

Uncovering Learner Heterogeneity Through Latent Class Analysis: Evidence from Elementary Pupils in the Philippines

Starr Clyde L. Sebial

Professor of Mathematics Education, School of Teacher Education, J. H. Cerilles State College
San Miguel, Zamboanga del Sur, Philippines

Abstract

Introduction: Learners from economically disadvantaged communities are often treated as a homogeneous population despite differences in their academic performance and household circumstances. Identifying distinct learner profiles based on academic and socio-demographic characteristics provides a more comprehensive understanding of learner heterogeneity and supports the development of targeted educational interventions.

Objectives: This study aimed to identify latent class profiles among elementary pupils based on their academic performance and household socio-demographic characteristics using Latent Class Analysis (LCA).

Methods: A cross-sectional quantitative design employing a person-centered analytical approach was utilized. The participants comprised 76 elementary pupils from a public elementary school in Margosatubig, Zamboanga del Sur, Philippines. Academic performance data and household socio-demographic information were obtained from official school and barangay records. Latent Class Analysis was performed using Latent GOLD 6.0 to identify homogeneous learner profiles based on academic performance and household characteristics.

Results: The analysis supported a five-class solution, demonstrating excellent model fit and classification quality. Five distinct latent class profiles were identified: Academically Stable Learners (38.8%), Supported Learners (22.9%), Resilient Learners (17.3%), Highly Vulnerable Learners (14.2%), and Exceptional Achievers (6.8%). The profiles revealed substantial heterogeneity among learners, showing that socioeconomic disadvantage did not uniformly correspond to lower academic achievement. While one profile exhibited multiple household disadvantages alongside lower academic performance, other profiles demonstrated consistently high academic achievement despite experiencing socioeconomic constraints.

Conclusions: The findings demonstrate the usefulness of Latent Class Analysis in uncovering meaningful learner heterogeneity that may remain undetected using conventional variable-centered approaches. The identified latent class profiles provide evidence for designing profile-responsive educational, and social interventions tailored to the diverse needs of elementary learners. Future research involving larger and more diverse populations is recommended to further validate the identified learner profiles.

Keywords: latent class analysis; learner heterogeneity; elementary pupils; academic performance; socio-demographic characteristics; person-centered approach

1. Introduction

Educational achievement during the elementary years provides the foundation for lifelong learning, human capital development, and social mobility. Despite significant global efforts to improve access to basic education, disparities in learning outcomes remain evident, particularly among children from socioeconomically disadvantaged communities. Increasing evidence suggests that children's

academic achievement is shaped not only by school-related experiences but also by a complex interaction of household socioeconomic conditions, and the quality of their home environment. Consequently, understanding how these factors collectively influence learning has become a major concern in educational research and policy, particularly in low- and middle-income countries where socioeconomic inequalities remain pronounced (Black et al., 2013; OECD, 2023).

In the Philippines, educational inequality continues to present a significant challenge despite sustained investments in basic education and social protection. Results from the Programme for International Student Assessment (PISA) 2022 indicate that Filipino learners continue to perform below the OECD average in mathematics, reading, and science. Nevertheless, the findings also demonstrate that a proportion of socioeconomically disadvantaged Filipino students achieve relatively high academic performance, suggesting that poverty alone does not determine educational success. This observation highlights the existence of diverse developmental pathways among learners and underscores the need to examine educational outcomes beyond simple socioeconomic comparisons (OECD, 2023).

To reduce educational disparities associated with poverty, the Philippine government has implemented social protection initiatives such as the Pantawid Pamilyang Pilipino Program (4Ps), which provides conditional cash transfers to economically disadvantaged households. Previous evaluations have shown that the program contributes positively to school attendance and educational participation. However, considerable variation in academic performance remains evident among both beneficiaries and non-beneficiaries, indicating that financial assistance alone cannot fully explain differences in learning outcomes. Rather, children's academic achievement appears to reflect the interaction of multiple household, environmental, and individual factors operating simultaneously.

The present study is conceptually anchored on Maslow's Hierarchy of Needs (Maslow, 1943), Piaget's Cognitive Development Theory (Piaget, 1952), and Bronfenbrenner's Ecological Systems Theory (Bronfenbrenner, 1979). Collectively, these perspectives propose that children's learning is influenced by the fulfillment of basic physiological needs, developmental readiness, and continuous interactions among family, school, and community environments. Taken together, these theories provide a comprehensive framework for understanding how socioeconomic, and environmental conditions interact to shape academic achievement.

