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Social inequalities in children's cognitive and socioemotional development: The role of home learning environments and early childhood education

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ABSTRACT

This study uses high-quality longitudinal data from the *Growing Up in Ireland* study to examine the interplay between home learning environment (HLE) and early childhood education (ECE) in explaining children's skills development from 9 months to 5 years old across parental socioeconomic status (SES). Random-effects linear regression models show that: (1) supportive HLE improves children's cognitive and socioemotional skills and ECE quality critically fosters early socioemotional skills; (2) SES is associated with higher early cognitive and socioemotional outcomes, while responsive and consistent parenting behaviours among low-SES parents is particularly critical to improve their children's socioemotional well-being; (3) high-quality ECE attendance compensates for children's behavioural problems in less responsive parenting environments, especially among low-SES families, whereas home literacy stimulation is necessary condition for high-quality ECE attendance to benefit children's early cognitive skills. Overall, HLE and ECE mutually interact in explaining differences in children's early skills development across SES groups.

1. Introduction

Early childhood is a key developmental stage in the acquisition of skills throughout life (Bäumer et al., 2011; Blossfeld & Von Maurice, 2011; Cunha & Heckman, 2007). Previous research has shown that the process of child development is strongly stratified across socioeconomic status (SES), showing marked inequalities in children's educational and socioemotional outcomes operating even before entry into primary school (Blossfeld et al., 2017; Kulic et al., 2019; Skopek & Passaretta, 2018). Therefore, examining the mechanisms by which learning contexts, both within and outside the family, explain disparities in children's early skills development is critical to understand the reproduction of social inequalities in contemporary societies.

The social stratification and educational literatures highlight two mutually reinforcing learning contexts of children's skill development during early childhood: (i) the home learning environment (HLE) and (ii) the early childhood education system (ECE). On the one hand, HLE is a decisive informal learning environment for children's academic and social development (Bäumer et al., 2011; McGinnity et al., 2017; Rose et al., 2018), playing a key role in explaining SES gaps in early child development (Lehrl, 2018; Sénéchal & LeFevre, 2002; Tamis-LeMonda et al., 2019). On the other hand, (high-quality) ECE attendance has been recognised as an important predictor of child outcomes, with particularly beneficial consequences among children from disadvantaged SES backgrounds (Becker, 2011; Gambaro et al., 2014). While existing studies suggest that these two dimensions are important determinants of children's skill development, how quality features of HLE and ECE interplay to explain inequalities in early skill development remains unclear.

The present study aims to close such important gap within the social stratification literature by examining the combined influence of HLE and ECE in children's early cognitive and socioemotional outcomes, paying particular attention to the moderating role of SES. Our study answers four key questions: (1) What role do HLE and ECE quality play in children's cognitive and socioemotional outcomes? (2) How do HLE and ECE quality influence the cognitive and socioemotional development of children across SES? (3) Is the impact of high-quality ECE attendance on skills development the same among children experiencing HLE of different quality? (4) Can ECE quality compensate for the effect of HLE on children's cognitive and socioemotional skills across different SES groups?

We use high-quality cohort data from Ireland to contribute to this

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insufficiently explored research area within the social stratification and education literatures. Only two studies have to our knowledge analysed the combined influence of HLE and ECE on early skills development, one using data from England (Melhuish et al., 2008) and the other from Germany (Anders et al., 2012). These two studies find that HLE and ECE influence children's academic skills. Our study significantly advances this literature in two main directions. First, we examine whether and how HLE and ECE explain, separately and in interaction, children's skill development across SES groups. We do this by using a much richer diversity of measures of quality features than previous literature in the field, including an examination of measures of home learning activities, diverse parenting styles, as well as indicators of ECE support for child's development and learning (e.g., materials and equipment and emotionally supportive interactions with relevant others). Second, we adopt a multidimensional approach to examine, not only how both HLE and ECE are related to children's early cognitive skills, but also the way the interaction of HLE and ECE are associate with socioemotional outcomes. In doing so we add to previous stratification literature, as scholars have for long demonstrated the key relevance of both cognitive and socioemotional skills in explaining cumulative life-long learning processes (e.g., Cunha & Heckman, 2007).

Ireland provides an interesting study case. Compared to most OECD countries, the Irish ECE system is expensive and highly commodified (Mahon & Bailey, 2015; McGinnity et al., 2015). To illustrate, childcare costs in Ireland represent over 27 % of dual-earner families' income, against 12 % of the OECD average (McGinnity et al., 2017, 2015). Although recent state-subsidised interventions like the Free Preschool Year (FPSY) scheme have helped 3-year-olds to access publicly subsidized preschool education (Mahon & Bailey, 2015; McGinnity et al., 2015), financial support of ECE by the Irish government is four times lower than the OECD average (McGinnity et al., 2017). Despite the introduction of a national standardised ECE framework in 2011 in Ireland (Neylon, 2014), ECE quality in Ireland differs across childcare centres several indicators, such as pedagogical guidelines and curricula, safety and hygiene standards, and staff-child ratios, compared to public subsidized settings (OECD, 2011; Plantenga & Remery, 2013). In our study, we exploit this interesting source of quality variation across ECE institutions in Ireland.

Overall, while existing research indicates that informal and formal learning environments influence children's academic scores (e.g., McGinnity et al., 2022; McMullin et al., 2020), we advance the literatures on child development and social stratification with a new approach that allows to (1) empirically show how HLE and ECE quality precisely interplay in explaining gaps in early child development across SES groups, and (2) how these processes influence both early cognitive and socioemotional outcomes.

2. Theoretical background

2.1. A process-quality model of inequalities in child development

In the early childhood literature, quality is defined as a crucial predictor of child development. Both sociologists and economists have for long stressed that accumulated (dis)advantages in quality care critically influence children's cognitive and socioemotional development throughout the life course (e.g., Cunha & Heckman, 2007; Datta Gupta & Simonsen, 2010; Kulic et al., 2019). From the combination of sociological and economics literature, we can conceive the intersecting areas of quality care in both HLE and ECE as central predictors of child development processes.

Meanwhile, educational researchers have defined quality as a multidimensional concept, captured by the *structure-process model* that is applied to both HLE (Kluczniok et al., 2013) and ECE (Kluczniok & Rossbach, 2014). This model defines four components of quality: (1) structural factors, (2) process quality, (3) educational beliefs and orientations, and (4) networking with families. Our study concentrates on the second component (i.e., process quality), which is a particularly relevant quality dimension for stimulating children's development and learning (Ulferts, Wolf, & Anders, 2019; Slot, Lerkkanen & Leseman, 2015). To date, how process quality impacts child development is insufficiently studied, as few surveys contain a rich combination of measures linked to process quality.

Following Kluczniok and colleagues (2013), *process quality* refers to the everyday interactions that children have with their parents, other children, and their spatial-material surroundings. In their study, 'global' educational processes indicate aspects that generally favour child development, such as everyday family activities and the family climate that parents and other relevant family features contribute to create. By contrast, 'domain-specific' educational processes incorporate all activities that foster specific developmental domains, such as children's availability of books and engagement in learning-oriented activities with parents or educators (Kluczniok et al., 2013). Although having access to books does not *per se* imply that families will actually use them in ways that promote children's literacy skills (e.g., Barone et al., 2021; Engzell, 2021), Kluczniok et al. (2013) consider educational materials of HLE that support literacy and numeracy (e.g., books, educational games) as domain-specific quality processes. This is because educational equipment, such as having a book nearby, is a necessary condition for family quality processes to emerge.

Our theoretical approach integrates two different academic traditions within the child development literature. On the one hand, we incorporate the life-course scholarship in sociology and economics defining inequalities in child development as cumulative processes that evolve over the years (e.g., Cunha & Heckman, 2007; Datta Gupta & Simonsen, 2010; Kulic et al., 2019; McMullin et al., 2020; Skopek & Passaretta, 2018). On the other hand, we consider the structural-process model (Slot, Lerkkanen, & Leseman, 2015; Ulferts et al., 2019; Kluczniok et al., 2013) by focusing specifically in the most complex domain of this model: "process quality". Unlike conceptualised in the original structural-process model, we follow a tradition that is closer to social stratification research to consider parental SES as a multifaceted variable of social background that encompasses and influences all features of quality, including process quality.

Our study contributes theoretically and empirically by: (1) readdressing the combined role of HLE and ECE in explaining child developmental outcomes; (2) examining both child cognitive and socioemotional outcomes; and (3) situating SES as a fundamental variable that intersects with HLE and ECE in the reproduction of social inequalities during early childhood. This study does not adopt an experimental causal design. While we use high-quality longitudinal data and consider various confounders in the empirical modelling, this study is correlational, based on observational data.

2.2. The separate role of HLE and ECE quality in children's skill development

Previous literature has added to our understanding of the separate role that HLE and ECE play in children's skills development processes. Literature on HLE has revealed how learning and school preparedness start at home. By investing their economic resources and time in education, as well as by providing necessary support and materials, families and parents are primary central actors in the process of their children's skill formation (Bäumer et al., 2011). To date, however, research has omitted an integrated approach that simultaneously examines how various HLE dimensions relate to children's cognitive and socioemotional skills. In contrast to research on the impact of a single HLE component on early learning, past studies on the influence of different HLE dimensions on child development are missing. All these many elements are considered in our study.

