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**Patterns of Literacy and Numeracy Activities in Preschool and their Relation to  
Structural Characteristics and Children's Home Activities**

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**Abstract**

Early literacy and numeracy activities in family and preschool are considered important for promoting children's early literacy and numeracy skills. However, little research exists, especially in Germany, on the frequency of such activities in different contexts. The current study identified patterns of literacy and numeracy activities in preschools and their relation to structural preschool characteristics and to attributes of the home learning environment. 421 children attending 89 preschool classes in two German federal states were examined. The results indicate that preschools fall into three different profiles of literacy and numeracy activities: low levels of engagement in both domains, numeracy-oriented engagement, and literacy-oriented engagement. Additionally, structural characteristics of the preschools and family literacy and numeracy activities were found to predict children's profile membership. The study's implications for future research and early education are discussed.

## **Patterns of Literacy and Numeracy Activities in Preschool and their Relation to Structural Characteristics and Children's Home Activities**

### **Introduction**

Reading, writing, and mathematical thinking are some of the most essential competencies children must acquire during their educational career. It has been shown that 'precursors' to reading and mathematics, which are acquired before formal schooling starts, are important for later school success (Weinert, Ebert, and Dubowy 2010; Krajewski and Schneider 2009; Duncan et al. 2007; Jordan et al. 2007). Presumably, children develop these skills through interacting with their environments. Research on the development of early literacy and numeracy skills suggests that, in addition to the learning that takes place at home, the quality of preschool education facilitates children's acquisition of these early skills (Camilli et al. 2010; Sylva et al. 2004). But children already arrive at school with different skills and abilities. In particular, children from disadvantaged backgrounds perform worse in mathematical and literacy tasks than do children raised in middle or upper middle class homes (e.g., Ginsburg, Lee, and Boyd 2008; Jordan et al. 2007). A major task faced by preschools is, therefore, to compensate for developmental disparities in children from disadvantaged homes (for example, low-income homes, homes with low SES, and low stimulating homes). However, if disadvantaged children attend preschools that engage in a low frequency of meaningful activities, closing the achievement gap becomes unlikely. Surprisingly little is known about the extent to which preschool teachers spend time on activities that promote literacy and numeracy. Hence, the present study examines specific patterns of literacy and numeracy activities in preschools and investigates their relation to the structural characteristics of the preschool and the children's experiences at home.

### **Theoretical Background**

#### ***Literacy and Numeracy Activities in Preschool***

Early literacy includes a set of skills assumed to be the precursors to reading (Sulzby and Teale 1991), such as the knowledge of the conventions of print, the alphabet, and linguistic and phonological awareness (Whitehurst and Lonigan 1998). Early numeracy describes the skills that precede formal mathematical learning, including the classification of objects, the formation of sequences, the memorisation of numbers and counting skills (e.g., Torbeyns et al. 2002; Ginsburg, Lee, and Boyd 2008). Due to the distinction between the domains of literacy and numeracy, scholars have assumed that domain-specific stimulation contributes to the development of each domain of skills (Rosbach 2005). For example, early literacy skills can be encouraged through a variety of activities, such as shared book reading, telling stories, and exposure to the alphabet (Beaty and Pratt 2007; see also Richgels 2003), while early numeracy skills can be encouraged through activities such as counting, comparing sizes, and learning numbers (Silinskas et al. 2010; Kuger and Kluczniok 2008). Engaging children in these activities at home and in preschools has proven to be fundamental to childhood development (LeFevre et al. 2010; Howes et al. 2008; Huntsinger et al. 2000). The extensive research on early literacy has led to varying models and frameworks for this concept. In a survey of various frameworks of early literacy, Caspe (2009) suggested perceiving early literacy as the two interrelated dimensions of print-related and language-related skills. While print-related skills, such as letter knowledge and concepts of print, predict later reading (Sénéchal and LeFevre 2002), language-related skills, such as vocabulary, general linguistic skills, phonological awareness and narrative, are predictive for reading comprehension (Sénéchal 2006; Griffin, Hemphill, Camp and Wolf 2004), receptive vocabulary, and reading mastery (Dickinson and Tabors 2001). Smidt et al. (2012) found in a German sample differences in the occurrence of print-related and language-related literacy activities during the final year of preschool. Print-related literacy activities constitute a relatively small proportion of all learning activities, whereas language-related activities

capture a relatively large proportion (Smidt et al. 2012). This lack of print-related activities led us to focus primarily on those activities in the present study. Other international studies have identified low proportions of early literacy activities compared to other activities as well (Olmsted and Lockhart 2003; European Child Care and Education (ECCE) Study Group 1997; Layzer, Goodson, and Moss 1993). Furthermore, engagement in numeracy activities is even less frequent than engagement in literacy activities (Early et al. 2010). Previous findings have also indicated that preschool classes vary in their focus on educational activities. This variation depends among other things on the preschool's structural characteristics. A study conducted in Germany showed that the frequency of educational activities was related to the percentage of children whose parents had a native language other than German, the mean age of the children in the class and the space available in the classroom (Kuger and Kluczniok 2008; Anders et al. 2012). International studies have shown that class size (e.g., Blatchford 2003), the teacher's level of job experience (e.g., Phillips, Gormley, and Lowenstein 2009; Pianta et al. 2005) as well as distal features such as the preschool's location (i.e., region, federal state; Pianta et al. 2005) vary with the quality of the preschool. Furthermore, a rich body of research has demonstrated that these same structural characteristics are associated with children's learning and educational outcomes as well (e.g., Vandell and Wolfe 2000; Clarke-Stewart and Allhusen 2005 for an overview). Anders et al. (2012) showed that structural characteristics of the preschool such as staff-child ratio, mean age of the class, spatial resources (m<sup>2</sup> per child), percentage of children whose parents have a native language other than German, and federal state were associated with the numerical skills of the children at the age of three but not with their subsequent development.