Although numerous studies have investigated the relationships among socioeconomic status, and academic performance, most have relied on variable-centered analytical approaches, such as correlation, regression, and comparative analyses. These methods estimate average relationships across populations and generally assume that learners are relatively homogeneous. While informative, such approaches may conceal meaningful differences among learners who exhibit similar academic outcomes despite experiencing markedly different household and environmental conditions. Increasingly, educational researchers have advocated person-centered approaches because they recognize learner heterogeneity and identify subgroups of individuals who share similar developmental characteristics.

Among these approaches, Latent Class Analysis (LCA) offers a robust model-based framework for identifying unobserved subgroups of individuals based on shared response patterns across multiple categorical indicators (Collins & Lanza, 2010; Nylund-Gibson & Choi, 2018). Rather than focusing solely on relationships among variables, LCA identifies meaningful learner profiles that reflect the multidimensional nature of children's educational experiences. Such profiles provide a richer understanding of learner diversity and generate evidence that can support more targeted educational, and social interventions.

Despite the growing application of person-centered methodologies internationally, studies employing Latent Class Analysis to simultaneously examine household socioeconomic conditions, and academic performance among Filipino elementary pupils remain limited. Existing Philippine research has predominantly examined these variables independently, providing limited evidence regarding how multiple educational and household characteristics combine to form distinct learner profiles. Addressing this gap is important because interventions based solely on average population characteristics may overlook learners who require different forms of educational, and social support.

Accordingly, this study employed Latent Class Analysis to identify latent learner profiles based on socio-demographic conditions, and academic performance among elementary pupils in a public

elementary school in the Philippines. By identifying hidden patterns of learner heterogeneity, the study contributes to the growing application of person-centered methodologies in educational research and demonstrates how Latent Class Analysis can inform evidence-based educational planning for learners experiencing diverse household circumstances.

2. Objectives

This study aimed to identify latent learner profiles among elementary pupils based on their socio-demographic conditions and academic performance using Latent Class Analysis (LCA). Specifically, the study sought to:

1. Describe the socio-demographic characteristics, and academic performance of the participating elementary pupils.
2. Identify and characterize the latent learner profiles based on socio-demographic, and academic indicators.
3. Examine the educational implications of the identified learner profiles for informing targeted educational, and social interventions.

3. Methods

3.1 Research Design

This study employed a cross-sectional quantitative research design using a person-centered analytical approach through Latent Class Analysis (LCA). Unlike variable-centered statistical techniques that estimate relationships among variables across an entire population, LCA identifies unobserved subgroups of individuals who exhibit similar response patterns across multiple indicators (Collins & Lanza, 2010; Nylund-Gibson & Choi, 2018). The approach was selected to uncover distinct learner profiles based on combinations of household socio-demographic characteristics and academic performance., thereby providing a more comprehensive understanding of learner heterogeneity.

3.2 Research Setting and Participants

The study was conducted in a public elementary school in Margosatubig, Zamboanga del Sur, Philippines, a predominantly rural municipality where agriculture serves as the primary livelihood of many households. The community is

characterized by varying socioeconomic conditions, making it an appropriate setting for examining the interaction among household circumstances, and pupils' academic performance.

The participants consisted of 76 elementary pupils who satisfied the inclusion criteria established for the study. Complete enumeration was employed to include all eligible pupils within the target population. Socio-demographic information was obtained from official records maintained by the barangay office and was verified using school records maintained by the respective class advisers. Academic performances were likewise obtained from official school records to ensure the accuracy and consistency of the collected information.

3.3 Measures

Two groups of indicators were included in the latent class model. Academic performance was represented by pupils' final grades in English and Mathematics, which were obtained from official school records. Grades were categorized according to the performance descriptors prescribed by the Philippine Department of Education.

Socio-demographic conditions included household participation in the Pantawid Pamilyang Pilipino Program (4Ps), monthly family income, household water supply, toilet facilities, dwelling type, household waste management practices, and selected household characteristics documented in barangay records and verified using school records.

