Can Parenting Styles Unlock the Best in University Students?

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Abstract

This study explores the impact of different parenting styles - authoritative, democratic, and strict - on the development of psychological trait. The relevance of this research is underscored by the growing recognition of how family dynamics and psychological factors play a crucial role in shaping children's behavior and character. By investigating how parenting styles influence the development of key psychological traits, this study aims to provide valuable insights that can inform targeted educational interventions. The findings are particularly important for psychologists, educators, policymakers, and parents-to-be, offering practical knowledge to better support children's emotional and cognitive growth. The methodology employs robust regression and clustering techniques, which allow for a nuanced understanding of the relationship between parenting styles and psychological development. These methods help to identify and quantify the impact of various parenting approaches on children's psychological traits, thus contributing to the broader field of educational and developmental psychology.

1 Dataset and Data Preparation

1.1 Dataset Description

The dataset comprises responses from 248 university students collected at Uludağ University in Turkey. It is organized into three principal informational frameworks: the demographic structure, the parental relationship's structure, and the personal characteristics structure.

The demographic structure encompasses variables pertaining to the participants' demographic attributes, including gender (Female = 1 and Male = 0), Age (ranging from 19 to 25 years), Faculty (spanning twelve distinct faculties such as Architecture and Engineering), and Year of study (from the first to the fourth year).

The parental relationship's structure includes summary scores that reflect students' perceptions of parental attitudes, derived from the Parental Attitude Scale. This scale consists of eighty items, with forty items each dedicated to mothers and fathers, and evaluates three primary dimensions of attitudes: authoritative, democratic, and strict. Authoritative parents make decisions but are willing to explain their reasoning and discuss with their children, combining clear rules and high expectations with support and communication; democratic are open to dialogue and actively involve their children in decision-making, encouraging negotiation and shared responsibility, while strict have a rigid approach, with strict rules, high expectations, and little room for negotiation or dialogue. Specifically, the authoritative dimension is measured by OAT (Authoritative Mother) and OBT (Authoritative Father), the democratic dimension by DAT (Democratic Mother) and DBT (Democratic Father), and the strict dimension by KAT (Strict Mother) and KBT (Strict Father). These scores are presented as aggregated mean values for each subdimension, based on responses to a five-point Likert scale.

The personal characteristics structure comprises scores for various character strength subdimensions, calculated using the Character Strengths Inventory (VIA-IS-P). This 96-item instrument is designed to assess students' character strengths through a five-point Likert scale and is divided into twenty-four subdimensions, including Courage, Creativity, Curiosity, Justice, Forgiveness, Gratitude, Honesty, Hope, Humor, Judgment, Kindness, Leadership, Love of Learning, Love, Humility, Perseverance, Perspective, Prudence, Self-Regulation, Social Intelligence, Spirituality, Teamwork, Zest, and EVMT, which represents the total sum of all character strengths for each individual.

1.2 Data Preparation Steps

The data preparation process for the analysis involved several critical steps aimed at cleaning, transforming, and standardizing the dataset. Initially, an examination for missing values revealed none, and a subsequent check confirmed the absence of duplicate records within the dataset. To enhance readability and ensure consistency, the original column names, which were in Turkish, were renamed to English. This renaming process included all twenty-three columns representing character strengths, as well as the variables for gender, age, faculty, and year of study.

Subsequently, unnecessary columns were removed to streamline the dataset. Specifically, the first two columns ("ID" and "Consent to Participate") were discarded, ninety-six variables that were used to calculate the Character Strengths Inventory and the eighty variables utilized for the Parental Attitude Scale, along with the demographic columns for the clustering part.

Finally, to prepare the data for further analysis and ensure comparability across variables, all numeric columns were standardized to a range between zero and one. This standardization was achieved using a

robust normalization formula, where each value was scaled relative to the minimum and maximum values of its respective column.

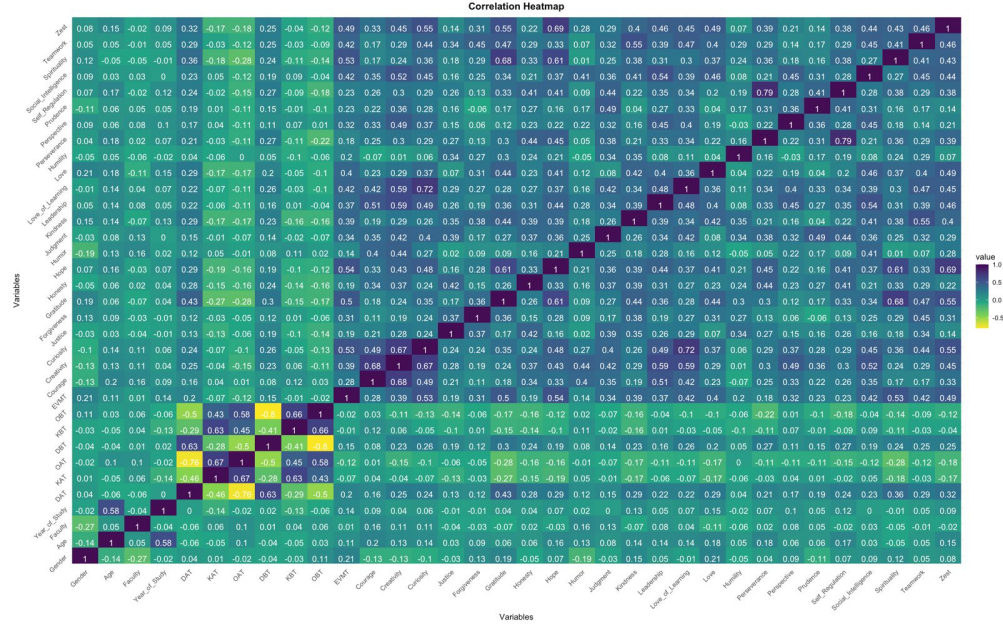# 2 Descriptive Statistics

2.1 Correlation Heatmap

Figure 1: Correlation heatmap between parenting styles and personal characteristics.

Examining the correlations, the democratic parenting styles (DAT, DBT) generally show positive associations with a variety of personal strengths. For instance, students reporting higher levels of maternal democratic parenting (DAT) tend to demonstrate stronger gratitude, teamwork, and zest. Similarly, paternal democratic behavior (DBT) correlates positively with traits like curiosity, perseverance, and hope. These patterns suggest that when parents adopt more communicative, supportive, and autonomy-granting methods, their children are more likely to cultivate positive personal qualities. In contrast, authoritative parenting styles (OAT, OBT) yield more mixed results: while certain authoritative elements may still relate positively to some character strengths, the correlation matrix often reveals weaker or even negative associations with traits like creativity, humility, or social intelligence. Additionally, strict parenting dimensions (KAT, KBT) appear less conducive to many positive personal attributes: negative or near-zero correlations with character strengths indicate that a more rigid, controlling environment may not foster the development of these desirable personal qualities.