Parent-child developmental activities (i.e., reading to children, playing educational games) and learning materials at home have the direct potential to enrich children's intellectual development (Gracia,

2012) by stimulating curiosity and motivation for learning (Pomerantz et al., 2007). Parenting styles are an additional component of HLE process quality that relate to the emotional climate in which children are raised. Previous research found that, among different types of parenting styles (Baumrind, 1978, 1991; Darling & Steinberg, 1993), authoritative parenting is the most conducive to children's skill formation and school readiness (Chan & Koo, 2011; Cobb-Clark et al., 2019). Also, authoritative parents have a "warm and responsive" relationship with their offspring and provide them with "affection and support in their explorations and pursuits of interests" (Spera, 2005:134), while supporting discipline through dialogue and the fostering of independence linked to child development.

With regards to ECE, previous studies have argued that high-quality formal care associates positively with children's cognitive, linguistic and social development in both the short and long run (Yoshikawa et al., 2016; Melhuish et al., 2015). Yet, compared to studies on unequal ECE access (Sprong & Skopek, 2023; Steinberg & Kleinert, 2022) and to those on the effect of ECE enrolment on children's competencies (Berger et al., 2021; Cebolla-Boado et al., 2017; Klein & Becker, 2017), studies examining the influence of ECE quality are scarce. When available, such studies (Stewart et al., 2019) have led to inconclusive findings on the role of ECE quality on skills development since they "differ in the components of quality being considered and in how these components are being assessed" (Kluczniok & Rossbach, 2014:146). This gap in the ECE literature deserves attention.

Although previous studies contributed to understand how HLE and ECE –separately– link to child development, our study further adds to the literature (1) by using, compared to previous studies, a richer diversity of measures of quality features for testing mechanisms, including HLE (e.g., home learning activities and parenting styles) and measures of ECE support for children's development and learning missing in previous literature (e.g., materials and equipment and emotionally supportive interactions with relevant others), and (2) by examining skills, not only in the cognitive domain, but also in the socioemotional domain, adding a multidimensional approach to how HLE and ECE influence individual development in early childhood. Concerning HLE we expect that *children (i) who engage more frequently in literacy activities with their parents; (ii) have adequate home educational materials; (iii) have highly supportive parents; and (iv) experience consistent parenting rules show disproportionately high cognitive and socioemotional outcomes* (H1). Meanwhile, for ECE, we expect that *children who attended high-quality ECE perform better in early cognitive tests and have fewer socioemotional problems than their peers who never went to ECE or attended low-quality childcare settings* (H2).

2.3. The role of SES inequalities

Prior studies found that SES is positively associated with skills from preschool age onwards (Bradbury et al., 2015; Duncan & Magnuson, 2011; Kulic et al., 2019; Skopek & Passaretta, 2018). Two theoretical perspectives have primarily accounted for it: the family investment model (FIM hereafter) and the family stress model (FSM hereafter). The FIM claims that social inequalities in skills originate because families with different SES backgrounds differ in the time and money they invest in their offspring, which is associated with unequal educational opportunities (Domina, 2005; Ermisch, 2008). The FSM focuses on the emotional and psychological stress brought on by financial difficulties and economic hardship, which can impair parenting and family functioning and, as a result, hinder the development of children (Conger & Donnellan, 2007).

Although the FIM and FSM models have played a relevant role in explaining inequalities in child development, new models are necessary to identify the exact role of HLE and ECE behind inequalities in children's skills development. This is particularly relevant as existing literature has provided little evidence on how HLE, and particularly ECE, separately and in combination, correlate with SES gaps in children's skills development, with literature missing a combined examination of cognitive and socioemotional outcomes.

We propose two alternative scenarios to explain how social inequalities relate to children's early skills' development, which remain understudied to identify the role of HLE and ECE in the formation of social inequalities in children's cognitive and socioemotional outcomes. One possible scenario is illustrated by the *substitution hypothesis*, which argues that low-SES kids benefit from process quality more than high-SES kids. For example, we know that informing parents about the cognitive-enhancing potential of shared book reading positively impacts the early vocabulary skills of children from less-educated families to a higher extent than among children of high-educated families (Barone et al., 2021). Similarly, children from families with limited resources who experience high levels of positive parenting do particularly well in their first year of primary school (Kiernan & Mensah, 2011). Although there is little evidence on high quality ECE attendance, one could expect that, due to their deprived socioeconomic conditions, low-SES children learn at a faster pace when exposed to high-quality ECE settings, compared to high-SES children, who are often more used to receive intensive learning stimulation. Thus, the substitution hypothesis suggests that ECE and HLE quality substitutes for children's social origins, meaning that *the learning benefits of high-quality HLE and ECE exposure are greater for low-SES children than for high-SES children* (H3a).

An alternative scenario is what we refer to as the *complementary hypothesis*. From this perspective, as high-SES children have access to a large set of material, cultural, and social resources at home that provides them with stronger learning support than low-SES children, high-SES kids may disproportionately benefit from quality process than low-SES kids, mirroring inequalities in their family of origin. For example, high-SES parents may be less likely to suffer from the emotional and psychological pressure that derives from economic hardship, compared to low-SES parents, thus damaging children's behavioural development and school grades among low-SES children (Kaiser et al., 2019). As regards ECE, if we know that high-SES parents are more likely to invest early in formal educational opportunities (Brilli et al., 2017; Van Lancker & Ghysels, 2016; Skopek, 2017) and also enter ECE with an already rich set of abilities that enables them to profit the most from interactions with teachers and peers (Jahreie, 2022), one could expect that ECE and HLE quality complements SES. Thus, from a complementary hypothesis, *the learning benefits of being exposed to high-quality HLE and ECE are higher for high-SES children than for low-SES children* (H3b).

2.4. The cross-fertilising influence of HLE and ECE on children's skill development

Our study further contributes to the literature by examining the *interactive role* of HLE and ECE to impact children's cognitive and socioemotional outcomes. Although HLE and ECE quality dimensions may have cross-fertilizing effects on children's cognitive and socioemotional outcomes, "little is known about their cumulative effects as well as their potential reciprocal, oppositional, or diminishing effects" (Bäumer et al., 2011: 92). To date, very few studies have explicitly addressed the reciprocal role of both HLE and ECE quality. Previous research from England indicates that aspects of both HLE and ECE matter for literacy scores at school entry (Melhuish et al., 2008). In Germany, the effects of these two learning environments on skills appear to not be simply additive, with children needing some sort of support at home to effectively benefit from high-quality ECE attendance (Anders et al., 2012). Cebolla-Boado and colleagues (2017) further suggest that preschool works as an equalizer of opportunities for the learning outcomes of children whose parents are less involved in their education before starting elementary school. We contribute to the literature by proposing two contrasting scenarios that may operate regarding the interactive role of HLE and ECE in explaining children's cumulative skills development. While we develop our hypotheses through an original approach that focuses on HLE and ECE, our model partly departs from previous

contributions in both economics (*e.g.*, Cunha et al., 2010; Cunha & Heckman, 2007; Del Boca et al., 2014) and sociology (*e.g.*, Bernardi, 2014; Cebolla-Boado et al., 2017; Jackson, 2015; Kulic et al., 2019; Sprong & Skopek, 2023) addressing the role of HLE and/or ECE in explaining inequalities in child outcomes.

One plausible scenario is that *the learning benefits of high-quality ECE attendance are greater for children who live in a poor-quality HLE rather than for those who live in a high-quality HLE* (H4a). ECE quality, therefore, may *substitute* for inadequate support and stimulation at home, thus lessening achievement gaps. Alternatively, a possible scenario would be that ECE quality acts as a *complement* to HLE quality in influencing child development, thus reinforcing achievement gaps so that *the learning benefits of high-quality ECE attendance are greater for children who are exposed to high-quality HLE rather than for children exposed to low-quality HLE* (H4b). We additionally add to the social stratification and child development literatures by examining whether this combined role of HLE and ECE operates differently across SES groups. While it is currently not clear how SES links to trade-off processes interacting HLE and ECE, which may depend on whether the substitution or complementary scenarios (presented above) apply, our study further adds to the literature by testing how cross-fertilising processes linking HLE and ECE operate across children from different SES backgrounds.

3. Data and methods

3.1. Data and sample

We use data from the *Growing Up in Ireland* (GUI) study. We use data from three waves of the GUI Infant cohort. The first interview (wave 1) took place between September 2008 and April 2009, when babies were 9 months old (N = 11,134 babies). Follow-up interviews were conducted in 2010/2011 (wave 2), and 2013/2014 (wave 3), when cohort members were three and five years old respectively (Quail et al., 2011, Quail and O'Reilly, 2019).