These indicators were selected because they represent key dimensions of children's educational, and household environments that have been consistently associated with academic achievement in previous studies.

3.4 Data Collection Procedure

Prior to data collection, approval to conduct the study was obtained from the school administration. Coordination was likewise established with barangay officials and class advisers to facilitate access to the necessary records. Parents or legal guardians were informed of the purpose and procedures of the study, after which written informed consent was obtained. Assent was likewise secured from all participating pupils.

Socio-demographic information was retrieved from official barangay records and cross-validated using school records maintained by the class advisers. Academic performance data were obtained from pupils' official class records. All data were examined for completeness and consistency before encoding and statistical analysis.

3.5 Ethical Considerations

The study adhered to the ethical principles of respect for persons, beneficence, and justice throughout the research process. Permission to conduct the study was obtained from the school administration, class advisers, and the concerned barangay officials. Written informed consent was secured from parents or legal guardians, while assent was obtained from the participating pupils before any data were collected.

Participation was voluntary, and respondents were informed of their right to decline participation or withdraw from the study at any time without consequence. To protect confidentiality, all personal identifiers were removed prior to data processing, and the information collected was used solely for research purposes. Access to the dataset was restricted to the research team, and all records were handled in accordance with established ethical standards for educational research.

3.6 Data Analysis

Descriptive statistics, including frequencies, percentages, means, and standard deviations where appropriate, were used to summarize the socio-demographic characteristics, and academic performance of the participants.

Latent Class Analysis (LCA) was performed using Latent GOLD to identify homogeneous learner profiles based on multiple categorical indicators. Competing models specifying different numbers of latent classes were estimated and compared. The optimal latent class solution was selected based on a combination of statistical fit indices and substantive interpretability. Model fit was evaluated using the log-likelihood (LL), Bayesian Information Criterion (BIC), sample-size adjusted Bayesian Information Criterion (SABIC), entropy (R^2), classification error, and the Vuong–Lo–Mendell–Rubin likelihood ratio test (VLMR), following recommended practices for latent class

modeling (Collins & Lanza, 2010; Nylund-Gibson & Choi, 2018).

After selecting the optimal model, posterior class membership probabilities were used to assign each pupil to the latent class with the highest probability of membership. The resulting latent learner profiles were subsequently characterized according to their socio-demographic conditions, and academic performance to facilitate interpretation and inform the educational implications of the findings.

4. Results

4.1 Participant Characteristics

The study involved 76 elementary pupils enrolled in a public elementary school in Margosatubig, Zamboanga del Sur, Philippines. Overall, the participants demonstrated generally satisfactory academic performance in both English and Mathematics, with most pupils obtaining grades within the satisfactory to outstanding performance levels. Nevertheless, variations in academic achievement remained evident across learners, indicating differences in educational outcomes despite their shared school environment.

The participants predominantly came from socioeconomically disadvantaged households. More than half (57.9%) were beneficiaries of the Pantawid Pamilyang Pilipino Program (4Ps), while the majority (77.6%) reported a monthly household income ranging from ₱8,000 to ₱9,000. Household conditions also varied with respect to dwelling type, access to safe water, sanitation facilities, and environmental practices, reflecting the diverse living environments experienced by the pupils. These findings suggest that although the participants belonged to the same school community, they were exposed to different household and socioeconomic circumstances that could potentially influence their educational experiences.

Taken together, the observed variation in academic performance and household socio-demographic conditions indicates that the study population was not homogeneous. Rather than assuming that all pupils shared similar educational and environmental characteristics, these differences provided a strong rationale for employing Latent

Class Analysis (LCA) to identify distinct learner profiles based on multiple interacting indicators. By adopting this person-centered approach, the study sought to uncover meaningful subgroups of learners that may not be evident through conventional variable-centered analyses, thereby providing a more nuanced understanding of learner diversity and informing more targeted educational, and social interventions.

4.2 Identification of the Latent Class Profiles

To examine the heterogeneity of learners based on their academic performance and household socio-demographic characteristics, Latent Class Analysis (LCA) was performed using Latent GOLD 6.0. The analysis identified a five-class solution as the optimal representation of the study population. Model selection was based on statistical fit, classification quality, and substantive interpretability, consistent with recommended practices in latent class modeling (Collins & Lanza, 2010; Nylund-Gibson & Choi, 2018).

