
PUSNTE	42,42	59,50	41,37	50,68	33,67	26,75	51,55

PTE	34,62	26,53	38,03	33,03	45,23	30,80	16,75
-----	-------	-------	-------	-------	-------	-------	-------

Table 5 Average values (%) of variables at cluster level

In terms of the average values recorded at the cluster level (Table 5), the best performers are clusters C and E with high average values of the shares of individuals who used GAIT in 2025 as well as of the population with tertiary education.

Cluster C (Denmark, Estonia, Sweden) ranks first in the use of AI tools by individuals for professional purposes (IUWP=24.43%) and formal educational purposes (IUFE=18.09%) and second, after cluster E, in the use of GAIT for private purposes (IUPP=35.32%), as well as the share of the population with tertiary education (PTE=38.03%). On the other hand, in cluster C there are relatively low values of the share of the population with low education (PLPLSE=20.53%).

Cluster E (Ireland, Cyprus, Luxembourg) is characterized by the highest share of individuals using GAITs for private purposes (IUPP=36.63%), as well as the highest share of the population with tertiary education (PTE=45.23%). It also ranks second in terms of the share of individuals using GAITs for professional purposes (IUWP=23.32%), as well as some of the lowest shares of the population with medium levels of education (PUSNTE=33.67%).

At the opposite end, with the lowest shares of individuals using GAITs are clusters B and G. These are also the clusters where the highest values of the share of the population with USNT education level are recorded, as well as the lowest values of the share of the population with tertiary education level (TE). The disparities compared to clusters C and E are evident (Figure 2).

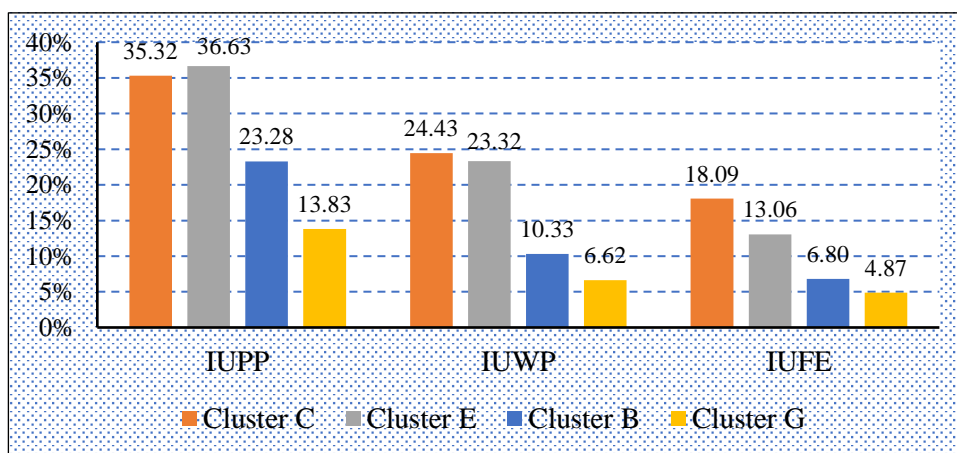


Figure 2 Disparities between clusters C, E, B and G regarding the shares of individuals using AI tools for private (IUPP), professional (IUWP) and educational purposes (IUFE)

Thus, in cluster G (Italy and Romania), at the level of the year 2025, the lowest values of IUPP (13.83%), IUWP (6.62%) and IUFE (4.86%) were recorded, values 2.64 times lower than the IUPP value recorded in cluster E and 3.72 times lower than the IUFE value recorded in cluster C. Also, the lowest value of the share of the population with tertiary education (PTE=16.75%) is recorded here, 2.70 times lower than in cluster E.

Although cluster B (Bulgaria, Czechia, Poland and Slovakia) is characterized by values close to cluster G, values that place it in the penultimate place in IUPP (23.28%), IUWP (10.33%) and IUFE (6.80%) and (PTE=26.53%), these clusters differ fundamentally in terms of the share of the population with LPLS education level. Thus, while in cluster B the average value of PLPLSE was 13.98%, in cluster G it was 31.75%, 2.27 times higher.

As for the other three clusters, they are in the median area in terms of the share of individuals using GAIT, but they show significant differences in terms of population shares according to education levels. While, by the values recorded in 2025, cluster A (Belgium, Greece, France, Netherlands, Austria and Finland) ranks third in terms of IUPP (32.02%), IUWP (21.37%), PLPLSE (22.92%) and PTE (34.62%) and 4th in terms of IUFE (11.88%) and PUSNTE (42.42%), cluster D (Germany, Latvia, Lithuania and Slovenia) ranks fifth in the shares of individuals using GAIT, regardless of the purpose of their use, with significantly higher shares (by 8.26 percentage points) than in cluster A regarding PUSNTE (50.68%) and significantly lower (by 6.59 percentage points) regarding PLPLSE (16.33%).

Cluster F (Spain and Portugal), although in terms of IUPP and IUPW it is between clusters A and D, records the second value of IUFE (15.36%), with only 2.73 percentage points less than the highest value (18.09%) recorded in cluster C and with 3.48 and 7.36 percentage points more than in clusters A and D. In terms of education levels, cluster F recorded the highest value of PLPLSE (42.45%) and the lowest value of PUSNTE (26.75%).

Analysing the characteristics of the clusters resulting from the relationships between the level of education of the population and the use of GAIT, significant differences emerged between the shares of the purposes for which individuals used these tools, as well as between the education levels of the users. It turned out that the level of education influences the shares of GAIT use, between them being a direct positive relationship. On the other hand, in terms of the purpose of using GAIT, in all clusters, private purposes were in first place, followed by professional purposes and only in third place by educational purposes, the shares being influenced by the educational level of the population.