Much of the research in this field thus far has utilized a variable-centred approach that relies on linear continua. However, Chien et al. (2010) demonstrated that moving beyond whole-sample averages by taking an individual-centred approach allowed different profiles of

activity patterns to be identified across children. This approach enables the researcher to detect small subgroups of special interest, such as preschools that emphasise literacy and numeracy activities. It therefore appears necessary both to investigate preschools with qualitatively different profiles of literacy and numeracy activities and to determine which structural characteristics play an important role in establishing the respective profiles.

### *Associations between Preschool Quality and Family Characteristics*

Approaches like the ecological theory of Bronfenbrenner (1993) provide a general framework for understanding relations between children's home and preschool environments. Connections between home and preschool can be described as a mesosystem reflecting relations between parents and preschool teachers that can potentially enhance children's development (Weigel and Martin 2009). In a similar way, approaches referring to parental involvement (e.g., Epstein 1987) stress the importance of supportive connections between family and preschool for the purpose of facilitating children's development.

The connection between the two environments is implicitly presumed when dealing with questions of selectivity into preschool. Mainly studies from the US have provided evidence that children from well-educated and well-situated families attend higher-quality preschools than their peers from families with lower socioeconomic status (Phillips and Adams 2001; Pungello and Kurtz-Costes 1999; National Institute of Child Health and Human Development Early Child Care Research Network [NICHD ECCRN] 1997). Because the effects of socioeconomic background on educational attainment are partially mediated by family educational activities (e.g., Melhuish et al. 2008), it is important to investigate the relation between these at-home activities and preschool selection as well. The results of the NICHD Study (NICHD ECCRN 1997) demonstrated that the quality of a child's educational experiences at home is associated with the educational quality of his or her preschool class. However, Weigel, Martin, and Bennett (2005) did not find any correlations between the home

and childcare literacy environments. Thus, instead of using overall quality measures, it seems necessary to investigate the domain-specific associations between educational practices at preschool and at home.

Parents engage their children in a variety of activities designed to promote early literacy. For example, parents teach their children how to write the alphabet, how to recognise sounds in words, and how to read simple words (Silinskas et al. 2010; Sénéchal et al. 1998; Evans and Shaw 2008; Sénéchal and LeFevre 2002). Parents also engage their children in activities designed to promote early numeracy, such as counting, identifying forms and shapes, and performing simple calculations (Silinskas et al. 2010; LeFevre et al. 2010). However, there are great variations in individual families' utilisation of activities that promote early literacy and numeracy. Studies have indicated that lower SES correlates with a lower degree of educational activities within the home (e.g., Kluczniok et al. in press; Bornstein and Bradley 2008). Children who lack educational enrichment at home may therefore benefit from engagement in these activities at preschool. However, the results of research on such interaction effects have been inconsistent and have indicated both compensatory effects (i.e., socially disadvantaged children benefit more from high-quality childcare settings than do children from more advantaged backgrounds; e.g., Sammons et al. 2008) and leveraging effects (i.e., children from advantaged backgrounds, in particular, benefit from high-quality childcare settings; e.g., Bryant et al. 1994). In this context, it is worth mentioning that because of the non-randomised distribution of children into high-quality childcare in non-experimental studies, some researchers doubt the existence of a causal relation between preschool education and cognitive development (NICHD and Duncan 2003). Consequently, this paper investigates the distribution of children with different socioeconomic and home education backgrounds in preschools that can be divided into profiles based on their different patterns of engagement with literacy and numeracy activities.



**Research questions**

The present study was designed to contribute to closing the gap in research on patterns of literacy and numeracy activities in preschools and the distribution of children across preschools by identifying typical profiles of preschools according to their use of literacy and numeracy activities and by examining the relation of profile membership to a) the structural characteristics of the preschool, b) the socioeconomic background of the child, and c) the home literacy and numeracy activities. To this end, we present findings from latent class analyses (LCA). LCA were used to identify relatively homogeneous profiles of patterns of literacy and numeracy activities in preschools.

As our review of the literature indicated, children differ in their experiences of literacy and numeracy activities at home and in preschools. While there is evidence that, on average, a child's exposure to these activities in preschools is relatively low, there have been no studies to date examining the qualitatively distinct patterns with which these activities are found in preschools.

It is, nevertheless, possible to infer hypotheses on these issues based on the preschool tradition in Germany. Children in Germany are, in general, cared for in 'mixed-age classes' that include several age cohorts. Preschools in Germany do have their own educational mandate, which refers to the socio-emotional, physical, and intellectual development of the child (Rossbach 2009). However, for many years, German preschools have somewhat neglected the promotion of academic skills in favour of the promotion of socio-emotional skills (Scheiwe and Willekens 2009). Consequently, one might expect to find a dominant profile reflecting a daily routine that places a relatively low emphasis on literacy- and numeracy-related activities. In addition to this expected profile, however, other patterns are possible. We may, for example, find a second profile reflecting preschools that more strongly emphasise the promotion of academic skills, including literacy and numeracy. A third and