The selected model demonstrated excellent statistical performance, yielding a log-likelihood (LL) of -550.25, a sample-size adjusted Bayesian Information Criterion (SABIC) of 1170.04, and a Bayesian Information Criterion based on L^2 [$BIC(L^2)$] of 397.38. Comparison with competing models further indicated that the five-class solution significantly improved model fit over the four-class solution, as evidenced by the significant Vuong–Lo–Mendell–Rubin likelihood ratio test ($aVLMR = 27.57, p = .0048$) and the corresponding Z-statistic ($p = .0309$). The model likewise demonstrated excellent classification quality, with a classification error of 0.0214, entropy (R^2) of 0.9475, and a dissimilarity index of 0.8825, indicating clear

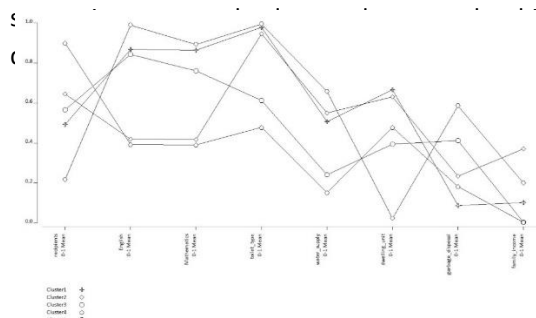


Figure 1. Profile plot of the identified latent class profiles across academic and household socio-demographic indicators

Figure 1 illustrates the profile plot of the five latent classes across the study indicators. The varying trajectories demonstrate distinct combinations of academic performance and household socio-demographic characteristics, confirming that the participating pupils were not a homogeneous population. While some latent classes exhibited consistently favorable academic and household characteristics, others reflected multiple socioeconomic and environmental disadvantages. Interestingly, certain latent classes demonstrated high academic performance despite less favorable household conditions, suggesting that learner outcomes cannot be explained solely by socioeconomic circumstances.

These distinct response patterns formed the basis for assigning descriptive labels to each latent class according to their dominant academic and household characteristics. The identified latent class profiles and their defining characteristics are presented in Table 1.

Table 1. Identified Latent Class Profiles

Latent Class	Latent Learner Profile	Defining Characteristics
Class 1	Academically Stable Learners	High academic performance with relatively favourable household conditions.
Class 2	Supported Learners	Moderate academic performance with high 4Ps participation and modest household resources.
Class 3	Resilient Learners	High academic performance despite

		socioeconomic disadvantages.
Class 4	Highly Vulnerable Learners	Low academic achievement accompanied by multiple socioeconomic and environmental disadvantages.
Class 5	Exceptional Achievers	Outstanding academic performance despite severe housing deprivation and limited social assistance.

4.3 Characterization of the Identified Latent Class Profiles

Table 1 presents the five identified latent class profiles and their defining characteristics, while Figure 1 illustrates the corresponding response patterns across the academic and household indicators included in the latent class model. Together, these results demonstrate that the participating pupils formed distinct latent class profiles characterized by different combinations of academic performance and household socio-demographic conditions. The identified profiles varied in terms of academic achievement, household resources, sanitation, water supply, dwelling type, waste management practices, family income, and participation in the Pantawid Pamilyang Pilipino Program (4Ps), indicating considerable heterogeneity within the study population.

Academically Stable Learners (Class 1). This latent class comprised 38.8% of the participants, making it the largest identified profile. Pupils in this class consistently demonstrated high academic performance in both English and Mathematics, with most obtaining grades within the 85–95 range. Household conditions were generally more favorable than those observed in the other latent

class profiles, including higher probabilities of residing in permanent or semi-permanent dwellings, access to improved sanitation facilities, relatively better water supply, and proper waste management practices. Approximately half of the households were beneficiaries of the Pantawid Pamilyang Pilipino Program (4Ps).

Supported Learners (Class 2). Representing 22.9% of the participants, this latent class was characterized by moderate academic performance, with most pupils obtaining grades within the 80–84 range in both English and Mathematics. This profile exhibited the highest proportion of 4Ps beneficiaries among the larger latent classes and was associated with modest household resources, including predominantly low household income, wooden dwellings, and access to improved sanitation and Level 2 water supply.

