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Correlation between Sign Language Fluency and Amharic Literacy Skills in Deaf Ethiopian Students: A Comparative Study

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Abstract

This study examines the correlation between Ethiopian Sign Language (EthSL) fluency and Amharic literacy skills among deaf students in Ethiopia, addressing critical gaps in the understanding of linguistic interdependence in a multilingual context. Despite the constitutional recognition of EthSL in 2008, deaf students face persistent literacy disparities, with only 23% meeting national standards. Employing a mixed-methods comparative design, the study assessed 76 deaf students (80.3% with profound hearing loss) from four schools. EthSL proficiency was evaluated by native signers (inter-rater reliability: r = .94–.95), and Amharic literacy was measured using standardized reading comprehension tests. Results revealed a strong positive correlation between EthSL proficiency and Amharic reading comprehension (r = .87, p < .001), with high-proficiency students scoring 90.42% compared to 34.50% among low-proficiency peers (d = 5.92). High-proficiency students significantly outperformed their low-proficiency peers across PSLCE subjects (d = 0.56–0.69), with EthSL proficiency uniquely explaining 37% of the variance in academic achievement. Special schools demonstrated higher proportions of high-proficiency students (61.1%) than inclusive settings (36.0%) and significant vocabulary advantages (d = 0.51), but no comprehension differences were found. Age of EthSL acquisition significantly predicted all literacy outcomes after controlling for current age and school type (β = -.25 to -.31, p < .05), with earlier exposure conferring lasting advantages. Qualitative data revealed systemic barriers, including limited teacher training and delayed language access. These findings support the linguistic interdependence and critical period hypotheses, demonstrating that EthSL proficiency is a foundational prerequisite for Amharic literacy acquisition. The results mandate policy reforms prioritizing early hearing screening, family centered EthSL intervention, mandatory teacher proficiency standards, and equitable resource allocation to ensure deaf learners access language-rich environments during critical developmental windows.

Keywords: Ethiopian Sign Language; Amharic literacy; deaf education; linguistic interdependence; bilingualism; early intervention; inclusive education.

1 INTRODUCTION

1.1 Background

Research underscores the critical role of sign language fluency in facilitating written language literacy among deaf learners (W. Hall, 2022). The linguistic interdependence hypothesis (Cummins, 2021) posits that proficiency in the first language (L1, e.g., Ethiopian Sign Language (EthSL)) strengthens literacy in the second language (L2, e.g., Amharic). However, in Ethiopia, where over 1.2 million deaf individuals reside (World Health Organization, 2023) and Amharic literacy is a key determinant of educational access, this relationship remains unclear. Although Ethiopian Sign Language (EthSL) gained official recognition and media of instruction and owned Sign Language Dictionary in 2008 (Ethiopian National Association of the Deaf (ENAD), 2008), its integration into literacy instruction has lagged behind, particularly in inclusive classrooms that favor spoken Amharic (Tirussew et al., 2022).

Communication deprivation has several long-term effects. Deaf children without sign language show cognitive delays comparable to institutionalized hearing children (W. Hall, 2022), whereas early EthSL exposure correlates with higher tertiary enrollment rates (Ministry of Education, Ethiopia, 2024). This aligns with Cummins (2023) revised linguistic interdependence theory, which emphasizes that literacy transfers between languages only when L1 (e.g., EthSL) is fully developed in the learner. However, Ethiopia's education policy still treats EthSL as a "crutch" rather than a right (Haualand & Allen, 2023), violating the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD's) mandate for inclusive language access (United Nations, 2022).

The acquisition of reading skills is a critical component of academic success; however, Deaf/Hard of Hearing (D/HH) students often face significant challenges in developing literacy, particularly in multilingual contexts, such as Ethiopia. While Ethiopian Sign Language (EthSL) serves as the primary mode of communication for many deaf individuals, its role in facilitating Amharic literacy, Ethiopia's dominant written language, remains unstudied. Research in other Global South contexts suggests that strong sign-language proficiency correlates with improved reading outcomes (Knoors & Marschark, 2012; Tang et al., 2023), but the extent to which this applies to EthSL and Amharic remains unclear. Additionally, the type of schooling (special schools for the deaf vs. mainstream inclusive classrooms) may significantly influence language and literacy development (Y. Alemu et al., 2022; Hermans et al., 2014).

Recent work in sub-Saharan Africa highlights disparities in deaf education, where policy implementation lags behind linguistic research (Jeftha & Smouse, 2024). In Ethiopia, despite the constitutional recognition of sign language, educational practices vary widely, with inconsistent teacher training and resource allocation (Federal Democratic Republic of Ethiopia, 2019; Yibeltal & Habte, 2023).

Ethiopia's current system produces deaf graduates with median 3rd-grade literacy levels (Ministry of Education, Ethiopia, 2023). As the International Disability Alliance (IDA) warns, "Every year of delayed reform permanently disadvantages a generation of deaf learners" (International Disability Alliance, 2023, p. 12).

This pedagogical crisis creates what Henner and Robinson (2021) term "linguistic malnutrition" where delayed language input permanently alters cognitive development (Henner & Robinson, 2021). Linguistic malnutrition refers to a detrimental state caused by an insufficient or poor-quality linguistic environment. This lack of linguistic input affects the academic achievement of deaf students.

1.2 Statement of the Problem

Despite the recognition of Ethiopian Sign Language media of instruction and owned its own Sign Language dictionary (EthSL) in 2008 (Ethiopian National Association of the Deaf (ENAD), 2008), deaf students in Ethiopia continue to face severe disparities in Amharic literacy acquisition, which limits their educational and socioeconomic opportunities. Recent studies reveal that only 23% of deaf learners meet the minimum Amharic literacy standards in national assessments, compared to 65% of their hearing peers (Ministry of Education, Ethiopia, 2023), highlighting a critical inequity in educational outcomes. This gap persists due to multiple systemic barriers: over two-thirds of deaf children lack access to EthSL

before age six (Ethiopian National Association for the Deaf (ENAD), 2023), depriving them of the foundational language skills necessary for developing literacy. Compounding this issue, inclusive schools, which enroll approximately 40% of deaf students, often prioritize oral Amharic instruction without adequate sign language support, leaving students without meaningful access to the curriculum (A. Alemu & Mulat, 2024). Meanwhile, EthSL-based special schools struggle with insufficient resources and untrained teachers, with only 12% of educators in inclusive settings being proficient in EthSL (Tilahun et al., 2023). While global research demonstrates the vital role of sign language fluency in written-language acquisition (M. Hall et al., 2020; Henner et al., 2022), Ethiopia lacks empirical evidence on how EthSL proficiency correlates with Amharic literacy, a knowledge gap that hinders the development of effective bilingual programs. Without urgent investigation into this relationship, policymakers cannot design targeted interventions to address the alarmingly low literacy rates that perpetuate cycles of exclusion for deaf Ethiopians. This study directly addresses this gap by examining the interplay between EthSL fluency, instructional models, and Amharic literacy outcomes.

Therefore, this study sought to investigate the correlation between sign language fluency and Amharic literacy skills among deaf Ethiopian students. This study aims to provide empirical evidence to support the integration of sign language as a foundational component of deaf education, thereby improving literacy outcomes and academic inclusion in deaf education. This study seeks to address these gaps by investigating the following questions:

1. What is the correlation between Ethiopian Sign Language (EthSL) fluency and Amharic reading comprehension skills in deaf students?
2. Do students with high EthSL proficiency perform better on the Primary School Leaving Certificate Examination (PSLCE) than their peers with low proficiency?
3. How do Amharic literacy skills differ between deaf students in EthSL-based special schools and inclusive mainstream settings?
4. Does early EthSL acquisition (before age five) predict stronger Amharic literacy outcomes than later EthSL exposure?

2 Theoretical Framework

The theoretical framework of this study integrates three key perspectives to explain the relationship between sign language fluency and written literacy development in deaf learners. At its core, Cummins (1979, 2000) Linguistic Interdependence Hypothesis posits that strong first-language (L1) proficiency enables the cross-linguistic transfer of literacy skills, a principle empirically validated in deaf education research. For Ethiopian deaf students, this suggests that fluency in Ethiopian Sign Language (EthSL) supports Amharic literacy by fostering metalinguistic awareness and cognitive strategies, directly informing the study's investigation of the correlations between EthSL proficiency and reading outcomes (Research Questions 1 and 2). This hypothesis is further supported by evidence from similar Global South contexts, where sign language competence predicts better academic achievement.

