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Room quality and composition matters: Children's verbal and numeracy abilities in Australian early childhood settings

Frank Niklas*, Collette Tayler

Melbourne Graduate School of Education, University of Melbourne, 100 Leicester Street, Carlton, VIC 3010, Australia

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Early literacy and numeracy competencies are an important foundation for successful school achievement. In this large-scale study data from over 2000 Australian children who attended formal early childhood education and care (ECEC) settings were analysed to identify predictors of these competencies. In addition to child and family characteristics, the quality and the composition of the attended ECEC rooms were included in hierarchic linear models. A significant amount of variance of both, verbal and numeracy competencies, was explained by child and family characteristics. In addition, room composition reflected by mean intelligence of the children in the rooms in which children participate and program quality were significant predictors. Children with lower in comparison to higher intelligence scores were affected more by being present in lower rather than higher average intelligence in the attended rooms. These and other findings are discussed in regard to the implications for children attending ECEC settings in Australia.

1. Introduction

From an early age, children's emergent competencies are highly influenced by innate and environmental factors. Adults and other children who come into contact with a child thus influence child learning. It follows then, that both educators and the children who attend early childhood education and care (ECEC) settings contribute to the learning and development of children attending a given program. International research indicates that in addition to effects of ECEC program quality (e.g. Sylva, Melhuish, Sammons, Siraj-Blatchford, & Taggart, 2008), group composition in regard to average cognitive abilities of the children attending the same room, average family socio-economic status (SES) or the proportion of children with a migration background may influence an individual child's competencies (e.g., Niklas, Schmiedeler, Pröstler, & Schneider, 2011; Palardy, 2008; Reid & Ready, 2013; Weiland & Yoshikawa, 2014; Westerbeek, 1999).

However, these variables have seldom been analysed simultaneously while controlling for various child and family characteristics. In addition, few studies have focused on possible interactions between child-level and room-level variables and for the most part, research was conducted in the US. This study analyses data from a large-scale Australian study with more than 2000 children attending over 200 ECEC settings and tests whether ECEC program quality and group composition are associated with children's early numeracy and verbal abilities when controlling for various child and family characteristics, and whether interactions between child- and room-level variables can be found.

1.1. Early verbal and numeracy abilities

Formal teaching and learning of literacy and mathematical competencies begin when children enter primary school. However, children acquire specific verbal and numeracy abilities long before school entry. Mastering early verbal and numeracy abilities is known to support further competency development across a range of school subjects, and to afford later success beyond the school years (Duncan et al., 2007; Geary, 2011). For instance, kindergarten children's early vocabulary is an important predictor of later reading comprehension (Joshi, 2005). Likewise, children's counting and numeracy abilities predicted scores on arithmetic achievement tests in the first grade (Niklas & Schneider, 2017).

Factors found to influence the development of these abilities include the SES of the family (Bradley & Corwyn, 2002) and the home learning environment (e.g., Niklas & Schneider, 2013, 2014).

* Corresponding author.
E-mail addresses: frank.niklas@unimelb.edu.au (F. Niklas), collette.tayler@unimelb.edu.au (C. Tayler).

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For instance, Tayler, Cloney, and Niklas (2015) showed that children aged three to four years differed in their verbal and numeracy abilities dependent on the frequency of shared reading. Other cognitive abilities are also important for the development of both child verbal and numeracy competencies. In a study by Schneider, Niklas, and Schmiedeler (2014) early measures of intelligence at age 4 predicted academic success at the end of primary school. Further, the attendance at early childhood education and care (ECEC) programs and the quality of ECEC have an impact on children's early and later abilities (e.g. Sylva et al., 2008).

1.2. Quality in early childhood and school settings and child achievement

From a contextual perspective, child development occurs within the context of the family, the ECEC program (where applicable) and the broader social and economic community (see Bronfenbrenner's ecological theory; e.g., Bronfenbrenner, 1979). Accordingly, all characteristics of the ECEC room attended play a role in a child's learning. Examination of the room quality and group composition will thus lead to a better understanding of factors that contribute to child learning.

International research shows that attending formal ECEC settings may support young children's cognitive skills and learning (Coley, Lombardi, Sims, & Votrbua-Drzal, 2013; Hamre, Hatfield, Pianta, & Jamil, 2014; Niklas et al., 2011). In addition to the longer total duration of ECEC attendance, room quality plays a major role. Here in particular, the quality of interactions between educators and children and educators' instructions within settings affect children's outcomes (Cote et al., 2013; Lehrl, Kluczniok, & Rossbach, 2016). Consequently, in addition to the structural quality of a room (e.g. resources), the process quality in ECEC rooms appears to be important (e.g., educator-child interactions and educators' pedagogical skills). High process quality means positive and meaningful interactions between teachers and children, and clear teacher communication with children (Ishimine, Tayler, & Thorpe, 2009).

For instance, in a study by Mashburn et al. (2008) the overall room quality and in particular the quality of interactions between children and educators predicted both, children's behavioural and cognitive outcomes. Children's literacy ability was associated with the instructional support children receive in an ECEC setting (Hamre et al., 2014). Similarly, growth in mathematics skills in primary school was positively predicted by preschool quality, even when controlling for the quality of subsequent learning environments (Lehrl et al., 2016).

However, associations between preschool quality measures and children's cognitive outcomes within preschool program are often very small (Weiland, Ulvestad, Sachs, & Yoshikawa, 2013). In addition, different aspects of ECEC quality may influence different child outcomes. These associations are not always consistent and do not always align with theory (Weiland et al., 2013). For instance, Blankson and Blair (2016) showed that only children with greater intelligence profited from high classroom quality. Consequently, assessing several measures of ECEC quality and interactions with child characteristics is important.

1.3. Room composition in early childhood and school settings and child achievement

In the context of ECEC and school effectiveness research, contingency theory suggests that the importance of ECEC structures, resources, and practices to ECEC effectiveness depends on environmental conditions present in the ECEC setting (cf. Palardy, 2008). One such critical condition is the composition of the ECEC group attended by a child. Group composition in regard to average cognitive abilities, average family SES or the proportion of children with a migration background in a room may influence children's learning through various mechanisms such as direct and indirect peer effects and resource allocation by educators.