fourth possible profile may reflect the specialisation of preschools in particular domains, such that a preschool's educational profile may be found to emphasise, almost exclusively, either literacy or numeracy activities. Based upon previous research on linear relations, it was assumed that the structural characteristics of the preschool would be important in defining its profile. Therefore, structural characteristics of the preschools were included in the present study. Another special feature of the German preschool system is that the administrative responsibility lies primarily with the regional ministries of social affairs and not with a central state-wide ministry. The federal government provides a general legal framework (Kinder- und Jugendhilfegesetz, Law on Child and Youth Welfare), which sets out general goals, financial issues, responsibilities, etc., and can be supplemented by federal state laws (Rossbach 2009). As a consequence, there are regional differences between federal states, for instance, regarding preschool provision and staff training. Up to 2005, the federal law was the only legislation covering preschool education in Germany; thus, up to then, the operating agencies were free to choose their own goals and methods. To overcome the resulting arbitrariness of programs, all of the federal states have developed and introduced preschool educational plans since 2005. These plans vary across the federal states. It should be noted that our study was conducted when educational plans were in the early stages of implementation. It covers preschools in two German federal states, Bavaria and Hesse, which introduced their state educational plans in 2005 and 2008, respectively. It is important to keep these contextual factors in mind when considering our findings.

Moreover, thus far—to the author's knowledge—no study has examined the effects of children's at-home literacy and numeracy activities on their engagement in literacy and numeracy activities in preschool. Consequently, we will not only examine how the identified profiles relate to the structural characteristics of the preschool but will also investigate the distribution of children with varying levels of home stimulation in preschools with different

profiles. Based on the results of previous research, we anticipate the discovery of both leveraging and compensatory effects in the relations to be explored in our second research question. We expect that leveraging effects will explain the way in which children with greater exposure to more literacy and numeracy education at home tend to attend preschools that offer more activities in these domains. In turn, we expect compensatory effects to explain why teachers tend to provide a higher degree of in-class education to children who have not been exposed to literacy and numeracy learning at home.

## **Method**

### ***Procedure and Participants***

The present study is part of the German longitudinal project BiKS: Bildungsprozesse, Kompetenzentwicklung und Selektionsentscheidungen im Vor- und Schulalter (Educational Processes, Competence Development, and Selection Decisions at Preschool and School Age), which is funded by the German Research Foundation.

All of the data in the present study were obtained within the longitudinal study BiKS-3-10, which included children aged three to 10. Child, family, and preschool variables were measured using questionnaires filled in by the parents and preschool teachers. Data collection took place during measurement points in the first, second, and third preschool years. The sample comprised 547 children from 97 preschool classes. Because preschool classes in Germany are usually mixed-age, children were included in the study if they were to reach the age of compulsory school enrolment by fall 2008. The average age of the children at the first measurement point was 45 months (min = 34, max = 57). Data from two German federal states were used. According to the design of our sample, 65.2% of the children were from Bavaria, and 34.8 % of the children were from Hesse. To ensure that the complexity of our statistical models stayed within reasonable limits, average scores across the three measurement points were used for the analyses. As measures of central tendency over time,

these mean scores were more accurate than measures based on single assessments. Due to missing values on covariates, the sample size for the following analyses was reduced to 421 children in 89 preschool classes. All of the sample characteristics are depicted in Table 1.

### ***Measures***

*Children's activities in preschools.* Overall level of engagement in literacy and numeracy activities in the entire preschool class were derived from standardized activity logs filled in by the preschool teachers in the first, second, and third preschool year. Teachers were asked to indicate what main activity the class engaged in every quarter of an hour over the day. For this, the preschool teachers could choose from 24 ordinary educational activities, e.g., transition period, use of printed material, role playing, doing jigsaw puzzles, singing or playing music, playing with sand and water. Additionally, the preschool teacher was asked to code the developmental area that each activity was designed to support. Take, for example, a situation in which children are playing 'post office' pretending to read and write letters. The preschool teacher would code this activity as 'role play' and list the developmental areas being supported by it as reading, writing, and social interaction. Twenty-two developmental areas, reflecting a wide range of important skills (e.g., social behaviour, gross motor skills, music, mathematics), were possible to record. Starting at the beginning of a preschool day (6 a.m. at the earliest), every quarter of an hour, teachers could code a maximum of three developmental areas simultaneously. The coding procedure ceased at the end of the preschool day (8 p.m. at the latest).

For the purposes of this paper, five variables were used to represent numeracy-related developmental areas: counting, numbers, shapes and dimensions, logic, and problem solving and categorising objects. Literacy-related developmental areas were divided into four categories: purpose of reading, precursors of reading, letter-phoneme correspondence activities, and precursors of writing. For a detailed description of the codes, see Table 2.

It should be noted that our definitions of early numeracy and literacy are pragmatically driven due to the necessarily limited range of activities captured by the activity logs.

However, the definitions of literacy and numeracy are in line with common operationalisation and have consistently shown to be associated with child development, e.g., covering important parts of recent numeracy (e.g., van de Rijt et al., 2003; Torbeyns et al., 2002) and literacy definitions (e.g., Whitehurst and Lonigan 1998). A similar operationalisation could be found in the Target Child Observation (Sylva et al. 2007). With respect to early literacy, the present study ties in with the distinction suggested by Caspe (2009) between language and print-related activities with a focus on the print-related activities (see also Sénéchal et al. 1998). Activity logs are widely used in the context of school research in particular (see Rowan and Correnti 2009 for an overview). To avoid measurement errors, which may be present in all surveys (e.g., due to respondents' comprehension, censoring, and memory), teachers were given detailed descriptions of the activity and developmental area codes as well as detailed descriptions of how to fill in the logs.