Resilient Learners (Class 3). This latent class accounted for 17.3% of the participants. Despite experiencing comparatively less favorable household conditions, including lower household income, limited access to improved water sources, and less durable housing materials, pupils within this profile demonstrated consistently high academic performance in both English and Mathematics. More than half of the households were beneficiaries of the 4Ps program.

Highly Vulnerable Learners (Class 4). Comprising 14.2% of the participants, this profile exhibited the lowest academic performance among the identified latent classes. The profile was characterized by multiple household disadvantages, including the highest proportion of 4Ps beneficiaries, predominantly low household income, limited access to improved sanitation facilities and water supply, and poorer housing conditions compared with the other latent class profiles.

Exceptional Achievers (Class 5). This latent class represented the smallest proportion of the participants (6.8%) but demonstrated the highest academic performance in both English and Mathematics. Despite the high prevalence of makeshift dwellings and comparatively lower participation in the 4Ps program, households within this profile generally exhibited relatively favourable access to sanitation facilities and improved water

supply compared with the other disadvantaged profiles.

Overall, the five latent class profiles illustrate distinct combinations of academic performance and household socio-demographic characteristics among elementary pupils. While some profiles demonstrated consistently favourable academic and household conditions, others combined socioeconomic disadvantage with either moderate or high academic achievement, whereas one profile exhibited multiple household disadvantages alongside comparatively lower academic performance. These distinct patterns provide the empirical basis for the discussion of the educational implications of the identified latent class profiles.

5. Discussion

5.1 Learner Heterogeneity Beyond Socioeconomic Status

The latent class analysis demonstrated that elementary pupils cannot be adequately characterized using a single socioeconomic or academic profile. Instead, the analysis identified five distinct latent class profiles representing different combinations of academic performance and household socio-demographic characteristics. This finding supports the value of person-centered analytical approaches, which recognize that learners experience diverse educational pathways even within the same school and community context (Collins & Lanza, 2010; Nylund-Gibson & Choi, 2018).

One of the most important findings was that socioeconomic disadvantage did not uniformly correspond to lower academic achievement. While the Highly Vulnerable Learners exhibited both household disadvantage and relatively poor academic performance, the Resilient Learners and Exceptional Achievers demonstrated high academic performance despite limited household resources. These contrasting profiles indicate that learners respond differently to similar socioeconomic circumstances, emphasizing that educational outcomes emerge from the interaction of multiple household, environmental, and individual factors rather than economic status alone.

This finding is consistent with Bronfenbrenner's Ecological Systems Theory (1979), which posits that

children's development results from dynamic interactions among family, school, and community environments. Rather than acting independently, these ecological systems collectively shape learners' opportunities for academic success. The identified latent class profiles therefore illustrate the complexity of children's educational experiences and reinforce the importance of examining multiple contextual factors simultaneously.

5.2 The Role of Household Conditions and Social Protection

The findings also demonstrate that favourable household conditions were generally associated with stronger academic performance. The Academically Stable Learners, who represented the largest latent class, were characterized by comparatively better housing conditions, improved sanitation, and more stable household environments alongside consistently high academic achievement. Likewise, the Supported Learners exhibited moderate academic performance despite limited household resources and represented the highest proportion of beneficiaries of the Pantawid Pamilyang Pilipino Program (4Ps).

These findings suggest that household resources and social protection may provide conditions that support children's educational participation. Previous evaluations of the 4Ps have shown improvements in school attendance, educational participation, and child welfare among beneficiary households (Reyes et al., 2013; Garcia & Enriquez, 2018). The present findings extend this evidence by demonstrating that learners receiving government assistance do not constitute a homogeneous group but instead belong to distinct latent class profiles characterized by varying combinations of educational and household conditions.

The results further align with Maslow's Hierarchy of Needs (Maslow, 1943), which proposes that physiological and safety needs provide the foundation for higher-order learning. Access to stable housing, sanitation, clean water, and household resources may therefore create conditions that facilitate academic engagement, although these factors alone do not fully explain educational outcomes.

