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The Importance of Early Childcare Teachers' Self-Efficacy Expectations for the Quality of Supportive Teacher-Child Interactions and the Frequency of Mathematical Activities

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Abstract:

Dispositional characteristics of early childcare teachers, such as self-efficacy expectations (SE), play an important role in realizing effective teacher-child interactions, which in turn are related to child development. However, the findings for children in daycare centers are sparse, especially about the importance of domain-specific SE. This study therefore investigated relationships between global and domain-specific SE and the realization of global interaction quality as well as the frequency of domain-specific mathematical activities. As part of the EarlyMath study, 92 educational professionals were rated on their interaction quality. In addition, they were asked about the frequency of mathematical activities and their pedagogical and mathematical SE. A positive relationship between mathematical SE and the frequency of mathematical activities was found. The implications of these findings are discussed.

Keywords:

Early childcare teachers
Interaction quality
Self-efficacy expectations
Mathematics

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1. Introduction

Against the backdrop of the expansion of institutional education, upbringing, and care for children under the age of three, there is an increasing focus on the quality of these facilities [1]. The connection between a high quality of stimulation in daycare centers and child development is well documented [2–3]. However, research indicates that the quality of interaction in Germany can only be classified in the medium quality range on average for both the over-threes (U3) and under-threes (U3) age groups [4–8]. For area-specific aspects such as language/literacy and maths, the quality is even more in the minimal quality range [6]. Models of professional competence development generally assume

that characteristics on the part of the professional play a central role in the realization of successful professional-child interactions [9–11]. A distinction is made between characteristics at the dispositional level (knowledge, situation perception and analysis, motivation and action potential/social skills) and performative level (action planning and willingness to act, action in the situation, analysis, and evaluation), which in turn are based on a professional attitude (action-guiding orientations, values, and attitudes) [11]. Dispositional characteristics have an effect on the characteristics at the performative level according to the model, which in turn has a feedback effect via analysis and evaluation [12]. Therefore, characteristics on the part of the professionals and the institutions are the focus of research interest to identify those conditions that are related to stimulating interactions in general and in specific areas such as language or maths [12]. In particular, competence facets of professionals are discussed, which include motivational factors such as self-efficacy expectations (SWE) [13–14]. According to the competence model by Fröhlich-Gildhoff et al., SWE can be regarded as a component of professional competencies at a dispositional level [11]. These have been shown, for example, to be a positive predictor of the quality of written language stimulation for children in the U3 sector [15–16]. A distinction is made between general (relating to all areas of life) and area-specific (e.g. occupational activity) SWE, the specific significance of which has, however, been little investigated in the U3 area [17]. Building on this, the present study distinguishes between occupation-specific (pedagogical) and domain-specific (mathematical) SWE and examines the relationship between SWE of professionals in relation to the design of global and domain-specific mathematical professional-child interactions in nurseries.

2. Educational quality in daycare centers

Quality in child day care centers can be described as a multidimensional construct that includes the facets of orientation quality (e.g. self-efficacy expectations), structural quality (e.g. staffing ratios), and process quality (e.g. professional-child interactions, joint activities), whereby the latter can be further differentiated into global (e.g. general social-emotional support) and area-specific (e.g. mathematical stimulation) aspects [18–19]. A central assumption is that characteristics of the structures and orientations influence the processes that are realized and that these in turn have an effect on the child's development [19]. Everyday interactions between professionals and children can be regarded as key situations concerning process quality in daycare centers [20]. Central to this is how sensitive professionals organize these interactions and the extent to which these interactions stimulate thinking and support learning [21–22].

Accordingly, La Paro et al. differentiate between emotional and behavioral aspects of support as well as active learning support [22]. Emotionally supportive interactions, which are characterized by emotional warmth and a sensitive approach to the child's needs, are regarded as the basis for learning-supportive behavior, which includes the stimulation of cognitive skills [23]. Accordingly, groups with a high quality of interaction are characterized by warm interactions, positive behavior management, and active learning support, in which the professionals meet the children at eye level, accept their emotions, follow the children's interests, and support them in their thinking and actions in terms of the zone of next development [23]. In addition to this rather global conception of interaction quality, additional area-specific aspects of interactions can be considered, which in the area of maths relate to the frequency of mathematical activities, e.g. comparing quantities, counting, or dealing with sizes [24]. This shows that children who were encouraged more frequently to compare shapes or sizes, for example, demonstrated higher mathematical competencies than children with whom the mathematical activities were carried out less frequently [24–25].