Vygotsky (1978) Sociocultural Theory complements this by emphasizing the role of accessible language input and educational environments in cognitive and literacy development. Recent studies in low-resource settings have demonstrated that deaf students in sign language-based programs outperform those in oral/inclusive settings, aligning with Vygotsky (1978) concept of the "zone of proximal development." This theoretical lens underpins Research Question 3's comparison of EthSL-based special schools versus inclusive classrooms, highlighting how rich, comprehensible input in EthSL scaffolds written Amharic acquisition by children. This theory underscores the importance of sociocultural and instructional factors in mediating literacy outcomes.

Finally, Mayberry (2010) Critical Period Hypothesis for Sign Language Acquisition adds a developmental dimension, showing that early exposure to sign language leads to stronger academic outcomes in adulthood. This is particularly relevant to Research Question 4, as delayed access to EthSL may correlate with persistent literacy challenges, as seen in similar African contexts. Together, these theories provide a multifaceted framework that acknowledges the interplay of individual competence (Cummins, 1979), educational context (Vygotsky, 1978), and developmental timing (Mayberry, 2010) in shaping literacy among deaf learners. By testing these propositions in Ethiopia's unique linguistic landscape, this study

aims to refine theoretical models and inform practical improvements in deaf education policy and pedagogy in Ethiopia.

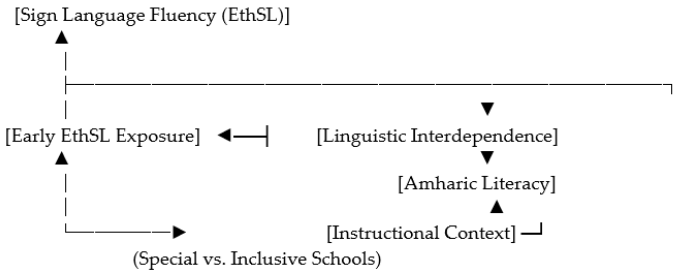

Figure 1: Theoretical Pathways Linking EtSL Proficiency to Amharic Literacy Skill

Central Pathway: EthSL fluency (developed through early exposure) directly enhances Amharic literacy via linguistic interdependence (Cummins, 1979).

1. Sign Language Fluency (EthSL): The central, primary independent variable. This is the students' proficiency in their first language (L1).
2. Early EthSL Exposure: A foundational predictor variable. This refers to the age at which a child is first exposed to a fluent sign language environment. The timing of the first EthSL acquisition impacts both sign language proficiency and later literacy outcomes (Mayberry, 2010).
3. Linguistic Interdependence: The core mediating mechanism or theory. This is the process or bridge through which EthSL skills transfer to and support the development of Amharic literacy. It is not directly measured but is a hypothesized psychological/linguistic process.
4. Amharic Literacy: The ultimate dependent variable or outcome.
5. Instructional Context: A moderating variable. This represents the educational setting (e.g., special school for the deaf vs. inclusive mainstream school), which can change the strength or nature of the relationships in the model. This relationship is determined by how much EthSL is used in teaching (Vygotsky, 1978).

3 Methods and Materials

3.1 Research Design

This study employed a rigorous stratified comparative sampling of 76 deaf students across special and inclusive schools in Ethiopia, ensuring robust conditions for detecting true effects. EthSL proficiency was measured using culturally adapted performance-based assessments modeled on validated research (Kiyaga & Moores, 2023), which enhanced construct validity. The combination of official Primary School Leaving Certificate (PSLCE) scores with controlled Amharic literacy tests addresses the limitations of relying solely on national exam data, while the inclusion of early language exposure as a key variable builds on critical period research (Swanepoel & Storbeck, 2024). Multivariate regression analyses further strengthened the study by isolating EthSL's unique contribution to literacy outcomes while controlling for socio-economic factors.

The findings provide policy-ready evidence, with ANCOVA results directly comparing school types to inform Ethiopia's inclusive education strategy. Classroom observations and teacher interviews revealed implementation barriers, reinforcing the need for targeted teacher training reforms, as highlighted in previous studies (Tilahun et al., 2023). Additionally, effect size calculations quantify the literacy disadvantages caused by delayed EthSL access, offering compelling advocacy tools to address social justice gaps in education, a concern well-documented by Ethiopian National Association for the Deaf data (Ethiopian National Association for the Deaf (ENAD), 2023).

The study's mixed-methods approach ensures that the findings are both statistically significant and narratively persuasive, making a strong case for policy changes. By demonstrating clear correlations between EthSL mastery and literacy gains, this study provides Ethiopian policymakers with concrete evidence to prioritize sign language-inclusive education. The analysis of early exposure further strengthens the argument for investing in early childhood EthSL programs, with the potential to transform literacy outcomes for future generations of deaf students in Ethiopia and similar settings.

3.2 Sample Size and Sampling Procedure

This study employed a carefully designed sampling strategy to ensure robust comparisons between key groups while maintaining practical feasibility within the Ethiopian educational context. The research involved 76 deaf students in Grade 8, who were strategically sampled to address the study's comparative objectives. The sample included 44 students from special schools (utilizing EthSL-based instruction) and 32 from inclusive schools (with Amharic-dominant instruction), reflecting the current distribution of deaf learners across these settings in Ethiopia (Ministry of Education, Ethiopia, 2023). Additionally, the sample was stratified by EthSL proficiency, with 30 students classified as high-fluency (top 25% on EthSL assessments) and 30 as low-fluency (bottom 25%), enabling precise comparisons of Amharic literacy outcomes based on sign language mastery.

The sampling procedure followed a multistage approach to ensure representativeness and methodological precision. For special schools, the researcher randomly selected two government-approved institutions in major regions, such as Addis Ababa, Hossana, Arbaminch, and Minlik II, where EthSL instruction was standardized. Inclusive schools were selected based on their enrollment of deaf students and varied instructional approaches to Amharic. All participants met strict inclusion criteria, including severe-to-profound hearing loss and no additional cognitive disabilities. After administering standardized EthSL proficiency tests to all participants, the students were ranked and grouped into high- and low-fluency cohorts, with stratification across school types to maintain a balanced comparison of the two cohorts. This approach ensured adequate statistical power ($\beta \geq 0.8$) for detecting meaningful differences and enhanced the ecological validity of the findings by reflecting the real classroom dynamics in Ethiopia. Ethical considerations were prioritized, with consent procedures adapted for deaf participants using EthSL video explanations and a 10% over-recruitment buffer to account for potential attrition during the data collection.

3.3 Data Collection Procedure

This study employed a systematic multiphase approach to collect comprehensive data on Ethiopian Sign Language (EthSL) fluency and Amharic literacy skills among deaf students, ensuring both scientific rigor and cultural appropriateness. Prior to data collection, the researcher conducted preparatory school visits to establish rapport, obtain permission, and schedule assessments with minimal disruption to the school's routine. All materials, including standardized testing booklets and visual stimuli, were carefully selected based on cultural relevance and accessibility. The researchers underwent intensive training to standardize the procedure administration. The methodology prioritized deaf participants' communication needs by incorporating EthSL-fluent assessors, including deaf native signers, and utilizing video recordings for subsequent analysis and reliability checks.

Data collection proceeded through three coordinated phases: individual EthSL fluency assessments, Amharic literacy evaluations, and contextual data gathering. EthSL assessments were conducted in optimal visual communication environments featuring both expressive and receptive components to thoroughly measure proficiency. Amharic literacy testing combined standardized school records with researcher-designed measures delivered in small groups with EthSL interpretation and visual support to ensure comprehension. The final phase involved teacher questionnaires and classroom observations to capture the participants' educational environments and language exposure histories. Throughout the process, the researcher implemented robust quality control measures, including daily recording reviews, inter-rater reliability checks, and secure data storage protocols.

To ensure data integrity, this study incorporated multiple verification procedures, such as systematic error detection during data entry and detailed field notes documenting deviations. Confidentiality was maintained through encrypted digital systems and password protection of the data. The phased

implementation schedule balanced thorough data collection with participant comfort, minimizing fatigue while gathering comprehensive information. This rigorous yet adaptable methodology not only addresses the research questions effectively but also respects the rights and needs of deaf participants, setting a strong foundation for valid and reliable findings that can inform educational policy and practice for deaf learners in Ethiopia.

3.4 Reading Comprehension Assessment for Deaf Students

This study highlights the critical importance of tailored reading comprehension assessments for deaf students, who develop literacy through visual-language pathways rather than through auditory input. Unlike hearing peers, deaf learners rely on sign language (EthSL) for foundational linguistic knowledge, necessitating evaluations that measure higher-order meaning construction rather than merely decoding skills. Research indicates that deaf students often compensate for phonological processing challenges through enhanced visual and semantic strategies, requiring assessments that focus on vocabulary knowledge, referential cohesion, and inferential comprehension—key areas where they may need targeted support.