#### **4. Similarities and disparities regarding the relationship between user age groups, educational level and purposes of GAIT use**

The second cluster analysis aimed to analyze the relationship between the age groups of users and the purposes for which they used GAIT in 2025. Three age groups were included in the analysis: 16-24 years, 25-54 years and 55-74 years. Regarding the purposes for which individuals used GAIT, as well as the levels of education, these were those used in the previous analysis, private purpose (PP), professional purpose (WP), educational purpose (EP), less than primary, primary and lower secondary (LPLS) education, upper secondary and post-secondary non-tertiary (USNT) education and tertiary education (TE).

#### 4.1. Cluster generation and validation

In this second cluster analysis, taking into account the values of the sixteen variables, as well as the analyses and tests performed, a grouping into six clusters resulted, including between two and six states, with one exception (Sweden). The dendrogram of cluster generation taking into account education levels (EL), age groups (AG) and GAIT used is illustrated in figure 3.

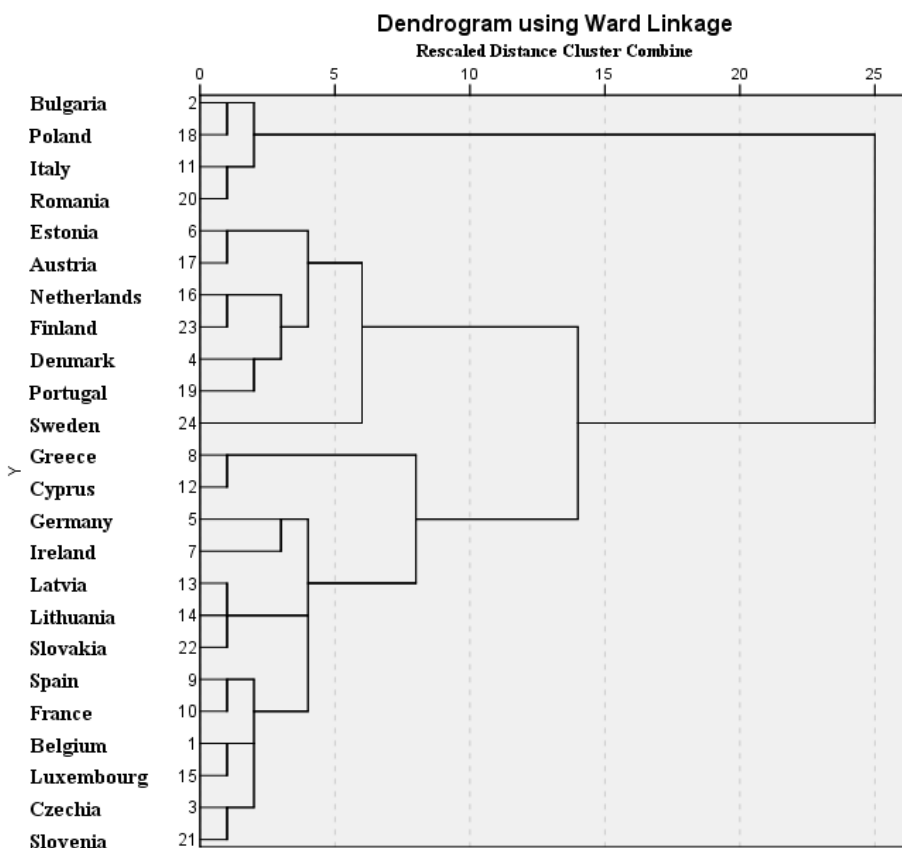


Figure 3. Dendrogram of cluster generation based on EL-AG-GAIT relationships

Among the six clusters (Table 6), clusters A and C each include six states, cluster B includes four states, cluster F includes three states, and clusters D and E each include two states.

Clusters	Structure of clusters
A	Belgium, Czechia, Spain, France, Luxembourg, Slovenia
B	Bulgaria, Italia, Poland, Romania
C	Denmark, Estonia, Netherlands, Austria, Portugal, Finland
D	Germany, Ireland
E	Greece Cyprus
F	Latvia, Lithuania, Slovakia

Table 6 The structure of clusters generated based on EL-AG-AI tools relationships

By taking into account the age groups of users, several changes occurred in the structure of the clusters. Thus, in cluster A only Belgium and France remained, joined by Czechia (from cluster B), Slovenia (from cluster D), Luxembourg (from cluster E) and Spain (from cluster F), while the Netherlands, Austria and Finland, together with Portugal (from cluster F) with Denmark and Estonia now form cluster C. In cluster B, of the four states, Bulgaria and Poland remained, joined by Italy and Romania (from cluster G). In cluster D, of the four states, only Germany remained, joined by Ireland (from cluster E). In cluster E, of the three states, only Cyprus remained, joined by Greece (from cluster A). Latvia and Lithuania (from cluster E) together with Slovakia (from cluster B) now form cluster F. Finally, in this new structuring, Sweden is not included in any cluster, constituting an exception.

Also, in this second analysis, the Levene test (Test of Homogeneity of Variance) was used to test the homogeneity of variances of the data series, the results being presented in Table 7. Taking into account the fact that all LS (Levene Statistic) values are lower than  $F(0,05;5;17)=2.810$  ( $\text{Sig}>\alpha=0,05$ ), it results that the null hypothesis  $H_0$  is accepted and, consequently, the ANOVA methodology can be used to test the statistical significance regarding the membership of the variables in clusters.

