PRESCHOOL TEACHERS' SELECTION OF PICTURE BOOKS FOR MATHEMATICS INSTRUCTION: AN INTERVIEW STUDY

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Various studies pointed to the potential of picture book reading (PBR) for supporting preschoolers' mathematical development. The features of picture books vary greatly, and these features contribute to the effectiveness of PBR. It is therefore important to adequately select picture books for mathematics instruction. We analyzed the general and mathematical PB features preschool teachers take into account when selecting picture books for this aim. Interviews with 66 preschool teachers indicated that they rate general features and features related to basic mathematical skills as most important, and explain their importance based on instructional goals rather than preschooler characteristics. Our results point to the need for professional development initiatives on the selection of picture books for mathematics instruction.

INTRODUCTION

Mathematics Instruction: Picture Books

Preschoolers' mathematical competencies are foundational for their later academic achievement (e.g., Anderson & Phillips, 2017; Watts et al., 2018). Preschool mathematics instruction can support the acquisition of these competencies. Recent studies point to the potential of picture book reading (PBR) activities for enhancing preschoolers' mathematical development (e.g., Purpura et al., 2017). Studies in the literacy domain showed that both general (e.g., tactile manipulations) and domain-specific (e.g., visual representations of words) picture book features contribute to the effectiveness of PBR activities for preschoolers' early language development (e.g., Chiong & DeLoache, 2012; Flack et al., 2018). Contrasting the literacy domain, studies on picture book features and their role in the selection of picture books and in the effectiveness of PBR activities in the domain of mathematics are almost non-existent. The limited number of studies on picture book features in the domain of mathematics revealed that picture books written with and without an explicit mathematical aim vary greatly in content and structural features (Ward et al., 2017; Splinter et al., Submitted). Moreover, according to Ward et al. (2017), they frequently contain features that are assumed to stimulate mathematical development (e.g., presence of Arabic numerals) but also features that may hinder this development (e.g., randomly presented items to

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be counted). It is therefore important that preschool teachers carefully select picture books for mathematics instruction, taking into account the picture book features.

Preschool Teachers' Selection of Picture Books

Current insights into preschool teachers' selection of picture books for mathematics instruction are scarce. Only three studies addressed this timely issue, thereby focusing on a limited range of picture book features. Pentimonti et al. (2011) and Stites et al. (2020) analyzed preschool teachers' selection of picture books in view of mathematical content. They found that preschool teachers infrequently selected picture books that include explicit mathematical content. Moreover, these teachers reported that powerful preschool mathematics instruction should include activities different from PBR. Cooper et al. (2018) studied which criteria pre-service preschool teachers take into account when selecting a picture book for mathematics instruction. Their findings indicate that pre-service preschool teachers select picture books on the basis of the mathematical topic to be taught and their lecturer's recommendations, rather than the quality of the picture book.

Current Study

Given the large variety in mathematical picture books features, and Ward et al. (2017)'s assumptions about the learning-supportive versus hindering role of these features for preschoolers' mathematical development, the careful selection of picture books in view of their features is crucial. Systematic analyses of preschool teachers' selection of picture books along a wide range of both general (e.g., tactility) and domain-specific (i.e., mathematical) features are currently lacking. We aimed to deepen current understanding of this topic by systematically analyzing preschool teachers' selection of picture books for mathematics instruction, with special attention for the features they rate as most important and why.

METHOD

Participants were 66 preschool teachers (M_{age} = 41y, $M_{teaching\ experience}$ = 9y), providing instruction to 2.5- to 4-year-olds (n = 22), 4- to 5-year-olds (n = 26), and 5- to 6-year-olds (n = 18). Participants were first offered an online questionnaire on their demographical and occupational information. They next participated in an online interview on their use and selection of picture books for stimulating preschoolers' mathematical development.