In a study by Palardy (2008), students attending 'lower social class schools' learned at slower rates than students attending 'higher social class' schools, even after controlling for student and school characteristics (see also Weiland & Yoshikawa, 2014). De Haan, Elbers, Hoofs, and Leseman (2013) found that disadvantaged children in mixed preschool classrooms gained more in academic skills than children in targeted classrooms. Similarly, Portes and Hao (2004) showed that the proportion of children with the same ethnical background had an influence on academic achievement.

However, these results are not limited to the United States. Westerbeek (1999) showed for a large sample of primary and secondary students in the Netherlands that academic achievement was influenced by the average SES background of students in the classroom, the average performance of students in the classroom and the proportion of children with a migration background. Walter and Stanat (2008) found the same associations for German adolescents in the context of the PISA study. In both studies, a higher average SES background, greater average cognitive ability, and a lower proportion of children with a migration background in the attended room was associated with greater individual child outcomes.

Whereas most analyses of room composition have been conducted in the school context, several studies have focussed on ECEC settings (e.g., Fram & Kim, 2012; Mashburn, Justice, Downer, & Pianta, 2009; Niklas et al., 2011; Reid & Ready, 2013). For instance, Fram and Kim (2012) showed that peer group composition contributed to the explanation of variance of vocabulary and mathematical skills of children aged from four to five years. In their study, Hispanic-dominant groups in comparison with black- or white-dominant groups were associated with lower individual child outcomes. Similarly, Niklas et al. (2011) found that a greater percentage of children with a migration background in an ECEC room was associated with lower individual vocabulary and phonological awareness scores in a German kindergarten.

Mashburn et al. (2009) found a positive association between peers' expressive language abilities and children's receptive language development in a large sample of 4-year olds. This association was also influenced by room quality. In fact, research indicates that interactions between different child- and room-level variables may play an important role for child outcomes (e.g. Hochweber, Hosenfeld, & Klieme, 2014; Niklas et al., 2011; Rjosk, Richter, Hochweber, Lüdtke, & Stanat, 2015). Children with a migration background, in particular, seem to be affected by classroom composition (Niklas et al., 2011; Rjosk et al., 2015). These findings indicate that room quality and room composition should be analysed simultaneously and that these interactions need to be tested.

1.4. Research focus

In an Australian context, the association of child outcomes and the composition of the attended ECEC room has yet to be analysed. Further, most earlier studies have analysed the associations of child outcomes with either ECEC quality *or* with the average family SES of children attending the same ECEC setting *or* the ethnical composition of ECEC groups. Few studies have taken into account the average cognitive abilities of children attending the same ECEC setting. Studies are needed that consider various measures of ECEC quality and room composition simultaneously, while controlling for child characteristics and taking into account interactions between child- and room-level variables. Consequently, we decided to use

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data from a large Australian early childhood sample to address a perceived gap by examining the associations of ECEC room quality and ECEC room composition with children's verbal and numeracy competencies, while controlling for individual child and family characteristics. Our hypotheses were as follows:

Hypothesis 1. We expected children to show greater verbal and mathematical abilities in higher quality rooms. Here, we hypothesised that the quality of instructional support should be most important (Hamre et al., 2014; Mashburn et al., 2008).

Hypothesis 2. We expected children to show greater verbal and mathematical abilities in rooms attended by children showing on average greater cognitive abilities (Niklas et al., 2011) or coming from families with on average higher SES (Weiland & Yoshikawa, 2014).

Hypothesis 3. We expected children with greater individual cognitive abilities to show greater outcomes in high (compared with low) quality ECEC rooms, but no such association for children with lower individual cognitive abilities (Blankson & Blair, 2016).

Hypothesis 4. We expected children with lower individual cognitive abilities or from lower individual SES backgrounds to show greater differences in their outcomes in rooms with varying group composition (e.g., Niklas et al., 2011; Rjosk et al., 2015).

Consequently, this study will analyse the well-documented association of ECEC quality with child outcomes in the context of room composition and of various child and family characteristics (Hypothesis 1). Further, the associations of child outcomes and various aspects of room composition will be analysed (Hypothesis 2). Here, we also tested for differences in child outcomes in the context of varying ratios of children with a migration background (Niklas et al., 2011; Rjosk et al., 2015). However, given that migration background seems to play a different role in child development in Australia than in other countries (Niklas, Tayler, & Schneider, 2015; OECD, 2010), we did not expect any significant association of child outcomes with the proportion of children with a migration background when controlling for other child, family and room characteristics. Finally, in an exploratory approach, we were interested in significant interactions between child and family characteristics on the one hand and room characteristics on the other (Hypotheses 3 and 4).

2. Material and methods

2.1. Sample

The E4Kids longitudinal study focused on the effects on children of participating in various forms of mainstream early childhood education and care programs in Australia. To form a sample that was representative of the diversity of Australian ECEC, all ECEC settings in greater urban areas of two major cities, one regional centre in Victoria and one remote area in Queensland were identified. Thereafter, a random selection of 141 ECEC services was drawn to include a range of high and low socio-economic status communities based on service location postcode data.

A cluster-randomised sampling design was thus used to select an Australian cohort of children attending typical or ‘everyday’ ECEC programs in 2010. Directors of the ECEC service were informed of the study via letters; follow-up phone calls were employed to explain the study and invite the directors and their centres to participate. Each of these services was screened using a standardized schedule that listed characteristics of ECEC classrooms such as type, capacity, and age-range of all classrooms. Classrooms that included at least five children aged between three and four years were included in the study and all children in selected classrooms were invited to participate (for more information on sampling and on the E4Kids study, please refer to Tayler, Cloney, Adams, & Nguyen, 2016).

For our analyses, the first round of data collected in 2010 only is considered. Here, test data of $N = 2123$ children from mostly Queensland and Victoria were obtained in the middle of the school year (mostly May to July). Children in the sample attended 265 different rooms with a mean of $M = 8.7$ children per room ($SD = 6.4$). This included a few family day care settings attended by one or two study children only. The mean age of the total sample was $M = 4$; 0 years ($SD = 6.9$ months; $Min = 2$; 1 $Max = 6$; 1) and 48.1% of the children were girls. A small proportion (5.7%) of the sample spoke a language other than English (LOTE) as their primary language.