Considering that, in this case, there are 6 clusters ( $r=6$ ) and 18 variables ( $n=18$ ), the ANOVA methodology was applied, namely the F test, for  $\alpha=0.05$  and degrees of freedom  $df_1=5$  and  $df_2=17$ , whose critical value is  $F(0.05;5;17)=2.809$ . The results obtained (Table 8) highlight

the fact that all Sig values <0.050, which leads to the rejection of the null hypothesis H02. All mean values of the variables recorded at the cluster level are statistically significant

Variables	LS	df1 (r-1)	df2 (n-r)	Sig.	Variables	LS	df1 (r-1)	df2 (n-r)	Sig.
L16PP	,970	5	17	,464	M25FE	,718	5	17	,619
L16WP	2,544	5	17	,068	H25PP	2,683	5	17	,058
L16FE	2,177	5	17	,105	H25WP	1,526	5	17	,234
M16PP	2,411	5	17	,080	H25FE	2,202	5	17	,102
M16WP	2,028	5	17	,126	M55PP	,824	5	17	,550
M16FE	2,727	5	17	,055	M55WP	2,278	5	17	,093
M25PP	2,495	5	17	,072	H55PP	1,351	5	17	,291
M25WP	1,336	5	17	,296	H55WP	1,841	5	17	,158

Table 7 Results of Levene tests

Variables	F	df1 (r-1)	df2 (n-r)	Sig.	Variables	F	df1 (r-1)	df2 (n-r)	Sig.
L16PP	,970	5	17	,464	M25FE	,718	5	17	,619
L16WP	2,544	5	17	,068	H25PP	2,683	5	17	,058
L16FE	2,177	5	17	,105	H25WP	1,526	5	17	,234
M16PP	2,411	5	17	,080	H25FE	2,202	5	17	,102
M16WP	2,028	5	17	,126	M55PP	,824	5	17	,550
M16FE	2,727	5	17	,055	M55WP	2,278	5	17	,093
M25PP	2,495	5	17	,072	H55PP	1,351	5	17	,291

M25WP	1,336	5	17	,296	H55WP	1,841	5	17	,158
-------	-------	---	----	------	-------	-------	---	----	------

Table 8 Results of ANOVA test

**4.2. Similarities and disparities between EU member countries regarding the relationships between age groups, education level and GAIT used by individuals**

The results of the cluster analysis on the relationships between education level (EL), age group (AG) and GAIT used by individuals (Table 9) highlight a much greater number of similarities and disparities between the countries included in the analysis.

	Clusters					
	A	B	C	D	D	F
L16PP	50,73	28,46	50,52	34,11	71,63	53,66
L16WP	5,62	2,16	12,70	13,28	7,30	5,84
L16FE	57,67	33,20	52,07	30,35	47,28	53,81
M16PP	53,09	34,55	54,84	46,17	74,90	54,16
M16WP	17,46	4,92	26,48	23,35	8,41	16,96
M16FE	52,58	26,06	50,41	40,94	60,11	40,35
M25PP	28,66	15,76	35,02	39,00	29,58	22,23
M25WP	14,09	6,37	23,64	13,37	8,49	8,39
M25FE	4,68	1,50	11,11	4,78	3,96	3,12
H25PP	49,80	33,24	49,88	41,97	68,04	50,71
H25WP	42,55	22,47	49,90	36,62	44,54	36,86
H25FE	9,60	4,32	16,01	8,66	14,30	9,50
M55PP	9,56	3,72	11,03	8,74	13,00	3,57
M55WP	3,22	1,44	6,23	3,08	4,20	0,80

H55PP	25,30	14,20	24,17	17,76	38,63	16,92
H55WP	15,98	9,98	21,63	12,76	20,68	10,63

Table 9 Average values (%) of variables at cluster level generated based on EL-AG-GAIT relationships

From the point of view of the use of GAIT by individuals for private purposes (PP), if in the first analysis the average shares ranged between a maximum of 36.63% and a minimum of 13.83% (Table 5), by taking into account the age groups (Table 9), the average values range between a maximum of 74.90%, a value recorded in cluster E (Greece and Cyprus), for individuals in the age group 16-24 years and with USNT education level (M16PP) and a minimum of 3.57%, a value recorded in cluster F (Latvia, Lithuania and Slovakia) for individuals in the age group 55-74 years and USNT education level (M55PP).

A relevant image of the differences between the first three clusters regarding the shares of GAIT use by individuals is illustrated in figure 4. Thus, in five of the six age groups and education levels the highest average values are recorded in cluster E (Greece and Cyprus) and only one (39.00%).in cluster D (Germany and Ireland).