3. Self-efficacy expectations (SWE) of educational professionals and their significance for interaction quality

SWE is defined as a person's subjective convictions that they can master difficult or new situations with the help of their competencies [26]. Profession-specific SWE describes assumptions of early childhood education professionals about their abilities to act in their everyday practice [27]. The few findings on

occupation-specific SWE of early childhood educators point to high occupation-specific SWE both nationally and internationally [15, 27–29]. Further evidence suggests that job-specific SWE and global interaction quality are positively related [14, 28]. However, some of the correlations only exist for certain areas of the CLASS quality dimensions, such as emotional and behavioral support or the organization of everyday life, an area that is recorded for children from the age of three [30–31]. There are only a few findings on the connection between the SWE of educational professionals and the area of active learning support. Wolstein, for example, reports a relationship between SWE and active learning support that was moderated by professional perception and additionally controlled for professional experience and professional knowledge. Another study by Todd Brown reports no correlation between profession-specific SWE and professional-child interactions. Although the educational professionals rated their job-specific SWE as high, which in turn was positively related to their beliefs about what they considered to be important areas of development in early mathematical competencies, no significant correlation was found with the observed mathematical interactions [29].

SWE can also be considered in terms of specific areas. Mathematical SWE describes how competent professionals feel in maths teaching-learning situations [32]. This has hardly been researched for early childhood education professionals, particularly in day nurseries. In the U3 sector, there is evidence of both high and low mathematical SWE among educational professionals [33–34]. MacDonald was able to show initial evidence of high mathematical SWE among early childhood educators in Australia, particularly in the crèche sector [35]. For example, the vast majority of professionals stated that they felt very confident in planning (88.8% agreement) and implementing (90.1% agreement) mathematical learning experiences with young children. This is surprising in light of the studies that tend to indicate unease among educational professionals with mathematical content [36]. The evidence of the connection between mathematical SWE and the quality of mathematical interaction is sparse. For the natural sciences, there are indications that area-specific SWE is positively related to area-specific teacher-child interactions [13]. According to this, professionals with high science SWE carried out science activities significantly more frequently than professionals with lower science SWE. A study by Zhu et al. reports that the mathematical SWE of educational professionals in the U3 sector influenced their interactions with children during play with building blocks [37]. In addition, mathematical SWE mediated the positive correlations between the constructivist beliefs of the professionals and child-centered interactions. Studies in the U3 sector that investigated relationships between mathematical SWE and mathematical professional-child interactions could not be identified.

Based on these inconsistent findings, this article examines the relationships between SWE (job-specific and mathematical) with the global quality of interaction and the realization of mathematical activities among early childhood education professionals. The question of whether there are correlations between the two dimensions of global interaction quality, the frequency of mathematical activities, and the area-specific and mathematical SWE of early childhood education professionals in day nurseries is investigated.

4. Method

4.1. Sample and procedure

This study is part of the “EarlyMath” intervention study, which has been analyzing $N = 95$ crèche groups from the Franconia region and the greater Munich area in a 2-cohort design since 2020 (intervention period: Cohort 1 ($N = 50$: 12 / 2020 to 04 / 2021), Cohort 2 ($N = 45$: 03 / 2022 to 06 / 20 22)). One specialist and an average of 4 children took part per daycare center. For the present analyses, data from the pre-test of both cohorts (cross-section) were used and those cases excluded in which the observation of the quality of interaction with the CLASS-Toddler was not available and/or the information on the activities and the SWE was missing ($N = 3$). The final sample comprises 92 early childhood education professionals (cf. Electronic Supplement ESM 1, Tables E1–E2). The average age of the early childhood education professionals was 36.21 years (SD = 11.05 years) and their mother tongue was predominantly German (81.1 %). 95.6 % of the professionals were

female (4.4 % male). The most frequently cited professional qualification was training as an educator (65.6%). The other qualifications were academic (23.3 %), child care (10.0 %), and trainee (1.1 %). On average, the professionals had 10.19 years of professional experience (SD = 7.97 years).

4.2. Survey instruments and analysis methods

4.2.1. Self-efficacy expectations

The items on the job-specific SWE scale (five items; Cronbach's α = .71) were based on Oppermann et al. in terms of language and on the scaffolding concept in terms of content and reformulated for the specific project (e.g. "It is easy for me to encourage the children to think further by asking specific questions or making comments") [38–39]. The mathematical SWE scale (five items, Cronbach's α = .82) is a scale developed by the "EarlyMath" project based on Oppermann et al., e.g. "I am confident that I can use everyday situations to stimulate mathematics" [40]. The assessments of the SWE were recorded on a 4-point Likert scale (1 = "strongly disagree" to 4 = "strongly agree"). The items for both SWE scales and the maths activities can be found in ESM 1 (Tables E3–E5).