*Structural characteristics of the preschools.* These included class size, the percentage of children in the class whose parents had a native language other than German, the level of job experience of the staff, mean age of children in class, spatial resources (m<sup>2</sup> per child), and the federal state in which the preschool was located. The teachers' qualification level was not included as a factor in our analyses because there is currently very little variation in the qualification level among German preschool teachers.

*SES and children's activities within the family.* To represent the socio-economic status of the family, the highest International Socio-economic Index of Occupational Status (ISEI; Ganzeboom, De Graf, and Treiman 1992) was used. The level of engagement in literacy- and numeracy-related activities at home was determined by using an adapted version of the Early Childhood Home Observation for Measurement of the Environment (HOME; Caldwell and

Bradley 1984). Parents were asked to rate the frequency with which they engaged their children in literacy- and numeracy-related activities on a four-point Likert-scale ranging from one (*never*) to four (*often*). Literacy-related activities included three items: learning the alphabet, reading simple words, and studying rhythmic speech. Numeracy-related activities also included three items: spatial relations, numbers, and shapes. To derive the two indicators representing at-home activities that promoted early literacy and numeracy during the preschool period, the means of the items were calculated. Considering that the scales were constructed on a theoretical basis concerning early literacy or numeracy and that only three items per scale were aggregated, internal consistency was satisfactory (literacy: *Cronbach's alpha* = .65, numeracy: *Cronbach's alpha* = .71). The correlation between the two scales was moderate ( $r = .60, p < 0.001$ ), indicating both the interrelation and the distinctly important role of academic activities at home.

### ***Statistical analysis***

Latent class analyses (LCA) were computed to identify subgroups of preschool classes with distinct patterns of literacy and numeracy promotion. LCA are used to identify groups of individuals who are similar with regard to a set of observed variables (e.g., Muthén and Muthén 2000). After the number of latent classes that best fit the data is identified, the latent class model provides estimates of class membership probabilities for each individual. Additionally, multinomial logistic regressions can be used to relate the class membership probabilities to a set of background variables. All analyses were completed using a so-called 'single-step-approach' (Clark and Muthén 2009) because the coefficients of the covariates are estimated simultaneously as part of the latent class model (Dayton and Macready 1988; Hagenaars and McCutcheon 2002). An alternative approach refers to the 'three-step model,' which first estimates the basic latent class model, then calculates the predicted posterior class membership probabilities, and finally considers these values as the dependent variables in a

regression model using the desired covariates (e.g., Linzer and Lewis, 2011). However, the three-step procedure produces biased coefficient estimates (Bolck, Croon, and Hagnaars 2004). Therefore, it is preferable to estimate the entire latent class regression model all at once.

The aim was to identify the smallest number of latent classes that describe the associations among the observed variables. Therefore, classes were added one by one to the analysis until the model fit the data well. To determine the optimal number of latent classes, Akaike's information criterion (AIC; Akaike 1974), Bayesian information criterion (BIC; Schwartz 1978), and sample size adjusted BIC (SSABIC; Sclove 1987) using models with different numbers of latent classes were compared. In general, the smaller the information criterion, the better the model fits the data. Furthermore, model selection was based on the accuracy of the latent classification scheme, as measured by entropy (Jedidi, Ramaswamy, and Descarbo 1993). Entropy ranged from 0 to 1, with higher values indicating better classification. We treated entropy values that are higher than 0.80 as suggesting an accurate classification (Muthén 2004; Wang and Bodner 2007).

Because the distribution of the children in preschool classes gave the data a nested structure, standard errors that were adjusted for the multilevel structure of the data (Williams 2000) were estimated. The models for this study were run using Mplus, version 6.11 (Muthén and Muthén 1998-2011). Preschools and families that failed to submit the necessary data were excluded from the study, which resulted in a final sample of 89 preschool classes with 421 children. A comparison of the activities between missing and non-missing data revealed no significant differences, except 'letter-phoneme correspondence' which was higher for the non-missing data (mean difference 0.23,  $p < .05$ ). Comparisons on the covariates reveal higher SES, higher home-numeracy activities, bigger class sizes, a higher percentage of children whose parents had a native language other than German, and a higher percentage of more

experienced preschool teachers in the non-missing data compared to the missing data. Therefore, results should be interpreted with caution in terms of generalizability.

## **Results**

### ***Descriptives***

Preschool, child, and family characteristics are summarised in Table 1. The descriptives represent the mean scores of all available assessments (questionnaires, observations) across the measurement points. An examination of the overall mean values calculated for the home literacy and numeracy activities (possible range: one to four; literacy:  $M = 2.44$ , numeracy:  $M = 2.97$ ) indicate significantly higher average scores for the numeracy scale compared to the literacy scale ( $t = 21.37$ ,  $df = 470$ ,  $p < 0.001$ ). This suggests that numeracy-related parent-child activities (e.g., counting) may occur more frequently than literacy-related activities (e.g., teaching the alphabet). In regard to the preschool characteristics, the activity counts are of special interest. The means of these counts indicate that the frequencies of domain-specific activities were very low (a 1 represents 15 minutes). The statistical spread demonstrates that some preschools frequently engaged students in literacy- and numeracy-related activities (see Table 1).