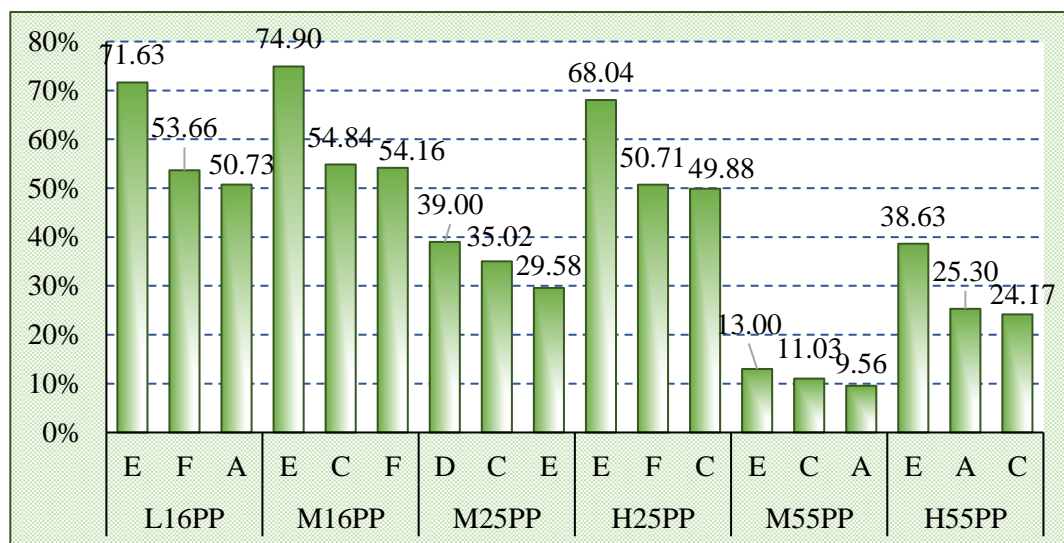


Figure 4. Ranking of the first three clusters according to the shares of GAIT use by individuals for private purposes (PP)

Also, significant shares of GAIT use for private purposes were also recorded in cluster C countries (Denmark, Estonia, Netherlands, Austria, Portugal and Finland), with high average values being recorded for individuals in the 16-24 age group and with USNT

education level (M16PP), of 54.84%, as well as 49.28%, for those with tertiary education and aged 25-54 (H25PP).

Regarding cluster F (Latvia, Lithuania and Slovakia) there were higher average values for individuals in the age group 16-24 with LPLS education level (L16PP), of 53.66%, as well as 50.71%, for those with tertiary education and aged 25-54 (H25PP). On the other hand, while for the population with USNT education level aged 16-24 (M16PP) the average share is 54.16%, for the age group 25-54 (M25PP) it is 22.23%, and for the age group 55-74 (M55PP) it is only 3.57%.

At the opposite pole, the lowest average values of the use of GAIT by individuals for private purposes, with the exception of individuals with USNT education level in the age group 55-74 years (M55PP), were recorded in cluster B (Bulgaria, Italy, Poland and Romania), the average values being between 34.55%, for individuals with USNT education level in the age group 16-25 years (M16PP), 2.16 times less than in cluster E (Greece and Cyprus), and 3.57% for individuals with USNT education level in the age group 55-74 years (M55PP), 3.49 times less than in cluster E. It is worth noting that in the case of individuals with USNT education level in the age group 25-54 years (M25PP) the average value was only 15.78%, 2.47 times less than in cluster D (Germany and Ireland).

Regarding cluster A (Belgium, Czechia, Spain, France, Luxembourg and Slovenia), in terms of the share of GAIT use for private purposes, the average values recorded were in an average area, the most significant being recorded in the case of individuals with LPLS education level, from the age group 16-25 years (L16PP), of 50.73%, and the lowest, of 9.56%, in the case of individuals with USNT education level from the age group 55-74 years (L16PP).

In terms of the use of GAIT by individuals for professional purposes (WP), in the first analysis the average shares ranged between a maximum of 24.43% (Table 5), for the cluster of countries Denmark, Estonia and Sweden and a minimum of 6.62%, for Italy and Romania. This time, by taking into account the age groups (Table 9), the average values ranged between a maximum of 49.90%, a value recorded in cluster C (Denmark, Estonia, Netherlands, Austria, Portugal and Finland) for individuals in the age group 25-54 years and with tertiary education level (H55WP) and a minimum of 0.22%, a value recorded in cluster F (Latvia, Lithuania and Slovakia) for individuals in the age group 55-74 years and USNT education level (M55WP).

Among the six clusters, the three highest average shares of GAIT use by individuals for professional purposes (Figure 5) were recorded in clusters A, C, D and E. In terms of educational level, the highest average values were recorded for individuals with tertiary education level in the age group 25-54 years, followed by those with USNT education level in the age groups 16-24 years and 25-54 years.

At cluster level, in cluster C (Denmark, Estonia, Netherlands, Austria, Portugal and Finland) maximum values were recorded for individuals with USNT education level in all three age groups, as well as for individuals with tertiary education level in the age groups 25-54 years (H25WP) and 55-74 years (H55WP).

Important shares of the use of GAIT for professional purposes were also recorded in cluster E (Greece and Cyprus), of 44.54%, in the case of individuals with tertiary educational level in the age group 25-54 (H25WP) and 20.68%, for those in the age group 55-74 (H55WP), as well as in cluster A (Belgium, Czechia, Spain, France, Luxembourg and Slovenia) of 42.55% and 15.98% for individuals with tertiary educational level in the age groups 25-54 (H25WP) and 55-64 (H55WP), as well as for individuals with USNT educational level in the age groups 16-24 (M16WP), of 17.46%, and 25-54 (M25WP), of 14.09%.

Regarding individuals with LPLS education level using GAIT for professional purposes (L16WP), the highest mean share of 13.28% was recorded in cluster D (Germany and Ireland). Also, in cluster D significant mean values of 23.35% and 13.37% were recorded, in the case of individuals with USNT educational level in the age groups 16-24 years (M16WP) and 25-54 years (M25WP).