4.2.2. Interaction quality

The present study uses the Classroom Assessment Scoring System-Toddler, which measures the global quality of professional-child interactions in children aged 15 to 36 months by observing group activities. The dimensions of Emotional and Behavioral Support (EVU) and Active Learning Support (AL) are rated by certified observers on a scale of 1 to 7; a higher number indicates higher quality.

The frequency of mathematical activities, as a catalyst for mathematical interaction quality, was recorded using 12 items (1 = "Rarely/Not at all" to 7 = "Several times a day") and is based on the NEPS study and the BIKS study [41–44]. The internal consistency of this scale is also satisfactory (Cronbach's α = .75). An example item is: "How often is counting done with the children in everyday life (e.g. children in the morning circle, fingers)."

4.2.3. Control variables

As previous findings show correlations between the quality of interaction professional experience and professional qualification, the influence of these variables is controlled for in the regressions [45].

4.2.4. Statistical analyses

Three linear multiple regression models were calculated using the statistical program R (version 4.1.1) and the lavaan package to investigate the correlations between the interaction quality of early childhood education professionals and their profession-specific and mathematical self-efficacy expectations [46]. Individual missing values were analyzed using the full information maximum likelihood (FIML) method. First, the models for the two self-efficacy scales were analyzed separately. To be able to make statements about whether job-specific and area-specific self-efficacy expectations make their specific explanatory contribution, both scales were then included in a joint model. As the results of the three regression models do not differ significantly, only the final model is reported below. The other two regression models can be found in ESM 1, Table E6. The standard test statistic requirements for conducting regression models showed that there was no multicollinearity (Tolerance > .10; VIF < 10, 2017; r > .85) [47–48]. It can also be assumed that homoscedasticity is present, as the residuals were normally distributed and independent of each other (Durbin-Watson test 1.688 - 2.506).

5. Results

Overall, educational professionals have high to very high self-efficacy expectations, whereby the profession-specific (M = 3.64, SD = 0.35) is slightly higher than the mathematical self-efficacy expectation (M = 3.19, SD = 0.50). The maths activities are carried out on average once a week (M = 4.43, SD = 0.89). Concerning the global quality of interaction, early childhood educators show a qualitatively high level of emotional and behavioral support (M = 5.32, SD = 0.58) and a medium level of active learning support (M = 3.23, SD = 0.69) (see **Table 1**, for further descriptive results and intercorrelations, see also ESM 1, Tables E7 and E8).

In the regression model, the correlations between

Table 1. Regression model (3) of job-specific and mathematical self-efficacy expectations on global interaction quality and mathematical activities

Model 3						
	Interaction quality					
	Global				Mathematical	
	EVU		AL		HmA	
	β	(SE)	β	(SE)	β	(SE)
Self-efficacy						
Occupation-specific	.07	(.22)	.10	(.27)	-.09	(.31)
Mathematical	.07	(.15)	.12	(.18)	.42 ***	(.21)
Control variables						
Highest vocational qualification	.31 ***	(.11)	.21 *	(.09)	.01	(.11)
Professional experience in daycare centers	-.10	(.01)	-.01	(.01)	.21 *	(.01)
Model quality						
R^2	.11		.08		.19**	

the occupation-specific and mathematical SWE with the two CLASS areas and the frequency of mathematical activities are analyzed. There are no significant correlations between the SWE (occupation-specific and domain-specific) and the two CLASS domains. However, these are predicted by the highest professional qualification of the professionals (emotional and behavioral support: $\beta = .31$, $p < .001$; active learning support: $\beta = .21$, $p < .010$). The area-specific SWE ($\beta = .42$, $p < .001$) and the professional experience of the early childhood education professionals ($\beta = .21$, $p < .050$) proved to be significant predictors of the frequency of mathematical activities. The higher the mathematical SWE of the professionals and the greater their professional experience, the more frequently they carry out mathematical activities in the daycare center and vice versa.