Teachers were first interviewed about their use of picture books for mathematics instruction. Next, they were offered a series of questions focusing on their selection of picture books for mathematics instruction. In a first question teachers were offered a list of 22 picture book features (17 domain-specific and 5 general). They had to rank them into four categories (i.e., very important, fairly important, slightly important, and not important). Afterwards they were asked to rank the features within each category

from most to least important so that a complete ranking of all features was made. Scores ranged from 1 up to 22, with 1 indicating least important and 22 most important. Picture book features were selected on the basis of previous studies (i.e., Splinter et al., submitted; Ward et al., 2017) and are shown in Table 1.

#	Domain-specific features	#	General features
1	Presence of numerosities 1-10	18	Possibilities for tactile manipulation
2	Presence of numerosities >10	19	Presence of story
3	Presence of the number zero	20	Having a good length or duration to read
4	Presence of Arabic numerals	21	Being child-oriented
5	Presence of number words	22	Presence of a theme that fits to the theme the teacher wants to use for the classes
6	Presence of an ascending counting format		
7	Presence of a descending counting format		
8	Presence of 1-1 correspondence		
9	Presence of cardinality		
10	Presence of ordinality		
11	Presence of arithmetical operations		
12	Presence of comparisons between quantities		
13	Presence of decomposition of sets		
14	Presence of items to be counted that have the same size		
15	Presence of items to be counted that are linearly arranged		
16	Presence of items to be counted are distinct		
17	Presence of items to be counted that are presented solely		

Table 1: Domain-Specific and General Features used in the Ranking Question

The second series of questions consisted of 14 forced-choice comparisons that required teachers to choose between two versions of a picture book. The two versions differed in one of the domain-specific features included in the ranking question. In ten comparisons the feature was present in one version versus absent in the other version (e.g., number zero is present versus absent). Four features did not allow such an operationalization; for these features, teachers had to compare two versions of the presence of the same feature (e.g., set arrangement: linearly versus randomly arranged). The 14 forced-choice comparisons are shown in Table 2. The teachers were asked to select the picture book version they would use for their preschool mathematics instruction and explain their choice.

Teachers' preferences were scored dichotomously, with 1 indicating version 1 and 2 indicating version 2. Their explanations for this preference were coded in three steps. First, every answer was checked for including only a reference to a feature, without any explanation (F), only an explanation, without any reference to a feature (E), or both a reference to a feature and an explanation (FE). Second, when a feature was mentioned (i.e., F and FE), we scored whether it was the manipulated feature (1), another feature (2), or unclear (3). Third, responses that included the manipulated feature and an explanation (i.e., FE, 1) were coded in terms of whether they referred to their preschoolers' characteristics (i.e., age or other characteristics), instruction (i.e., learning goals or other instructional possibilities), or other (personal reasons, reference to another domain than mathematics, unclear responses). Inter-rater reliability (9 teachers) was sufficient for all three steps (*Cohen's kappa* = 0.75-0.86).

Comparison	Version 1	Version 2
1. Number range[b]	Numerosities >10 present	Numerosities 1-10 present
2. Presence of zero[a]	Zero not present	Zero present
3. Presence of Arabic[a] numerals	Arabic numerals not present	Arabic numerals present
4. Counting format[b]	Ascending counting format	Descending counting format
5. Presence of arithmetical operations[a]	Arithmetical operations not present	Arithmetical operations present
6. Presence of 1-to-1 correspondence[a]	1-to-1 correspondence present	1-to-1 correspondence not present
7. Presence of cardinality[a]	Cardinality present	Cardinality not present
8. Presence of ordinality[a]	Ordinality not present	Ordinality present
9. Presence of decomposition[a]	Decomposition present	Decomposition not present
10. Presence of comparisons[a]	Comparisons not present	Comparisons present
11. Set size[b]	Items of same size	Items of discrepant sizes
12. Set arrangement[b]	Linearly arranged items	Randomly arranged items
13. Set differentiation[b]	Overlapping items	Distinct items
14. Presence of distractors[a]	Distractors not present	Distractors present

[a] Comparison between the presence versus absence of the feature.
[b] Comparison between two versions of the presence of the same feature.