2.2. Child- and family-level measures

2.2.1. Child assessments

A selection of Woodcock-Johnson-III tests were used to assess children's cognitive outcomes (WJIII; Mather & Woodcock, 2001a, 2001b; McGrew, Woodcock, & Mather, 2001). The Woodcock-Johnson III is a standardized, normed measure frequently used to assess children's achievement (e.g., Duncan et al., 2007). Here, the “Brief Intelligence Assessment” (BIA) was used as a measure of intelligence. “Applied Problems” (AP) measured numeracy and “Verbal Ability” (VA) was used to measure verbal competencies.

2.2.1.1. Verbal ability. This test has four subtests: Picture Vocabulary (e.g., identify the picture of a horse from a set of pictures), Synonyms (e.g., another word for ‘angry’ is?), Antonyms (e.g., the opposite of ‘no’?), and Verbal Analogies (e.g., ‘eye is to see, as ear is to … ’). Each subtest starts with a sample item to demonstrate how to approach the question and for the researcher to provide feedback to the child. Thereafter, no feedback is provided. Together, these subtests measure different aspects of children's acquired vocabulary skills, language development in the form of spoken-language skills that do not require reading, and lexical reasoning. For four- to six-year-old children, estimated reliabilities on Verbal Ability range from 0.89 to 0.90.

2.2.1.2. Mathematical competencies. The AP subtest evaluates the participant's ability to analyse and solve mathematical problems by identifying and applying an appropriate mathematical strategy to calculate the answer. This requires quantitative reasoning and mathematical understanding, as well as the ability to disregard superfluous information (median test reliability = 0.93). For example, when presented with pictures of three flowers in a row, with different numbers of bees on each flower, the researcher asks: ‘Put your finger on the flower with three bees’. The difficulty of the problems increases as the child advances through the test.

2.2.1.3. Intelligence. As a co-variable, the BIA was used as a brief measure of intelligence. It is derived from the three cognitive tests that measure general cognitive ability: verbal comprehension, fluid reasoning, and processing speed (median cluster reliability = 0.95). Processing speed was assessed with a timed test that required children to identify two shapes in each row that are the same (e.g., two squares). Fluid reasoning was assessed with a concept formation task that required rule application and frequent switching from one rule to another. For each presented item, the child tries to determine the rule that distinguishes a set of symbols into two groups, and the child receives feedback on performance during the test. The verbal comprehension task measures children's verbal abilities.

For all tests, we used the W score, a Rasch (like) scale that places all participants on a single continuous scale reflecting individual ability at the child's age (in months) as a function of the difficulty of the items that they answer correctly (see for example Tayler et al., 2015).

2.2.2. Family characteristics

Parent surveys were used in addition to child assessment measures. The main caregivers were asked about their own and their partner's educational background and occupations as two different indicators for family SES.

In about half of the sample, the highest parental education was either a bachelor or a postgraduate university degree. Almost 20% reported having had either no formal schooling or having attended primary school, Year 10 or Year 12 only. In addition, another 30% indicated that a 'Technical and Further Education' certificate or a diploma was their highest level of education.

A second indicator of family SES, the prestige of parental occupation, was assessed with the Australian Socioeconomic Index 2006 (AUSEI06) which assigns values ranging from 0 to 100 to each occupation. For example, a livestock farmer would be assigned the value of 34.0, a primary school teacher 84.6, and a doctor 100.0. The average highest AUSEI score in a household in our sample was $M = 59.65$ ($SD = 22.00$).

In addition to these measures of family SES, parents were also asked how frequently someone in the family read to the study child from a book in the last week (0–7 days). This item was used as an indicator for the quality of the home learning environment as research indicates that shared reading is one of its most important aspects (Niklas, Nguyen, Cloney, Tayler, & Adams, 2016; Niklas et al., 2015). In addition, Australian research showed that the reading frequency is a good predictor for early verbal and mathematical abilities (Tayler et al., 2015). On average, children were read to on more than 5 days a week ($M = 5.30$; $SD = 1.96$).

2.3. Room quality data

2.3.1. Room quality

To assess a variety of structural and process quality characteristics of the rooms attended by study children two different measures were used: The Early Childhood Environment Rating Scale-Revised (ECERS-R; Harms, Clifford, & Cryer, 2005) and the Classroom Assessment Scoring System (CLASS; Pianta, LaParo, & Hamre, 2008).

ECERS-R is one of the most frequently used measures of quality in early childhood settings (e.g., Mashburn et al., 2008; Weiland et al., 2013). It was designed in an effort to assess the quality of group programs for children of preschool through kindergarten age, 2½ years to 5 years. In this study, the areas *Furnishings* (e.g., room arrangement, furniture for routine care or relaxation, gross motor equipment), *Personal Care Routines* (e.g., children's level of independence and self-help skills in regard to health practices, snack or meal time and toileting), and *Activities* (e.g., availability of material for fine motor, art, music, dramatic play, nature or number activities in the room) were assessed (Interrater Internal Consistency: 0.76, 0.72 and 0.88, Harms et al., 2005). Data were collected by fieldworkers who underwent ECERS-R training and the interrater agreement was greater than 90%. Scores in the ECERS-R scales ranged from 1 (inadequate) to 7 (excellent).

The CLASS tool is psychometrically sound and may be used as a measure of associations between classroom processes and children's development and behaviour over time, as well as an objective and concrete measure of teaching practices for accountability and teacher professional development purposes (Pianta et al., 2008). The tool consists of three domains: *Emotional Support* (positive and negative climate, teacher sensitivity, and regard for child perspectives), *Classroom Organisation* (behaviour management, productivity, and the use of instructional learning formats or multiple modalities), and *Instructional Support* (concept development, quality of feedback, and language modelling). In particular, instructional support has been proven to be a good predictor of cognitive child outcomes (e.g., Mashburn et al., 2008).

Data were collected by fieldworkers who underwent three days of training. Information on these three domains was gathered by making a minimum of four repeated 20-min observations in rooms. Scores range from 1 (inadequate) to 7 (excellent) and scores from 3 to 5 are considered medium-range quality. Fieldworkers also undertook initial reliability tests and drift assessments over the period of data collection. The interrater reliability was greater than 90%, indicating that the fieldworkers did not require remedial training (cf. Pianta et al., 2008). Estimates of internal consistency in the E4Kids study are reported as 0.87 for Emotional Support, 0.85 for Classroom Organisation, and 0.89 for Instructional Support, respectively (Cloney, Cleveland, Hattie, & Tayler, 2016).