6. Discussion

In this article, relationships between SWE as a facet of orientation quality and aspects of process quality for the pedagogical and mathematical areas in nurseries were investigated. The high quality of emotional and behavioral support found and the comparatively lower quality of active learning support, as dimensions of global interaction quality at an intermediate level, are consistent with the findings from previous research in the U3 sector [49–50]. According to this, the professionals succeed in creating a group climate that is characterized by close and warm interactions, in which the professionals meet the children at eye level, perceive their needs, and stimulate the children's thinking and learning. However, neither the profession-specific nor the mathematical SWE are related to the two dimensions of global interaction quality. At first glance, this appears to contradict previous findings from daycare centers [14, 28]. However, it should be noted that these correlations mostly relate to the area of organization of everyday life, a sub-area that does not exist in the CLASS Toddler and which could not be investigated in the present study. It therefore remains open for the nursery sector whether SWE is related to other global quality facets, such as the organization of everyday life. In addition, a more recent study by Reyhing and Perren indicates that the correlations between SWE and process quality in crèches may be influenced by the situation in which the quality was recorded (e.g. group size, mealtime or free play situation) and therefore provide contradictory results in some cases [51]. Further analyses, taking into account the observation situation, could promise deeper insights here. The correlations between the global quality of interaction

and professional experience can also be found in other studies [52–53]. According to this, professionals are better able to create high-quality emotional and behavioral support as well as active learning support in the groups if they have been working in childcare facilities for a longer period.

The frequency of mathematical activities was used as a catalyst for interaction quality in the area of mathematics in this study. Overall, this confirms the trends of previous study results, which found a low to medium level of quality in the area of maths and thus indicate a potential for improving mathematical stimulation in childcare centers [54–55]. At least for some specific activities in the areas of space and shape as well as quantities and measurement, educational professionals seem to be able to integrate these more frequently into everyday life [56]. One possible explanation for this could be that teachers may find it difficult to recognize mathematical potential in everyday situations and/or to adequately pick up on children's activities. Studies on the correlations between the mathematical didactic knowledge of prospective educational professionals and their ability to pick up on mathematical situations provide indications of this [57]. The frequency of mathematical activities in the crèche is also predicted by mathematical SWE. This study thus provides initial evidence that mathematical SWE in crèches plays an important role in connection with mathematical stimulation.

7. Limitations

The voluntary participation of the childcare centers in the study suggests that commonalities between the childcare centers that were not surveyed but exist influence the results found on the specialist variables and the quality of interaction. The project name "EarlyMath" may have aroused the interest of professionals who were already interested in mathematical processes in childcare centers. Furthermore, nurseries with more favorable structural characteristics may have been more likely to agree to participate, as these presumably facilitate project participation and in turn have a positive effect on the quality of interaction. It should also be noted that the cross-sectional design of the study does not allow the direction of effect to be determined. Although many studies find positive findings for individual competence facets of professionals in connection with aspects of process quality, this may not correspond to the effects in reality, as not all interactions between quality dimensions and competencies of professionals can be taken into account [9, 19]. The use of self-reports to record SWE is accompanied by the problem that the objectivity of the statements is difficult to verify. Nevertheless, they are economic instruments that provide insights into the inner life of the interviewees. Furthermore, it is not possible to draw any direct conclusions about the quality of interaction from simply recording the frequency of activities; these can only be interpreted as tendencies. The inclusion of further area-specific quality indicators, such as the mathematical language input of the professionals, may provide deeper insights into the correlations found.

8. Conclusion

In the present study, positive correlations were found between mathematical SWE and the frequency of mathematical activities, but not with global interaction quality. This study was therefore able to show that early childhood educators carry out mathematical activities in crèches and that these are related to their mathematical SWE. The results thus provide initial indications that the mathematical SWE of early childhood educators in the U3 sector in particular play an important role in maths educator-child interactions. How the maths teacher-child interactions are organized remains to be seen. Further research could pick up here and investigate the connections between aspects of mathematical process quality and mathematical SWE. In terms of increasing (area-specific) quality in crèches and daycare centers, it seems sensible to take a closer look at mathematical SWE as a changeable competence facet, especially in light of the findings on the positive correlation between further training of professionals and quality [58].

9. Electronic supplements (ESM)

The electronic supplements are available with the online version of this article at https://doi.org/10. 1026/2191-9186/a000646

ESM 1 Table E1. Sample characteristics: Gender and highest professional qualification; Table E2. Sample characteristics: Age, work experience; Table E3. Items of the job-specific self-efficacy expectations scale; Table E4. Items of the mathematical self-efficacy expectations scale; Table E5. Items of the scale frequency of mathematical activities; Table E6. Regression models (1–3) for job-specific and mathematical self-efficacy expectations on global interaction quality and mathematical activities; Table E7. Mean values, standard deviation, and range of criteria and predictors; Table E8. Intercorrelations between criteria (01–02), predictors (03–05), and control variables (06–07).

Disclosure statement

The authors declare no conflict of interest.

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