Overall, these patterns support the notion that more democratic parental engagement tends to correspond with richer personal growth, while stricter, more controlling approaches may hinder the cultivation of character strengths.

The interrelationships among the parenting dimensions themselves reveal that more democratic approaches are often inversely correlated with stricter or more authoritative behaviors. This suggests that

parents who exhibit high levels of supportive, open communication are less likely to engage in controlling or rigid practices.

2.2 Summary Statistics

Table 1: Summary Statistics

Variable	Mean	Std.Dev	Min	Max
Gender	0.77	0.42	0.00	1.00
Age	20.85	2.11	19.00	25.00
Faculty	4.00	3.97	1.00	13.00
Year_of_Study	2.10	1.18	1.00	4.00
DAT	57.23	12.47	21.00	75.00
KAT	32.98	9.87	15.00	65.00
OAT	20.48	7.11	10.00	48.00
DBT	50.92	14.14	15.00	75.00
KBT	33.48	11.26	15.00	72.00
OBT	23.86	7.91	10.00	47.00
EVMT	3.82	0.77	1.50	5.00
Courage	3.59	0.63	1.50	5.00
Creativity	3.78	0.78	1.00	5.00
Curiosity	3.66	0.81	1.00	5.00
Justice	3.67	0.78	1.50	5.00
Forgiveness	3.36	0.82	1.25	5.00
Gratitude	3.44	0.87	1.00	5.00
Honesty	4.18	0.55	2.25	5.00
Hope	3.46	0.82	1.00	5.00
Humor	3.62	0.92	1.25	5.00
Judgment	4.06	0.59	2.00	5.00
Kindness	4.06	0.70	1.00	5.00
Leadership	3.35	0.95	1.00	5.00
Love_of_Learning	3.93	0.79	1.50	5.00
Love	3.70	0.96	1.00	5.00
Humility	3.63	0.71	1.00	5.00
Perseverance	3.38	0.89	1.00	5.00
Perspective	3.48	0.79	1.00	5.00
Prudence	3.71	0.74	1.25	5.00
Self_Regulation	3.32	0.83	1.00	5.00
Social_Intelligence	3.74	0.70	1.50	5.00
Spirituality	3.81	0.87	1.00	5.00
Teamwork	4.01	0.59	2.00	5.00
Zest	3.08	1.01	1.00	5.00

Note. N = 248.

Table 1 provides a broad overview of the variables included in this study. The parenting style dimensions show considerable variation, but the democratic parenting style is notably more prevalent. Personal characteristics, such as honesty, judgment, kindness, and teamwork, generally display relatively high mean values, suggesting that these positive traits are quite prevalent. In contrast, traits like perseverance, self-regulation, and zest show more moderate averages, indicating areas where participants might vary more widely.

3   Forward Regression Analysis

The methodology implemented encompassed variable selection, bootstrap, model evaluation and outlier detection employing both classical and robust techniques.

To check the presence of outliers in the various sub-datasets, the average proportion of outliers was estimated using a bootstrap-based approach: this involved repeatedly generating samples with replacement from the original dataset and computing Mahalanobis distances for each sample using a robust covariance estimate derived from the Minimum Covariance Determinant (MCD) method. The threshold for identifying the outliers was determined by the chi-square distribution and the average proportion of outliers was calculated as the mean of proportions obtained across all bootstrap samples. To guide model selection, a decision threshold was established: when the proportion of outliers ranged between 10% and 40%, a more aggressive robust model like Least Trimmed Squares (LTS) was selected, while if below 10%, a more flexible model like `lmrob` was applied. For all the sub-datasets, the proportion of outliers for all response variables was approximately 30%, leading to the selection of the LTS model.

Variable selection was conducted using a forward selection approach based on the Akaike Information Criterion (AIC). The process began with a null model containing only the intercept, with variables iteratively added to minimize the AIC. For the robust variant, the variables selected through forward selection were subsequently used to construct a robust regression model using the LTS method. To ensure the stability and reproducibility of the selected predictors, a bootstrap-based validation approach was employed. Multiple datasets were generated through resampling, and the forward selection process was repeated for each sample. In robust models, the variables selected during forward selection were validated using the LTS approach, thereby identifying variables that remained consistently significant even in the presence of extreme data points.

Final predictive models were constructed using the selected predictors from the variable selection step. Depending on the analysis, non-robust models were built using traditional linear regression, while robust models employed the LTS method. Additional procedures were implemented to evaluate model performance, detect and manage outliers, and refine the analysis for each parenting style. The performance of the final models was assessed on both training and test datasets using metrics such as R^2_{adj} and Root Mean Squared Error (RMSE). Robust outlier detection was carried out using Mahalanobis distances calculated with the MCD method, classifying outliers into leverage outliers, residual outliers, and those exhibiting both characteristics. An outlier map, plotting robust distances against standardized residuals, provided a visual representation of the results.

The described methodology was applied to analyze specific response variables, with separate regression models developed for each characteristic of students' character (e.g., Courage, Creativity). Predictor variables related to other characteristics were excluded to avoid multicollinearity, and variables such as year of study, faculty, gender, and age were also removed. Consequently, only various types of parenting styles, such as OAT, were used as independent variables.

3.1 NOT ROBUST

Table 2: Coefficients and Significance Codes for Each Final Model

Response	Intercept	DAT	KAT	OAT	DBT	KBT	OBT
Courage	0.2777	0.3052	-	0.2752*	-	0.1079	-
Creativity	0.4833	0.2072	-	-	-	0.2022	-
Curiosity	0.1549	0.2472	-	0.2595	0.2941	-	0.2501
Justice	0.6102*	-	-	-	-	-	-
Forgiveness	0.5505*	-	-	-	-	-	-
Gratitude	0.1156	0.5993*	-	0.1548	-	-	0.1344
Honesty	0.4546	0.3624	-	0.2256·	-	−0.2142*	-
Hope	0.2991	0.412	−0.2132	0.4102	-	-	-
Humor	0.4633	0.1674	-	-	-	0.1949·	-
Judgment	0.5924	0.1397	-	-	-	-	-
Kindness	0.512	0.3149	-	0.144	-	-	-
Leadership	0.4479	0.2199*	-	-	-	-	-
Love of Learning	0.2357	-	-	-	0.4762	-	0.4686*
Love	0.3087	0.4195*	-	0.2739·	-	-	-
Humility	0.6944*	-	-	-	-	−0.1096	-
Perseverance	0.233	0.1832	-	0.2868	0.2655	-	-
Perspective	0.3209	-	-	-	0.3037	-	0.3154*
Prudence	0.4582	0.1904	0.1829*	-	-	-	-
Self-Regulation	0.3148	0.282	0.2226*	-	-	-	-
Social Intelligence	0.4388	0.1937	-	-	-	0.1962	-
Spirituality	0.3453	0.4321	-	-	-	-	0.1982*
Teamwork	0.2843	0.453	-	0.2701	-	-	-
Zest	0.0609	0.5478	-	0.3478	-	-	-

3.1.1 Intercept

In nearly all models, the intercept is statistically significant: this suggests that the dependent variables have a baseline value that is significantly different from zero, even when all predictors are set to their reference levels (or zero). In cases where the intercept is not significant (e.g., Curiosity, Gratitude, Zest), this indicates that there is insufficient evidence to conclude that the baseline level of the dependent variable is different from zero.