Means and standard deviations for the CLASS domains were as follows: Emotional Support, $M = 5.14$; $SD = 0.91$; Classroom Organisation, $M = 4.60$; $SD = 0.92$; Instructional Support, $M = 2.38$; $SD = 0.96$. In a further step, the three CLASS domains were transformed using a multi-facetted IRT-model (cf. Wright & Masters, 1982). Here, the logit-score was calculated for each of the classrooms based on four to six cycles of observations of the interactions between teachers and students.

2.3.2. Room composition

In addition to the quality measures, other room characteristics were also analysed. Various of the aforementioned child and family variables were aggregated for each room to act as indicators of room composition (e.g., Niklas et al., 2011; Rjosk et al., 2015; Weiland & Yoshikawa, 2014). The average BIA of the study children attending a certain room, the average highest AUSEI score and the average highest parental education in a room were considered in the analyses. Further, the proportion of study children in a room speaking a language other than English as main language was taken into account. Only data of study children were available. In some cases, these data related to all children in a room. In other rooms, data describing a room related only to the child participants in the E4Kids study.

2.4. Data analytic approach

Descriptive statistics and results of correlational analyses for all study variables will be presented first. In a second step, hierarchic linear modelling (HLM) was used to predict children's verbal abilities and their performance in WJIII Applied Problems. Here, the intraclass-correlation-coefficient (ICC) was calculated to test how much of the total variance was explained by room characteristics (level 2 variables). Further, models were developed using level 1 variables such as child and family characteristics first, before all level 2 variables were introduced. Only significant predictors remained in the models to achieve parsimonious models. Finally, in an exploratory approach, interaction terms between the remaining level 1 variables and all level 2 variables were included in the models and tested for significance. Presented will be Model 1 that includes all level 1 variables, model 2 that includes only significant level 1 and significant level 2 variables, and model 3 that shows in addition all significant interaction terms between level 1 and level 2 variables.

HLM uses the "Full Information Maximum Likelihood" (FIML)-method (cf. Enders, 2001; Peugh & Enders, 2004). Using this method, the analytic model is specified for all cases, including those

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cases for which no complete data could be obtained. The FIML-method takes all observed values into account when estimating the model parameters. Missing values are ignored for the estimations without reduction of the total sample size.

3. Results

3.1. Descriptive statistics and correlational analyses

Tables 1 and 2 present descriptive statistics and the results of the correlational analyses of all level 1 and level 2 study variables. Older children and children speaking English as main language achieved higher scores on the WJIII. Parental education and parental occupation as well as the frequency a child was read to were moderately to highly associated with each other and they were moderately correlated with the outcome measures. All measures of room quality were significantly correlated, with very high correlations between the three CLASS domains and between the ECERS-R subscales *furnishing* with *routines* and with *activities.* Few significant correlations were found for the ECERS-R subscale and the aggregated room characteristics, whereas significantly greater scores in the CLASS subscales were found in rooms with a greater average family SES and in rooms attended by children with a greater mean BIA. Finally, the two aggregated measures of average family SES were highly correlated and moderately associated with the mean BIA, which in turn was significantly lower in rooms with a higher proportion of 'LOTE' children.

3.2. Hierarchic linear modelling

In a second step analysis, hierarchic linear modelling was used to predict children's verbal abilities and mathematical competencies from level-1- and level-2- variables. The ICCs of 0.31 and 0.30 indicated that level 2 variables accounted for a meaningful amount of variance. These variables were entered in Model 2 after child characteristics had been included (Model 1). In Model 3 significant interactions between level-1- and level 2 variables are presented.

3.2.1. Prediction of children's verbal abilities

Table 3 shows the results of HLM to predict children's verbal abilities. Child and family characteristics explained 69% of the variance of children's verbal abilities (Model 1). All variables with the exception of parental educational level were significant predictors of verbal abilities. Boys, older children, children speaking English as main language and who were read to more often, children whose parents had more prestigious occupation, and in particular, children with higher scores in BIA showed greater verbal abilities. The intercept can be interpreted as the verbal abilities score of a boy with average age, average BIA score, speaking English as main language, who is not read to and whose parents have average education and jobs with average prestige scores (AUSEI06). If this boy was, for example, five months older than the average, he would score one additional point in the verbal ability scale and if he spoke a language other than English as main language he would score 5.5 points less.

In addition to these level 1 variables, the average BIA of children attending the same room and the instructional support provided by educators in the room were significantly associated with children's verbal abilities (Model 2). Here, in rooms with better and more instructional support and a higher average BIA children showed greater verbal abilities. No other measures of room quality or composition were significant predictors. Finally, in an exploratory approach, some significant interaction terms were found and this final model explained 70% of the variance of children's verbal abilities (Model 3).

Fig. 1 shows the interaction between child age and instructional support in a room. Whereas young children in the sample did not differ in their verbal abilities in the context of varying instructional support experienced in their ECEC setting, older children had greater verbal abilities in rooms with a higher quality of instructional support.

Fig. 2 shows the interaction between children's individual intelligence scores as measured with the BIA and the average BIA of children attending the same room. For children with high individual scores in the BIA the average BIA in a room was not associated with their verbal abilities. However, for children with lower individual BIA scores greater verbal abilities were found in rooms with higher average BIA scores of the attending children.

Fig. 3 shows the interaction between children's main language and the average parental education of children attending the same room. For children speaking English as their main language, verbal abilities were not associated with the average parental education in the rooms attended. However, 'LOTE children' showed lower verbal abilities in rooms that were attended by children whose parents on average had lower education in comparison to higher education.

Finally, the significant interactions between prestige of parental occupation (AUSEI06) and the room quality (instructional support and routines) indicated that in high quality rooms, children's verbal ability was not associated with the AUSEI, whereas in low quality rooms children whose parents had more prestigious occupations showed significantly greater verbal abilities. However, for these two interactions the differences were minimal (up to two points on the verbal abilities scale only).

3.2.2. Prediction of children's mathematical abilities

Table 4 shows the results of HLM to predict children's mathematical competencies. Child and family characteristics explained 57% of the variance of children's mathematical competencies (Model 1). All variables with the exception of parental occupation

Table 1
Descriptive statistics and correlational analyses for child and family variables.