Table 2: Forced-choice Comparisons of the Domain-Specific Features

RESULTS

Use of Picture Books

We analyzed the occurrence and frequency of picture book use for mathematics instruction. All teachers reported to use picture books in their instruction, but not all of them did so for mathematics: 8 teachers (12.1%) did not use picture books in view of preschoolers' mathematical development. Although 43 teachers (65.2%) reported to

use picture books on a daily basis, only 4 (6.1%) used them for mathematics instruction every day. When asked which picture books they most frequently used for mathematics instruction, teachers spontaneously referred to picture books written with as well as without an explicit mathematical aim.

Selection: Picture book features

To deepen our insights into the selection process, we analyzed teachers' responses to the ranking question and the forced-choice comparisons.

When analyzing the teachers' rankings of the 22 features, we found that four general features and one domain-specific feature were part of the five features for picture book selection that were ranked as most important: (1) the picture book is child-oriented (*M* = 19.44, *SD* = 4.4), (2) includes a story (*M* = 17.2, *SD* = 4.6), (3) presents a fitting theme (M = 16.8, SD = 5.7), (4) has a proper length or duration to read (*M* = 15.0, *SD* = 5.4). The most important domain-specific feature was (5) the inclusion of the numerosities 1-10 (*M* = 16.9, *SD* = 4.2). The seven features ranked least important included six features related to more complex mathematical contents or the visual representation of the content, i.e., (1) includes the number zero (*M* = 7.4, *SD* = 4.8), (2) includes numerosities larger than 10 (*M* = 6.4, *SD* = 4.3), (3) includes arithmetical operations (*M* = 4.9, *SD* = 4.8), (4) has no distractors (*M* = 7.5, *SD* = 5.3), (5) has items to be counted that are linearly arranged (*M* = 7.0, *SD* = 5.3), and (6) includes items to be counted that have the same size (*M* = 6.9, *SD* = 4.1). The inclusion of tactile manipulations (*M* = 8.2, *SD* = 6.5) was also scored as not important (7). All other domain-specific features were ranked as slightly to fairly important (*M* = 8.4-14.8).

Regarding the forced-choice comparisons, we calculated the percentage of teachers that preferred version 1 versus version 2 per comparison. For most features, teachers clearly preferred one version over the other: 96% preferred the presence of Arabic numerals, 91% the presence of an ascending counting format, 88% the presence of ordinality, 85% the presence of decomposition and the presence of distinctly presented items, 83% the presence of numerosities 1-10, and 82% the presence of distractors. In addition, 74% preferred the presence of cardinality, 71% the presence of linearly arranged items, and 70% the presence of comparisons. For four features there was no overall agreement, i.e., 61% preferred the presence of zero, 60%, one-to-one correspondence, 63% items with the same set size, and 55% arithmetical operations.

Selection: Explanations

To better understand teachers' selections, we analyzed their explanations for their choices in the forced-choice comparisons. The results are presented in Table 3. Overall, for each of the 14 domain-specific features, teachers referred to preschooler characteristics and/or instruction in their explanation. But they explained their preferences more frequently on the basis of instructional goals compared to preschooler

characteristics. Only for the feature "number range presented" teachers more frequently referred to preschooler characteristics to than instructional goals.

Furthermore, most teachers generally selected the picture book version with the feature assumed most learning-supportive by Ward et al. (2017; e.g., presence of Arabic numerals, presence of cardinality, presence of comparisons). Teachers explained these choices often in terms of instructional goals. A substantial number of teachers also preferred features that are assumed not to support children's mathematical development (Ward et al., 2017), i.e., the presence of items with discrepant sizes, randomly arranged items, and the inclusion of distractors. Teachers' explanations for these choices often referred to the potential of these more complex contents for stimulating their preschoolers' mathematical development.