3.1.2 Significant Predictors

DAT (Democratic Mother)   DAT appears frequently as a significant predictor across models, often with strong positive effects: the two models where the coefficient for DAT is higher are Gratitude (0.5993) and Zest (0.5478). This style supports a broad spectrum of qualities - from moral values like Courage and Honesty, to emotional strengths like Hope and Zest, relational abilities like Social Intelligence and Love, cognitive assets like Curiosity and Creativity, and spiritual dimensions such as Gratitude and Spirituality. By fostering open communication, respect, and involvement, the mother's democratic approach creates an environment that encourages balanced personal and relational growth, forming resilient, curious, grateful, and socially adept individuals.

KAT (Strict Mother)   A strict mother (KAT) leads to lower levels of Hope, suggesting a more negative outlook due to high expectations and lack of emotional support. However, Prudence and Self-regulation

increase, though these traits could be driven more by fear of punishment than by personal reflection. Overall, strict parenting fosters caution and self-control but diminishes hope, impacting students' confidence and optimism.

OAT (Authoritative Mother)   Courage, Curiosity, Hope, and Perseverance are all significant, suggesting that students raised in an authoritative environment develop a strong sense of bravery, curiosity, optimism, and the ability to persist through challenges. Additionally, Teamwork and Zest are also significant, indicating that an authoritative mother's approach promotes a positive, supportive atmosphere that encourages students to work well with others and approach life with energy and enthusiasm.

DBT (Democratic Father)   students raised by a democratic father show increased Curiosity, fostering a deeper engagement with the world. They also develop a strong Love of Learning, motivated by a supportive environment. Perseverance grows as they face challenges with determination, while Perspective enhances their ability to think critically and view situations thoughtfully.

In summary, the democratic father promotes "curiosity", "love of learning", "perseverance", and "perspective", helping students build intellectual curiosity, resilience, and a balanced outlook.

KBT (Strict Father)   The model reveals mixed effects on students' traits: Creativity increases, as children develop innovative solutions within a structured environment and, on the other end Honesty decreases due to the fear of punishment, leading to potential dishonesty. Additionally, Social Intelligence improves, as students learn to navigate social interactions within a rigid framework. In summary, the strict father fosters creativity and social intelligence but may hinder honesty due to the emphasis on discipline and fear of consequences.

OBT (Authoritative Father)   Love of Learning increases, as children are encouraged to develop a passion for learning through a balance of clear expectations and emotional support. Perspective also increases, suggesting that students raised by an authoritative father are more likely to develop a balanced and thoughtful view of the world, enabling them to make mature decisions. Spirituality is positively influenced, with the authoritative style fostering the development of spiritual values like gratitude and respect and Curiosity is nurtured, supporting intellectual exploration and the desire to learn.

In summary, the authoritative father parenting style promotes love of learning, perspective, and spirituality, contributing to well-rounded personal development and a strong foundation for future growth.

3.2 ROBUST

Table 3: Coefficients and Significance Codes for Each Final Model (Robust)

Response	Intercept	DAT	KAT	OAT	DBT	KBT	OBT
Courage	0.0743	0.5813	-	0.4001	-	0.0373	-
Creativity	0.4885	0.1453·	-	-	0.0782	0.1894	-
Curiosity	−0.0071	0.2891	-	0.1983	0.4525	-	0.4195
Justice	0.6102*	-	-	-	-	-	-
Forgiveness	0.5505*	-	-	-	-	-	-
Gratitude	0.0828	0.6285	-	0.0138	-	-	0.2937
Honesty	0.4588	0.3375	-	0.2073·	-	−0.1333	-
Hope	0.0839	0.5902	-	0.2458	-	-	0.189*
Humor	0.5305	0.1564	-	-	-	-	-
Judgment	0.5927	0.1799*	-	-	-	-	-
Kindness	0.469	0.3699	-	0.2784	-	-	-
Leadership	0.2821	0.3931	-	-	-	-	0.1825*
Love of Learning	−0.0069	-	-	-	0.7589	-	0.6947
Love	0.0534	0.7995*	-	0.2273	-	-	-
Humility	0.6503*	-	-	-	-	0.0993	-
Perseverance	0.1882	0.229	0.2988	-	0.2293	-	-
Perspective	0.2384	-	-	-	0.3705	-	0.457
Prudence	0.5964	0.1151	-	-	-	-	-
Self-Regulation	0.3024	0.3292	0.2544	-	-	-	-
Social Intelligence	0.3646	0.2659	-	-	-	0.3068*	-
Spirituality	0.4762	0.3442	-	-	-	-	0.1131
Teamwork	0.1527·	0.6046	-	0.3613	-	-	-
Zest	−0.0995	0.7287	-	0.493	-	-	-

DAT (Democratic Mother) It can be observed that all the characteristics that were significant in the non-robust regressions remain statistically significant in the robust model: for most of the coefficients, there is an increase in their values. Additionally, the characteristic of Perseverance, which was not significant previously, is now significant, further emphasizing the importance of the democratic mother in the development of the child's character.

KAT (Authoritarian Mother) The emergence of Perseverance and the increase in Self-Regulation suggest that students in a strict environment may develop a stronger ability to endure challenges and control their impulses, likely as a response to the high demands and limited emotional flexibility. The absence of Hope and Prudence indicates that the strict style might undermine the development of optimism and cautious decision-making, as the focus tends to be on compliance rather than reflective thinking or emotional support.

OAT (Authoritative Mother) In the robust model for authoritative mother (OAT) parenting, the focus shifts towards traits like motivation, resilience, courage, teamwork, and kindness: the increase in Courage, Teamwork, and Zest suggests a stronger emphasis on intrinsic motivation and resilience. Although Hope and Curiosity remain significant, Hope slightly declines, indicating a shift toward more practical traits. The emergence of Kindness instead of Perseverance highlights the importance of empathy and prosocial behavior.

DBT (Democratic Father) In the context of the democratic father (DBT), transitioning from a non-robust to a robust model reveals several key changes: first, Creativity appears but is not significant, suggesting that while creativity may play a role, it is not strongly influenced by this parenting style. Secondly there is an increase in Curiosity, indicating that democratic fathers foster a stronger sense of curiosity in their children, in Love of Learning, highlighting the positive impact on a child's intellectual growth, and in Perspective, showing that they tend to develop a more thoughtful and well-rounded view of the world. However, Perseverance decreases, suggesting that the focus in the robust model shifts more toward intrinsic motivation and curiosity rather than mere persistence.