	1	2	3	4	5	6	7	8	M	SD	N
Age	0.00	0.00	-0.02	-0.06^{*}	-0.09^{**}	0.54^{**}	0.49^{**}	0.50^{**}	48.23	6.95	2123
Sex (♂ = 0; ♀ = 1) (1)		0.03	-0.03	-0.02	0.02	0.09^{**}	0.01	0.06^{**}	0.48	0.50	2123
Main language + (2)			-0.03	-0.04	-0.15^{**}	-0.14^{**}	-0.22^{**}	-0.17^{**}	0.06	0.23	2054
Edu (3)				0.59^{**}	0.34^{**}	0.21^{**}	0.19^{**}	0.21^{**}	5.11	1.62	1989
AUSEI (4)					0.29^{**}	0.18^{**}	0.19^{**}	0.17^{**}	59.65	22.00	1627
Reading frequency (5)						0.16^{**}	0.18^{**}	0.16^{**}	5.30	1.96	1714
Intelligence (6)							0.82^{**}	0.74^{**}	441.65	12.77	2090
Verbal ability (7)								0.70^{**}	450.43	13.73	2123
Applied problems (8)									394.83	26.79	2111

$^{**}p < 0.001$; $^{*}p < 0.05$; Edu: highest level of parental education in the household.
+ 0 = English is main language; 1 = a language other than English is main language.

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Table 2
Descriptive statistics and correlational analyses for room level variables.

	1	2	3	4	5	6	7	8	9	M	SD	N
Furnishing	0.44**	0.50**	0.20**	0.21**	0.22**	-0.04	0.06	0.05	0.07	4.11	1.02	257
Routines (1)		0.28**	0.30**	0.28**	0.26**	-0.17**	0.02	0.02	0.03	2.94	1.29	257
Activities (2)			0.19**	0.13*	0.25**	0.13*	0.09	0.13*	0.13*	3.46	0.88	257
Emotional support (3)				0.87**	0.75**	0.27**	0.18**	0.20**	-0.06	−0.28	0.83	250
Classroom organisation (4)					0.70**	0.25**	0.16*	0.19**	-0.05	−0.34	0.75	250
Instructional support (5)						0.24**	0.21**	0.26**	-0.08	−0.17	0.76	250
average BIA (6)							0.21**	0.35**	-0.22**	440.79	9.44	265
average AUSEI (7)								0.66**	-0.07	58.10	14.89	262
average Edu (8)									-0.09	4.96	1.16	265
Proportion of LOTE (9)										0.07	0.18	265

**p < 0.001; *p < 0.05.

Table 3
Results of hierarchic linear modelling to predict verbal abilities (explained variance in parenthesis).

Level 1	Modell 1 (0.69)			Modell 2 (0.69)			Modell 3 (0.70)		
	B	SE	t	B	SE	t	B	SE	t
Intercept	450.25	0.70	640.72***	450.24	0.67	671.82***	450.66	0.68	661.96***
Sex (♂ = 0; ♀ = 1)	−1.82	0.42	−4.28***	−1.78	0.42	−4.28***	−1.92	0.41	−4.68***
Age in months #	0.20	0.04	4.73***	0.15	0.04	3.61**	0.14	0.04	3.60**
BIA #	0.76	0.02	33.94***	0.72	0.02	29.13***	0.75	0.03	29.42***
AUSEI #	0.02	0.01	2.03*	0.02	0.01	1.78	0.02	0.01	1.79
EDU #	0.04	0.20	0.22						
Reading frequency	0.29	0.13	2.26*	0.25	0.12	2.09*	0.26	0.12	2.17*
Language +	−5.52	1.29	−4.27***	−5.23	1.24	−4.23***	−5.05	1.04	−4.85***
Level 2 and Interactions									
Intercept X Instructions				0.77	0.35	2.19*	0.82	0.34	2.44*
Intercept X Average BIA				0.13	0.04	3.47**	0.13	0.04	3.28**
Age #X Instructions							0.15	0.04	3.51**
BIA #X Average BIA							-0.01	0.00	−3.03**
AUSEI #X Instructions							-0.03	0.01	−2.14*
AUSEI #X Routines							-0.02	0.01	−2.37*
Language X Average EDU							2.62	1.27	2.06*

* = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$.
# Age, Brief Intelligence Assessment (BIA), parental occupational prestige (AUSEI), parental education (EDU), and all level 2 variables have been centred around their grand means.
+ 0 = English is main language; 1 = a language other than English is main language.

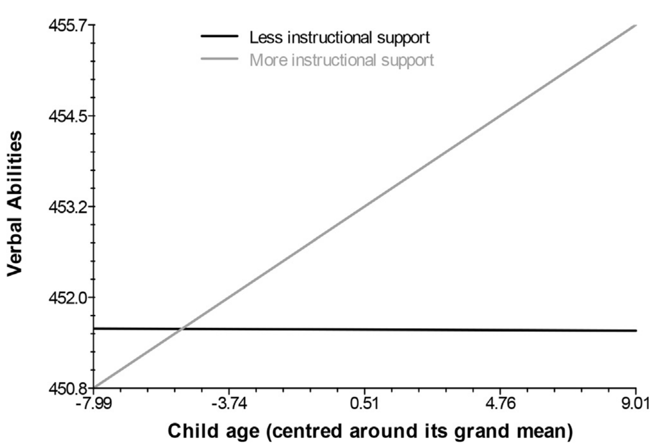

Fig. 1. Interaction between children's age and instructional support in the room attended and its association with children's verbal abilities.

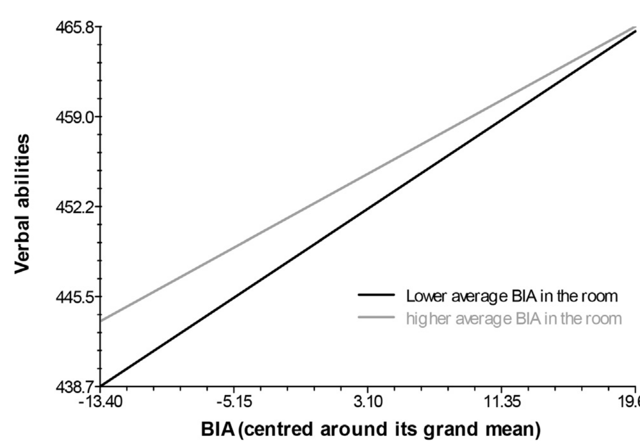

Fig. 2. Interaction between children's individual intelligence score and average child intelligence in the room attended and its association with children's verbal abilities.

and sex were significant predictors of mathematical competencies. Older children, children speaking English as main language and who were read to more often, children whose parents had higher levels of education, and in particular, children with higher scores in BIA showed greater mathematical competencies. In addition to these level 1 variables, the average BIA of children attending the same room and the care *routines* provided by educators in the room were significantly associated with children's mathematical competencies (Model 2). Here, in rooms with higher quality and a higher average BIA children showed greater mathematical competencies. No other measures of room quality or composition were significant predictors. Again, some significant interaction terms were found and the final model explained 59% of the variance of children's mathematical competencies (Model 3).