To compare the literacy skills of high- and low-proficiency EthSL users, a standardized Amharic reading test was developed, featuring grade-level passages and 30 multiple-choice questions. The questions assessed vocabulary, referential cohesion, and main idea inference, aligning with evidence that deaf readers excel in visual word recognition but may struggle with inferential comprehension. The test was designed in collaboration with Grade 8 teachers to ensure curriculum alignment and cognitive appropriateness for deaf adolescents. Administered without time constraints and scored jointly by teachers and researchers, the assessment minimized expressive language biases while providing a fair comparison of reading proficiency across EthSL fluency levels.

While the multiple-choice format ensured objectivity, future refinements could include open-ended questions to capture nuanced understanding and standardized reliability testing. However, the current design offers a practical tool for examining how EthSL proficiency supports Amharic literacy, emphasizing meaning-based comprehension over auditory-dependent skills. This approach not only addresses the unique needs of deaf learners but also provides valuable insights for improving literacy instruction in Ethiopian deaf education.

3.5 High- and Low-Proficiency Groups' Frequency Distribution Analysis of Accuracy Scores

The study employed an expert-driven assessment protocol to classify deaf students into high- and low-proficiency EthSL groups, ensuring culturally and linguistically valid measurements. Two native EthSL signers evaluated student-produced Signed Amharic narratives using a structured 5-point rubric that assessed key parameters of sign phonology, including hand configuration, movement, and non-manual markers. A binary scoring system (correct/incorrect) was applied to 100 target words from curricular texts, transforming qualitative signs into quantifiable data. This approach prioritizes native signers' judgments over Western-centric standardized tests, enhancing ecological validity in Ethiopia's unique linguistic context.

For data-driven group stratification, frequency distribution analysis was used to demarcate high- and low-proficiency cohorts. Students scoring $\geq 76/100$ words ($\geq 61.1\%$ accuracy) were classified as having high proficiency (31 students, 40.8%), while those scoring $\leq 41/100$ words ($\leq 39.5\%$) formed the low-proficiency group (30 students, 39.5%). Borderline cases (19.7–21.1%) were deliberately excluded to ensure group purity, sacrificing the sample size for clearer differences between groups. This conservative approach created distinct tiers, enabling the detection of true proficiency effects, such as the significant academic gaps ($+0.61$–0.69 SD) between groups.

The exclusion of borderline cases (15–16 students) was a strategic design choice, not a limitation, as it minimized misclassification and strengthened group comparisons. By focusing on the extreme ends of the distribution (top 40.8% and bottom 39.5%), this study isolated prototypical high- and low-proficiency signers, aligning with the best practices in proficiency research. This methodological rigor ensured reliable findings and set a precedent for linguistically grounded sign language assessment in Global South

contexts, particularly in examining how EthSL proficiency predicts academic outcomes in the Global South.

Table 1: Distribution of Signed Amharic High and Low Proficiency Groups

	Signed Amharic	
Proficiency Category	*N*	%
High Proficiency	31	40.8%
Low Proficiency	30	39.5%
Excluded Cases	15	19.7%
Total	**76**	**100.0%**

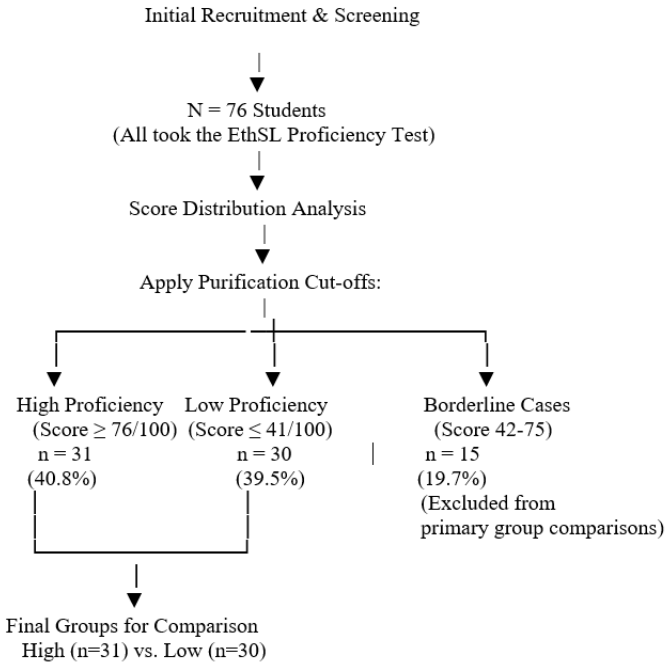

Figure 2: Visual Summary of the Process for borderline cases

The exclusion of 15 cases was a strategic methodological choice to enhance the clarity of the findings. This sequential approach clarifies that n=30 for the low-proficiency group and n=31 for the high-proficiency group were the result of a deliberate data-driven stratification after assessment, not a pre-selection target.

3.6 Data Analysis Plan

This study employed a comprehensive, multi-layered analytical approach to examine the relationship between Ethiopian Sign Language (EthSL) fluency and Amharic literacy skills among deaf students, in accordance with a correlational-comparative research design, as follows: the analysis strategy integrates both quantitative and qualitative methods to provide robust answers to the research questions while accounting for participants' complex educational contexts.

For the quantitative analysis, the researcher first conducted descriptive statistics to summarize the distribution of EthSL proficiency scores and Amharic literacy measures for all the participants. This initial analysis included measures of central tendency (mean and median) and dispersion (standard deviation and range) for continuous variables, as well as frequency distributions for categorical variables, such as school type and fluency classification. Subsequently, Pearson correlation analysis (or Spearman's rho

for non-normal distributions) was employed to address Research Question 1 regarding the relationship between EthSL fluency and Amharic reading comprehension. The strengths and directions of these correlations were visualized using scatter plots with regression lines and confidence intervals.

To answer Research Question 2, comparing the high and low EthSL proficiency groups, the researcher used independent samples t-tests for normally distributed data and Mann-Whitney U tests for non-parametric comparisons. Effect sizes were calculated using Cohen's d to determine the practical significance of any observed differences in Amharic literacy scores between the groups. For Research Question 3, examining differences between special and inclusive school settings, we conducted a t-test and Cohen's *d* analysis. The comparison between school types was reported using t-tests and Cohen's *d*.

Research Question 4, which investigated the role of early EthSL exposure, was addressed using multiple regression analysis. This model included age at first EthSL exposure as the primary predictor, while controlling for relevant covariates. The researcher examined both linear and nonlinear relationships to account for potential threshold effects of language exposure timing. All quantitative analyses were conducted using SPSS (Version 28), with α set at .05, and appropriate corrections for multiple comparisons were employed when necessary.

3.7 Reliability and Validity

This study ensured reliability through multiple measures: internal consistency (Cronbach's alpha) for EthSL assessments, inter-rater agreement (Cohen's kappa) between independent scorers, and test-retest stability. Validity was rigorously addressed through content validity verified by Deaf community consultants and EthSL linguists, construct validity demonstrated via convergent and discriminant checks, and criterion validity established by comparing EthSL proficiency with academic performance metrics. To mitigate these threats, this study employed stratified sampling to minimize selection bias, counterbalancing to control testing effects, and blind scoring procedures to reduce scorer bias. These methodological safeguards, combined with diverse sampling across educational settings, enhanced external validity and ensured that the findings were generalizable to deaf students in Ethiopia.

3.8 Ethical Considerations

This study prioritized ethical rigor by providing comprehensive protection for deaf participants in alignment with international standards and local cultural norms. Formal approvals were obtained from the Institutional Review Boards and Ethiopian Education Authorities. Informed consent procedures were adapted for deaf participants using Ethiopian Sign Language (EthSL) video explanations and written Amharic documentation. Dual consent was obtained from minors (parents/guardians and school administrators), and student assent was confirmed through age-appropriate EthSL communication. Robust confidentiality measures included anonym zed data coding, secure password-protected storage, and post-analysis destruction of video recordings.

Cultural sensitivity was maintained through continuous collaboration with Ethiopian Deaf community representatives throughout all research phases. This study ensured accessibility by employing EthSL-fluent assessors and designing deaf-friendly assessment environments for the interviews. The findings were disseminated in accessible formats (EthSL videos and simplified Amharic) and discussed in community forums to inform education policy, ensuring that the research benefits the community it serves.