KBT (Strict Father) In the context of a strict father (KBT), from a non-robust to a robust model: Creativity decreases but remains significant, indicating some influence of a strict upbringing on creativity, though less pronounced. Honesty becomes insignificant and Humor disappears, pointing to a lack of emotional warmth that may limit the development of playfulness. Lastly, Social Intelligence increases, suggesting that students raised in a strict environment may develop stronger social awareness to navigate their structured surroundings. Overall, the robust model highlights a focus on social intelligence, with reduced emphasis on creativity, honesty, and humor.

OBT (Authoritative Father) In the context of an authoritative father (OBT), Curiosity, Love of Learning and Perspective increase significantly, reflecting the encouragement of exploration, a passion for learning and balanced worldview in this parenting style. Gratitude and Leadership become significant, indicating that students develop a strong sense of appreciation and leadership qualities, while Hope appears as a significant trait, showing a positive outlook on the future fostered by this balanced approach. However, Spirituality no longer remains significant, indicating that while authoritative parenting fosters many positive traits, it has less impact on the development of spirituality

3.3   Model Evaluation Results

Table 4: Comparison of Results of Non-Robust and Robust Regression through R^2_{adj} and RMSE

Response	Original Metrics				Robust Metrics			
	Selected Variables	Train R^2_{adj}	Train RMSE	Test R^2_{adj}	Test RMSE	Selected Variables	Train R^2_{adj}	Train RMSE	Test R^2_{adj}	Test RMSE
Courage	DAT, KBT, OAT	0.0692	0.1748	−0.0205	0.1670	DAT, KBT, OAT	0.2569	0.1825	−0.1009	0.1735
Creativity	DAT, KBT	0.0558	0.1968	0.0326	0.1670	DAT, DBT, KBT	0.0528	0.1964	0.0875	0.1610
Curiosity	DAT, DBT, OAT, OBT	0.1010	0.1914	−0.1194	0.1978	DAT, DBT, OAT, OBT	0.2055	0.1941	−0.1546	0.2009
Justice	None	0.0000	0.2210	−0.0253	0.2266	None	0.0000	0.2210	−0.0253	0.2266
Forgiveness	None	0.0000	0.2225	−0.0431	0.2121	None	0.0000	0.2225	−0.0431	0.2121
Gratitude	DAT, OAT, OBT	0.2267	0.1920	−0.0082	0.2078	DAT, OAT, OBT	0.3026	0.1943	−0.1023	0.2172
Honesty	DAT, KBT, OAT	0.1046	0.1963	−0.1968	0.1741	DAT, KBT, OAT	0.0797	0.1971	−0.0991	0.1668
Hope	DAT, KAT, OAT	0.1016	0.1982	0.0107	0.1856	DAT, OAT, OBT	0.2036	0.2014	−0.1656	0.2014
Humor	DAT, KBT	0.0245	0.2376	−0.0013	0.2493	DAT	0.0167	0.2403	−0.0076	0.2519
Judgment	DAT	0.0194	0.1962	0.0029	0.1930	DAT	0.0542	0.1982	−0.0198	0.1952
Kindness	DAT, OAT	0.0807	0.1740	0.0613	0.1492	DAT, OAT	0.1245	0.1775	0.0122	0.1531
Leadership	DAT	0.0385	0.2304	0.0367	0.2313	DAT, OBT	0.1164	0.2298	−0.0483	0.2396
Love of Learning	DBT, OBT	0.0897	0.2143	0.0096	0.2235	DBT, OBT	0.2226	0.2186	0.0054	0.2240
Love	DAT, OAT	0.0635	0.2403	0.0528	0.1980	DAT, OAT	0.2658	0.2579	−0.0246	0.2059
Humility	KBT	0.0069	0.1786	−0.0151	0.1726	KBT	0.0061	0.1841	−0.0823	0.1782
Perseverance	DAT, DBT, OAT	0.0822	0.2130	−0.0446	0.2172	DAT, DBT, KAT	0.1498	0.2158	−0.0654	0.2194
Perspective	DBT, OBT	0.0459	0.1886	−0.0300	0.2057	DBT, OBT	0.1031	0.1899	−0.0759	0.2102
Prudence	DAT, KAT	0.0326	0.1961	0.0105	0.1830	DAT	0.0174	0.1999	0.0574	0.1798
Self-Regulation	DAT, KAT	0.0705	0.1986	−0.0144	0.2088	DAT, KAT	0.1272	0.2012	−0.0627	0.2137
Social Intelligence	DAT, KBT	0.0481	0.1990	0.0508	0.1786	DAT, KBT	0.1218	0.2005	0.0486	0.1788
Spirituality	DAT, OBT	0.1529	0.1944	−0.0234	0.2251	DAT, OBT	0.1544	0.1995	−0.0437	0.2273
Teamwork	DAT, OAT	0.1267	0.1881	−0.0551	0.1842	DAT, OAT	0.2372	0.1899	−0.1235	0.1901
Zest	DAT, OAT	0.1155	0.2358	0.0453	0.2389	DAT, OAT	0.2095	0.2375	0.0131	0.2429

3.3.1 ADJUSTED R^2

In non-robust models, the R^2_{adj} values tend to be relatively low and show a significant discrepancy between training and test data (e.g in Courage, the R^2_{adj} value in the training set is 0.0692 and drops to -0.0205 in the test set). This fluctuation suggests that the non-robust model has limited generalization ability on the test data, with an error that grows significantly outside the training set: this is likely due to overfitting, because the model is too closely fitted to the training data, losing its predictive ability on unseen data.

In the robust model, the R^2_{adj} values are generally higher in the training set, but there is a greater variation between the training and test data (e.g. in Courage, the value in the training set is 0.2569, but drops to -0.1009 in the test set. This suggests that while the robust model explains more of the variance in the training data, its ability to generalize is limited by the model: this could result from the model being more sensitive to test data, which may contain features not represented in the training data, and consequently struggle to adapt to new information, despite being robust against outliers and other distortions.

3.3.2 RMSE (Root Mean Squared Error)

In non-robust models, the RMSE values tend to be relatively low and stable between training and test data, with slight fluctuations (e.g for Courage, the RMSE in the training data is 0.1748 and 0.1670 in the test data). This small difference suggests that the non- robust model maintains a similar level of accuracy between the training and test data.

In the robust model, the RMSE values are generally very similar to those of the non-robust model, with a small difference between training and test data (e.g. for Courage, the RMSE in the training data is 0.1825 and 0.1735 in the test data). Although the robust model shows a slightly higher overall error compared to the non-robust model, the difference between training and test data is very similar, suggesting the model has a balanced generalization ability.