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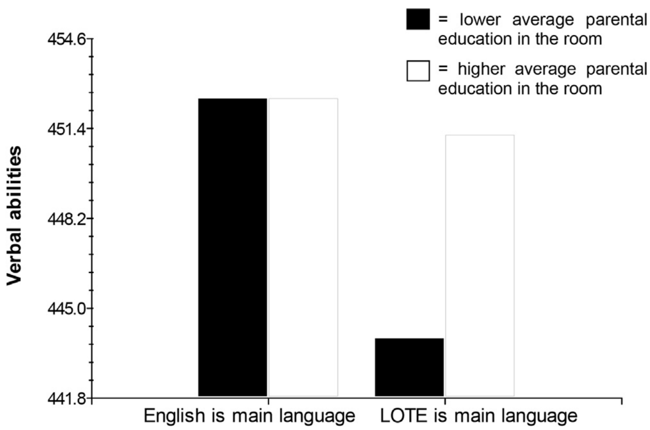

Fig. 3. Interaction between children's main language and average parental education in the room attended and its association with children's verbal abilities.

Fig. 4 shows the interaction between children's individual BIA and average BIA and average AUSEI score in a room. As with verbal abilities, children with high individual BIA scores had similar scores in Applied Problems in rooms characterised by higher *or* lower average BIA in a room. However, children with lower individual BIA scores showed greater mathematical competencies in rooms with higher average BIA scores than in rooms with lower average BIA scores. In addition, children with low BIA scores showed lower AP scores in rooms with a low average in comparison to high average AUSEI, whereas children with high individual BIA scores scored slightly higher in rooms with lower average AUSEI. However, these differences were fairly small.

Finally, Fig. 5 demonstrates the interaction between parental education level and the classroom organisation in the attended room. In rooms with high quality classroom organisation, the AP score was not associated with parental education level, however in low quality rooms, children performed better in the AP assessment when their parents had a higher level of education.

Table 4
Results of hierarchic linear modelling to predict applied problems (explained variance in parenthesis).

Level 1	Modell 1 (0.57)			Modell 2 (0.58)			Modell 3 (0.59)		
	B	SE	t	B	SE	t	B	SE	t
Intercept	396.59	0.69	574.58***	396.66	0.51	784.50***	398.81	0.51	784.98***
Sex (♂ = 0; ♀ = 1)	1.05	0.98	1.07						
Age in months #	0.66	0.09	7.27***	0.59	0.09	6.31***	0.50	0.09	5.88***
BIA #	1.14	0.06	20.16***	1.09	0.06	19.28***	1.21	0.05	24.36***
AUSEI #	0.01	0.03	0.28						
EDU #	1.07	0.45	2.38*	0.97	0.35	2.74**	0.83	0.32	2.62**
Reading frequency	0.66	0.27	2.51*	0.74	0.24	3.06**	0.69	0.24	2.87**
Language +	−10.33	3.58	−2.89**	−9.33	3.11	−3.00**	−7.35	2.18	−3.37**
Level 2 and Interactions									
Intercept X Routines				0.76	0.36	2.11*	0.95	0.36	2.69**
Intercept X Average BIA				0.32	0.08	3.90***	0.36	0.08	4.68***
BIA #X Average BIA							-0.03	0.00	−8.35***
BIA #X Average AUSEI							-0.01	0.00	−2.07*
EDU #X Classroom organisation							-0.99	0.35	−2.81**

* = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$.
# Age, Brief Intelligence Assessment (BIA), parental occupational prestige (AUSEI), parental education (EDU), and all level 2 variables have been centred around their grand means.
+ 0 = English is main language; 1 = a language other than English is main language.

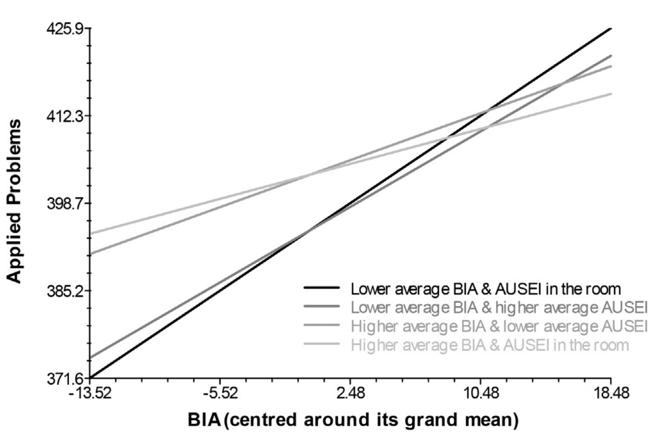

Fig. 4. Interactions between child intelligence with average intelligence of children in the room and average prestige of parental occupation in the room and their association with children's applied problems score.

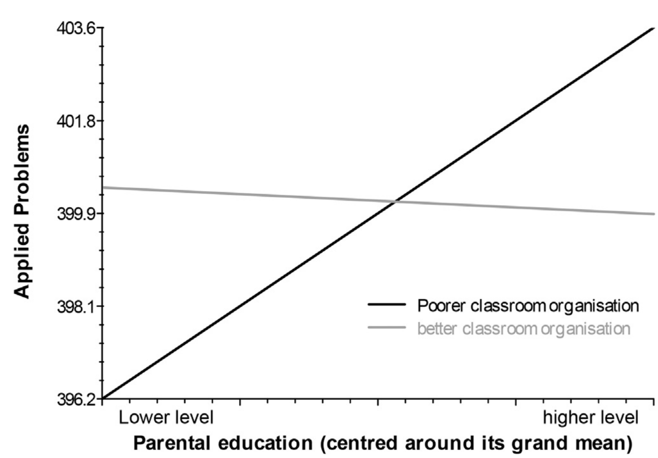

Fig. 5. Interaction between prestige of parental education with quality of classroom organisation in the room attended by the child and its association with children's applied problems scores.