### ***Statistical Determination and Characterisation of the Latent Classes***

The LCA models were run by first testing a one-class model and then exploring models with more classes. The respective information criteria are reported in Table 3. Fit indices indicate that the four-class model best fits the data, as it resulted in a smaller information criterion than all of the other models. However, the addition of the fourth class to the three-class model resulted in an additional, very small ( $n = 5$  preschool classes with 18 children) and conceptually unclear class. According to Nylund, Asparouhov, and Muthén (2007), the addition of a fourth class does not result in a conceptually important improvement of the model. We therefore decided to accept the three-class solution.



A closer examination of the three different preschool profiles in terms of their engagement in literacy and numeracy (see Table 4) revealed that one profile was characterized by significantly lower engagement in all literacy- and numeracy-related activities ( $n = 60$  preschool classes with 293 children; ‘lower engagement in both domains’). The preschool teachers whose classes belonged to this profile reported a much lower frequency of engagement in both literacy-related activities (i.e., purpose of reading, precursors of reading, letter-phoneme correspondence, precursors of writing) and numeracy-related activities (i.e., counting, numbers, shapes and dimensions, logic and problem solving, categorising objects) related activities (all  $ps < .05$ ) than did the teachers whose classes belonged to the other two profiles.

However, the two profiles with higher engagement differed with regard to their engagement in stressing certain aspects of numeracy ( $n = 23$  preschool classes with 94 children; ‘numeracy-oriented’) and on certain aspects of literacy ( $n = 6$  preschool classes with 34 children; ‘literacy-oriented’).

In detail, compared to the profile ‘literacy-oriented,’ the profile ‘numeracy-oriented’ showed significantly higher frequencies in ‘numbers’ and ‘categorizing objects’ (both  $ps < .05$ ). The profile ‘literacy-oriented’, on the other side, was characterised by more frequent activities that can be categorized as ‘precursors of reading’ and ‘letter-phoneme correspondence’ compared to the ‘numeracy-oriented’ profile (both  $ps < .05$ ; see Table 4). The different profiles show the importance of moving beyond sample means when examining literacy and numeracy. The items—all indicators of either literacy or numeracy—were distributed very differently among the preschools of our sample.

### ***Predicting the Latent Class Membership***

Table 5 presents the association between the structural characteristics of the preschool, family SES and activities, and latent class membership. Three covariate comparisons were

made: (a) the likelihood of membership in the ‘literacy-oriented’ profile compared to the ‘lower-engagement’ profile, (b) the likelihood of membership in the ‘numeracy-oriented’ profile compared to the ‘literacy-oriented’ profile, and (c) the likelihood of membership in the lower-engagement profile compared to the numeracy-oriented profile.

Table 5 demonstrates that the probability of profile membership was predicted by class size, exposure to literacy- and numeracy-related activities at home, and the child’s federal state of residence. Larger classes were less likely to fit the profile of ‘literacy-oriented engagement’ and more likely to fit the other two profiles. The federal state of residence discriminated between the probabilities of membership in the class with ‘lower engagement in both domains’ compared to the membership of the ‘literacy-oriented’ profile as well as compared to the ‘numeracy-oriented’ profile, indicating that although by living in Hesse, children were more likely to fit the profile ‘numeracy-oriented’ compared to the ‘literacy-oriented’ profile, they were also more likely to fit the profile ‘lower engagement in both domains’ when comparing it to the ‘numeracy-oriented’ profile.

Regarding the relation between home and preschool activities, significant effects were found. At-home literacy and numeracy activities had marginal effects on the probabilities of class membership ( $p < .10$ ). Higher levels of literacy-related activities at home increased the probability that the child would attend a preschool that fit the profile of ‘literacy-oriented engagement’ as opposed to the attendance of a preschool with a profile of ‘lower engagement in both domains.’ However, higher levels of at-home numeracy-related activities decreased the likelihood that the child would attend a preschool that fit the profile of ‘literacy-oriented engagement’ as opposed to attending a preschool with a profile of ‘numeracy-oriented engagement’ or ‘lower engagement in both domains’. All other variables had no effect on the latent class membership of the children who participated in the study.

## **Discussion**

The goal of the present study was to explore, using an individual-centred LCA approach, patterns of literacy- and numeracy-related activities in preschools and their dependence on the structural characteristics of the preschool and the child's at-home educational activities. Thus, answers to two substantive research questions on early childhood education were obtained. First, we established that preschools can be understood as belonging to different profiles defined by their inclusion of literacy- and numeracy-related activities: 'lower engagement in both domains', 'numeracy-oriented engagement', and 'literacy-oriented engagement.' We also demonstrated the validity of LCA in confirming the expected, meaningful class differences in the structural characteristics of the preschools. Second, we identified the leveraging and compensatory relations between the child's level of exposure to at-home literacy- and numeracy-related activities and what type of preschool he or she attended.