When comparing the adjusted R-squared and RMSE values between training and test data, it is clear that robust models generally show greater fluctuation in the adjusted R-squared values compared to non-robust models: this means that while robust models reduce the effect of outliers and errors in the training data, they may also struggle to generalize correctly in some situations, leading to test performance that can be inferior to the non- robust model.

In conclusion the non-robust model may seem more accurate on the training data but risks overestimating its predictive capacity and failing to generalize correctly on the test data, as evidenced by the low R^2_{adj} values and the high risk of overfitting. In contrast, the robust model tends to be more conservative and less influenced by outliers, but shows greater fluctuation in performance between training and test data, indicating that, while it is more robust against distortions, it may encounter difficulties in fully adapting to unseen data.

3.4 Robust Regression Outlier Analysis

Table 5: Outlier Detection Results

Target	Leverage	Residual	Leverage_Residual	Regular
Courage	18	3	-	154
Creativity	22	4	-	149
Curiosity	16	1	-	158
Gratitude	16	3	-	156
Honesty	18	2	1	154
Hope	15	2	1	157
Humor	4	-	-	171
Judgment	4	5	-	166
Kindness	14	4	-	157
Leadership	13	2	-	160
Love of Learning	5	3	-	167
Love	14	-	-	161
Humility	2	2	2	169
Perseverance	8	4	-	163
Perspective	4	3	1	167
Prudence	4	5	-	166
Self-Regulation	8	6	-	161
Social Intelligence	10	1	-	164
Spirituality	11	5	-	159
Teamwork	14	2	-	159
Zest	14	3	-	158

The outlier analysis performed after applying robust regression helped identify particularly significant observations in the data, divided into three main categories: leverage outliers, residuals outliers and leverage-residuals outliers.

Some targets, such as Creativity, Curiosity, and Honesty, show a high number of leverage outliers. These data points represent observations with predictor characteristics that deviate significantly from the norm. Although, thanks to robust regression, these observations no longer distort the model estimates, they remain relevant for interpretation. It is possible that these leverage outliers represent distinct subgroups or specific contexts within the general population, suggesting the need for further analysis to understand what factors make them so extreme.

Targets like Judgment, Self_Regulation, and Spirituality show a significant number of observations with residuals outliers. The robust nature of the model limits the influence of leverage outliers on these residuals, meaning these observations are likely difficult to explain with the current model. This could indicate missing variables or relationships between predictors and targets that are not properly modeled.

Some targets, such as Honesty, Hope, Humility, and Perspective, show critical outliers, which are observations that combine both leverage outliers and residuals outliers. These cases are particularly significant because they signal anomalies on multiple fronts: both in the predictors and in the target values. However, in our case, even after removing the observations identified as problematic, the performance and results of the regressions do not change. Therefore, we can conclude that robust regression effectively handles critical outliers.

In summary, the outlier analysis revealed both subgroups of observations with unique behaviors and potential gaps in the current model.

4 Clustering

4.1 Introduction

Various dimensionality reduction and clustering methodologies were employed to elucidate significant patterns and groupings within the dataset while minimizing the effects of noise and outliers. Initially, Principal Component Analysis (PCA) was utilized to decrease the dataset's dimensionality, retaining the first seven principal components based on their explained variance. Subsequently, two Gaussian-based clustering models were implemented: the non-robust Mclust model, which applied a mixture of Gaussian distributions to the PCA-reduced data and assessed cluster membership probabilities, and the robust Tclust model, which incorporated a trimming parameter to exclude the top 5% of anomalous observations, thereby diminishing the influence of outliers. The quality of these clustering solutions was evaluated using silhouette scores to measure cluster cohesion and separation.

Following this, Uniform Manifold Approximation and Projection (UMAP) was applied for dimensionality reduction, succeeded by non-robust K-means clustering and robust trimmed K-means clustering, the latter also removing 5% of outliers to enhance robustness. The clustering results were further assessed through multiple analyses, including the computation of average variable values within clusters, determination of cluster sizes, visualization of cluster separation via UMAP scatter plots, calculation of silhouette scores, and the generation of radar charts to illustrate the profiles of trimmed clusters based on average variable values.

4.2 Mclust

For the subsequent analysis, the first seven principal components obtained from PCA were selected, as the cumulative variance explained reached 0.6706.

A Gaussian Mixture Model (Mclust) was then applied to this PCA-reduced dataset. The model used a VVI (diagonal, varying volume and shape) parameterization, which allows for different covariance structures across the clusters. The model identified two clusters with the following results:

Metric	Value
Log-likelihood	-3077.164
BIC (Bayesian Information Criterion)	-6314.218
ICL (Integrated Completed Likelihood)	-6409.292

Table 6: Model Evaluation Metrics

Figure 2: Mclust Clustering Results

The clustering results from the Mclust method reveal two main clusters: Cluster 1 (in red), with 102 observations, and Cluster 2 (in blue), with 146 observations. The ellipses surrounding each cluster represent the density of the data points, and their shape suggests some overlap between the two clusters, particularly in the central area, indicating that the separation is not very distinct.

This overlap, combined with a low silhouette score of 0.081, suggests that although the Mclust model identifies two clusters, the grouping is not well-defined.

4.3   Tclust

After the Mclust model, a Tclust model was applied using the PCA-reduced data, with the number of clusters chosen based on the suggestion from Mclust. This robust clustering approach handles outliers.
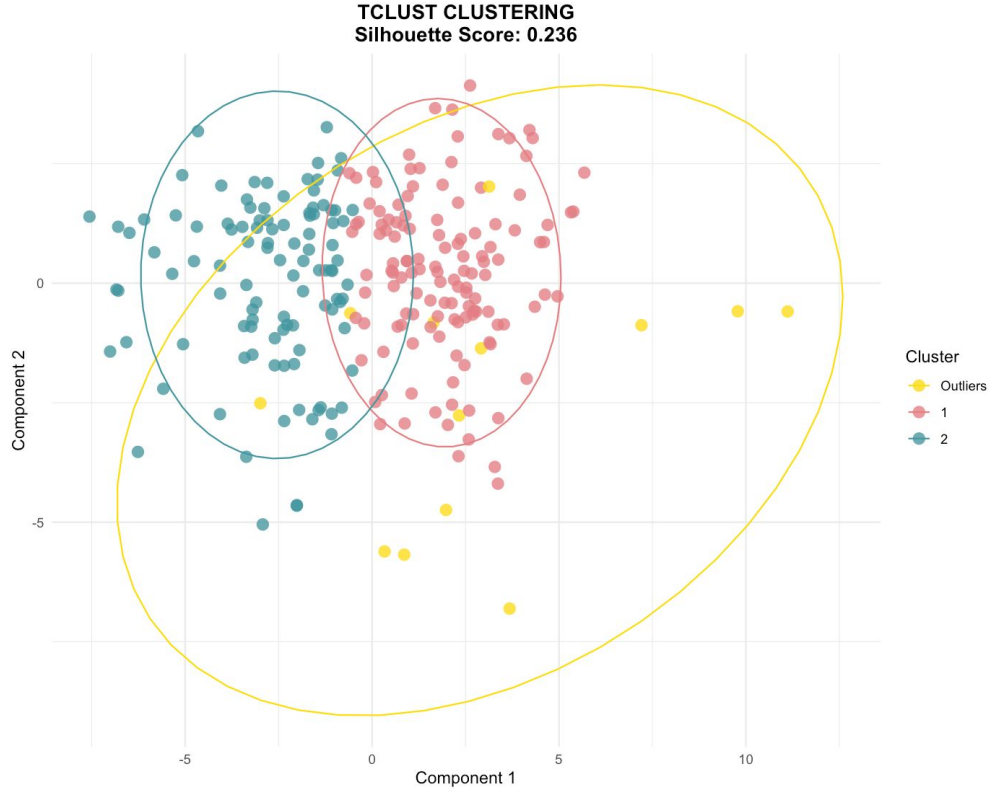
Figure 3: Tclust Clustering