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4. Discussion

Early cognitive abilities are very good predictors of later performance in school and educational success in general (e.g., Schneider et al., 2014). Among these abilities are children's verbal abilities such as vocabulary and numeracy abilities such as counting (Joshi, 2005; Niklas & Schneider, 2017). Consequently, it is important to identify factors that are associated with early child abilities as increasing child competencies in the early years supports later academic success. One such factor is the quality of the ECEC learning environment (e.g., Lehrl et al., 2016; Mashburn et al., 2009; Sylva et al., 2008; Weiland et al., 2013).

Our findings align with results from earlier studies that demonstrate an association between program quality in the attended room and children's cognitive outcomes (e.g. Hamre et al., 2014; Mashburn et al., 2008). Instructional support, measured by the CLASS instrument, was a significant predictor of children's verbal abilities when controlling for various child and family characteristics. This association was also found in a recent study by Hamre et al. (2014). Mashburn et al. (2008) found that instructional support was also a significant predictor of children's early numeracy abilities. However, we found that contrary to our hypothesis, the ECERS-R subscale *Routines* related to children's performance in Applied Problems. These differing results might be due to Mashburn and colleagues using a total ECERS-R score instead of differentiating between individual subscales.

The subscale *Routines* measures, inter alia, children's level of independence and self-help skills in the centre such as health practices, independence at snack or meal time and toileting (Harms et al., 2005). Independence and self-help skills may support the kind of thinking needed for solving maths problems. Further, *Routines* also takes into account that staff should sit with children at the end of meals and snacks, engage in back-and-forth conversations, rehearse recall, and encourage extended peer conversations. Such conversations encourage child metacognition, and perspective taking. Together, these practices contribute to reasoning and to logical thinking – practices that may contribute to enhanced performance on the AP subtest. Our finding indicates that it may be useful to analyse different aspects of ECEC program quality simultaneously to identify relevant associations with child outcomes.

In contrast to our hypothesis based on results reported by Reid and Ready (2013) and Weiland and Yoshikawa (2014), the average SES in a room was not a direct predictor of child outcomes in our study. This is probably due to neither of these studies taking the average level of cognitive abilities in an early childhood setting into account in their analyses. Indeed, the average SES in a room proved to be a significant predictor of children's verbal and mathematical abilities in our study, only when the average intelligence in a room was not controlled for.

As expected, the average intelligence in a room was significantly associated with child outcomes, but also with measures of the average SES in a room (for similar results see also Niklas et al., 2011). It thus appears that greater average intelligence of children attending the same room is associated with greater individual verbal and mathematical abilities. Given that the mean BIA scores were positively correlated with the CLASS room quality measures, one can assume an interrelationship between room quality and room composition (cf. Mashburn et al., 2009; Rjosk et al., 2015). Whether this association is due to selection effects or whether room quality may act as a mediator between room composition and child outcomes is yet to be investigated (cf. Rjosk, Richter, Hochweber, Lüdtke, Klieme & Stanat, 2014).

Contrary to studies conducted within United States and German contexts, the proportion of 'LOTE' children in a room played a minor role in the Australian context. In Germany and the US, room composition – both in regard to the main language spoken by the children or in regard to their migration background – was found to be important (e.g., Fram & Kim, 2012; Niklas et al., 2011; Portes & Hao, 2004). In our sample, main language spoken and measures of SES were unrelated at both, child and room level, indicating that migrants often had an average SES. The independence of child outcomes of the proportion of 'LOTE' children in our findings is also reflected in Australian PISA results and earlier comparative research with younger Australian samples showing that a migration background is not a disadvantage for children living in Australia (Niklas et al., 2015; OECD, 2010). This may also reflect Australian immigration policy which has favoured skilled migration.

In addition to effects of room quality and composition, some significant interactions were found in an exploratory approach. In our sample, the average SES in a room interacted with children's main language and their verbal abilities: where children spoke a language other than English as a first language, verbal abilities were associated with the average SES in the room. These children showed greater verbal abilities in rooms attended by children whose parents had a higher average education (see also Reid & Ready, 2013).

Our results also indicated that the room composition did not matter much for children with high individual intelligence scores who performed well, on average, in verbal and numeracy tasks. However, children with lower individual BIA scores differed markedly in their outcomes when attending rooms with lower (vs higher) average BIA than other children attending the same room. These children showed greater verbal and numeracy abilities in rooms with higher average BIA than in rooms with lower average BIA, aligning with our hypothesis.

Children younger than four years in the sample did not differ in their verbal abilities in the context of varying instructional support, but older children showed greater verbal abilities in rooms with a higher quality instructional support. This finding indicates that in particular children four years old and older might profit from greater quality of instructional support. Blankson and Blair (2016) showed that only children with greater intelligence profited from high classroom quality and indeed, the younger children in our sample might not bring the necessary cognitive prerequisites to do so. However, since the levels of instructional support in all of the study rooms were relatively low, this finding warrants further investigation about the enactment of intentional teaching in play based learning contexts. In addition, it would be of interest whether such findings are also found in older samples.

Further, children whose parents employed in 'low prestige' jobs (AUSEI06) showed greater verbal abilities in rooms with higher quality and lower outcomes in rooms with lower quality. Finally, an interaction between classroom organisation, parental education and the AP score was observed. No differences were found between children whose parents had diverse educational backgrounds in rooms with higher scores for classroom organisation. However, children whose parents had a higher education showed higher AP scores in rooms with lower scores for classroom organisation than their peers whose parents had a lower education. This finding indicates that better classroom organisation might contribute to flattening the social gradient.

Early verbal and numeracy abilities are among the best predictors of later success in school and beyond (Duncan et al., 2007; Geary, 2011), consequently, the development of early competencies should be supported. For instance, when parents are supported in the provision of a high quality home learning environments for their children, child outcomes improve (e.g., Niklas & Schneider, in press). However, economic, language or other constraints mean that not all families are able to provide optimal support to their children. Therefore, formal ECEC settings are the next best target for early interventions.