Comparison	*n*[a]	Preschoolers		Instruction		Other
		Age	Other	Learning goals	Other	
1. Numerosities >10 present	8	50%	38%	0%	25%	13%
Numerosities 1-10 present	48	42%	19%	35%	23%	13%
2. Zero not present	24	30%	13%	50%	17%	4%
Zero present	37	3%	14%	49%	24%	16%
3. Arabic numerals not present	3	0%	100%	33%	33%	33%
Arabic numerals present	55	9%	24%	47%	26%	6%
4. Ascending counting format	47	30%	21%	32%	28%	6%
Descending counting format	6	0.%	17%	50%	50%	0%
5. Arith. operations not present	27	26%	7%	52%	19%	4%
Arith. operations present	27	7%	37%	15%	63%	4%
6. 1-1 correspondence present	25	0%	8%	60%	40%	0%
1-1 correspondence not present	14	14%	14%	7%	57%	29%
7. Cardinality present	35	6%	40%	34%	46%	11%
Cardinality not present	8	13%	38%	50%	50%	25%
8. Ordinality not present	4	0%	0%	0%	100%	0%
Ordinality present	36	3%	19%	47%	47%	11%
9. Decomposition present	21	5%	19%	29%	67%	5%
Decomposition not present	4	50%	25%	0%	25%	0%
10. Comparisons not present	9	33%	11%	22%	22%	44%
Comparisons present	23	9%	4%	52%	35%	4%
11. Items have the same size	35	26%	14%	6%	63%	0%
Items have discrepant sizes	17	18%	0%	53%	41%	0%
12. Items are linearly arranged	38	5%	26%	3%	63%	5%
Items are randomly arranged	18	28%	17%	17%	50%	6%
13. Items are overlapping	7	14.%	14%	0%	71%	43%
Items are distinct	31	23%	10%	7%	74%	13%
14. Distractors present	50	16%	12%	2%	76%	22%
Distractors not present	11	9%	36%	0%	91%	0%

[a] Number of teachers whose answers were labelled as FE, 1.

Table 3: Explanations for Forced-Choice Comparisons (in Percentages)

DISCUSSION

An increasing number of studies points to the potential of PBR activities for preschoolers' mathematical development. Studies in the domain of literacy revealed that picture book features contribute to the effectiveness of these activities. Given the large variety in picture book features and the scarcity of current insights into teachers' selection of picture books in view of these features in the domain of mathematics, we systematically analyzed preschool teachers' selection of picture books for mathematics instruction on the basis of general and domain-specific picture book features as well as their rationales for these choices.

Our results showed that all teachers use picture books for instructional purposes, and most of them even on a daily basis, but that these findings do not apply when focusing on the domain of mathematics. About 10% of the teachers reported not to use picture books for mathematics instruction and only a minority of the teachers who used picture books for mathematics instruction did so on a daily basis. Teachers referred to both picture books with explicit mathematical content and picture books without explicit mathematical content for the latter purpose. Our findings show higher percentages of picture book use for mathematics instruction compared to previous studies, which is probably due to the fact that these studies focused on mathematical content as indicator of this use (Pentimonti et al., 2011; Stites et al., 2020). Furthermore, when selecting picture books for mathematics instruction, teachers rated general (i.e., not domain-specific, mathematical) picture book features most important, and features related to more advanced mathematical concepts or visual representations of mathematical content least important. Although teachers generally preferred picture books with features that are assumed learning-supportive by Ward et al. (2017), they also selected picture books with features that these researchers assume to hinder preschoolers' mathematical development. Teachers' explanations for the latter choices clearly pointed to the potential of these (assumed hindering) features for engaging in complex mathematical thought during instruction. Hence, an important next step is to investigate whether and to what extent teachers effectively make use of these features in their mathematics instruction. The findings of those studies can significantly add to, and change, current assumptions about the beneficial role of specific picture book features for children's mathematical development.

Although future studies are needed to deepen our understanding of teachers' use and selection of picture books for mathematics instruction, our findings significantly complement previous work on the topic. Also, our study points to the need for further professional development initiatives for preschool teachers related to the use and selection of picture books for mathematics instruction.

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