The plot clearly shows two main clusters: Cluster 1 (in red) with 129 observations, and Cluster 2 (in blue) with 106 observations. They are separated by an ellipse indicating the density of the data within each cluster. The shape of the ellipses suggests that the clusters are not perfectly separated, and there is some overlap between the two groups, which explains the relatively low silhouette score (0.236).

Additionally, the outliers are represented by yellow points (13 outliers): these points have been identified by the model as observations that do not clearly belong to either of the two main clusters. The presence of these outliers suggests that some data points do not fit well with the cluster structure and may need to be treated separately.

4.4   UMAP and K-means

UMAP analysis was applied to the normalized data, resulting in dimensionality reduction from multiple variables to a two-dimensional plane. Next, K-means clustering with 3 centers was applied to identify distinct groups within the data projected into the UMAP plane.
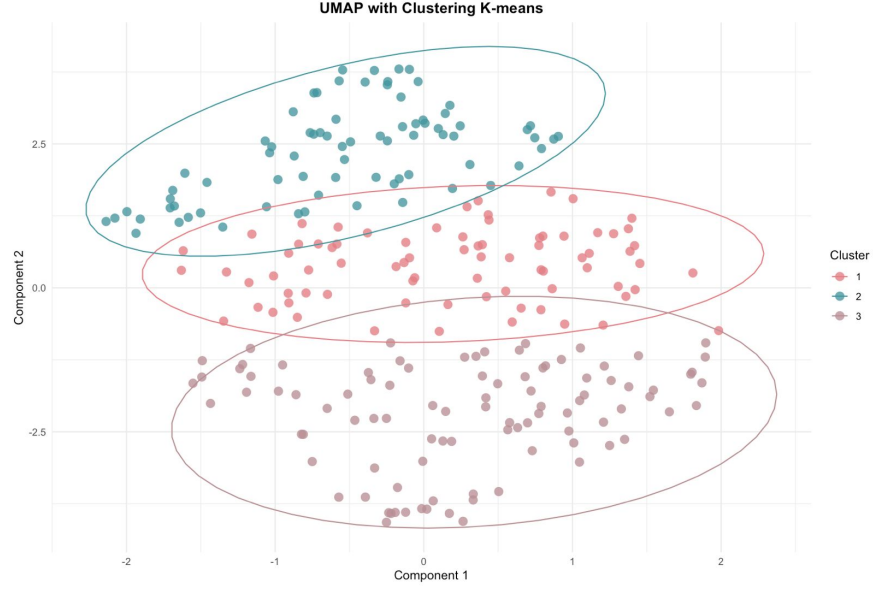
Figure 4: Non-Robust UMAP and K-means Clustering Results

The figure clearly shows how the three clusters are separated in the two-dimensional space: Cluster 1 (red) has 77 observations, Cluster 2 (blue) with 76 observations and Cluster 3 (gray) has 95 observations.

This visible separation suggests that K-means clustering identified distinct groups, but the visible overlap, that aligns with the Silhouette score of 0.402, suggests that while the clusters are distinct in many areas, some regions, particularly in the center, exhibit less clear boundaries between groups.

To further explore the characteristics of the clusters, a radar chart was analyzed, representing the averages for each variable based on the clusters as shown in Table 7.
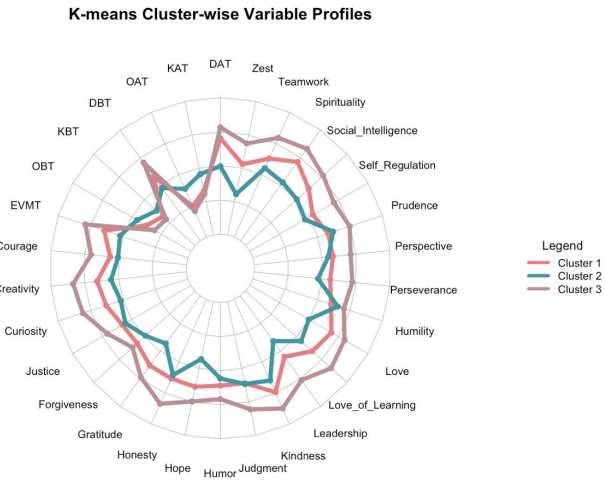

Figure 5: Radar Chart for Non-Robust UMAP/K-means Clustering

4.4.1 Cluster characteristics 7

Cluster 1   predominantly displays a democratic parenting style, particularly from their mothers, as shown by a high Democratic Mother score (DAT = 0.703), with minimal influence from authoritative parenting (OAT = 0.249). Fathers in this cluster also tend to adopt a democratic approach, as evidenced by a Democratic Father score (DBT = 0.583), while the authoritative influence from fathers (OBT = 0.377) is moderate. Both Strict Mother (KAT = 0.331) and Strict Father (KBT = 0.316) indicate a moderate level of strictness in their parenting styles. On the personal characteristics front, individuals demonstrate strong interpersonal virtues: Courage (0.562), Creativity (0.659), and Curiosity (0.630) are notably high, indicating a creative and inquisitive nature. Honesty (0.634) and Kindness (0.744) scores are also elevated, highlighting integrity and compassion. Hope (0.637) and Humor (0.609) suggest a positive and light-hearted disposition. However, Perseverance (0.560), Self-Regulation (0.533), and Zest (0.530) are comparatively lower, pointing to potential areas for personal development. Leadership (0.551) and Love of Learning (0.657) are moderately high, contributing to a balanced and motivated personality profile.