### *Activity patterns in preschools*

The first step of our study was to define preschool profiles according to their inclusion of literacy- and numeracy-oriented activities. As expected, most children were likely to attend preschools that fit the profile defined by comparatively low levels of occurrence of the mentioned literacy- and numeracy-related activities. Thus, the majority of preschools in our sample emphasise daily activities that are not designed to promote early literacy and numeracy competencies. One possible explanation—although one that leaves considerable room for interpretation and uncertainty due to its abstraction from details—may be derived from the role of the preschool in the German educational system. In Germany, the preschool is administered by the social welfare system and is not fully integrated into the educational system. The traditional role of the preschool is therefore more a social than an educational one (Rossbach 2009). In the light of the above, the literacy-related activities examined in the present study might be perceived by preschool teachers at least partly as tasks of primary

school teaching. But in addition to this profile, we identified two smaller profiles defined by higher levels of both literacy- and numeracy-related activities compared to the aforementioned profile. These two profiles differed in their specific literacy and numeracy activities. While one profile showed higher frequencies in ‘precursors of reading’ and ‘letter-phoneme correspondence,’ the other showed higher frequencies in ‘numbers’ and ‘categorizing objects.’ However, no profile of preschools was detected that showed higher frequencies on all of the items. Strictly speaking, no profile covered all literacy- and numeracy-related content equally well. It appears rather that preschools specialise in certain aspects of literacy and numeracy activities and that this specialisation depends mainly on the state in which they are located. The objection may therefore be raised that the differences across states disprove the aforementioned assumption German preschools conform to traditional notions of the preschool’s role in the educational system. One must nevertheless bear in mind that engagement in both literacy and numeracy activities is fairly low in all three of our profiles, even in those preschools promoting literacy and numeracy. That is, despite differences between states, the amount of time spent in literacy- and numeracy-related activities overall is relatively low. However, future studies will have to establish the amount of time actually necessary and sufficient to promote children’s literacy and numeracy skills.

### ***Relations between structural characteristics and profile membership***

The second goal of this study was to explore possible predictors of these profiles to further understand both the importance of the structural characteristics of preschools in determining educational activities and the influence of children’s socioeconomic status and home educational activities. Therefore, we examined the joint effects of home literacy and numeracy activities, family SES, and the structural characteristics of preschools on the likelihood that the child will attend a school fitting each of the three profiles. It was hypothesized that all of the predictors would relate to the probability of membership in the

various profiles. However, the mean age of the children in the preschool class, the percentage of children whose parents had a native language other than German in the class, the teacher's level of job experience, spatial resources, and SES did not significantly relate to the profiles. Conversely, class size and federal state predicted the probability of membership in each of the three profiles. Interestingly, the membership in the lower engagement versus the numeracy-oriented profile was not predicted by the structural characteristics considered, except federal state, indicating that whether a preschool fit a numeracy-oriented profile versus a lower-engagement profile was not dependent on most of the structural features of the preschool classes but on where the preschool is located. Additionally, preschools that fit the literacy-oriented profile were only found in Bavaria. The observations of Pianta et al. (2005) likewise demonstrated differences in the quality of preschool education across the different states in the US. Generally, regional differences are multifaceted and involve various structural differences (Durham and Smith 2006). However, it seems difficult to entangle possible relations with proximal characteristics, which are covered by the federal state variable. This variable might serve as a proxy for structural characteristics not considered in the present study. In Germany, the federal states have different statutes governing preschool education and hold full responsibility for the training of preschool staff. As a consequence, entry requirements, curricula, and examination regulations for preschool educators vary from state to state (Janssen 2010). Although the entry requirements to higher education or vocational training for those pursuing a career in preschool education are nearly the same in Hesse and Bavaria (intermediate-track qualification plus vocational training in a social pedagogy or social care field), there are differences in the substitution options for vocational training: in Bavaria, it is possible to complete a state-certified non-specific vocational training program with an additional one-year social pedagogy seminar—which is not possible in Hesse. Here, only four years of directly related occupational experience can be substituted for vocational

training in a social pedagogy or social care field. Regarding the curricula and the examination regulations, the greatest difference between Hesse and Bavaria is in state regulation. Bavaria has a high level of state regulation, while in Hesse, schools are able to act more independently—for instance, in defining sets of overlapping subject areas that are referred to as ‘learning fields’ (for further details, see Janssen 2010).

Another key difference between the two states lies in the implementation of educational plans. These plans were introduced at different points in time—in 2008 in Hesse and in 2005 in Bavaria—and with different contents (Diskowski 2008). Although a national-level ministerial committee provided recommendations (Jugendministerkonferenz and Kultusministerkonferenz 2004) that served as a foundation for developing state-level educational plans, Bavaria and Hesse developed plans that differ markedly in terms of both detail (e.g., whether practical examples are given explaining how to support children) and operationalisation. The substantial difference in length of the two educational plans (Bavaria: 488 pages, Hesse: 133 pages) alone makes it clear that the Bavarian plan is much more detailed. Although both plans were developed by the same institution (State Institute of Early Childhood Research), the main differences lie in the degree of detail in the contents and in the specificity of instructions for promoting these goals in educational practice. Despite the lack of empirical evidence on the actual implementation process of the plans (Smidt and Schmidt 2012), and despite the aforementioned state-specific characteristics of teacher training, the evidence available suggests a high likelihood that differences in the two states’ educational plans are reflected in different profiles of literacy and numeracy activities.

Furthermore, the results demonstrated that larger classes were more likely to fit the lower-engagement profile than the literacy-oriented profile. In addition, larger classes were more likely to fit the numeracy-oriented profile than the literacy-engagement profile. This is consistent with earlier research that highlighted the importance of class-size in

educational practices (Kuger and Kluczniok 2008; Blatchford 2003; Vandell and Wolfe 2000). Mashburn et al. (2008) found that a class size of 20 children is associated with decreased competency in letter naming among four-year-old children. This suggests that preschool teachers with larger classes might have difficulties to provide children with activities that promote literacy. However, our results also show that better spatial resources, more experienced teachers, and fewer children whose parents had a native language other than German in the class do not correlate with an increase in literacy- and numeracy-related activities in preschool. Although previous studies have established the association between structural features and process quality in preschools, some studies have reported relatively low explained variance in process quality by structural characteristics (e.g., Kuger and Kluczniok 2008). Thus, the implementation of these educational activities seems to be strongly connected to the preschool teachers themselves (e.g., their values and approach to education).