5.3 Academic Resilience Under Adverse Household Conditions

Perhaps the most noteworthy finding of the study was the identification of the Resilient Learners and Exceptional Achievers, both of whom demonstrated favourable academic performance despite experiencing varying forms of socioeconomic disadvantage. These profiles challenge the conventional assumption that poverty inevitably results in poor educational outcomes and instead illustrate the presence of substantial heterogeneity among economically disadvantaged learners.

This observation is consistent with international research on academic resilience, which describes learners who achieve positive educational outcomes despite exposure to socioeconomic adversity (OECD, 2023). Previous studies have similarly suggested that learner motivation, parental support, positive school climate, and effective teaching may serve as protective factors that enable children to overcome household disadvantages (UNESCO, 2021; Tugade & Fredrickson, 2004). Although these factors were not directly measured in the present study, the emergence of these latent class profiles suggests that future research should examine psychosocial and school-related characteristics that may distinguish academically resilient learners from other disadvantaged groups.

The identification of these profiles further demonstrates the advantage of Latent Class Analysis over traditional variable-centered approaches. Had the study relied solely on correlations or regression analyses, these unique learner groups may have remained undetected because average relationships often obscure meaningful subgroup differences.

5.4 Implications for Educational Policy and Practice

The latent class profiles identified in this study suggest that educational interventions should move beyond one-size-fits-all approaches. Instead, interventions should recognize that learners with similar socioeconomic backgrounds may exhibit substantially different educational needs and academic outcomes.

For instance, the Highly Vulnerable Learners may benefit from integrated educational and social support programs that simultaneously address academic challenges and household deprivation. Conversely, the Resilient Learners and Exceptional Achievers present opportunities for future research to identify protective factors that can be strengthened and replicated among other disadvantaged learners. Similarly, the Supported Learners illustrate the importance of sustaining government social protection initiatives while complementing financial assistance with educational and psychosocial support.

Overall, the findings demonstrate that person-centered approaches such as Latent Class Analysis provide valuable evidence for identifying distinct learner groups and designing targeted interventions that respond to the diverse educational realities of children living in economically disadvantaged communities.

5.5 Limitations of the Study

This study was conducted in a single public elementary school with a relatively small sample size; therefore, the identified latent class profiles should be interpreted within the context of the study population. The model was also limited to academic performance and household socio-demographic indicators and did not include psychosocial, motivational, or school-level factors that may further explain learner outcomes. Future studies involving larger and more diverse samples are recommended to validate and extend the identified latent class profiles.

6. Conclusions and Recommendations

The present study demonstrated the value of Latent Class Analysis (LCA) in uncovering meaningful heterogeneity among elementary pupils based on their academic performance and household socio-demographic characteristics. Five distinct latent class profiles were identified, namely Academically Stable Learners, Supported Learners, Resilient Learners, Highly Vulnerable Learners, and Exceptional Achievers. The findings revealed that pupils from the same school community experienced diverse combinations of educational achievement and household conditions, highlighting that learner outcomes cannot be

adequately explained by socioeconomic status alone.

The identified latent class profiles further showed that socioeconomic disadvantage did not uniformly correspond to poor academic performance. While the Highly Vulnerable Learners experienced multiple household disadvantages alongside relatively lower academic achievement, the Resilient Learners and Exceptional Achievers demonstrated favorable academic outcomes despite experiencing varying degrees of socioeconomic deprivation. These findings underscore the multidimensional nature of educational achievement and emphasize the importance of considering multiple household and environmental factors when examining learner performance.

The study likewise illustrates the usefulness of person-centered analytical approaches in educational research. By identifying latent learner subgroups rather than relying solely on average relationships among variables, Latent Class Analysis provided a more nuanced understanding of learner diversity. The resulting profiles offer valuable evidence for educators, school leaders, and policymakers in designing interventions that are responsive to the varying educational and household circumstances of learners.

Based on these findings, schools and education stakeholders are encouraged to develop profile-responsive interventions rather than adopting uniform support strategies for all learners. Particular attention should be given to learners belonging to the Highly Vulnerable profile through integrated academic, and social support programs. At the same time, further investigation is recommended to identify the protective factors associated with the Resilient and Exceptional Achiever profiles, particularly those related to learner motivation, parental involvement, school climate, and teacher support. Future studies involving larger and more diverse populations, together with additional psychosocial and school-related variables, may further refine latent class profiles and strengthen their applicability in educational planning and policy development.

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