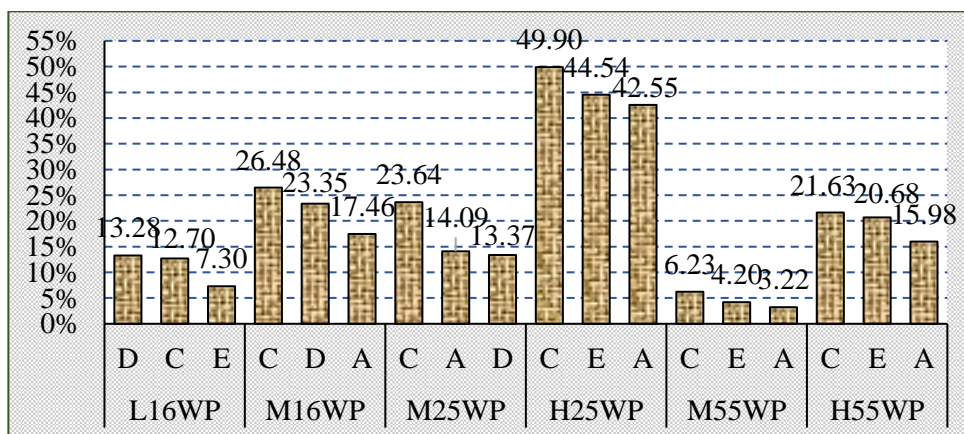


Figure 5 Ranking of the first three clusters according to the shares of GAIT use by individuals for professional purposes (WP)

The lowest values, in terms of the use of GAIT by individuals for professional purposes (WP), were recorded, as in the case of their use for private purposes (PP), in cluster B (Bulgaria, Italy, Poland and Romania), with values ranging between 22.47% in the case of individuals with tertiary educational level in the age group 25-54 years (H25WP), 2.22 times less than in cluster C (Denmark, Estonia, Netherlands, Austria, Portugal and Finland), and 1.44% in the case of individuals with USNT educational level in the age group 55-74 years (M55WP), 4.34 times less than in cluster C.

Regarding cluster F (Latvia, Lithuania and Slovakia), except for individuals with USNT educational level in the age group 55-74 years (M55WP), for whom the average share of

using GAIT for professional purposes was 0.80%, the other values are in the middle range, ranging between 36.86% for individuals with tertiary educational level in the age group 25-54 years (H25WP) and 8.39% for individuals with USNT educational level in the age group 25-54 years (M25WP).

In terms of the use of GAIT by individuals in formal education purpose (FE), by taking into account age groups, the values ranged between a maximum of 60.11%, a value recorded in cluster E (Greece and Cyprus) for individuals in the age group 16-24 years and with USNT education level (M16FE) and a minimum of 1.50%, a value recorded in cluster B (Bulgaria, Italy, Poland and Romania) for individuals in the age group 25-54 years and USNT education level (M25FE).

Unlike the average shares of individuals using GAIT for private or professional purposes, in the case of their use for formal education purposes the differences between age groups are particularly large (Figure 6). Thus, while in the case of the 16-24 age group the lowest share of individuals using GAIT for formal education purposes was 26.06%, a value recorded in cluster B (Bulgaria, Italy, Poland and Romania) for individuals with USNT education level, in the case of the 25-54 age group the highest average share was only 16.01%, a value recorded in cluster C (Denmark, Estonia, Netherlands, Austria, Portugal, Finland) for individuals with tertiary education level, from the age group 55-74 years.

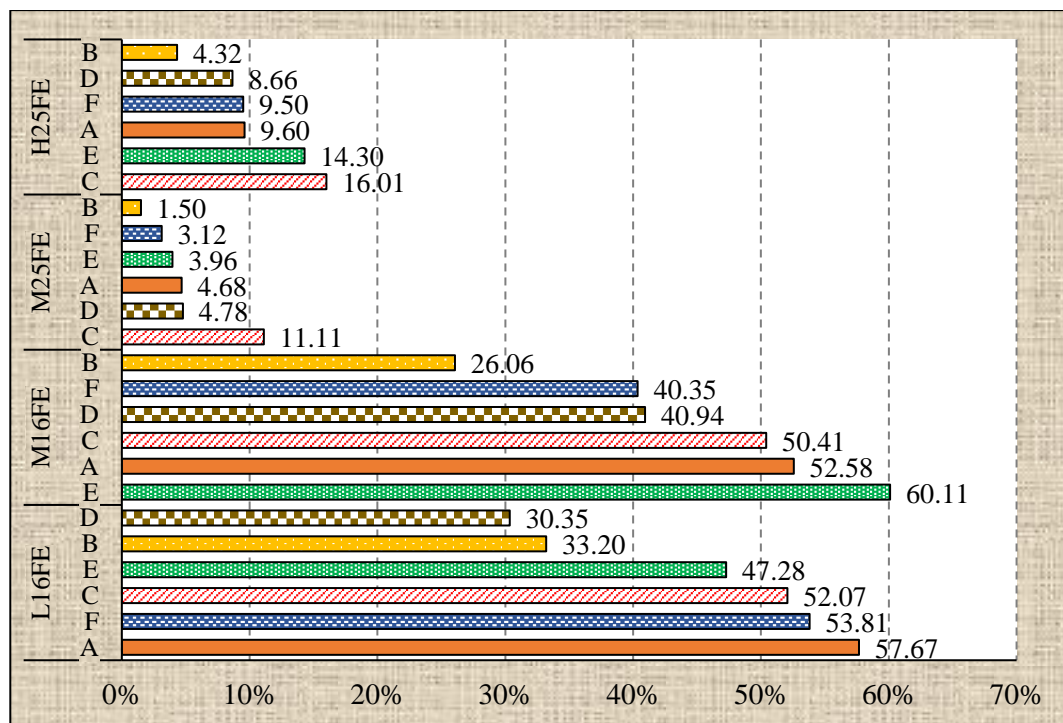


Figure 6. Hierarchy of clusters according to the share of GAIT use by individuals in formal education purpose (FE)

Among individuals in the 16-24 age group, those most interested in using GAIT for formal education purposes were those in clusters A (Belgium, Czechia, Spain, France, Luxembourg, Slovenia) and C (Denmark, Estonia, Netherlands, Austria, Portugal, Finland), both those with LPLS education level (57.67% in cluster A and 52.07% in cluster C) and those with USNT education level (52.58% in cluster A and 50.41% in cluster C). Also, individuals with LPLS education level in cluster F (Latvia, Lithuania and Slovakia), registered a share of 53.81%, and those with USNT education level in cluster E (Greece and Cyprus), registered a share of 60.11%. At the opposite pole, low values were recorded in cluster B (Bulgaria, Italy, Poland and Romania), of 33.20% for individuals with LPLS education level, and 26.06% for individuals with USNT education level.