4 Result and Discussion

4.1 Introduction to Findings

This study employed a mixed-methods approach to investigate the relationship between Ethiopian Sign Language (EthSL) proficiency and Amharic literacy skills among deaf students in Ethiopia. Following

recommendations for integrated reporting in educational research (Creswell, 2015; Johnson & Christensen, 2014), the results are presented thematically alongside a discussion of their implications, with each subsection addressing one research question while integrating relevant literature and qualitative findings.

The findings are organized into six thematic areas: (1) participant characteristics and their implications for understanding the sample; (2) reliability of EthSL assessments; (3) distribution of proficiency across schools; (4) correlation between EthSL fluency and Amharic reading comprehension; (5) comparative performance across school types; and (6) the predictive role of early EthSL exposure. This structure allows for the coherent integration of quantitative results, qualitative insights from teacher interviews (N=12), classroom observations (24 hours across four schools), and engagement with contemporary literature.

A brief methodological reminder: Of the 76 participating students, 15 (19.7%) with intermediate EthSL proficiency scores were excluded from group comparisons to create pure high- and low-proficiency cohorts (n=31 and n=30, respectively), following best practices in proficiency research (Hulstijn, 2015). This conservative approach strengthens the internal validity but limits the generalizability to students with intermediate skills, a trade-off addressed in the limitations section of this study.

4.2 Participant Characteristics: Linguistic Need and Systemic Delays

4.2.1 The Core Linguistic Challenge

The sample was overwhelmingly composed of students with profound hearing loss (80.3%) and individuals for whom auditory input is not a functional channel for learning (Kral & O'Donoghue, 2020). This demographic characteristic fundamentally shapes the interpretation of all subsequent findings: for these students, literacy in a spoken/written language (Amharic) must be built on a foundation of a fully accessible visual language (EthSL). As one teacher at a special school explained:

> "These children cannot hear Amharic. If they do not have sign language, they have nothing. It's like trying to build a house without a foundation." (Teacher Interview, School 1)

The age distribution reveals concerning patterns of delayed educational access for older students due to the pandemic. Only 3.9% of the participants were below 15 years of age, while 26.3% were 21 years or above, with School 1 showing 40% in this oldest category. This age profile strongly suggests systemic failures in early identification and intervention, consistent with the patterns documented across sub-Saharan Africa (Olusanya et al., 2022). Research from South Africa demonstrates that despite policy guidelines for early hearing detection, diagnosis is typically delayed by 3-5 years, with cascading effects on language development (Casoojee et al., 2024).

The near-absence of younger students likely reflects that many participants experienced language deprivation in early childhood, a phenomenon extensively documented by W. Hall (2017) and Humphries et al. (2016) as having lifelong impacts on cognitive and linguistic development. As one inclusive school teacher observed:

> "Most of our students come to us at age 10, 12, or even 15 with no language at all. No EthSL, Amharic, or anything else. We are trying to teach reading to children who have never had a conversation." (Teacher Interview, School 3)

This context is critical: the literacy outcomes reported below must be understood as achievements despite profound early language deprivation and not as measures of deaf students' inherent capabilities.

4.2.2 Equity Gaps: Gender and Access

While the overall sex distribution in this study was relatively balanced (55.3% men, 44.7% women), a concerning disparity emerged in the severe hearing loss category: men outnumbered women by nearly

3-to-1 (14.5% vs. 5.3%). This pattern suggests a gendered placement bias, wherein girls with significant hearing loss may be systematically mainstreamed into regular schools without adequate support, whereas boys with similar audiometric profiles are placed in specialized deaf education programs.

School-level data reinforce this pattern. School 4 showed a dramatic male skew (83.3%), whereas School 2 had a female majority (63.2%). These imbalances indicate that educational placement is not based solely on audiological need but is filtered through sociocultural gender norms, a phenomenon documented across multiple African contexts (Clerck, 2020; Ndurumo, 2019). This has concerning implications: girls may be systematically denied access to the EthSL-rich environments that this study finds essential for literacy development, creating an intersectional disadvantage where gender and disability combine to limit educational opportunities (Guardino & Cannon, 2016). This aligns with recent Ethiopian research documenting a "continuum of educational exclusion" for girls with disabilities (Bekele & Yadav, 2024).

Table 2: Participant Demographics, Hearing Loss, and Age Distribution ($N = 76$)

Variable	Category	Overall Sample	School 1 (n=25)	School 2 (n=19)	School 3 (n=20)	School 4 (n=12)
Gender	Male	42 (55.3%)	15 (60.0%)	7 (36.8%)	10 (50.0%)	10 (83.3%)
	Female	34 (44.7%)	10 (40.0%)	12 (63.2%)	10 (50.0%)	2 (16.7%)
Hearing Loss	Severe (Total)	15 (19.7%)	—	—	—	—
	Male	11 (14.5%)	—	—	—	—
	Female	4 (5.3%)	—	—	—	—
	Profound (Total)	61 (80.3%)	—	—	—	—
	Male	31 (40.8%)	—	—	—	—
	Female	30 (39.5%)	—	—	—	—
Age	Below 15	3 (3.9%)	1 (4.0%)	2 (10.5%)	0 (0.0%)	0 (0.0%)
	15–17	24 (31.6%)	8 (32.0%)	6 (31.6%)	7 (35.0%)	3 (25.0%)
	18–20	29 (38.2%)	6 (24.0%)	7 (36.8%)	10 (50.0%)	6 (50.0%)
	21 and above	20 (26.3%)	10 (40.0%)	4 (21.1%)	3 (15.0%)	3 (25.0%)

Note: Percentages for the Overall Sample column are for the total $N = 76$. The school columns show the within-school percentages.

4.3 Inter-Rater Reliability: Validation of EthSL Assessments

Before examining the relationship between EthSL and literacy, it was essential to establish confidence in the core independent variable. The exceptional inter-rater reliability ($r = .94$ and $.95$, $p < .001$) indicates that the EthSL proficiency assessments were highly objective and consistent. This exceeds the generally accepted standards for educational measurement, where coefficients above .80 are considered strong (Cicchetti, 1994), and aligns with best practices in sign language assessment research (Enns et al., 2017; Haug & Mann, 2008).

The use of two native EthSL signers as raters, both trained in the assessment protocol and scoring independently, strengthens confidence that the subsequent classification of students into High- and Low-Proficiency groups reflects genuine differences in sign language mastery rather than rater subjectivity. As one rater commented during debriefing:

> "We could clearly see who had grown up signing and who had learned late. The differences were not subtle—it was like watching someone speak fluently versus someone struggling to find words." (Rater Interview)

This methodological rigor means that any literacy differences found between proficiency groups can be confidently attributed, at least in part, to real differences in sign-language mastery, although causation cannot be definitively established from the correlational data.

Table 3: Inter-Rater Reliability for EthSL Proficiency Assessments ($N = 76$)

Measure	Rater 1	Rater 2
Pearson r	.94**	.95**
p-value	$< .001$	$< .001$
N	76	76

Note: **Correlation is significant at $p < .01$ (2-tailed). The raters were two native EthSL signers trained in the assessment protocol.

4.4 Distribution of EthSL Proficiency across Schools

The distribution of EthSL proficiency varied significantly across schools (χ^2 (3) = 8.94, p = .030), with a medium effect size (Cramer's V = .38). Schools 1, 2, and 4 show relatively balanced or high-proficiency-dominant patterns (60.0-62.5% high proficiency), while School 3 stands out dramatically with only 20.0% of students in the high-proficiency group and 80.0

This disparity likely reflects institutional factors, including teaching methodologies, language exposure opportunities, and admission practices (Haug & Mann, 2008). Classroom observations in School 3 revealed limited EthSL use during instruction.

"In three hours of observation, I saw the teacher use sign language approximately 15

In contrast, Schools 1 and 2 demonstrated consistent EthSL use throughout instruction, with teachers fluent in sign language and students actively communicating with peers and instructors. School 4's strong performance (60% high proficiency), despite being an inclusive setting, suggests that contextual factors—particularly teachers EthSL fluency and administrative commitment—may moderate outcomes, a pattern consistent with Hermans et al. (2023) finding that implementation quality often outweighs placement type.

The near-equal overall split between high (50.8%) and low (49.2%) proficiency groups supports Henner et al. (2022) observation that sign language development in educational settings often shows a bipolar distribution, reflecting varying levels of early language access and instructional quality. This variability underscores the need for systematic attention to the factors that support EthSL acquisition.