In the GUI, missing responses are more prevalent in less-educated, low-SES and lone-parent families (Mccrory et al., 2013; McNamara et al., 2020; Williams et al., 2019). We address this issue by generating inverse probability weighting for each round of the data, as in Mari and Keizer (2021). We estimate weights separately between W1 and W2, W2 and W3 and then we multiply them within each household (see Appendix). To avoid data inconsistencies and ensure comparability between families, we apply basic criteria for comparability by including households where parents are partnered, have completed at least compulsory school, thus being older than 15 years old, and where primary respondents remained the same across the waves. Additionally, we exclude all observations with incomplete records in one or more measures in our analyses through listwise deletion. To account for these exclusions, we create new inverse probability weights for the chance of being included in the analytical sample (see Appendix). Our final sample consists of 5079 children and their parents, with 10,158 person-year observations.

3.2. Dependent variables

We focus on two dependent variables: *cognitive abilities* and *socio-emotional skills*. Expressive English vocabulary and reasoning skills capture cognitive abilities assessed by the Naming Vocabulary (NA) and the Picture Similarities (PS) tests, respectively. During the NA, children should name the item displayed from a picture book. In the PS children choose the stimulus that, from four alternatives, shared elements or concepts in common with a given picture (Williams et al., 2019). To ease the interpretability and comparability across waves, we transform the original total test scores into z-scores with a mean equal to 0 and a standard deviation equal to 1. Higher scores correspond to higher performances in cognitive tests.

To capture socioemotional skills, we rely on the Strength and Difficulties Questionnaire (SDQ), a parent-report measure of children's behaviours (Goodman, 1997) and a highly validated tool for screening psychopathologies in children and adolescents. Following previous literature (Bohnert & Gracia, 2021; Goodman et al., 2010; Mari & Keizer, 2021), we combine measures for emotional and peer relational problems into a scale capturing emotional (internalizing) problems, while we add up measures of conduct problems and hyperactivity generating a second index of behavioural (externalizing) problems. Internal consistency has proven to be reliable (Cronbach's alpha amounts to 0.78 for externalizing problems and to 0.73 for internalizing problems; Goodman et al., 2010, 1186). We use a z-standard of the scales so that the means equal 0 and the standard deviation equals 1. Higher scores correspond to higher emotional and behavioural problems.

3.3. Independent variables

To capture *HLE process quality,* we run a factor analysis with iterated principal axes that allow us to construct two additive scales of home literacy activities in W2 (Cronbach's Alpha: 0.70) and W3[1] (Cronbach's Alpha: 0.56). Both scales were transformed into three-category variables, dividing the scales into terciles with values (1) Low (T1), (2) Medium (T2), and (3) High (T3). Moreover, we consider the number of children's books owned by the family, recoding the original item from W2 and W3 into an ordinal variable, taking values (1) owing a maximum of 20 children's books; (2) from 21 to 30; (3) more than 30.[2] Finally, to capture parenting styles, we use two metric scales measuring maternal and paternal self-reported perceptions of (i) *warmth* i.e., responsive parenting, showing affection and awareness of children's needs; and (ii) *consistency*, i.e., demandingness, setting and consistently applying age-appropriate rules and expectations. From these two scales, we create an average measure of parenting styles recoded into terciles, (Low = 1; Medium = 2; High = 3). One may argue that a construct measure combining warmth and consistency into a single variable gives a powerful measurement to test the effect of parenting in the context of HLE on child development. However, the two scales (warmth and consistency) result in a Cronbach alpha that is too low to interpret the resulting scale as reliable. Therefore, we kept these two measures separately in our analyses. For more details on the original items used, see the Appendix (Table A1).

In Wave 2, five items measured by a five-category Likert scale capture *ECE quality*. We create an additive scale that ranges from 0 – i.e., lowest quality– to 5 –highest quality–. We recode the latter scale into a three-category variable with values (1) if children did not attend ECE, (2) if ECE is of low quality, and (3) if ECE is of high quality.[3] In Wave 3, two scales are used, which measure parental perceptions of (i) the richness of the care environment, and (ii) the quality of care. The primary caregivers expressed their views on ECE quality on a five-point Likert scale, ranging from "Never" to "Always": the higher the scores, the better the perception of quality. We first obtained the mean value from the two subscales measuring ECE quality for those children who attend infant classes in W3 and those who did not. Then, we divided the obtained scale into quintiles. From these two 5-category ordinal

[1] We rely only on primary caregivers' perspectives as secondary caregivers' opinions present a high number of missing responses on the same items.

[2] We are aware of the debate in studies of educational achievement on the measure of students' self-reported number of books in the family home, which is often used as a proxy for social, cultural, and economic background (Engzell, 2021). However, in our framework, we use this measure as a proxy for domain-specific process quality, specifically linked to children's book at home rather than number of books in general, potentially leading to meaningful literacy behaviours (Kluczniok et al., 2013).

[3] High quality means that parents declared to strongly agree with the statements proposed in all five original items. All other cases, i.e., when the ECE quality scale takes value from 0 to 4, are grouped in value 2, Low ECE quality.

variables, we created a categorical variable taking values (1) if children did not attend ECE; (2) if ECE was of Low quality (1st, 2nd, and 3rd quintile), and (3) if ECE was of High quality (4th and 5th quintile) regardless children's attendance to infant classes. For more details on the original items used, see Appendix, Table A.1.

3.4. Moderator variable

To measure *children's social origin,* we construct a scale of SES based on three original ordinal variables as a moderator measure. The first variable measures family educational level by grouping the highest educational level of children's parents, (1) lower secondary school level, (2) upper secondary school level, and (3) university degree. The second variable measures family social class by grouping parental social class into (1) never employed, (2) semi-skilled or unskilled manual, (3) non-manual or skilled manual, and (4) professional or managerial. Finally, the third variable measures family net income from the lowest (1) to the highest quintile (5). We apply the polychoric principal component analysis for obtaining a standardized measure of children's SES from these three ordinal variables, where mean equals 0 and standard deviations equals 1. While previous literature on social stratification has discussed the importance of considering different variables (e.g., education, income, occupation) to test different mechanisms in the reproduction of social inequalities (Barone et al., 2022; Ghirardi et al., 2023; Gracia & Ghysels, 2017), for reasons of space we have decided to use this previously validated polychoric score. We used this scale by weighting each component appropriately and calculating a single continuous scale via polychoric score technique. This technique to measure SES gaps has been recently used, for example, in studies that were concerned with child development and the role of ECE (e.g., Ghirardi et al., 2023). Additional analyses (not shown) reveal that using education, income and occupational class separately, rather than combining them into an SES single polychoric score, yields comparable results to the ones presented in the study.

3.5. Control variables

We adjust all analyses for a series of both time-constant and time-varying controls. We control for children's sex, migration background, developmental skills at eight months, and attendance to infant classes at five years old. We include measures of previous ECE attendance, parental attachment, routine, care, and early literacy parental practices, measured in Wave 1. Finally, we control for the area of residence.

3.6. Empirical strategy

We conduct linear random effects (RE), using a longitudinal design focusing on between-difference estimates. RE models suffer from a rigid assumption, namely that level-2 errors are not correlated with the covariates. If the latter assumption fails to be matched, then the RE estimates are biased. In our case, level-1 units are person-years observations and level-two units are individuals (i.e., children with their parents). We are aware of the existence of more flexible models than RE that decompose the variance in a between and within part, such as hybrid models (Allison, 2009) and correlated random-effects models (e.g., Mundlack models) (Wooldridge, 2010). However, we decided to apply RE rather than hybrid models primarily because the panel data that we use, with only two waves, was too short to correctly interpret a Mundlack within-between correction with interaction terms, further reinforcing our decision of implementing RE models as the best statistical modelling to test our hypotheses.

Our analyses follow three steps (See Table A.3 for a complete explanation of our equation modelling). In the first empirical step, we assess the association of HLE and ECE quality with children's skills before entry into primary school by assessing the mean performance in cognitive and socioemotional skills among children (i) from different SES backgrounds; (ii) socialized with different parenting styles, involvement, and educational materials at home; and (iii) with variations in the quality ECE. In the second empirical step, we ask whether the influence of HLE and ECE quality on skills varies according to children's social origins, testing whether substitution or complementarity mechanisms are in place. Finally, in the third empirical step, we ask whether the impact of ECE quality on skills is the same among children with different HLE. To detect the presence of either substitution or complementarity mechanisms, we calculate the difference in (Δ) skill performance between attending high-quality ECE and not attending ECE among children cared for in high-quality HLE and among those who experienced poor-quality HLE. For example, if the difference between high-quality ECE attendees and not attendees is greater for kids who experienced high-quality HLE than for those who live in poor-quality HLE, we corroborate the substitution hypothesis, as high-quality ECE compensates for reduced HLE (Eq. 2). Otherwise, high-quality ECE attendance complements a high-quality HLE (Eq. 1).

$$\Delta HLE_{high} < \Delta HLE_{low} \quad (1)$$

$$\Delta HLE_{high} > \Delta HLE_{low} \quad (2)$$

4. Findings

4.1. Descriptive analyses

Table 1 presents basic summary statistics with sample distributions for all our variables of study, which are further separated by SES groups, differentiating between the more disadvantaged (lowest half of the SES scale) and more advantaged (highest half of the SES scale) children. We observe that low-SES children are not only disadvantaged in cognitive and socioemotional outcomes, compared to high-SES children, but we also find clear SES differences in the HLE and ECE quality measures. Globally speaking, low-SES kids show, compared to high-SES kids, lower levels of parenting consistency, lower levels of literacy practices, lower number of books at home, and lower access to high-quality ECE, and higher levels of parental warmth. These overall differences link to the previous literature discussed above, suggesting clearly stratified dynamics in child cognitive and socioemotional skills, HLE quality, and ECE quality. This further justifies adjusting for multiple covariates (critically concerning HLE, ECE and SES) in our empirical models.