After the age of 25, data recorded at the level of 2025 highlights a sharp decrease in individuals' interest in using GAIT for formal educational purposes, especially among those with LPLS education level, as well as for those in the 55-74 age group, for whom the data series are of low reliability. In the case of the 25-54 age group, while for those with USNT education level (M25FE) it decreases to values between 11.11% in cluster C and 1.50%, in cluster B, in the case of individuals with tertiary education level (H25FE) the interest in using GAIT in formal education purpose is maintained, although at a lower level than in the case of those in the 16-24 age group, the highest average share, of 16.01%, also being registered in cluster C, and the lowest, of 4.32% in cluster B (Bulgaria, Italy, Poland and Romania).

## **5. Conclusions**

In the first part of the analyses carried out, based on data recorded in 2025, it resulted that the main purpose for which individuals between 16 and 74 years old use GAIT was private, with the highest average share of 36.63% being recorded in the group of states Ireland, Cyprus and Luxembourg. In the second place was professional purpose with a maximum average share of 24.43%, recorded in the group of states Denmark, Estonia and Sweden, and in third place was formal education purpose with a maximum average share of 18.09%, also recorded in the group of states Denmark, Estonia and Sweden. At the opposite pole, the lowest average share of GAIT use by individuals were recorded in the group of states formed by Italy and Romania.

In the second part of the analysis, by taking into account the age groups and education level of individuals, a series of new similarities and disparities emerged between the twenty-four European Union countries included in the analysis.

In terms of the use of GAIT by individuals for private purposes (PP), by taking into account the age groups, at the level of the year 2025, the average shares ranged between a maximum of 74.90%, a value recorded in cluster E (Greece and Cyprus), for individuals in the age

group 16-24 years and with USNT education level, and a minimum of 3.57%, a value recorded in cluster F (Latvia, Lithuania and Slovakia) for individuals in the age group 55-74 years and with USNT education level. Differences in the average shares of the use of GAIT for private purposes resulted, both between the education levels of the individuals and between the age groups, especially between the age group 16-24 years and the others. Within the age group 16-24 years, the differences between the education levels of the individuals did not significantly influence the shares of the use of GAIT for private purposes.

The level of education is a significant differentiating factor between the shares of individuals using GAIT for professional purposes (WP), the highest average values being recorded for individuals in the age group 25-54 with tertiary educational level, of 49.90%, in cluster C (Denmark, Estonia, Netherlands, Austria, Portugal and Finland), of 45.54%, in cluster E (Greece and Cyprus) and of 42.55%, in cluster A (Belgium, Czechia, Spain, France, Luxembourg and Slovenia). The lowest values of the shares of individuals using GAIT for professional purposes were recorded in clusters B (Bulgaria, Italy, Poland and Romania) and F (Latvia, Lithuania and Slovakia).

In terms of the use of GAIT by individuals in formal education purpose (FE), unlike the average shares of individuals using GAIT for private or professional purposes, differences between age groups are significantly large, with the highest shares being recorded for individuals in the 16-24 age group, over 2.5 times higher than in the other age groups. As individuals age increases, the shares of GAIT use for educational purposes decrease exponentially, but remain, to some extent, for individuals with tertiary educational level in the 25-54 age group, especially for those in the countries included in cluster C (Denmark, Estonia, Netherlands, Austria, Portugal and Finland).

Finally, regarding Romania's place, it was included in the first analysis, together with Italy, in the cluster with the worst results in the use of GAIT by individuals. In Romania, in 2025, the shares of GAIT use by individuals were 14.85% for private purpose, 5.24% for professional purpose and only 3.37% for formal educational purpose, while the share of the population with LPLS education level was 24.3%, and with tertiary educational level was only 15.1%. By age groups and education levels, in Romania, in the age group 16-24 years, the share of GAIT use in formal education purpose was 21.09% for those with LPLS education level and 25.84% for those with USNT education level. In the age group 25-54 years, the share using GAIT was only 0.15%, in the case of those with USNT education level, and only 1.43% in the case of those with tertiary education level.

## References

[1] Bick, Alexander, Blandin, Adam and Deming, David, (2025), [The State of Generative AI Adoption in 2025](#), On the Economy, Federal Reserve Bank of St. Louis.