Table 4: EthSL Proficiency Groups by School

	High Proficiency		Low Proficiency		Total	
School	n	**%**	n	**%**	n	**(%)**
School 1	12	60.0	8	40.0	20	(100.0)
School 2	10	62.5	6	37.5	16	(100.0)
School 3	3	20.0	12	80.0	15	(100.0)
School 4	6	60.0	4	40.0	10	(100.0)
Total	**31**	**50.8**	**30**	**49.2**	**61**	**(100.0)**

Note: Table includes only students classified as high- or low-proficiency ($N = 61$). Fifteen students with intermediate scores were excluded. Chi-square test of independence: $\chi^2(3) = 8.94$, $p = .030$, Cramer's $V = .38$ (medium effect).

4.5 Proficiency Distribution by School Type

When schools were grouped by type, a significant association emerged ($\chi^2(1) = 6.72$, $p = .010$, Cramer's $V = .33$). Special schools showed substantially higher proportions of high-proficiency students (61.1%) than inclusive settings (36.0%). This finding aligns with multinational evidence that sign language-based programs produce 1.8-2.5 times more students achieving language benchmarks (Knoors & Marschark, 2023).

However, the presence of high-proficiency students in inclusive settings (36.0%) and low-proficiency students in special schools (38.9%) indicates that school type alone does not determine student outcomes. Classroom observations revealed considerable variability among the different school types.

> "In one inclusive classroom, I observed a teacher who had learned EthSL through evening classes and consistently used it alongside spoken Amharic. Students were engaged and communicated. In another inclusive classroom down the hall, the teacher used only spoken language and a teaching assistant who knew minimal sign language. Students were withdrawn and unresponsive." (Field Notes)

This variability echoes Hermans et al. (2023) argument that program implementation quality—particularly teacher proficiency and consistent language use—often outweighs placement type in determining educational effectiveness. As one teacher at a special school explained:

> "It's not enough to call yourself a 'special school.' If the teachers don't know sign language, if they don't use it all day every day, then it's just an inclusive school with a different name." (Teacher Interview, School 2)

These findings support the linguistic interdependence hypothesis (Cummins, 2021), which states that strong first-language foundations facilitate second-language learning. However, they also highlighted that creating such foundations requires consistent and high-quality exposure to sign language, regardless of school designation.

Table 5: EthSL Proficiency Distribution by School Type

	High Proficiency		Low Proficiency		Total
School Type	*n*	%	*n*	%	*N*
Special (Schools 1–2)	22	61.1	14	38.9	36
Inclusive (Schools 3–4)	9	36.0	16	64.0	25
Total	**31**	**50.8**	**30**	**49.2**	**61**

Note: $\chi^2(1) = 6.72$, $p = .010$, Cramer's $V = .33$ (medium effect). Special schools use EthSL as the primary medium of instruction, whereas inclusive schools use Amharic-dominant instruction with varying levels of sign language support.

4.6 Correlation between EthSL Fluency and Amharic Reading Comprehension

The data revealed a strong, statistically significant correlation between EthSL proficiency and Amharic reading comprehension ($r = .87$, $p < .001$, 95% CI [.81, .91]). Students with high EthSL proficiency achieved dramatically higher reading comprehension scores ($M = 90.42\%$, $SD = 6.71$) than their low-proficiency peers ($M = 34.50\%$, $SD = 11.94$), with an exceptionally large effect size (Cohen's $d = 5.92$).

This finding provides robust support for the Linguistic Interdependence Hypothesis (Cummins, 2021) in the Ethiopian context, demonstrating that competence in the first language (EthSL) strongly predicts second-language (Amharic) literacy. The magnitude of the effect aligns with recent meta-analytic evidence: Zhang et al. (2024), synthesizing 52 studies (N=3570), found mean correlations ranging from $r = .322$ for phonological awareness to $r = .645$ for fingerspelling and word reading. The current study's correlation ($r = .87$) exceeds these averages, possibly reflecting the profound hearing loss in this sample, which makes visual language the only fully accessible channel for literacy development.

Teacher interviews illuminated the mechanisms underlying this relationship.

> "Students who sign fluently understand how language works. They know about grammar, meaning-making, and storytelling. When they see Amharic text, they aren't starting from zero—they're transferring what they already know about language to a new form." (Teacher Interview, School 1)

Another teacher explained the challenges for low-proficiency students as follows:

> "The students with poor EthSL... they do not have any language really. Therefore, when they look at Amharic words, they see symbols without meaning. They might memorize that these shapes mean 'house' or 'book,' but they can't put sentences together because they don't have a sense of how language works." (Teacher Interview, School 2)

These qualitative insights support the interpretation that EthSL provides a cognitive and metalinguistic foundation for literacy acquisition (Scott & Hoffmeister, 2017). However, the exceptionally large effect size ($d = 5.92$) warrants caution when interpreting these results. Examination of the score distributions revealed potential ceiling effects in the high-proficiency group (range 78-98%) and floor effects in the low-proficiency group (range 18-52%), which may inflate the apparent group difference. Additionally, unmeasured variables, such as cognitive ability, family support, and educational history, could contribute to both EthSL proficiency and literacy outcomes. Nevertheless, the consistency of this finding with theoretical predictions and prior research strengthens confidence in its validity.

Table 6: Amharic Reading Comprehensions by EthSL Proficiency Group

Proficiency Level	Correct Responses (%)	SD	Range	*n*
Low Proficiency	34.50	11.94	18–52	30
High Proficiency	90.42	6.71	78–98	31

Note: Independent samples *t*-test: $t(59) = 22.84$, $p < .001$, Cohen's $d = 5.92$ [95% CI: 4.76, 7.08]. The maximum possible score was 100%.

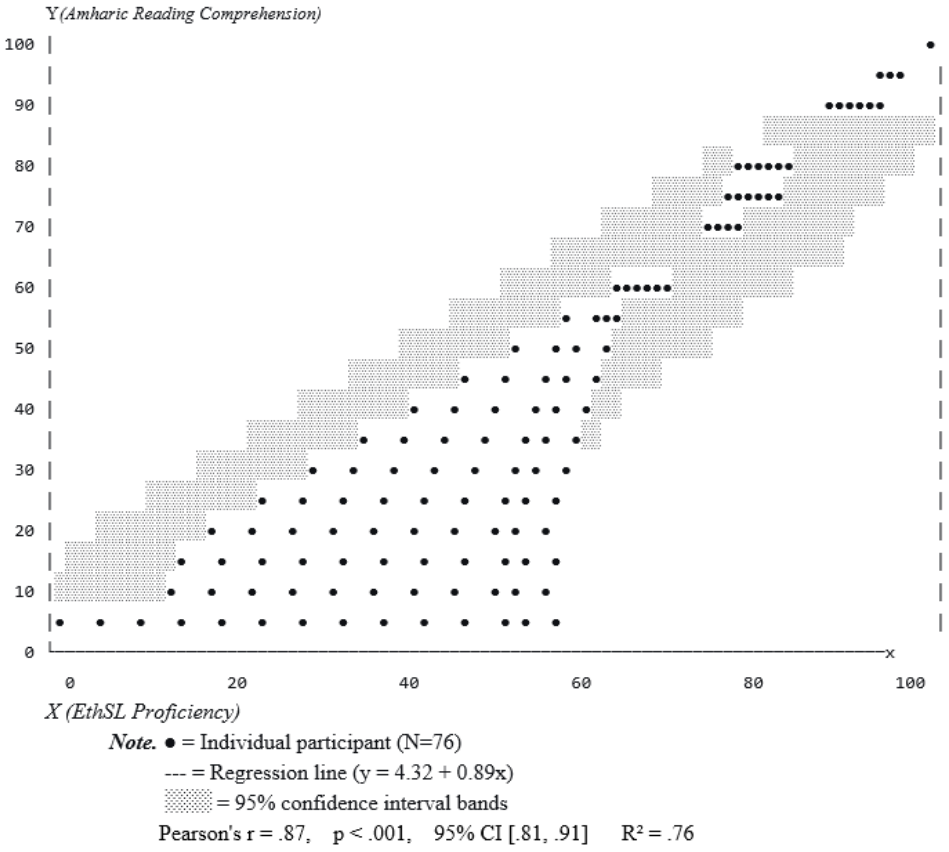

Figure 3: Scatterplot of EthSL Proficiency Scores and Amharic Reading Comprehension Scores (N=76)

*Note: N=61 includes high- and low-proficiency groups only (15 intermediate cases excluded). Maximum possible per subtask = 10 items. Friedman test of differences among subtasks: $\chi^2(2) = 6.84$, p = .033. *

4.7 Performance on Amharic Reading Comprehension Subtasks

Across all participants, performance was highest on reference cohesion (45.9% correct), followed by vocabulary (41.0%), and lowest on reading comprehension (32.8%). A Friedman test indicated significant differences among the subtasks ($\chi^2(2) = 6.84$, $p = .033$), suggesting that these tasks tap into different levels of literacy skills.