4.2. Determinants of early gaps in cognitive and socioemotional outcomes

As a first step, we look at the main effects of HLE and ECE quality on skill development. Fig. 1 reports average marginal effects (AME) on early cognitive and socioemotional skills of HLE and ECE quality.

Regarding cognitive skills, alongside HLE structural features, highly responsive and consistent parenting behaviours, rather than low, boost vocabulary scores of, on average, 0.06 ($p < 0.05$) and 0.10 ($p < 0.001$) standard deviation points, respectively. When looking at reasoning skills, the gain amounts to 0.11 ($p < 0.001$) and 0.05 ($p < 0.05$) standard deviation points. Highly frequent literacy activities at home, rather than scarce, correspond to an improvement in vocabulary scores of, on average, 0.9 ($p < 0.05$) standard deviation points. Instead, no effect is observed on reasoning skills. Compared to children who have access to fewer home educational materials, children who have a high number of books score 0.23 ($p < 0.001$) and 0.20 ($p < 0.001$) standard deviation points higher in vocabulary and reasoning tests, respectively. Finally, attending high-quality rather than low-quality ECE settings is not associated with early cognitive development.

As for socioemotional outcomes, we observe that a highly responsive or consistent parenting style is beneficial for both emotional (AME $= -0.16$, $p < 0.001$; and AME $= -0.14$, $p < 0.001$, respectively) and behavioural problems (AME $= -0.26$, $p < 0.001$; and AME -0.37, $p < 0.001$, respectively). Highly frequent literacy activities foster

Table 1
Summary statistics of all study variables, by the whole sample and by SES.

	All sample (N = 10,158)		Low-SES (N = 5189)		High-SES (N = 4969)	
Variables	***Mean***	***SD***	***Mean***	***SD***	***Mean***	***SD***
Vocabulary (z-score)	0.04	1.00	−0.09	1.00	0.23	1.00 *
Reasoning (z-score)	0.06	1.00	−0.00	1.00	0.14	1.00 *
Externalizing problems (z-score)	−0.05	1.00	0.06	1.00	−0.20	1.00 *
Internalizing problems (z-score)	−0.05	1.00	0.02	1.00	−0.14	1.00 *
SES (z-score)	0.04	1.00	n.a.		n.a.	
HLE: Warmth						
Low	38.31 %		37.34 %		39.66 %	
Medium	34.16 %		32.57 %		36.35 %	
High	27.52 %		30.09 %		23.99 %	*
HLE: Consistency						
Low	34.62 %		39.31 %		28.15 %	
Medium	32.54 %		32.34 %		32.80 %	
High	32.85 %		28.35 %		39.05 %	*
HLE: Literacy practices						
Low	32.98 %		36.55 %		28.05 %	
Medium	41.77 %		40.80 %		43.10 %	
High	25.26 %		22.65 %		28.84 %	*
HLE: Children's books						
20 or less	19.07 %		26.19 %		9.27 %	
21–30	17.34 %		19.23 %		14.74 %	
More than 30	63.58 %		54.58 %		75.98 %	*
ECE quality						
No ECE	37.28 %		40.42 %		32.96 %	
Low	35.50 %		35.10 %		36.03 %	
High	27.22 %		24.47 %		31.01 %	*
Children's sex						
Boy	50.54 %		49.15 %		52.44 %	
Girl	49.46 %		50.85 %		47.56 %	
Migration background						
Migrant	33.30 %		37.43 %		27.60 %	
Native	66.70 %		62.57 %		72.40 %	*
Area of residence						
Rural	59.45 %		63.70 %		53.60 %	
Urban	40.55 %		36.30 %		46.40 %	*
Development test at 8 months						
Fail	8.27 %		8.60 %		7.81 %	
Pass	91.73 %		91.40 %		92.19 %	
Attendance to ECE at 9 months						
No	87.08 %		92.98 %		78.96 %	
Yes	12.92 %		7.02 %		21.04 %	*
Parenting styles – attachment at 9 months						
Low	46.25 %		40.00 %		54.85 %	
Medium	41.62 %		43.01 %		39.71 %	
High	12.13 %		16.98 %		5.44 %	*
Parental Care activities at 9 months						
Low	29.92 %		32.72 %		26.07 %	
Medium	48.75 %		47.14 %		50.97 %	
High	21.32 %		20.14 %		22.96 %	*
Parental Literacy activities at 9 months						
Low	52.38 %		54.33 %		49.69 %	
Medium	18.78 %		18.24 %		19.53 %	
High	28.84 %		27.43 %		30.78 %	*
Parental Routine activities at 9 months						
Low	32.63 %		37.69 %		25.66 %	
Medium	45.21 %		41.64 %		50.14 %	
High	22.16 %		20.68 %		24.20 %	*
Attendance of Junior Infant Schools at 5 years						
No	28.74 %		25.35 %		33.41 %	
Yes	71.26 %		74.65 %		66.59 %	*

Source: Authors' calculations from the Growing Up in Ireland (GUI) study (N = 10,158 person observations). *Note:* more disadvantaged children (lowest half of the SES scale) and more advantaged children (highest half of the SES scale); analyses are weighted for the population of study, * indicates statistically significant estimates at the 95 % level or higher through Chi-Squared tests.

children's socioemotional skills by about 0.13 ($p < 0.001$) standard deviation points. Many children's books at home, rather than a few, enhance behavioural skills by 0.08 standard deviation points ($p < 0.05$) on average but have any influence on emotional skills. Finally, attending a high-quality ECE rather than a low-quality one is beneficial for both emotional and behavioural skills (AME −0.08, $p < 0.05$; and AME −0.11, $p < 0.001$, respectively).

In short, analyses from Fig. 1 show that parental involvement in literacy activities relates positively to early vocabulary and socioemotional development, the presence of adequate educational materials is relevant in boosting cognitive and behavioural skills. Additionally, highly consistent and responsive parenting behaviours matter for improving both children's early cognitive and socioemotional skills. These results are in line with H1. Whereas high-quality ECE attendance is not associated with better cognitive development, exposure to high-quality formal care settings does foster socioemotional development. These results give partial support to H2, as predictions apply only to socioemotional outcomes.

Finally, Fig. 1 reveals clear SES gaps in child development outcomes, net of other covariates. First, we observe that a standard deviation increase on the scale of SES corresponds to 0.12 ($p < 0.001$) and 0.8 ($p < 0.001$) standard deviation points increment in early vocabulary and reasoning performances. Meanwhile, one standard deviation increase on the scale of SES corresponds to fewer emotional (internalizing) and behavioural (externalizing) problems (AME = −0.7, $p < 0.001$; and AME = −0.10, $p < 0.001$ respectively).

4.3. The role of SES

Fig. 2 shows AME on early cognitive and socioemotional skills of HLE and ECE quality by different SES levels. Panels A and B of Fig. 2 present the results for early cognitive skills, whereas the findings for socioemotional skills are presented in Panels C and D. We focus on the difference between experiencing high-quality HLE against low-quality HLE on early skills by SES levels.

The results for the interaction effects on early cognitive abilities in Fig. 2 are mostly statistically non-significant (Panels A and B). In contrast, we observe that the learning gains on vocabulary scores of experiencing highly rather than scarcely consistent parenting styles are slightly greater for low-SES children (AME = 0.13, $p < 0.05$) than for high-SES children (AME = 0.09, $p < 0.001$) (Panel A, Fig. 2). The latter is in line with the substitution hypothesis (H3a).