Cluster 2   is characterized by a balanced yet moderately democratic parenting style from both mothers and fathers: (DAT = 0.498) and (DBT = 0.477), indicating a moderate democratic approach. Authoritative influences are the highest among the clusters, with (OAT = 0.387) and (OBT = 0.456) along with Strictness, with (KAT = 0.456) and (KBT = 0.380). Personal traits show a well-rounded profile with strengths in Honesty (0.606), Judgment (0.616), and Prudence (0.620), reflecting reliability and sound decision-making abilities. Kindness (0.650) is also high, indicating a compassionate nature. Creativity (0.556) and Curiosity (0.518) are moderately strong, suggesting intellectual engagement. However, Hope (0.430), Perseverance (0.470), and Zest (0.305) are lower, indicating areas where individuals may seek further growth and resilience. Leadership (0.410) and Love of Learning (0.547) are present but not as pronounced, suggesting potential for development in these areas. Overall, Cluster 2 individuals appear well-integrated academically and personally, supported by balanced democratic parental influences.

Cluster 3   stands out with the highest levels of democratic parenting styles from both mothers and fathers: (DAT = 0.783) and (DBT = 0.708), indicating a very strong democratic approach. Authoritative influences are minimal, (OAT = 0.209) and (OBT = 0.308), and strictness is also low, with (KAT = 0.306) and (KBT = 0.286), reflecting a more permissive and supportive parenting environment. Personal characteristics are remarkably high across the board. Creativity (0.836), Curiosity (0.810), and Honesty (0.836) are exceptionally strong, indicating highly creative, inquisitive, and truthful individuals. Kindness (0.874) is the highest among all clusters, showcasing an outstanding level of compassion. Judgment (0.806) and Social Intelligence (0.765) are also significantly high, suggesting excellent decision-making and interpersonal skills. Additional strengths include Courage (0.703), Justice (0.707), Hope (0.747), and Perseverance (0.723), all of which contribute to a resilient and optimistic personality. Leadership (0.762) and Love of Learning (0.843) scores further emphasize strong motivational and educational engagement. Self-Regulation (0.712) and Spirituality (0.832) are also notably high, indicating well-developed self-control and spiritual awareness. Zest (0.684) reflects a lively and enthusiastic disposition. Overall, Cluster 3 individuals possess exceptional personal and interpersonal strengths, fostered by highly democratic and supportive parenting styles that promote comprehensive personal growth and well-being.

4.5 Robust UMAP and Trimmed K-means

A Trimmed K-means was then applied to manage outliers and improve the quality of the data segmentation, with a trimming of 5% (alpha = 0.05). The 5% of the observations furthest from the cluster centers were identified as outliers and removed from the clustering process.
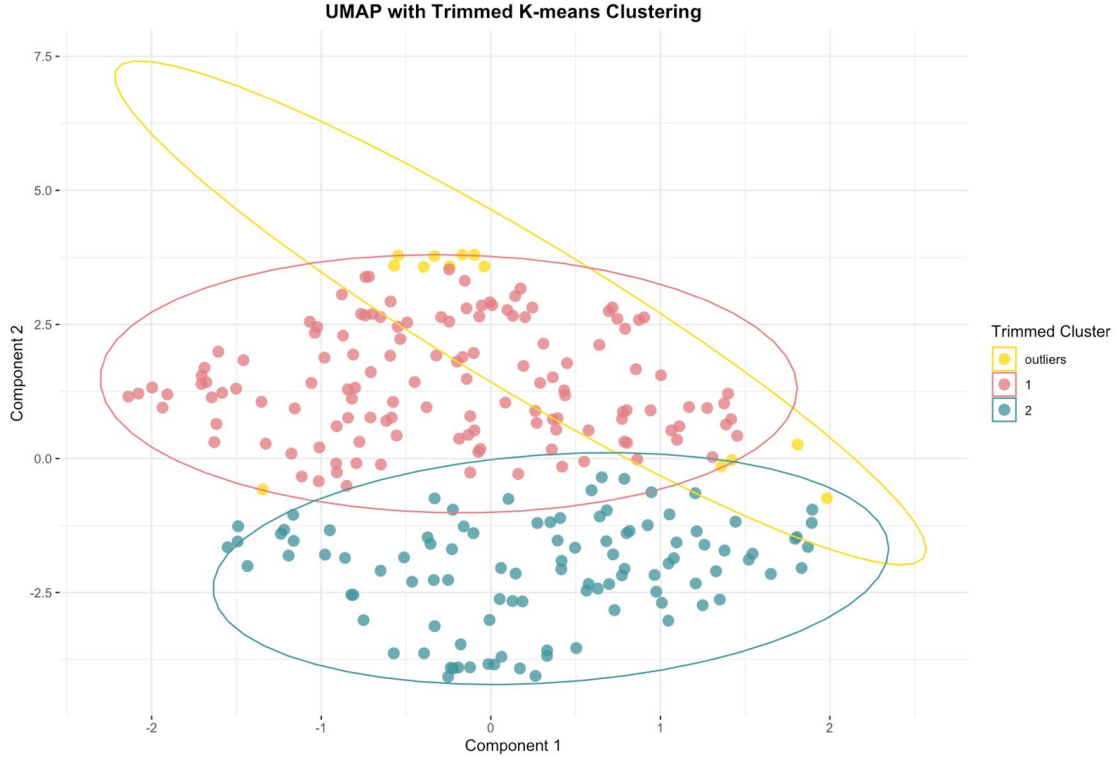

Figure 6: Robust UMAP and Trimmed K-means Clustering Results

Trimming the outliers led to a clearer separation between clusters, improving group definition and reducing overlap. The Silhouette of 0.368 indicates moderate separation, with some uncertainty in boundary regions between clusters.

The cluster sizes are relatively balanced: Cluster 1 with 133 observations, Cluster 2 with 102 observations, while the outlier group consists of 13 points. Trimmed K-means reduced the influence of outliers, increasing precision and providing clearer separation compared to the non-robust model. To further explore the characteristics of the clusters, a radar chart was analyzed, representing the averages for each variable based on the clusters as shown in Table 7.
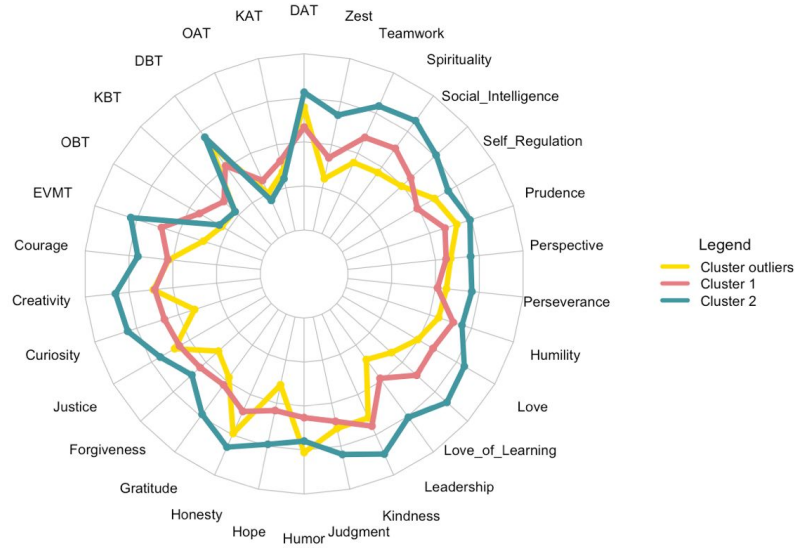
Figure 7: Radar Chart for Robust UMAP/Trimmed K-means Clustering