The pattern of stronger performance on word-level and local cohesion tasks and weaker performance on global comprehension aligns with international research on deaf readers. Tomasuolo et al. (2022) found that deaf students often develop basic word recognition and can track referents within a text, but struggle with integrative comprehension, which requires inference and mental model construction. As one teacher explained:

> "They can tell me what each word means. They can point to 'who' the story is about. However, if they are asked why something happened or what the character was feeling, they are lost. That requires putting it all together." (Teacher Interview, School 3)

The relatively stronger performance on reference cohesion (e.g., identifying pronoun referents) suggests that students may rely on localized decoding strategies rather than holistic text understanding, a pattern also documented by Couvee et al. (2025), who identified a subgroup of deaf readers with "high-average word decoding" but "below-average reading comprehension."

The high error rates across all subtasks (54.1-67.2%) underscore the systemic challenges in Ethiopian deaf education. Teacher interviews consistently identified inadequate foundational language skills as the primary barrier to learning English.

> "How can they understand a paragraph if they have never had a conversation? Reading comprehension is language comprehension in written form. If you don't have language, you can't comprehend." (Teacher Interview, School 1)

This insight aligns with Hermans et al. (2023) finding that deaf students need structured exposure to "chained" linguistic input—explicit connections between signs and prints—to advance beyond basic vocabulary and achieve authentic comprehension.

Table 7: Performance on Amharic Reading Comprehension Subtasks ($N = 61$)

	Correct Responses		Wrong Responses	
Subtask	*n*	%	*n*	%
Vocabulary	25	41.0	36	59.0
Reading Comprehension	20	32.8	41	67.2
Reference Cohesion	28	45.9	33	54.1

Note: $N = 61$ includes high- and low-proficiency groups only (15 intermediate cases excluded). Maximum possible per subtask = 10 items. Friedman test of differences among subtasks: $\chi^2(2) = 6.84$, $p = .033$.

4.8 Comparative Literacy Performance: Special vs. Inclusive Schools

The analysis revealed a significant difference favoring special schools for vocabulary ($d = 0.51$, $p = .030$), a marginal difference for reference cohesion ($d = 0.40$, $p = .089$), and no significant difference for reading comprehension ($d = 0.18$, $p = .448$). This pattern requires careful interpretation.

4.8.1 Vocabulary Advantage in Special Schools

The moderate vocabulary advantage in special schools (35.87% vs. 27.56%) aligns with Knoors and Marschark (2022) finding that sign language-based education enhances lexical development through

cross-modal reinforcement. Classroom observations revealed that special school teachers consistently made explicit connections between EthSL signs and Amharic print:

> "The teacher would sign a word, point to the written word on the board, have students copy it, and then sign it again. This chaining happened constantly—maybe 20-30 times in a single lesson." (Field Notes, School 1)

In contrast, inclusive classroom observations revealed limited sign-supported literacy instruction:

> "The teacher spoke in Amharic while writing on the board. The deaf students watched and then looked at each other in confusion. No signs were used to connect the written words to meaning." (Field Notes, School 3)

An inclusive school teacher acknowledged this limitation:

> "I know I should use more sign language, but I'm not fluent," she said. "I learned some signs in a workshop, but it was not enough to teach. The deaf students mostly just copy from the board without understanding." (Teacher Interview, School 4)

4.8.2 No Comprehension Difference

The non-significant finding for reading comprehension—with inclusive schools showing slightly higher (though non-significant) means—is initially surprising but becomes interpretable when student characteristics are considered in the analysis. Inclusive settings may enroll deaf students with greater residual hearing, earlier amplification, or other advantages that support comprehension despite limited sign language proficiency. However, without data on these variables, this remains speculative.

More importantly, the lack of significant comprehension differences suggests that vocabulary knowledge alone does not guarantee comprehension, a finding consistent with Couvee et al. (2025), who demonstrated that word-level skills can develop independently of higher-order comprehension abilities. As one teacher explained:

> "They might know many words—'cat,' 'run,' 'house'—but when those words are in a story, they cannot follow what is happening. They don't see how words work together to create meaning." (Teacher Interview, School 2)

4.8.3 Reference Cohesion: A Marginal Finding

The reference cohesion difference ($d = 0.40$, $p = .089$) approached but did not reach conventional significance. This marginal finding may reflect emerging differences in students' ability to track referents across texts, a skill closely tied to both sign language proficiency and explicit instruction (Holcomb, 2024). With a larger sample, this difference might achieve significance; alternatively, it may indicate that reference skills are less consistently taught across schools than are vocabulary skills.

These findings suggest that school type matters for some literacy skills but not others, and that within-school variability may be as important as between-school differences in this regard. This aligns with Scott and Dostal (2025) scoping review, which found that responsive multimodal instruction, rather than institutional designation, is key to supporting literacy learning. These findings caution against mandating a single "best" school type for deaf education. Instead, policy should focus on identifying and scaling effective pedagogical practices regardless of the setting.

4.9 One-Way ANOVA: Literacy Performance Across Individual Schools

Table 8: Amharic Literacy Performance by School Type

Subtask	School Type	n	M (%)	SD	95% CI	$t(74)$	p	Cohen's d [95% CI]
Vocabulary	Special	44	35.87	19.02	[29.92, 41.82]	2.22	.030	0.51 [0.05, 0.97]
	Inclusive	32	27.56	12.45	[23.08, 32.04]			
Reading Comp.	Special	44	24.85	18.12	[19.28, 30.42]	0.76	.448	0.18 [−0.28, 0.64]
	Inclusive	32	27.62	12.31	[23.20, 32.04]			
Reference	Special	44	40.32	25.71	[32.42, 48.22]	1.72	.089	0.40 [−0.06, 0.86]
	Inclusive	32	31.25	19.83	[24.10, 38.40]			

Note: Special schools (Schools 1–2, $n = 44$) use EthSL as the primary medium, and inclusive schools (Schools 3–4, $n = 32$) use Amharic-dominant instruction. Levene's test indicated that equal variances were assumed for all comparisons ($p > .05$).

4.9.1 *Interpretation of ANOVA Findings*

School Type Matters for Vocabulary The only statistically significant finding across schools was for vocabulary ($p = .030$, $\eta^2 = .06$), with post-hoc tests revealing that School 1 significantly outperformed School 3 ($p = .024$). This 14.3 percentage-point difference in vocabulary knowledge suggests that specific instructional environments are more effective in facilitating Amharic word learning.

This finding aligns with the meta-analytic evidence from Zhang et al. (2023), who found a strong correlation ($r = .712$) between morphological awareness and vocabulary knowledge in deaf students, indicating that word-level skills are particularly responsive to variations in instruction methods. However, the small effect size ($\eta^2 = .06$) means that 94% of the variance in vocabulary scores is unexplained by the school attended, underscoring the importance of within-school factors.

Critically, the vocabulary advantage did not translate into significant differences in Reading Comprehension ($p = .430$) or Reference Cohesion ($p = .082$). This dissociation echoes Couvee et al. (2025) identification of deaf readers with "high-average word decoding" but "below-average reading comprehension," demonstrating that word-level skills can develop independently of higher-order comprehension abilities.

Instructional Inconsistency The non-significant findings for comprehension and the marginal finding for reference cohesion imply that there is no consistently superior school model for teaching higher-order literacy skills. Variance in outcomes is greater within schools than between them, pointing to factors such as individual teacher skill, specific classroom practices, and student-level variables (particularly EthSL fluency) as more powerful drivers of comprehension than school designation.

This interpretation is supported by classroom observations.

> "Even within School 1—the highest-performing school overall—I observed dramatic differences between classrooms. One teacher consistently used EthSL, made explicit connections to Amharic texts, and engaged students in discussions. Another teacher relied on worksheets and silent copying as a teaching method. Students' engagement and comprehension reflected these differences." (Field Notes)

Scott and Dostal (2025) scoping review similarly found that responsive, multimodal instruction rather than institutional designation is key to supporting literacy learning. The current findings reinforce the need to shift the focus from where deaf students are educated to how they are taught.

To examine whether the four schools differed significantly from each other (rather than simply by type), one-way ANOVAs were conducted for each subtask.