ECEC room quality is clearly important for children's early verbal and numeracy abilities and educators should have the necessary qualifications and should receive support to provide a high level of structural and process quality in the rooms in which they teach. In particular, meaningful interactions between educators and children, and clear educator communication with children need to be fostered (Ishimine et al., 2009). Further, our results show that ECEC room composition is associated with children's early verbal and numeracy abilities. Given that this association seems to be strongest for disadvantaged children who show for example a lower performance in their individual intelligence assessments, or speak a language other than English as main language, more attention should be paid to the child grouping within ECEC settings. If possible, children with low cognitive abilities, coming from families with low SES or children speaking a language other than English should be included in heterogeneous groups (see also Niklas et al., 2011). Mixed groups should be preferred as higher verbal and numeracy outcomes were found in such groups independent of children's individual characteristics.

This study provides some important insight into the Australian ECEC context. Findings from recent studies have differed in their conclusions regarding the impact of attendance of formal ECEC settings during early childhood (Coley et al., 2013; Hildenbrand, Niklas, Cohrssen, & Tayler, 2017). For instance, Hildenbrand et al. (2017) showed that informal rather than formal care might promote children's mathematics learning. However, no measures of duration and intensity of ECEC attendance or program quality and room composition were taken into account in their study. Our findings indicate that room quality and room composition should be considered in order to analyse the association of ECEC attendance and child outcomes.

In addition, the significant interactions between the level 1 and the level 2 variables are of importance. Recent analyses of the trajectories of Australian children demonstrate that young vulnerable children are at risk of doing poorly over time and start school at a disadvantage (Tayler et al., 2015). Consequently, these children would benefit from additional targeted support. Our findings indicate that cognitive outcomes of these children compared to their peers are also more closely associated with room composition. Consequently, policy makers and educators should target room quality and room composition in order to support children's development.

4.1. Limitations

This study has some limitations. Only cross-sectional data were analysed and thus the findings need to be interpreted carefully in regard to causation and effects. The significant associations of room quality and room composition with children's competencies could also be partly due to selection or omitted variables bias. For instance, in Australia many young children do not attend formal ECEC settings (Gilley, Niklas, Tayler, & Cloney, 2015) and our sample consisted only of children attending ECEC settings. Further, we did not include assessments of parental income or child temperament that also may play a role in early child competencies (Hildenbrand et al., 2017).

In addition, a longitudinal approach would be needed to test for causal and mediation effects. For instance, it is possible that ECEC quality acts as a mediator between room composition and child outcomes (e.g, educators adjust their teaching according to the group they teach and its composition). Alternatively, room composition may act as mediator or moderator between ECEC quality and child outcomes (e.g., quality plays a varying role depending on the group composition). Longitudinal studies should test and compare these possible mechanisms of mediation.

Given that in Australia the number of children attending formal ECEC settings is much lower than in many other countries (Gilley et al., 2015; OECD, 2010), the stability and duration of attendance in ECEC settings in Australia may be a confounding factor. It would be of interest to compare the outcomes of Australian children attending informal care only for a significant period of their early years with children who attend formal ECEC settings varying in program quality and room composition for similar periods of their early years (cf. Coley et al., 2013; Hildenbrand et al., 2017).

Further, we assessed the home learning environment with one item only. Given the focus of our analyses on ECEC room quality and composition, we used reading frequency as a readily assessable indicator and perhaps the most important aspect of the home learning environment (Niklas et al., 2016). Indeed, reading frequency explained additional variance in verbal and numeracy abilities in our analyses. However, the home learning environment may have played an even more important role, if assessed with comprehensive measures (e.g., Niklas & Schneider, 2014, 2017).

Finally, room composition variables were obtained using the available study children's data. Consequently, in some rooms actual room composition will have differed at least slightly from the variables used in our analyses. However, recent research indicates that the vast majority of Australian families tend to use ECEC programs situated close to their homes (Cloney et al., 2016) and thus most children attending a room will come from the same neighbourhood enabling some assumptions regarding shared SES. Therefore, we believe that our room composition variables are at least fair indicators for the actual room composition of the rooms analysed.

4.2. Strengths

Despite these limitations, this study has several strengths. In comparison with many other studies (e.g., Niklas et al., 2011), we were able to use a large sample and to the best of our knowledge this is the first Australian study to address this topic. Our results should be representative for young Australian children attending formal ECEC settings.

Furthermore, we were also able to use standardized assessment measures that are reliable and have been validated to assess child outcomes and program quality. In addition, various aspects of program quality have been assessed and analysed. Distinguishing this work from most research on ECEC attendance, we included measures of both, room quality and room composition simultaneously. Here, we included the average cognitive ability in a room, an important variable seldom available in studies analysing room composition effects.

Our exploratory analyses of the interactions indicate that room composition is closely associated with verbal and mathematical abilities, particularly in the case of children with low individual competencies. Room quality seems to be associated with child outcomes independent of children's individual ability levels. For instance, only older and thus more advanced children showed greater verbal abilities in high quality ECEC rooms, whereas only children whose parents worked in a ‘low prestige’ jobs (AUSEI06) showed variation in their verbal abilities in rooms with lower vs higher quality. Consequently, our findings show the importance of analysing interactions between child and room characteristics. Clearly more research is needed.

5. Conclusion and implications

Using a large-scale Australian sample, the present study shows

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the importance of ECEC program quality and further, the influence of the composition of the room the child attends on child outcomes. Whereas child and family characteristics explained the better part of children's verbal and numeracy competencies, room characteristics added significantly to the explained variance. Our results showed that better program quality and a greater mean intelligence of the children attending the same room was associated with greater verbal and mathematical abilities of the children in the room while controlling for various child and family characteristics. Further, our findings indicate that the average intelligence in a room might be a better predictor of child outcomes than the average SES or the proportion of migrants in a room and should be assessed and analysed in research focusing on children attending ECEC classrooms. In addition, our results suggest that is worthwhile to include different measures of program quality to identify specific associations with child outcomes.

Our exploratory analyses of child- and room-level interactions indicate further that ECEC room composition matters in particular for those disadvantaged children, who either show a lower performance in their individual intelligence assessments, or speak a language other than English as main language. Consequently, educators and policy makers need to tackle both, ECEC room quality and room composition to support these children.

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