4.5.1 Cluster characteristics 7

Cluster 1 characterized by a moderately democratic parenting style and slightly stricter maternal approach: (DAT = 0.583) suggests a fair degree of maternal democracy, alongside a (KAT = 0.405), indicating more firmness than in the previous cluster, while the authoritative mother (OAT = 0.331) remains moderate, suggesting a balanced approach without a strong authoritative presence. Fathers in this cluster mirror a similar pattern, with (DBT = 0.509) and (OBT = 0.436), signifying a moderately directive yet democratic paternal style, and (KBT = 0.364), indicating a moderate degree of paternal strictness. In terms of personal characteristics, individuals in Cluster 1 show a well-rounded but not extreme profile. Kindness (0.696) is notably high, indicating compassionate behavior and empathy. Creativity (0.602), Curiosity (0.584), and Honesty (0.605) are all moderately strong, suggesting open-mindedness, inquisitiveness, and moral integrity. Hope (0.543) and Humor (0.566) point to a positive outlook, while Love of Learning (0.610) reveals a healthy appetite for knowledge. Perseverance (0.512), Self-Regulation (0.492), and Zest (0.425) are present but not pronounced, indicating areas where additional encouragement or personal effort might enhance resilience and enthusiasm. Spirituality (0.631) and Teamwork (0.598) also stand out as relatively robust traits, suggesting a connection to meaning-making and cooperative interaction.

Cluster 2 is distinguished by strongly democratic parenting styles, especially on the maternal side: (DAT = 0.781) is notably high, accompanied by low (KAT = 0.303) and (OAT = 0.207) scores. Fathers reflect a similarly democratic style, with (DBT = 0.709) and relatively low (KBT = 0.278) and (OBT = 0.306) values, reinforcing a parenting style centered on guidance rather than control. In this supportive environment, individuals in Cluster 2 have the highest values like for Creativity (0.827), Curiosity (0.803), Honesty (0.826),

Judgment (0.798), Kindness (0.869), Learning (0.840), Leadership (0.757), etc.

Outliers exhibit high levels of democratic parenting and low levels of strict and authoritative parenting, like Cluster 2. However their personal characteristics tend to have lower scores compared to those in Cluster 2 (expect for Humor).

Table 7: Mean values of variables by cluster under K-means and Trimmed K-means

Variable	K-means			Trimmed K-means		
	C1	C2	C3	C1	C2	Outliers
DAT	0.703	0.498	0.783	0.583	0.781	0.698
KAT	0.331	0.456	0.306	0.405	0.303	0.342
OAT	0.249	0.387	0.209	0.331	0.207	0.251
DBT	0.583	0.477	0.708	0.509	0.709	0.651
KBT	0.316	0.380	0.286	0.364	0.278	0.281
OBT	0.377	0.456	0.308	0.436	0.306	0.289
EVMT	0.646	0.523	0.791	0.602	0.785	0.352
Courage	0.562	0.505	0.703	0.528	0.700	0.522
Creativity	0.659	0.556	0.836	0.602	0.827	0.611
Curiosity	0.630	0.518	0.810	0.584	0.803	0.404
Justice	0.580	0.555	0.707	0.567	0.693	0.599
Forgiveness	0.571	0.489	0.616	0.544	0.608	0.405
Gratitude	0.630	0.431	0.739	0.529	0.735	0.476
Honesty	0.634	0.606	0.836	0.605	0.826	0.741
Hope	0.637	0.430	0.747	0.543	0.739	0.394
Humor	0.609	0.557	0.708	0.566	0.699	0.764
Judgment	0.610	0.616	0.806	0.606	0.798	0.647
Kindness	0.744	0.650	0.874	0.696	0.869	0.644
Leadership	0.551	0.410	0.762	0.483	0.757	0.351
Love_of_Learning	0.657	0.547	0.843	0.610	0.840	0.418
Love	0.691	0.499	0.801	0.595	0.800	0.495
Humility	0.604	0.655	0.702	0.641	0.692	0.553
Perseverance	0.560	0.470	0.723	0.512	0.708	0.562
Perspective	0.581	0.545	0.711	0.561	0.701	0.587
Prudence	0.580	0.620	0.747	0.591	0.741	0.662
Self_Regulation	0.533	0.466	0.712	0.492	0.694	0.606
Social_Intelligence	0.622	0.505	0.765	0.564	0.758	0.495
Spirituality	0.713	0.528	0.832	0.631	0.825	0.462
Teamwork	0.630	0.554	0.796	0.598	0.793	0.442
Zest	0.530	0.305	0.684	0.425	0.672	0.303

5   Conclusion

In conclusion, this study provides empirical evidence that parenting styles - particularly democratic approaches - can exert meaningful influence on the psychological profiles of university students. Across both descriptive and inferential analyses, democratic maternal and paternal attitudes consistently aligned with a broad range of positive character strengths, such as curiosity, creativity, hope, honesty, gratitude, and social intelligence. By contrast, strict parenting styles were associated with more mixed or limited benefits, often fostering traits like prudence or perseverance at the expense of optimism or openness, while authoritative influences had moderate and context-specific effects.

The regression analyses, both non-robust and robust, underscored the pivotal role of a democratic maternal environment in nurturing well-rounded personal qualities, and similarly highlighted the importance of a democratic paternal style. Although authoritative and strict styles sometimes contributed to developing certain strengths - such as creativity or self-regulation - their influence appeared more constrained and less predictably beneficial. Robust analytical methods confirmed these patterns, demonstrating that the observed relationships remained stable even after accounting for outliers and data irregularities.

Clustering analyses, integrating both dimensionality reduction and robust clustering methods, further illustrated that students with more democratic parenting backgrounds clustered together, sharing consistently higher levels of a wide range of positive attributes. In contrast, less supportive or more rigid parental approaches generally corresponded to clusters of students whose traits were less pronounced or more narrowly developed.

Collectively, the results emphasize that democratic parenting styles serve as fertile ground for cultivating personal strengths critical to academic success, emotional well-being, and social engagement. These insights hold practical value for parents, educators, and policymakers, pointing to the significance of fostering open communication, empathy, and guided autonomy within the family context. In doing so, caregivers and institutions can help shape more resilient, curious, and morally grounded future generations, better prepared to face the challenges and opportunities of the university environment and beyond.