Similarly, highly responsive and consistent parenting styles are found to compensate for being born in socially deprived circumstances (Panels C and D, Fig. 2). More specifically, the learning gains on behavioural skills of experiencing high rather than low responsiveness and age-appropriate parenting behaviours are greater for low-SES children (AME = −0.35, $p < 0.001$; and AME −0.48, $p < 0.001$, respectively) than for high-SES children (AME = −0.22, p < 0.001; and AME = −0.32, $p < 0.001$, respectively). This holds for emotional skills as well since highly supportive behaviours correspond to −0.25 ($p < 0.001$) standard deviation points for the low- SES group against −0.12

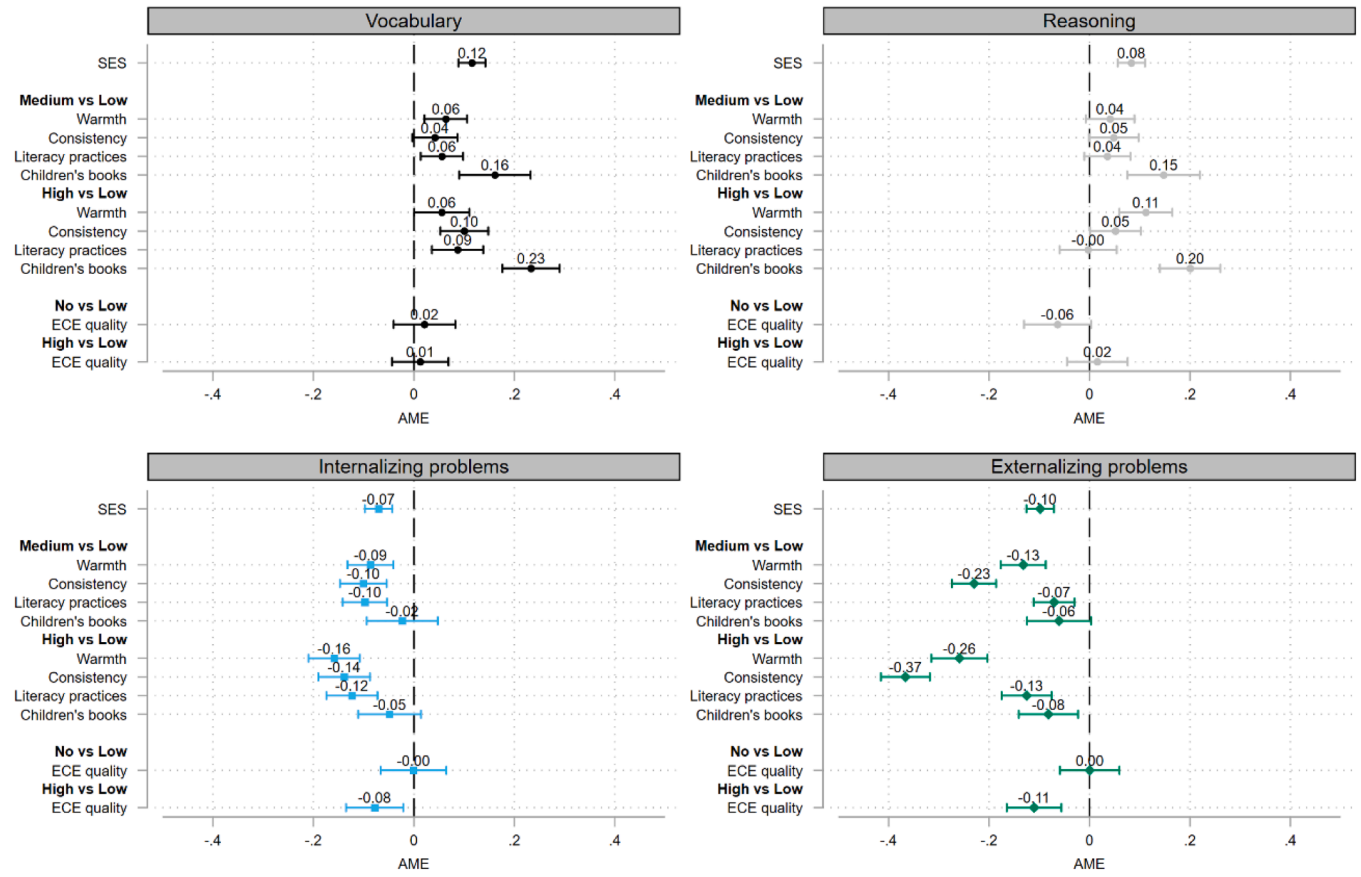

Fig. 1. Average marginal effects (AME) on early cognitive and socioemotional skills of quality dimensions of the home-learning environment (HLE) and early childhood education (ECE). Note: Results show average marginal effects on cognitive and socioemotional skills of different indicators of quality, both at home and in Early Childhood Education (ECE). Margins (dydx) are calculated using Stata 17 for the full model of our study (Model 7), including interactions terms between SES and ECE quality, SES and HLE process quality, ECE quality and HLE process quality and control for the following variables: children's sex and migration background, developmental skills at eight months, area of residence, attendance of infant school, ECE attendance, parental attachment, routine, care, and early literacy parental practices at nine months. Analyses are weighted for the population of study, with confidence intervals at the 95 % level. Number of observations: 10,158. *Source*: Authors' calculations based on the Growing Up in Ireland (GUI) study.

($p < 0.001$) of the high-SES. On these skills, to highly consistent parenting styles the AME for the low-SES group amounts to -0.20 ($p < 0.001$) against -0.09 ($p < 0.001$) for the high-SES group. Moreover, highly frequent involvement in home literacy practices rather than occasional is more beneficial for low-SES children than for high-SES children on both externalizing and internalizing problems. More specifically, the AME for the low-SES group on the former skills amounts to -0.18 ($p < 0.05$) against -0.10 ($p < 0.001$) for the high-SES group whereas, on emotional problems, the AME of the low-SES group measures -0.20 ($p < 0.05$) against -0.09 ($p < 0.05$) for the high-SES group. Overall, these findings support the substitution hypothesis (H3a).

When looking at the interaction effect of attending ECE and SES on cognitive skills, we do not observe any relevant difference (Panels A and B, Fig. 3). Turning to socioemotional skills (Panels C and D, Fig. 3), we corroborate the substitution hypothesis on behavioural problems. Attending high-quality rather than low-quality ECE settings compensates for being born in socially disadvantaged circumstances (AME of the low-SES group $= -0.13$, $p < 0.05$; AME of the high-SES group $= -0.10$, $p < 0.001$). Moreover, it is noticeable that children from low-SES families who do not attend ECE are those who have the worst performances in both early vocabulary (AME $= -0.19$, $p < 0.05$) and emotional skills (AME $= 0.22$, $p < 0.001$).

4.4. *Cross-fertilizing effects*

Fig. 4 allows answering whether the influence of ECE quality on skills is the same among children exposed to HLE of different qualities, using AMEs on early skills of ECE quality by different levels of HLE quality (i.e., low, medium, and high). To detect whether there is a substitution or complementarity mechanism, we calculate the difference between attending high-quality ECE versus not attending ECE for two groups separately, namely children who (1) experienced high-quality HLE and (2) those experiencing low-quality HLE. If the difference calculated for group (1) is greater than that measured for the group (2), we gain evidence for the substitution hypothesis. Otherwise, we confirm the complementarity hypothesis. We focus on AMEs for statistically significant ($p < 0.05$) group differences.

Panels A and B of Fig. 4 show AMEs on cognitive skills of the multiplicative effects of HLE and ECE. Most results are not statistically significant, thus indicating that the effect of ECE quality on early cognitive skills is the same among children exposed to either high or low quality at home. However, for literacy activities, we find support for the complementarity hypothesis (H4b). Both for early vocabulary and reasoning abilities, the learning benefits of attending high-quality ECE are higher for children who are highly stimulated at home via frequent parental engagement in joint literacy activities. When looking at socioemotional skills in Panels C and D of Fig. 4, the impact of ECE quality does not vary, in general, by the level of quality experienced at home, except for internalizing problems (Panel D, Fig. 4) where results are in line with the substitution hypothesis (H4a). Hence, high-quality ECE attendance compensates for a lack of responsiveness at home, as the learning gains of attending high-quality ECE on early emotional skills are greater for