### ***Relations between home and profile membership***

We also hypothesised that variables operating at the family level would correlate with the child's likelihood of attending a particular profile of preschool. While SES did not affect these probabilities, the child's level of exposure to literacy and numeracy activities at home was associated with his or her likelihood of attending preschools belonging to one of the three profiles. Greater exposure to literacy-related activities in the family increased the probability that the child would attend a preschool that fit the literacy-oriented profile compared to the lower-engagement profile. However, exposure to literacy-promoting activities at home did not correlate with a higher likelihood of attending a preschool that fit the literacy-oriented profile rather than one fitting the numeracy-oriented profile. Greater exposure to numeracy activities at home made it more likely that the child would attend a

preschool that fit the numeracy-oriented or the low-engagement profile rather than one fitting the literacy-oriented profile.

In sum, we distinguished the following pattern: children who are less exposed to numeracy-related activities at home are more likely to be exposed to these activities in preschool than are children who are more exposed to numeracy-related activities at home—this appears to be a compensatory phenomenon. Conversely, children who are less exposed to literacy-related educational experiences at home find themselves in a kind of ‘double jeopardy’: they are more likely to attend a preschool where the occurrence of literacy- and numeracy-related activities is comparatively low. However, it is important to bear in mind that most of the children attended preschools that provided comparatively low levels of activities in both domains. Therefore, detailed case studies should examine why certain preschools emphasise literacy whereas others emphasize numeracy.

Summarizing, the probability of a child attending a preschool belonging to a particular profile could be predicted by class size, federal state, and at-home educational activities; this demonstrates a relation between home and preschool educational activities that cannot be explained by family SES or the structural features of the preschool. We postulate two reasons for this relation: (1) preschool teachers supplement the children’s experiences at home by involving them in more literacy-oriented activities; (2) parents select day-care centers that support their home learning environment (e.g., search for preschool teachers who share their values regarding early childhood education) and consequently urge preschool teachers to provide literacy-related activities. Surprisingly, this was only true for literacy activities and not for numeracy activities, which may indicate a broader awareness of the importance of early literacy activities. The general educational discourse in Germany and specifically the discussion of the great importance of reading skills later in life might lead



some parents to emphasize literacy at home and to insist that preschools provide more intensive activities promoting literacy.

Although there were some preschools that promoted both literacy and numeracy, the majority of preschools did not seem to stress either. These findings indicate that preschool teachers are failing to provide children with new literacy- and numeracy-related experiences. This is consistent with what Bredekamp and Rosegrant (1992, p.3) have called the ‘Early Childhood Error’: preschool teachers are often successful in creating a stimulating preschool environment (e.g., one with a variety of appropriate learning materials), but they are too passive in guiding preschool children’s educational experiences (Kontos 1999).

### **Limitations and Avenues for Future Research**

The present study simultaneously assessed the promotion of early literacy and numeracy at home and in preschools. In contrast to previous studies on preschool education, our goal was to establish profiles for preschools according to literacy and numeracy promotion. In spite of this strength, the present study has some limitations.

First, the teacher logs of children’s activities that we used might potentially be subjective and biased. However, teacher logs on instruction are widely used (e.g., Smith 2001; Tietze et al. 1998) and are considered a reliable and valid way to measure instructional techniques (for an overview see Rowan and Correnti 2009). Nevertheless, future studies should examine whether our results can be replicated using different methods of measuring children’s preschool activities. For example, time-sampling observation instruments are widely used to capture educational processes and levels of engagement (i.e., children’s and teacher’s activities and interactions) in a perhaps more fine-grained way (see Halle et al. 2010 for an extensive overview of measures for educational processes).

Second, the absolute level of engagement in activities promoting literacy and numeracy found for our sample of preschools was rather low. This may be due to the concept

of preschool in the German educational system and thus beyond our control. Therefore, the degree to which our results can be transferred to other countries with different policies on preschool education seems limited. It would be very interesting to see how the home and preschool environments are related in countries where preschool education is designed to be more cognitively oriented than in Germany (i.e., UK). Another explanation for the comparatively low level in engagement in literacy- and numeracy-related activities may lie in the relatively narrow definition of both concepts. Further research should therefore address relations between children's activities at home and at preschool considering a broader operationalisation of early literacy and numeracy. Furthermore, our sample size was relatively low, which did not allow us to examine other profiles of engagement.

Finally, it is important to note that our study was conducted in only two of Germany's federal states, Bavaria and Hesse. Therefore, it is necessary to exercise caution in applying the results to other federal states in Germany.

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Table 1. Means, standard deviations, minimum and maximum of the considered preschool and family variables (N = 89).