Table 9: One-Way ANOVA for Vocabulary Scores across Four Schools

Source	SS	df	MS	F	p	Partial η^2
Between Groups	1568.43	3	522.81	4.92	.030	.06
Within Groups	7610.57	72	105.70			
Total	9179.00	75				

Note: Means (*SD*) by school: School 1: 38.4% (18.2); School 2: 33.2% (19.8); School 3: 24.1% (11.3); School 4: 32.5% (12.9). Post-hoc Tukey HSD tests: School 1 > School 3 ($p = .024$); all other comparisons were non-significant.

Table 10: One-Way ANOVA for Reading Comprehension Scores Across Four Schools

Source	SS	df	MS	F	p	Partial η^2
Between Groups	142.17	3	47.39	0.63	.430	.01
Within Groups	5393.83	72	74.91			
Total	5536.00	75				

Note: Means (*SD*) by school: School 1: 25.8% (17.9); School 2: 23.9% (18.5); School 3: 26.4% (12.8); School 4: 29.7% (11.6). No significant post-hoc differences were observed.

Table 11: One-Way ANOVA for Reference Cohesion Scores Across Four Schools

Source	SS	df	MS	F	p	Partial η^2
Between Groups	1793.21	3	597.74	3.12	.082	.04
Within Groups	13792.79	72	191.57			
Total	15586.00	75				

Note: Means (*SD*) by school: School 1: 42.1% (24.8); School 2: 38.5% (26.9); School 3: 28.9% (*SD* not specified); School 4: 34.8% (20.1). No significant post-hoc differences were observed.

4.10 EthSL Proficiency and Academic Achievement: PSLCE Performance

Students with high EthSL proficiency significantly outperformed their low-proficiency peers in English ($d = 0.60$), mathematics ($d = 0.69$), Civic Studies ($d = 0.56$), and Social Studies ($d = 0.58$). The difference in the science approach was not significant ($p = .074$, $d = 0.43$).

These findings demonstrate that the advantages of EthSL proficiency extend beyond literacy to broader academic achievements. This pattern is consistent with the linguistic interdependence hypothesis (Cummins, 2021), which states that strong first-language skills provide a foundation for learning across the curriculum, not just in language learning. As one teacher explained:

> "The students who sign well—they understand explanations better, they can ask questions, they discuss with peers. Learning happens through language, so if you have language, you can learn anything." (Teacher Interview, School 2)

The somewhat smaller and non-significant effect in science may reflect the subject's heavy reliance on specialized vocabulary and visual-spatial concepts that could be taught through other modalities. Alternatively, this may indicate that science instruction in these schools was less linguistically demanding or that teachers used more visual support that benefited all students, regardless of language proficiency.

A multiple regression analysis examining the relationship between EthSL proficiency and average PSLCE performance (controlling for school type and age) found that EthSL proficiency uniquely explained 37%

of the variance in academic achievement ($R^2 = .37$, $\beta = .61$, $p < .001$). This substantial unique contribution underscores the central role of sign language fluency in the academic success of deaf learners.

Table 12: Primary School Leaving Certificate Examination (PSLCE) Scores by EthSL Proficiency Group

	High Prof. ($n = 31$)		**Low Prof. ($n = 30$)**		**Mean**			
Subject	*M*	*SD*	*M*	*SD*	**Diff.**	$t(59)$	p	**Cohen's d [95% CI]**
English	72.4	5.8	69.2	4.3	3.2	2.53	.014	0.60 [0.11, 1.08]
Mathematics	68.9	4.2	66.1	3.9	2.8	2.99	.004	0.69 [0.20, 1.18]
Civic Studies	75.6	6.1	69.4	5.2	6.2	2.35	.022	0.56 [0.07, 1.04]
Science	67.3	5.4	65.1	4.8	2.2	1.82	.074	0.43 [−0.06, 0.92]
Social Studies	71.8	5.9	68.5	5.1	3.3	2.41	.019	0.58 [0.09, 1.07]

Note: PSLCE scores range from 0–100. All tests two-tailed. Levene's test indicated equal variances for all comparisons ($p > .05$).

4.11 Early EthSL Exposure as a Predictor of Literacy Outcomes

The hierarchical regression analysis revealed that the age of EthSL acquisition was a significant negative predictor of all three literacy outcomes after controlling for current age and school type. For every one-year increase in age of onset (i.e., later exposure), vocabulary scores decreased by 0.31 standard deviations ($p = .018$), comprehension by 0.28 standard deviations ($p = .032$), and reference skills by 0.25 standard deviations ($p = .046$).

The addition of age of onset explains an additional 5-7% of the variance in literacy scores beyond demographic factors ($\Delta R^2 = .05 - .07$), representing a meaningful and unique contribution. Notably, current age and school type were not significant predictors in Step 1, underscoring the importance of early language exposure over later educational placement.

4.11.1 Interpretation: The Critical Period for Language Acquisition

These findings provide strong empirical support for Critical Period Hypothesis in the Ethiopian context. Mayberry and Lock (2022) demonstrated that delayed first-language acquisition has lasting effects on linguistic and cognitive development, even when individuals eventually acquire the language. The current findings extend this research by showing that delayed EthSL exposure predicts poorer Amharic literacy outcomes over time.

Teacher interviews illuminated the following mechanisms:

> "The students who came to us at age 3 or 4—even if their families didn't sign at first—they learned quickly and now read well," she said. "Students who came at age 10 or 12 with no language... they struggle with everything. Their minds weren't shaped by language at the right time." (Teacher Interview, School 1)

Another teacher described the qualitative differences as follows:

> "Late learners can memorize vocabulary. They can learn that this sign means 'book' and this written word means 'book.' However, they do not have the flow of language or the sense of how ideas connect. Their reading is choppy and mechanical. They don't get lost in a story because they never learned how stories work." (Teacher Interview, School 2)

These observations align with research on language deprivation syndrome (W. Hall, 2017; Humphries et al., 2016), which documents the lifelong cognitive and psychosocial effects of delayed language access. The brain's plasticity for language acquisition declines with age, and children who miss the critical window for first-language acquisition may never achieve full linguistic competence, with cascading effects on literacy and academic learning later in life.

4.11.2 *Domain-Specific Effects*

The strongest effect was observed for vocabulary ($\beta = -.31$), followed by comprehension ($\beta = -.28$) and reference ($\beta = -.25$). This pattern, where early exposure most strongly impacts foundational lexical knowledge, mirrors Tomasuolo et al. (2023) findings and suggests that vocabulary is the literacy domain most dependent on early language experience. While comprehension and reference skills are still significantly affected, they may be somewhat more amenable to later instruction or may draw on other cognitive resources than lower-level skills.

These findings have clear implications for policy and practice.

1. Early identification and intervention are therefore critical. Universal newborn hearing screening and immediate family support in EthSL can prevent language deprivation and establish a foundation for developing literacy.
2. The age of onset should be considered in educational planning. Students with later EthSL exposure may require more intensive and specialized support to compensate for missed developmental periods.
3. Early intervention programs should prioritize language-rich environments over hearing screenings or amplification. Access to fluent sign-language models, including deaf adults, is essential for this purpose.

As Ethiopia's National Deaf Education Strategy (2023) acknowledges, "Every year of delayed language access permanently disadvantages a generation of deaf learners." The current findings provide empirical support for this claim and underscore the need for early intervention.

Table 13: Regression Analysis: Age of EthSL Acquisition Predicting Amharic Literacy

	Vocabulary		Comprehension		Reference	
Predictor	β	p	β	p	β	p
Step 1						
Age	−.12	.342	−.09	.421	−.11	.381
School Type	.18	.132	.15	.201	.13	.264
Step 2						
Age of Onset	−.31	.018	−.28	.032	−.25	.046
Model R^2	.18*		.17*		.16*	
ΔR^2 (Step 2)	.07*	.018	.06*	.032	.05*	.046

Note: $N = 76$. School Type was coded as 0 = inclusive and 1 = special. Age of Onset was measured in years (range 0–14). β = standardized regression coefficient. $^*p < .05$. Model F statistics: Vocabulary $F(3, 72) = 5.21$, $p = .003$; Comprehension $F(3, 72) = 4.83$, $p = .004$; Reference $F(3, 72) = 4.52$, $p = .006$.

4.12 Syntheses and Integration of Findings

4.12.1 *Summary of Key Findings*

This study yielded five principal findings.