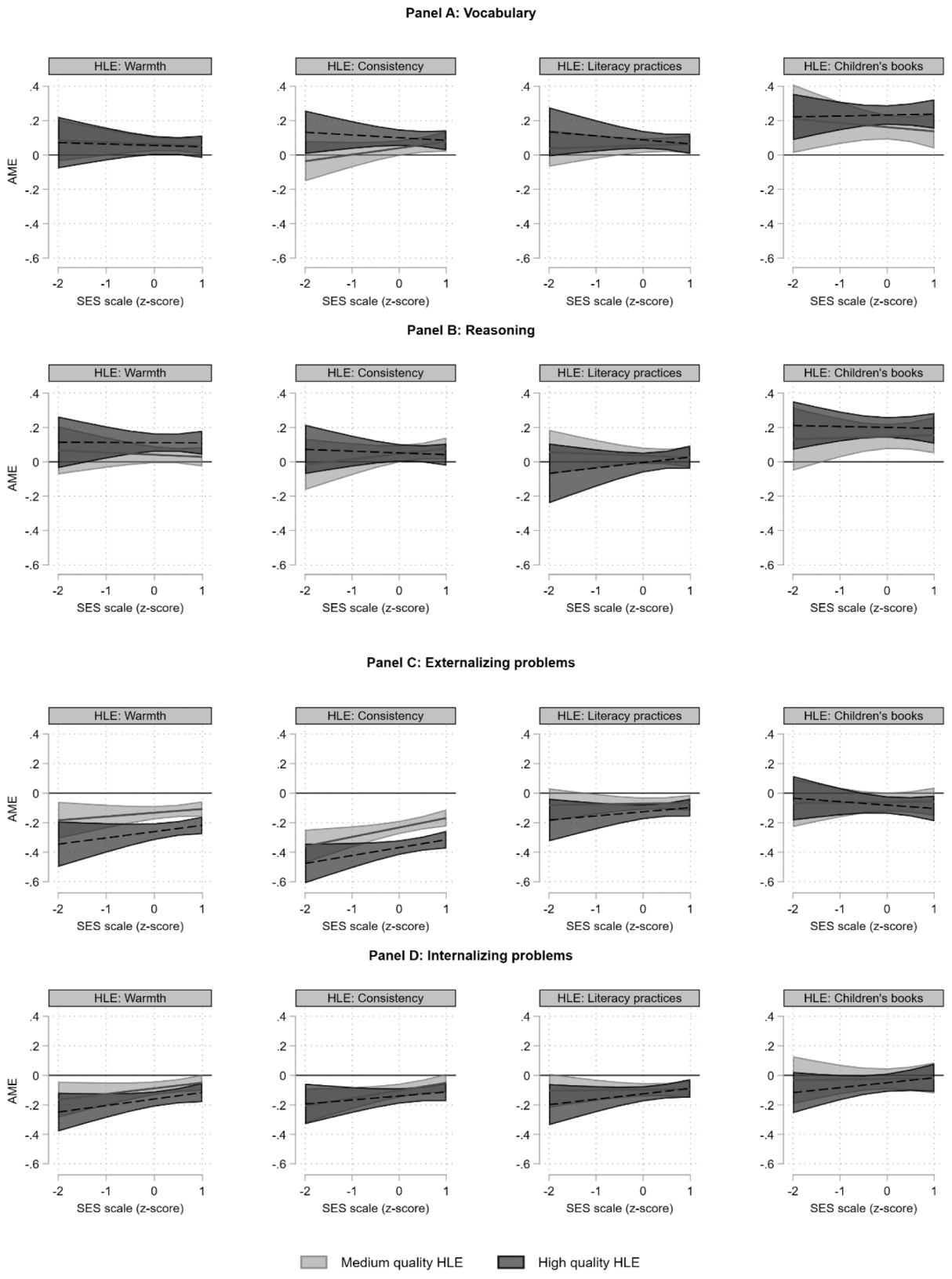

Fig. 2. Average marginal effects (AME) on early cognitive and socioemotional skills of quality dimensions in the home learning environment (HLE), by socio-economic backgrounds (SES). Note: Results show average marginal effects on cognitive and socioemotional skills of different indicators of quality at home across the SES scale, with −2 being the lowest SES level and 1 the highest. Margins (dydx) are calculated using Stata 17 for the full model of our study (Model 7) and controlling for the following variables: children's sex and migration background, developmental skills at eight months, area of residence, attendance of infant school, ECE attendance, parental attachment, routine, care, and early literacy parental practices at nine months. Analyses are weighted for the population of study, with confidence intervals at the 95 % level. Reference category: Low-quality HLE. Number of observations: 10,158. *Source*: Authors' calculations based on the Growing Up in Ireland (GUI) study.

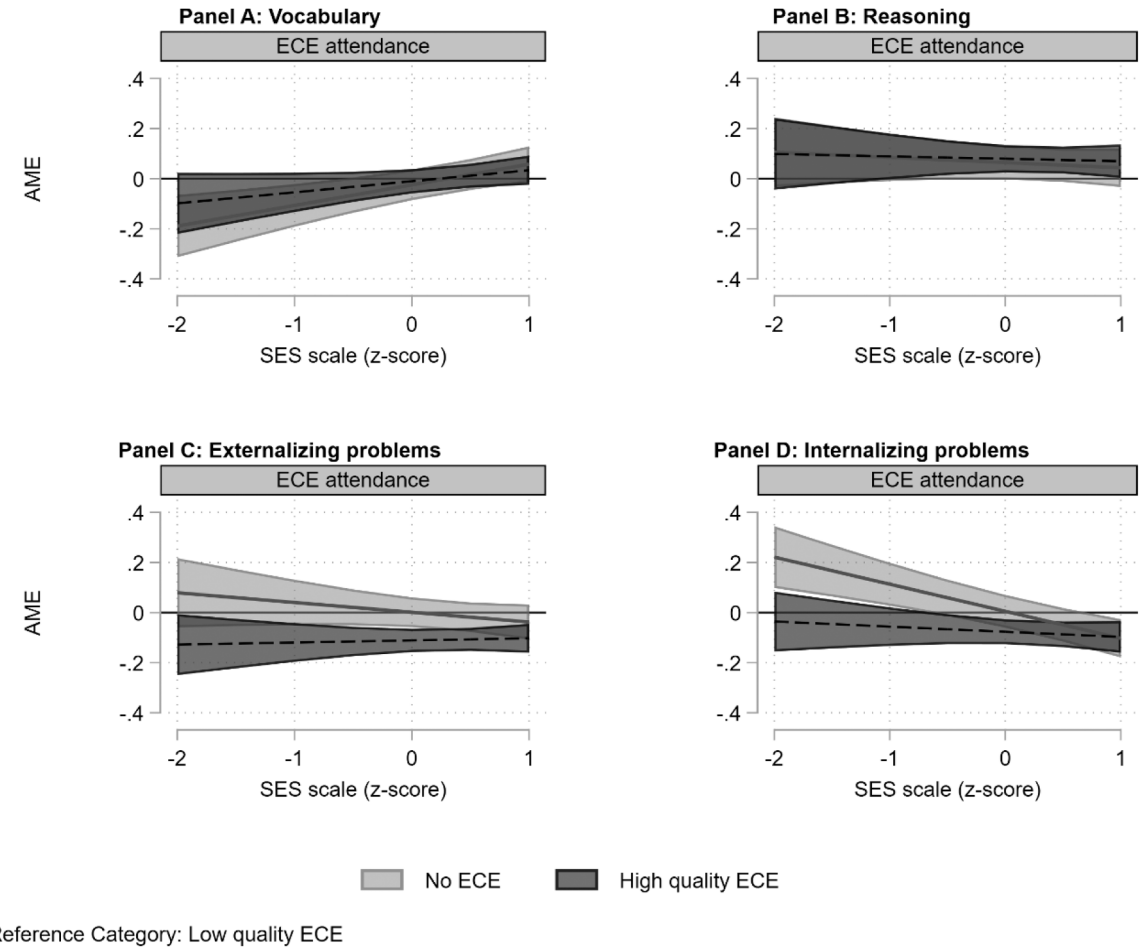

Fig. 3. Average marginal effects (AME) on early cognitive and socioemotional skills of early childhood education (ECE), by socio-economic backgrounds (SES). Note: Results show average marginal effects on cognitive and socioemotional skills of ECE quality across the SES scale, with −2 being the lowest SES level and 1 the highest. Margins (dydx) are calculated using Stata 17 for the full model of our study (Model 7) and controlling for the following variables: children's sex and migration background, developmental skills at eight months, area of residence, attendance of infant school, ECE attendance, parental attachment, routine, care, and early literacy parental practices at nine months. Analyses are weighted for the population of study, with confidence intervals at the 95 % level. Reference category: Low-quality ECE. Number of observations: 10,158. *Source*: Authors' calculations based on the Growing Up in Ireland (GUI) study.

Fig. 4. Average marginal effects (AME) on early cognitive and socioemotional skills of early childhood education (ECE) quality by home-learning environment (HLE) quality dimensions. *Note*: Results show average marginal effects on cognitive and socioemotional skills of ECE quality by different levels of quality at home. Margins are calculated using Stata 17 for the full model of our study (Model 7) and controlling for the following variables: children's sex and migration background, developmental skills at eight months, area of residence, attendance of infant school, ECE attendance, parental attachment, routine, care, and early literacy parental practices at nine months. Analyses are weighted for the population of study, with confidence intervals at the 95 % level. Number of observations: 10,158. *Source*: Authors' calculations based on the Growing Up in Ireland (GUI) study.

children whose parents are scarcely responsive to their needs at home, compared to those living in a more attentive family climate.

Finally, we run the same cross-fertilizing effects separately by SES, differentiating between the more disadvantaged (lowest half of the SES scale) and more advantaged (highest half of the SES scale) children (see Figure A.2 in Appendix). For both SES groups, being highly stimulated with literacy activities at home is pivotal for gaining the highest returns on cognitive skills from high-quality ECE attendance. These results are in line with the complementary hypothesis for both low-SES and high-SES groups (H4b). Yet, for behavioural problems, we find evidence for the substitution hypothesis (H4a), as attending high-quality ECE compensates for living with less responsive parents. We observe that this process is more pronounced for low-SES children than for high-SES children.

5. Discussion

This paper has contributed to the child development and social stratification literatures by investigating the interplay between home learning environment (HLE) and early childhood education (ECE) in explaining inequalities in children's skills development across SES groups. We report three main findings that contribute to research on child development and social inequalities.

First, parental SES matters for early development (i.e., high-SES children score better than their low-SES peers in all the analysed skill domains), but other important features are associated with children's cognitive and socioemotional abilities as well. The family climate, parental literacy involvement, and home learning materials are strongly associated with early skills. Additionally, we find that ECE quality promotes children's socioemotional skills, but interestingly not cognitive skills.