- [2] Pearson, Andrew, (2024), [Creativity: Firing on all generative AI cylinders](#), *Journal of Digital & Social Media Marketing*, **12**, issue 1, p. 52-64.
- [3] Bick, Alexander, Blandin, Adam and Deming, David, (2025), [The Impact of Generative AI on Work Productivity](#), On the Economy, Federal Reserve Bank of St. Louis.
- [4] Calvino, Flavio, Haerle, Daniel and Liu, Sarah, (2025), [Is generative AI a General Purpose Technology?: Implications for productivity and policy](#), No 40, OECD Artificial Intelligence Papers, OECD Publishing.
- [5] Fioravante, Rosa and Vaccaro, Antonino, (2025), [Personalism in Generative AI Deployment: Deciding Ethically When Human Creative Expression is at Stake](#), *Humanistic Management Journal*, **10**, issue 3, p. 387-409.
- [6] Al-Falahat, Ala'a M., (2025), [Artificial Intelligence tools perceptions: A survey to measure the Perceptions of Engineering Students](#), *International Journal of Innovative Research and Scientific Studies*, **8**, issue 3, p. 3344-3355.
- [7] Abri, Maimoona Al, Mamari, Abdullah Al and Marzouqi, Zakria Al, (2025), [Exploring the implications of generative-AI tools in teaching and learning practices](#), *Journal of Education and e-Learning Research*, **12**, issue 1, p. 31-41.
- [8] Osondu, James, (2024), [Benefits of Using Artificial Intelligence Tools in Education](#), *Nauchni trudove*, issue 1.
- [9] Juraj, Fabus, Miriam, Garbarova, Lukas, Vartiak and Ludmila, Mitkova, (2025), [The Use of AI Tools in Managerial Education](#), *Management Theory and Studies for Rural Business and Infrastructure Development*, **47**, issue 2, p. 251-259.
- [10] Petrescu Irina Elena & Gole Iulian & Balu Florentina Olivia & Sabie Oana Matilda, 2025. "[The Role of AI Tools in Increasing the Efficiency of Research and Teaching](#)," [Proceedings of the International Conference on Business Excellence](#), Sciendo, vol. 19(1), pages 656-663.
- [11] Taeihagh, Araz, (2025), [Governance of Generative AI](#), *Policy and Society*, **44**, issue 1, p. 1-22.  
[https://econpapers.repec.org/article/ouppolsoc/v\\_3a44\\_3ay\\_3a2025\\_3ai\\_3a1\\_3ap\\_3a1-22..htm](https://econpapers.repec.org/article/ouppolsoc/v_3a44_3ay_3a2025_3ai_3a1_3ap_3a1-22..htm)
- [12] Rebekka Schwesig & Irina Brich & Jürgen Buder & Markus Huff & Nadia Said, 2023. "[Using artificial intelligence \(AI\)? Risk and opportunity perception of AI predict people's willingness to use AI](#)," [Journal of Risk Research](#), Taylor & Francis Journals, vol. 26(10), pages 1053-1084, October.
- [13] Kim, Jhonghee and Kim, Hyungjoon, (2025), [The use of generative AI tools in design work: Motivation and decision-making process of users](#), *Edelweiss Applied Science and Technology*, **9**, issue 4, p. 74-82

- [14] Leonardo Gambacorta & Tullio Jappelli & Tommaso Oliviero, 2025. "[Exploring household adoption and usage of generative AI: new evidence from Italy](#)," [BIS Working Papers](#) 1298, Bank for International Settlements.
- [15] [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=International\\_Standard\\_Classification\\_of\\_Education\\_\(ISCED\)](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=International_Standard_Classification_of_Education_(ISCED))
- [16] [https://ec.europa.eu/eurostat/databrowser/view/edat\\_ifs\\_9903\\_custom\\_19879848/default/table](https://ec.europa.eu/eurostat/databrowser/view/edat_ifs_9903_custom_19879848/default/table) Population in private households by educational attainment level (%), 20-01.2026
- [17] [https://ec.europa.eu/eurostat/databrowser/view/isoc\\_ai\\_iaiu/default/table?lang=en&category=isoc.isoc\\_i.isoc\\_ai](https://ec.europa.eu/eurostat/databrowser/view/isoc_ai_iaiu/default/table?lang=en&category=isoc.isoc_i.isoc_ai) Individuals - use of generative AI tools, 20-01.2026
- [18] Johnson, S.C., Hierarchical clustering schemes, *Psychometrika* 32, 241–254 (1967)
- [19] D'Andrade, R.G. U-statistic hierarchical clustering, *Psychometrika* 43, 59–67 (1978)
- [20] García-Escudero, L. A., Gordaliza, A., Matrán, C., & Mayo-Isar, A. (2010). A review of robust clustering methods. *Advances in Data Analysis and Classification*, 4(2–3), 89–109.
- [21] Murtagh, F., & Legendre, P. (2014). Ward's hierarchical agglomerative clustering method: Which algorithms implement Ward's criterion? *Journal of Classification*, 31(3), 274–295.

## **Bibliography**

- Abri, Maimoona Al, Mamari, Abdullah Al and Marzouqi, Zakria Al, (2025), [Exploring the implications of generative-AI tools in teaching and learning practices](#), *Journal of Education and e-Learning Research*, 12, issue 1, p. 31-41.
- Aisha Zahid Huriye, 2023. "[The Ethics of Artificial Intelligence: Examining the Ethical Considerations Surrounding the Development and Use of AI](#)," [American Journal of Technology](#), Global Peer Reviewed Journals, vol. 2(1), pages 37-44.
- Al-Falahat, Ala'a M., (2025), [Artificial Intelligence tools perceptions: A survey to measure the Perceptions of Engineering Students](#), *International Journal of Innovative Research and Scientific Studies*, 8, issue 3, p. 3344-3355.
- Bick, Alexander, Blandin, Adam and Deming, David, (2025), [The Impact of Generative AI on Work Productivity](#), On the Economy, Federal Reserve Bank of St. Louis.
- Bick, Alexander, Blandin, Adam and Deming, David, (2025), [The State of Generative AI Adoption in 2025](#), On the Economy, Federal Reserve Bank of St. Louis.

Bogoslov, Ioana Andreea and Stoica, Eduard, (2024), [GENERATIVE AI ADOPTION IN TEACHING PROCESSES: ANALYZING INSIGHTS FROM CHATGPT](#), *Revista Economica*, 76, issue 3, p. 7-20.