	<i>Min</i>	<i>Max</i>	<i>M</i>	<i>SD</i>
Teacher counts of Literacy and Numeracy related activities in preschool (1 = 15 minutes)				
Purpose of reading	0.00	5.00	0.51	0.85
Precursors of reading	0.00	2.13	0.20	0.46
Letter-phoneme correspondence	0.00	4.25	0.67	0.98
Precursors of writing	0.00	3.00	0.27	0.56
Counting	0.00	5.63	1.61	1.38
Numbers	0.00	3.67	0.57	0.81
Shapes and dimensions	0.00	4.50	0.90	1.12
Logic and problem solving	0.00	5.00	1.37	1.51
Categorizing objects	0.00	5.33	1.39	1.37
Structural characteristics of the preschool				
Percentage of children whose parents had a native language other than German in the class	0.00	90.31	22.37	23.22
Mean age of children in class in years	3.26	5.44	4.82	0.30
Job-experience of staff in years	0.30	40.00	15.16	9.01
Class Size	9.50	41.75	20.17	4.44
Spatial resources (m <sup>2</sup> per child)	1.47	20.81	3.58	2.69
Characteristics of the family				
SES (HISEI)	16	90	53.50	16.41
Home-Literacy	1.00	4.00	2.45	0.64
Home-Numeracy	1.42	4.00	2.98	0.52

Table 2. Activity categories/ developmental areas of the standardised preschool teacher logs.

Category	Description: Activities including...
Counting	... one-on-one assignments, creating sequences of objects or sets (ascending or descending) and naming numbers.
Numbers	... becoming familiar with and using numerals and digits.
Shapes and dimensions	... experiences with shapes, patterns, geometry and spatial relations.
Logic and problem solving	... analysing, reasoning, brainstorming and logic operations.
Categorising objects	... classification, finding similarities/differences and assigning objects to categories.
Purpose of reading	... to learn that writing and letters contain information and are present/necessary in all areas of life.
Precursors of reading	... extraction of information from letters and the use of printed materials (e.g., books). It is irrelevant whether the children's attempts are successful.
Letter-phoneme correspondence	... phonological recoding.
Precursors of writing	... pretending to write and using written symbols to gather or pass information. It is irrelevant whether the children's attempts are successful.

Table 3. Statistical determination of the optimal number of latent classes.

	Log Likelihood	AIC	BIC	SSABIC	ENTROPY
One-class	-16213.527	32499.054	32654.014	32539.736	-
Two-class	-4686.791	9447.581	9597.159	9479.746	0.995
Three-class	-4433.439	8978.877	9205.265	9027.559	0.952
Four-class	-4244.561	8639.122	8942.320	8704.321	0.993

Note: N = 421; AIC = Akaike information criterion; BIC = Bayesian information criterion; SSABIC = sample-size adjusted Bayesian information criterion.

Table 4. Means, standard deviations and ANOVA comparisons of the three Preschool profiles on nine defining variables.

	Literacy-oriented		Lower engagement		Numeracy-oriented		F(2, 420)
	M	SD	M	SD	M	SD	
Purpose of reading	0.15 <sup>a</sup>	0.16	-0.10 <sup>b</sup>	0.10	0.25 <sup>a</sup>	0.23	6.86***
Precursors of reading	1.41 <sup>a</sup>	0.13	-0.14 <sup>b</sup>	0.03	-0.07 <sup>c</sup>	0.07	854.47***
Letter-phoneme correspondence	1.36 <sup>a</sup>	0.64	-0.24 <sup>b</sup>	0.12	0.25 <sup>c</sup>	0.36	52.66***
Precursors of writing	0.17 <sup>a</sup>	0.19	-0.12 <sup>b</sup>	0.08	0.30 <sup>a</sup>	0.18	25.01***
Counting	1.00 <sup>a</sup>	0.57	-0.29 <sup>b</sup>	0.20	0.52 <sup>a</sup>	0.24	23.85***
Numbers	0.13 <sup>a</sup>	0.28	-0.18 <sup>b</sup>	0.12	0.52 <sup>c</sup>	0.23	37.09***
Shapes and dimensions	1.12 <sup>a</sup>	0.53	-0.42 <sup>b</sup>	0.12	0.91 <sup>a</sup>	0.39	103.61***
Logic and problem solving	1.70 <sup>a</sup>	0.57	-0.67 <sup>b</sup>	0.29	1.48 <sup>a</sup>	0.43	206.74***
Categorizing objects	1.09 <sup>a</sup>	0.40	-0.70 <sup>b</sup>	0.10	1.76 <sup>c</sup>	0.79	328.74***

Note: Post hoc comparisons used Tukey's HSD to control for alpha level. ANOVA = analysis of variance. All variables were centered (grandmean), N= 421. Values with different superscripts differ significantly at  $p < .05$ .

\*\*\* $p < .001$

Table 5. Predicting the latent class membership (Multinomial regression).

Predictors	Latent Class					
	Literacy-oriented (ref. lower engagement)		Numeracy-oriented (ref. literacy-oriented)		Lower engagement (ref. numeracy-oriented)	
	<i>B</i>	<i>SE</i>	<i>B</i>	<i>SE</i>	<i>B</i>	<i>SE</i>
Percentage of children whose parents had a native language other than German in the class	-0.79	0.54	0.83	0.56	-0.04	0.24
Mean age of children in class	0.86	0.57	-0.56	0.60	-0.30	0.27
Job-experience	0.72	0.53	-0.96	0.61	0.24	0.32
Class Size	-1.83*	0.84	1.85*	0.87	-0.02	0.39
m <sup>2</sup> per child	-0.87	1.57	0.76	1.62	0.12	0.28
Federal state (ref. Bavaria)	-8.45*	0.97	7.83*	0.55	0.62#	0.35
SES (HISEI)	0.01	0.16	0.01	0.21	-0.02	0.17
Home-Literacy	0.51#	0.26	-0.32	0.28	-0.19	0.15
Home-Numeracy	-0.52#	0.27	0.60#	0.31	-0.08	0.15

Note: #  $p < .10$ ; \*  $p < .05$ ; all variables were z-standardized, 'ref.' refers to reference category, N= 421