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Identifying Profiles of Adolescent Flourishing Through Unsupervised Machine Learning and Variables Including Self-Compassion, Meaning in Life, Digital Wellbeing, Gratitude, and Peer Support

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1. Round 1

1.1. Reviewer 1

Reviewer:

The paragraph beginning with “Recent evidence suggests that flourishing in adolescence is strongly influenced by positive psychological resources” lacks sufficient theoretical integration between self-compassion and flourishing. While empirical associations are reviewed, the manuscript would benefit from a clearer mechanistic explanation regarding how self-compassion theoretically contributes to flourishing trajectories during adolescence. For example, the authors may discuss whether self-compassion functions as an emotion regulation strategy, resilience factor, or metacognitive coping process within positive developmental systems theory.

The paragraph discussing “Meaning in life has also been recognized as a central dimension of flourishing” requires stronger differentiation between the “presence of meaning” and “search for meaning” dimensions. Because the Meaning in Life Questionnaire includes theoretically distinct subscales, collapsing these dimensions into a global interpretation may obscure important developmental distinctions. Adolescents actively searching for meaning may not necessarily exhibit flourishing at the same level as those already experiencing existential coherence. The authors should justify why both dimensions were combined analytically during clustering procedures.

The sentence “Digital wellbeing has consequently become an essential component of contemporary adolescent flourishing research” raises an important issue; however, the manuscript does not sufficiently define digital wellbeing conceptually. The authors should clarify whether digital wellbeing is being treated as a behavioral construct, a subjective emotional experience related to technology use, or a multidimensional psychosocial adaptation process. Additionally, the construct overlaps substantially with problematic internet use and media regulation research, yet the distinctions are not adequately explained.

The paragraph beginning with “Machine learning methods, particularly unsupervised learning techniques” overstates the novelty of machine learning integration without sufficiently acknowledging limitations associated with clustering algorithms in psychological research. The authors should discuss known concerns including cluster instability, sensitivity to initialization, algorithmic arbitrariness, and the risk of imposing artificial subgroup structures on continuous psychological phenomena. Without such discussion, the methodological framing appears overly optimistic.

In the Methods section, the sentence “The statistical population consisted of high school students enrolled in public secondary schools in Toronto, Vancouver, Montreal, Calgary, and Ottawa” requires additional detail regarding school selection procedures. The manuscript states that multistage cluster sampling was used, but the exact number of school districts, schools, and classrooms selected is not reported. This omission limits reproducibility and raises concerns regarding representativeness and sampling bias.

The inclusion criteria paragraph states that participants with “incomplete questionnaire responses exceeding 15% of total items were excluded.” The rationale for selecting the 15% threshold is not justified. The authors should explain whether this cutoff was based on prior psychometric recommendations or empirical missing-data diagnostics. Additionally, it is unclear how many cases were excluded specifically due to missingness versus multivariate outlier detection.

The Measures section contains a significant methodological issue regarding the operationalization of “peer support.” The manuscript states that peer support was assessed using “the peer subscale of the Multidimensional Scale of Perceived Social Support developed by Zimet et al. (1988).” However, the MSPSS traditionally contains family, friend, and significant other dimensions rather than a dedicated “peer support” subscale. The authors should clarify exactly which items were used and justify the adaptation terminology to avoid construct misrepresentation.

The description of the Digital Wellbeing Scale for Adolescents requires more psychometric detail. Specifically, the authors should report whether the instrument has been validated previously within Canadian adolescent populations. Because digital wellbeing is culturally sensitive and strongly shaped by technological ecosystems, evidence of cross-cultural measurement validity is necessary before drawing conclusions regarding flourishing profiles among Canadian adolescents.

The Data Analysis section states that “all variables were standardized using z-score normalization.” However, the manuscript does not report whether outliers were winsorized or otherwise treated before standardization. Since clustering methods are highly sensitive to extreme values, failure to manage influential observations may substantially distort centroid formation and cluster boundaries.

The sentence “Hierarchical agglomerative clustering was first conducted to estimate the optimal number of clusters” requires additional methodological transparency. The manuscript does not specify which linkage method was used (e.g., Ward’s, average linkage, complete linkage), nor does it explain why that linkage criterion was selected. Because different linkage methods can produce substantially different dendrogram structures, this omission is methodologically important.

In Table 3, the manuscript reports highly significant F-values and large partial eta squared statistics across all variables. However, because flourishing itself was included both as a clustering variable and as an outcome in profile comparisons, the analysis risks circularity. The authors should clarify whether flourishing scores were used during cluster formation. If so, reporting flourishing differences between clusters as independent findings becomes tautological.

The paragraph interpreting the t-SNE visualization states that “meaning in life, gratitude, and self-compassion contributed strongly to cluster separation.” This conclusion is problematic because t-SNE is primarily a visualization technique and does not provide inferential evidence regarding variable importance. The authors should avoid causal or contribution-oriented interpretations unless supported by formal feature importance analyses or discriminant modeling.

Authors uploaded the revised manuscript.

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1.2. Reviewer 2

Reviewer:

The manuscript states that "K-means clustering was implemented using Euclidean distance metrics and iterative centroid optimization procedures," yet there is no discussion of the algorithm initialization strategy. The authors should clarify whether k-means++ initialization was used and report the number of random starts performed to reduce the likelihood of local minima influencing cluster solutions.

The statement "Cluster stability was further evaluated through bootstrapped resampling procedures and split-sample validation" is insufficiently detailed. The manuscript does not provide the number of bootstrap iterations, stability coefficients, or agreement statistics (e.g., adjusted Rand index). Since cluster reproducibility is central to the credibility of person-centered analyses, the authors must report these indices explicitly rather than referencing stability procedures generically.

Table 1 presents correlations among study variables, but the manuscript does not report confidence intervals for the correlation coefficients. Given the large sample size and the manuscript's emphasis on precision, reporting 95% confidence intervals would improve statistical transparency and allow readers to evaluate estimate stability more rigorously.

In the Results section, the sentence "Preliminary data screening indicated that skewness and kurtosis values for all study variables fell within the acceptable range of ±2" is statistically oversimplified. The authors should provide exact skewness and kurtosis values for each variable or include them in a supplementary table. Furthermore, relying solely on ±2 cutoffs may not sufficiently establish multivariate normality assumptions relevant to MANOVA procedures.

The interpretation of Table 2 requires greater caution. Although the three-cluster solution demonstrated superior statistical fit indices, silhouette coefficients around 0.53 generally indicate moderate rather than strong separation. The manuscript repeatedly describes the profiles as "clear" and "distinct," which may overstate the actual discriminative precision of the clustering solution. More balanced language is recommended.

The labels "High Flourishing Adaptive Profile," "Moderate Flourishing Vulnerable Profile," and "Low Flourishing At-Risk Profile" appear somewhat interpretively loaded and potentially stigmatizing. Particularly, the term "At-Risk" implies clinically elevated vulnerability despite the absence of psychopathology measures in the study. The authors should justify the naming conventions more carefully or consider more descriptive, less pathologizing terminology.

Authors uploaded the revised manuscript.

2. Revised

Editor's decision after revisions: Accepted.
Editor in Chief's decision: Accepted.

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