Second, HLE and ECE act as equalizing tools for socioemotional development, but each follows different processes. Low-SES children are those who benefit socioemotionally the most from supportive and consistent parental behaviours. Also, consistent parenting behaviours partly substitute for having a disadvantaged SES background in vocabulary skills, whereas high-quality ECE attendance is compensating for the early disadvantage of being born in low-SES families with regards to behavioural outcomes. Our analyses further reveal that low-SES children who do not attend formal care are those who score the worst in terms of both early emotional and vocabulary scores.

Third, our findings indicate that highly frequent literacy support at home is a necessary condition for children to be able to benefit from high-quality ECE attendance. On the contrary, children of less responsive parents are those who gain the most in terms of emotional skills from attending high-quality ECE settings, and such benefits are stronger for lower-SES children than for higher-SES children. This pattern warns researchers to examine the influence of home and preschool learning environments simultaneously, which relate to important patterns of SES inequalities in early skills development.

Our study suggests that the quality of learning environments of both HLE and ECE matter for early inequalities in child development. Regarding HLE quality, parents can foster their offspring's development by providing them with adequate materials, emotional support, and everyday enriching activities. While parental SES matters tremendously for the child's early development, we also show that a supportive family climate can compensate socioemotionally for the disadvantage of growing up in low-SES families. This implies that support in providing better conditions for parental involvement among families from disadvantaged socioeconomic backgrounds is critical to reduce SES gaps in early skills development. Prior intervention studies point also in this direction by stressing the important role of parenting self-efficacy resources (Barone et al., 2021; Sylva et al., 2008). Likewise, research suggests that reducing family poverty, joblessness and precarious conditions provides parents with better opportunities to reduce stress and increase self-efficacy, which is key to engage in supportive parenting and promote child development (Blair & Raver, 2016; Mari & Keizer, 2021). Our study adds to this literature by showing important mechanisms on early SES inequalities linking HLE quality to child outcomes.

As for ECE quality, our study indicates that high-quality formal care improves children's early socioemotional skills. We show that high-quality ECE attendance compensates for a lack of responsiveness at home, at least in Ireland. That is, the learning gains of attending high-quality ECE on early emotional skills are greater for children whose parents are scarcely responsive to their needs, not much to those in more attentive family climates. This is an important contribution to the literature, considering that previous studies considering both HLE and ECE omitted a focus on child socioemotional abilities (Anders et al., 2012; McMullin et al., 2020; Melhuish et al., 2008). Previous literature suggests that the relationship between ECE attendance and early development depends on variables like policy context, age of entry, weekly hours, type of outcome, school composition, and family demographics (e.g., Blossfeld et al., 2017; Cebolla-Boado et al., 2017; Kulic et al., 2019; Pingault et al., 2015; Yamauchi & Leigh, 2011). We focus on both ECE quality, as well as HLE quality. A recent large meta-analysis with articles identified from 2010 to 2020 found that ECE quality is associated with reductions in behavioural and socioemotional problems among children aged 0–6 (Von Suchodoletz et al., 2023). Meanwhile, a meta-analytic study suggests that ECE quality interventions require from certain levels of intensity to improve children's early behavioural outcomes (Schindler et al., 2015). Using Irish longitudinal data, our study adds to this literature by showing that the role of ECE quality in child development partly depends on HLE contexts, whereas ECE quality seems to benefit early socioemotional outcomes more than cognitive outcomes. This finding warns practitioners and policymakers about the relevance of high-quality ECE to support parents with promoting their offspring's early behavioural and emotional development.

We hope future studies will address questions that we were unable to address for reasons of data limitations. First, future research in this field should further address causality. Due to the nature of our data, in our model we unfortunately cannot control for possible biases that derive from omitted variables (e.g., child endowments) (Grätz, 2015; Hart et al., 2021). Similarly, unobserved heterogeneity in ECE quality needs further attention: sorting into ECE attendance and quality is unlikely to be random, and ECE quality is in fact correlated to SES and HLE. While our study contributes to the literature by adjusting for multiple covariates, we cannot completely rule out issues of selection and causality. Future studies should address this question into detail, which is particularly relevant in highly stratified ECE systems like the Irish one.

Second, future studies should develop a comparative design. Countries differ in terms of ECE availability, accessibility, and affordability, which influences how HLE and ECE quality links to child development (Cryer et al., 2002). We have focused on a childcare system, the Irish, that is expensive, highly commodified and strongly stratified in comparative perspective. Cross-national comparisons are needed to understand how HLE and ECE interact to explain inequalities in child outcomes across societies.

Third, and finally, our study has concentrated on two-parent families only. The reason of this sample strategy was that (1) it allowed us to gather richer information on (i) SES (i.e., only for two-parent families we have data on the two parents' SES characteristics) and (ii) parenting practices (i.e., the intensity and quality of time and emotional investment from two parents is only available for two-parent households), and (2) it enabled us to make estimations clearer, for example as opposed to calculating SES and parenting for a parent in one household (e.g., a mother) and for two parents in another household (e.g., a mother and a father from the same household). Although our empirical approach for the selected sample allows to establish homogeneous comparisons, we must acknowledge that family structure is an important variable in shaping inequalities in both child development (e.g., McLanahan et al., 2013) and parental well-being (e.g., McDonnell & Gracia, 2024). Future studies should further address the role of family structure within

research on the combined role of HLE and ECE in child developmental outcomes.

To conclude, and despite some limitations that will need further attention in future literature, this study has critically contributed to social stratification and child development research by showing the ways in which HLE and ECE intersect to relate to inequalities in children's early cognitive and socioemotional development across SES groups.

CRediT authorship contribution statement

Pietropoli Ilaria: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Gracia Pablo:** Writing – review & editing, Supervision.

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Appendix

Table A.1
Original items included in the scales measuring HLE and ECE quality

Wave	Children's age	Original items included in the scale
HLE domain-specific educational processes		
W2	3 years	(i) reading to the children, (ii) learning the alphabet, (iii) counting, (iv) singing songs, (v) playing games, and (vi) painting.
W3	5 years	(i) playing with children using toys or games/puzzles; (ii) visiting libraries; (iii) listening to children read; (iv) reading to children; (v) doing sports or physical activities; (vi) going on educational visits outside the home such as museums, farms.
ECE quality		
W2	3 years	(i) there are plenty of toys, books, pictures, and music for my child; (ii) my caregiver knows a lot about children and their needs; (iii) the place my child is cared for is kept clean; (iv) there are different play activities, e.g., water-based, sand based, outdoor play, construction, painting etc. available; (v) My child spends time learning letters and numbers.
W3	5 years	(i) there were lots of creative activities going on; (ii) it was an interesting place for my child, (iii) there were plenty of toys, books, pictures, and music for my child; (iv) in care, my child had many natural learning experiences; (v) the caregiver provided activities that are just right for my child; (vi) my child felt safe and secure in care; (vii) The caregiver was warm and affectionate toward my child; (viii) It was a healthy place for my child; (ix) My child was treated with respect; (x) My child was safe with this caregiver; (xi) My child got a lot of individual attention; (xii) My caregiver and I shared information; (xiii) My caregiver was open to new information and learning; (xiv) My caregiver showed she (he) knew a lot about children and their needs; (xv) The caregiver handled discipline matters easily without being harsh; (xvi) My child liked the caregiver; (xvii) My caregiver was supportive of me as a parent; (xviii) My caregiver was happy to see my child.

Table A.2
Missing data among participants in waves 2–3 (N. 7993)

	Wave	% Missing	N. missing
Vocabulary	2	5.63	450
	3	1.23	98
Reasoning	2	2.10	168
	3	0.83	66
Externalizing problems	2	0.08	6
	3	0.04	3
Internalizing problems	2	0.05	4
	3	0.03	2
SES	2	12.96	1036
	3	9.52	761
Parenting styles: warmth	2	0.03	2
	3	0.04	3
Parenting styles: consistency	2	0.06	5
	3	0.09	7
Parental literacy practices	2	0.08	6
	3	0.03	2
Number of children's books	2	0.03	2
	3	0.01	1
Area of residence	2	0.39	31
	3	0.28	22
Skill development at 8 months	2&3	2.94	235
Parental attachment at 9 months	2&3	0.10	8

Source: Authors' calculations based on GUI.