Calvino, Flavio, Haerle, Daniel and Liu, Sarah, (2025), [Is generative AI a General Purpose Technology?: Implications for productivity and policy](#), No 40, OECD Artificial Intelligence Papers, OECD Publishing.

D'Andrade, R.G. U-statistic hierarchical clustering, *Psychometrika* 43, 59–67 (1978)

Eduard-Mihai, Manta, Cristina, Geambasu Maria and Ioana, Birlan, (2025), [Mapping AI Adoption across Europe: A Cluster Analysis of National Responsibility](#), *Proceedings of the International Conference on Business Excellence*, 19, issue 1, p. 1532-1545.

Fioravante, Rosa and Vaccaro, Antonino, (2025), [Personalism in Generative AI Deployment: Deciding Ethically When Human Creative Expression is at Stake](#), *Humanistic Management Journal*, 10, issue 3, p. 387-409.

García-Escudero, L. A., Gordaliza, A., Matrán, C., & Mayo-Iscar, A. (2010). A review of robust clustering methods. *Advances in Data Analysis and Classification*, 4(2–3), 89–109.

Horia Alexandru Modran & Doru Ursuțiu & Cornel Samoilă, 2024. "[Using the Theoretical-Experiential Binomial for Educating AI-Literate Students](#)," [Sustainability](#), MDPI, vol. 16(10), pages 1-20, May.

[https://ec.europa.eu/eurostat/databrowser/view/edat\\_lfs\\_9903\\_custom\\_19879848/default/table](https://ec.europa.eu/eurostat/databrowser/view/edat_lfs_9903_custom_19879848/default/table) Population in private households by educational attainment level (%), 20-01.2026

[https://ec.europa.eu/eurostat/databrowser/view/isoc\\_ai\\_iaiu/default/table?lang=en&category=isoc.isoc\\_i.isoc\\_ai](https://ec.europa.eu/eurostat/databrowser/view/isoc_ai_iaiu/default/table?lang=en&category=isoc.isoc_i.isoc_ai) Individuals - use of generative AI tools, 20-01.2026

[https://ec.europa.eu/eurostat/statistics-explained/index.php?title=International\\_Standard\\_Classification\\_of\\_Education\\_\(ISCED\)](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=International_Standard_Classification_of_Education_(ISCED))

Johnson, S.C., Hierarchical clustering schemes, *Psychometrika* 32, 241–254 (1967)

Juraj, Fabus, Miriam, Garbarova, Lukas, Vartiak and Ludmila, Mitkova, (2025), [The Use of AI Tools in Managerial Education](#), *Management Theory and Studies for Rural Business and Infrastructure Development*, 47, issue 2, p. 251-259.

Kim, Jhonghee and Kim, Hyungjoon, (2025), [The use of generative AI tools in design work: Motivation and decision-making process of users](#), *Edelweiss Applied Science and Technology*, 9, issue 4, p. 74-82

Leonardo Gambacorta & Tullio Jappelli & Tommaso Oliviero, 2025. "[Exploring household adoption and usage of generative AI: new evidence from Italy](#)," [BIS Working Papers](#) 1298, Bank for International Settlements.  
<https://ideas.repec.org/p/bis/biswps/1298.html>

Murtagh, F., & Legendre, P. (2014). Ward's hierarchical agglomerative clustering method: Which algorithms implement Ward's criterion? *Journal of Classification*, 31(3), 274–295.

Osondu, James, (2024), [Benefits of Using Artificial Intelligence Tools in Education](#), *Nauchni trudove*, issue 1.

Pearson, Andrew, (2024), [Creativity: Firing on all generative AI cylinders](#), *Journal of Digital & Social Media Marketing*, 12, issue 1, p. 52-64.

Petrescu Irina Elena & Gole Iulian & Balu Florentina Olivia & Sabie Oana Matilda, 2025. "[The Role of AI Tools in Increasing the Efficiency of Research and Teaching](#)," *Proceedings of the International Conference on Business Excellence*, Sciendo, vol. 19(1), pages 656-663.

Rebeka Schwegel & Irina Brich & Jürgen Buder & Markus Huff & Nadia Said, 2023. "[Using artificial intelligence \(AI\)? Risk and opportunity perception of AI predict people's willingness to use AI](#)," *Journal of Risk Research*, Taylor & Francis Journals, vol. 26(10), pages 1053-1084, October.

Şahin Gökçeşlan & Elif Esiyok & Kemal Gurkan Kucukergin, 2025. "[Understanding the intention to use artificial intelligence chatbots in education: The role of individual innovativeness and AI trust among university students](#)," *Journal of Computational Social Science*, Springer, vol. 8(3), pages 1-23, August.

Sangbum Kang & Yongjoo Choi & Boyoung Kim, 2024. "[Impact of Motivation Factors for Using Generative AI Services on Continuous Use Intention: Mediating Trust and Acceptance Attitude](#)," *Social Sciences*, MDPI, vol. 13(9), pages 1-18, September.

Stan Marian & Ciobotea Mihai & Voda Adina Maria & Badea Doina Liliana, 2025. "[Artificial Intelligence Landscape in the European Union. A Comparative Study](#)," *Proceedings of the International Conference on Business Excellence*, Sciendo, vol. 19(1), pages 3432-3445.

Taeihagh, Araz, (2025), [Governance of Generative AI](#), *Policy and Society*, 44, issue 1, p. 1-22.

Tallberg, Jonas & Lundgren, Magnus & Geith, Johannes, 2024. "[AI regulation in the European Union: examining non-state actor preferences](#)," *Business and Politics*, Cambridge University Press, vol. 26(2), pages 218-239, June.