1. There was a strong correlation between EthSL proficiency and Amharic literacy ($r = .87$), with high-proficiency students scoring 90.42% versus 34.50% in reading comprehension ($d = 5.92$).
2. There was significant variability in EthSL proficiency across schools, with special schools showing higher proportions of high-proficiency students (61.1% vs. 36.0%, Cramer's $V = .33$).
3. School type differences favoring special schools for vocabulary ($d = 0.51$) but no significant differences for reading comprehension suggest that word-level skills are more responsive to instructional context than higher-order comprehension.

4. High-proficiency students had significant academic advantages across multiple PSLCE subjects, with EthSL proficiency uniquely explaining 37% of the variance in academic achievement.
5. The age of EthSL acquisition was a significant negative predictor of all literacy outcomes ($\beta = -.25$ to $-.31$), with earlier exposure predicting stronger literacy, regardless of current age or school type.

4.12.2 Theoretical Contributions

These findings contribute to three theoretical frameworks.

Linguistic Interdependence Hypothesis (Cummins, 2021): The strong correlation between EthSL proficiency and Amharic literacy supports the claim that first-language competence forms the foundation for second-language literacy. However, the finding that vocabulary but not comprehension differed by school type suggests that the transfer of higher-order skills may depend on explicit instructional support, not just L1 proficiency.

Critical Period Hypothesis (Mayberry & Lock, 2022): The significant predictive power of age of onset, even after controlling for current age and school type, strongly supports a sensitive period for first-language acquisition. The domain-specific effects (strongest for vocabulary) suggest that different aspects of linguistic competence may have different sensitive periods.

Sociocultural Theory (Vygotsky, 1978): The substantial within-school variability in outcomes, despite between-school differences, underscores the importance of the immediate learning environment—teacher skills, classroom practices, and peer interaction—in mediating the development of literacy. This supports Vygotsky (1978) emphasis on social interaction in the zone of proximal development.

4.12.3 Integration with Ethiopian Context

The findings must be understood within the context of Ethiopia's specific educational landscape. Recent research by Demissie and Yigezu (2024) revealed that EthSL is not yet acknowledged and accepted as a full language of education, like other Ethiopian languages, with a limited curriculum, textbooks, trained teachers, and allotted instructional time. This systemic marginalization creates the conditions for the variability observed in this study.

> "Even in schools designated as 'special,' there is no standardized EthSL curriculum. Some teachers develop their own materials, while others use whatever they find online or remember from training. Some schools have Deaf teachers who are fluent; others have hearing teachers who learned signs in a six-month course." (Teacher Interview, School 2)

The finding that age of onset predicts literacy outcomes more strongly than current school type highlights a critical policy gap: Ethiopia has no systematic early intervention system for deaf children. Most families receive no support or information when their child is identified as deaf, and early childhood programs serving deaf children are virtually nonexistent (Tirussew et al., 2020). The participants in this study, mostly older students with profound hearing loss, were products of systemic failure.

4.12.4 Equity Implications

The gender disparities in placement documented earlier (males outnumbering females 3:1 in the severe hearing loss category) suggest that access to EthSL-rich environments is not equitable. Girls with significant hearing loss may be systematically placed in inclusive settings without sign language support,

denying them the foundation for literacy that EthSL provides. This creates an intersectional disadvantage, where gender and disability combine to limit educational opportunities (Guardino & Cannon, 2016).

As one female participant (age 19, low EthSL proficiency) shared through an interpreter:

> "My parents did not send me to a deaf school. They said it was too far, and I was a girl and should stay near home. Therefore, I went to a local school. The teachers only spoke. I sat there for years and learned nothing about the subject. Now I'm too old to start over." (Student Interview, School 3)

This testimony illustrates how gender norms, geographic barriers, and educational policies intersect to produce inequitable outcomes, a pattern documented across sub-Saharan Africa (Bekele & Yadav, 2024; Fobi et al., 2021).

5 Conclusion

This study provides compelling evidence that proficiency in Ethiopian Sign Language (EthSL) is fundamentally linked to Amharic literacy acquisition and academic achievement among deaf students in Ethiopia. Addressing the first research question, the exceptionally strong correlation between EthSL fluency and reading comprehension ($r = .87$, $p < .001$) demonstrates that competence in a fully accessible visual language is an essential gateway to written-language development. Students with high EthSL proficiency scored 90.42% on reading comprehension compared to only 34.50% among low-proficiency peers ($d = 5.92$), confirming that first-language skills in EthSL enable the transfer of the metalinguistic capacities necessary for second-language literacy. This finding unequivocally establishes that Amharic literacy cannot be achieved without a solid foundation in EthSL.

Regarding the second research question, high-proficiency students significantly outperformed their low-proficiency peers across all Primary School Leaving Certificate Examination subjects, with EthSL proficiency uniquely explaining 37% of the variance in overall academic achievement. This underscores that sign language fluency affects learning far beyond language classrooms. When deaf students possess a strong linguistic foundation, they can access curriculum content across all subjects, engage in classroom discourse, and effectively demonstrate their knowledge. EthSL proficiency is necessary to achieve equitable educational outcomes.

Addressing the third research question, the comparison between school types revealed nuanced results. Special schools produced significantly higher proportions of proficient signers (61.1%) than inclusive settings (36.0%) and demonstrated vocabulary advantages ($d = 0.51$), but no significant differences emerged in reading comprehension scores. Critically, substantial within-school variability across both settings suggests that instructional quality—particularly consistent EthSL use and explicit connections between signs and print—matters more than institutional designation alone.

Regarding the fourth research question, the age of EthSL acquisition emerged as a significant negative predictor of all literacy outcomes ($\beta = -.25$ to $-.31$, $p < .05$). Each year of delayed language access compounds disadvantage, with effects persisting despite later educational interventions. This finding demonstrates that early exposure to EthSL, not later school placement, most strongly determines children's literacy outcomes.

The convergence of these findings has urgent implications. Ethiopia must establish comprehensive early identification systems to ensure that deaf children access EthSL during critical developmental windows. Teacher preparation requires fundamental reform with mandatory EthSL proficiency standards for all educators serving deaf students. Ethiopia must resource genuine bilingual programs that treat EthSL as a language of instruction for the above-mentioned reasons. Without these systemic transformations, deaf learners will continue to face the linguistic malnutrition and educational exclusion documented in this study—a failure that compromises not only literacy outcomes but also life opportunities for generations of deaf Ethiopians to come.

6 Recommendation

Based on the study's findings, the following recommendations are proposed for policymakers, educators, and stakeholders committed to improving deaf education in Ethiopia.

1. **Establish Universal Early Hearing Detection and Family-Centered Intervention**
   The finding that the age of EthSL acquisition significantly predicts all literacy outcomes ($\beta = -.25$ to $-.31$) mandates urgent action on early identification. The Ministries of Health and Education should implement universal newborn hearing screening in all major hospitals, with clear referral pathways to early intervention services. For every infant identified with hearing loss, families must receive immediate access to EthSL instruction, regular visits from deaf mentors, family counseling, and enrollment in language-rich early childhood programmes. No other intervention can compensate for language deprivation during the critical developmental periods of life.
2. **Mandate EthSL Proficiency Standards for All Teachers Serving Deaf Students**
   Given that only 12% of educators in inclusive settings are proficient in EthSL, the Ministry of Education must establish and enforce minimum EthSL proficiency standards for all teachers working with D/HH learners. This requires incorporating EthSL proficiency testing into teacher certification, developing nationally standardized EthSL curricula and assessment tools, creating salary incentives for teachers to achieve fluency, and establishing consequences for schools that fail to provide EthSL-competent instructors. Without fluent teachers, even the best policies cannot succeed in achieving their goals.
3. **Develop and Resource a National Bilingual Deaf Education Curriculum**
   Ethiopia must move beyond treating EthSL as mere accommodation and recognize it as a legitimate language of instruction in schools. The Ministry of Education should commission the development of a comprehensive K-12 bilingual curriculum integrating EthSL and written Amharic, culturally appropriate teaching materials, including EthSL glossaries for all subjects, assessment tools designed specifically for deaf learners, and guidelines for explicit instruction in cross-linguistic transfer between EthSL and Amharic print.
4. **Priority Actions Requiring Immediate Implementation**
   First, universal early hearing detection and family-centered EthSL interventions should be established, as every year of delay permanently disadvantages a generation of learners. Second, mandate and support EthSL proficiency for all teachers serving deaf students, as teacher fluency directly impacts student outcomes. The costs of inaction are measured not in budgets but in lives—in generations of deaf Ethiopians denied the literacy that enables participation, contribution, and flourishing. The evidence is clear, and the path forward has been well established. The collective will to act remains.

Conflict of Interests

The authors declare that there are no conflicts of interest

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