Table A3
Statistical Modelling

$yit = \alpha$it + $\beta 1 SESit + Zit + \alpha i + \varepsilon it$ (1)
In Eq. (2), we include process features of HLE, thus adding items linked to both general and domain-specific educational processes *HLEit.* β2 accounts for the average influence of HLE process quality on skills, net of HLE structural characteristics and controls. In Equation (3), we add quality features of the formal learning environments, *ECEit.* β3 represent the average influence of ECE quality on skills, net of structural and process HLE and controls.
$yit = \alpha$it + β1SESit + $\beta 2 HLEit$ + Zit + $\alpha i + \varepsilon it$ (2)
$yit = \alpha$it + β1SESit + $\beta 2 HLEit + \beta 3 ECEit$ + Zit + $\alpha i + \varepsilon it$ (3)
We introduce a set of interaction terms for testing for the substitution vs. complementarity hypothesis. More precisely, we test singularly (i) the multiplicative impact of children's social origins and HLE process quality (4), (ii) the interaction of children's social origins with ECE quality (5) and, (iii) the interaction between HLE process and ECE quality (6).
$yit = \alpha$it + β1SESit + $\beta 2 HLEit + \beta 3 ECEit + \beta 4 SESit * HLEit$ + Zit + $\alpha i + \varepsilon it$ (4)
$yit = \alpha$it + β1SESit + $\beta 2 HLEit + \beta 3 ECEit + \beta 4 SESit * ECEit$ + Zit + $\alpha i + \varepsilon it$ (5)
$yit = \alpha$it + β1SESit + $\beta 2 HLEit + \beta 3 ECEit + \beta 4 HLEit * ECEit$ + Zit + $\alpha i + \varepsilon it$ (6)
Finally, in Equation (7), we include all these three interactions jointly.
$yit = \alpha$it + β1SESit + $\beta 2 HLEit + \beta 3 ECEit + \beta 4 SESit * HLEit + \beta 5 SESit * ECEit$ + $\beta 6 HLEit * ECEit$ + Zit + $\alpha i + \varepsilon it$ (7)

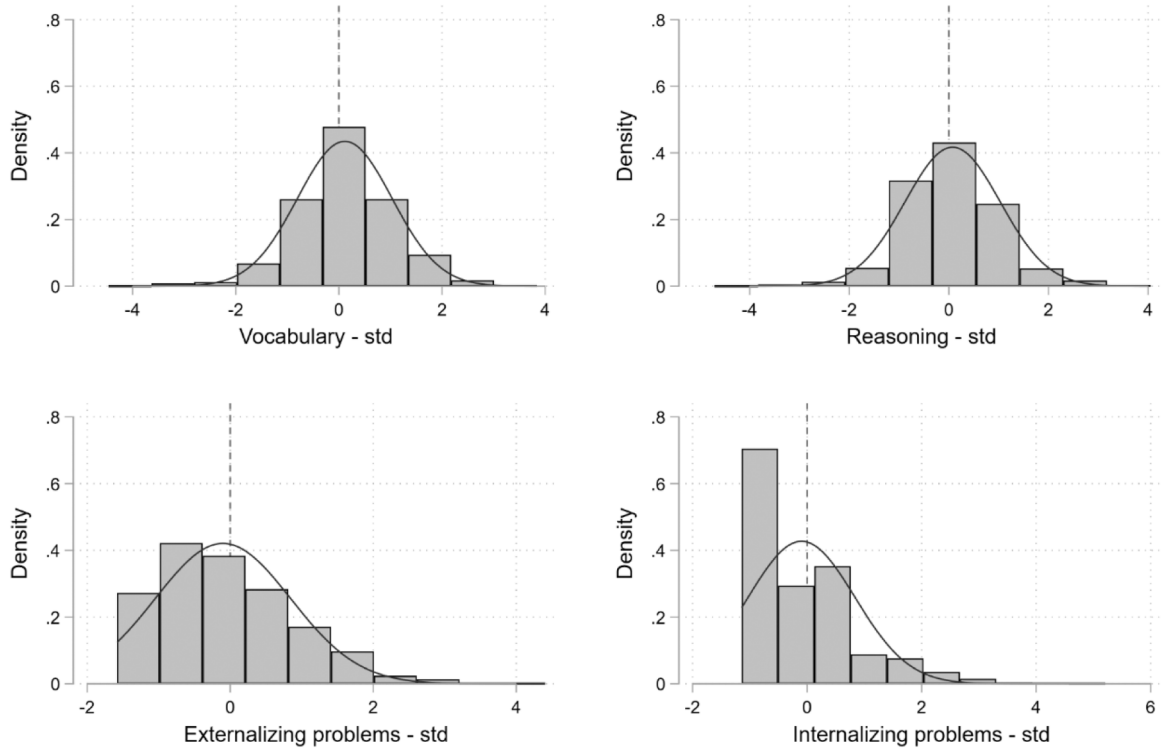

Fig. A.1. Histogram with normal distributions of early cognitive and non-cognitive skills. Note: Histogram of distribution of study dependent variables (unweighted analyses).*Source:* Authors' calculations based on the Growing Up in Ireland (W2 & W3)

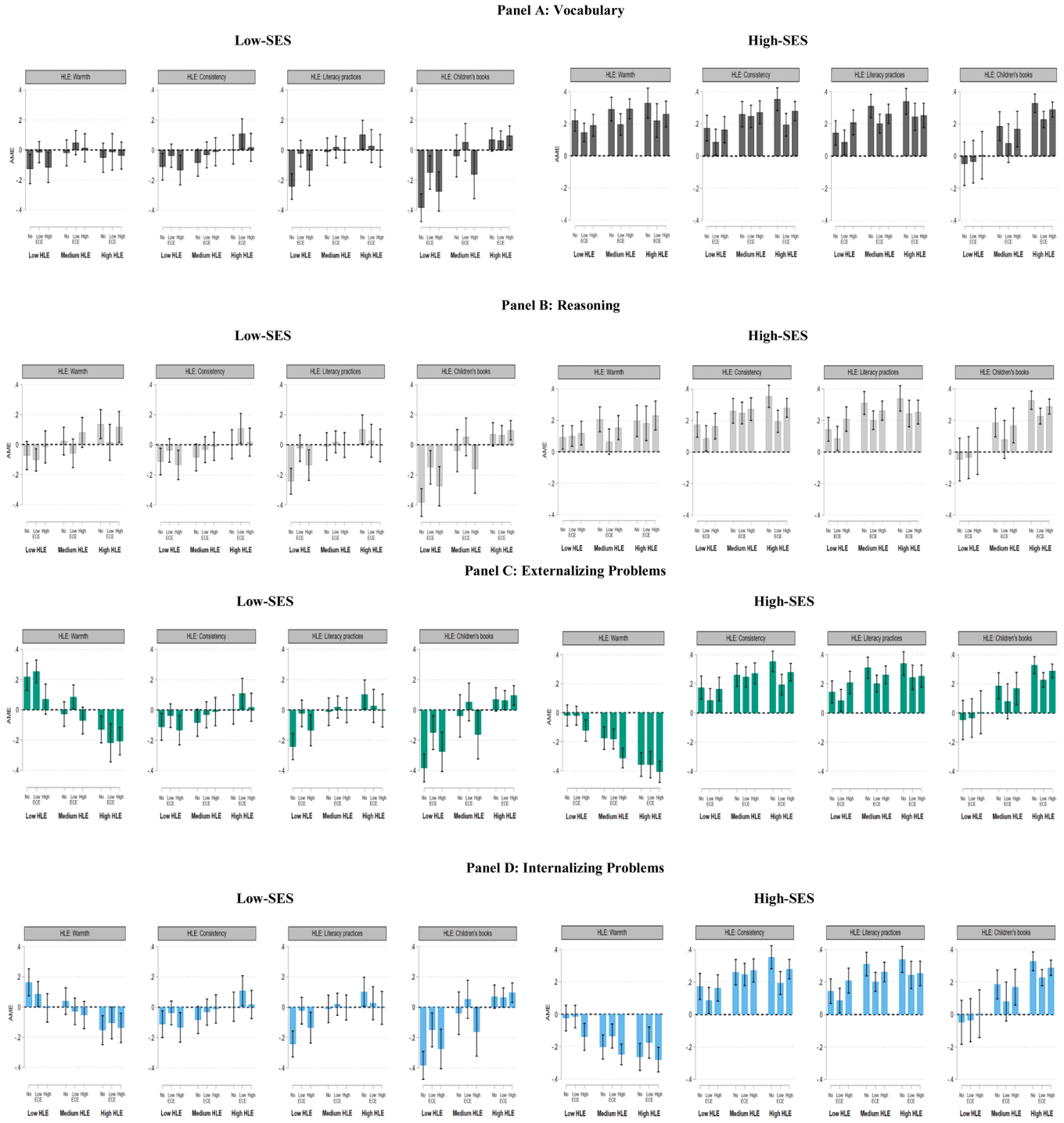

Fig. A.2. Average marginal effects (AME) on early cognitive and socioemotional skills of early childhood education (ECE) quality by home-learning environment (HLE) by parental SES. *Note*: Results show average marginal effects on cognitive and socioemotional skills of ECE quality by different levels of quality at home for low-SES children and high-SES children separately. Margins are calculated using Stata 17 for the full model of our study (Model 7) and controlling for the following variables: children's sex and migration background, developmental skills at eight months, area of residence, attendance of infant school, ECE attendance, parental attachment, routine, care, and early literacy parental practices at nine months. Analyses are weighted for the population of study, with confidence intervals at the 95 % level. Number of observations: 10,158. *Source*: Authors' calculations based on the Growing Up in Ireland (GUI) study

Data availability statement

Growing Up in Ireland is funded by the Government of Ireland and is overseen and managed by the Department of Children and Youth Affairs in conjunction with the Central Statistics Office. It is implemented by researchers at the Economic and Social Research Institute and Trinity College Dublin. Data that support the findings of this study have been accessed via the Irish Social Science Data Archive — https://www.ucd.ie/issda/ and they are available upon reasonable request.

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