"NUMBERS ARE ACTUALLY NOT BAD"

Attitudes of people working in German kindergarten about mathematics in kindergarten[1]

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The following article deals with the results of a questionnaire survey, in which attitudes and beliefs of German kindergarten teachers[2] about "mathematics", "teaching and learning of mathematics" and "mathematics in the early years" were evaluated. After a quantitative analysis it can be stated that a schematic view of mathematics of kindergarten teachers prevailed and active and constructive learning of mathematics was highly agreed upon. The answers of the open question about learning goals revealed a broad range. With the help of the results, consequences for pre-service and in-service kindergarten teacher education are shown.

Key words: early years, kindergarten teachers, attitudes, competences, kindergarten teacher education

INTRODUCTION AND BACKGROUND

The interest in mathematics learning and education for the early years has increased immensely in the last years. A few years ago, mathematics did not play an official role in German kindergartens. Learning mathematics was reserved for school. Kindergarten teachers were not confronted during their pre-service education with mathematics education. Recently, different educational policy documents have begun to include references to mathematics learning. But the curricula of the single federal states of Germany differ in the explicitness of the statements made concerning mathematics. It ranges from very in-depth descriptions of mathematical content to be used in kindergartens, to others, where mathematics does not play an important role. In most of the curricula, there are very vague statements about learning goals. Therefore it depends heavily on the knowledge, attitudes, values and emotions of the people who are working in the kindergarten if and how they do mathematics together with the children. The kindergarten teachers play an important role because they create and influence the contexts for learning mathematics in kindergarten. "They are the architects of the environment, the guides and mentors for the explorations, the model reasoners and communicators and the on-the-spot evaluators of children's performances" (Greenes 2004, p. 46).

[1] In Germany the pre-school institution is called kindergarten (for children from year 3 to 6).

[2] In German language the expression teacher is not used for people working in kindergarten, they are called educator. For this article I use the expression kindergarten teacher according to the English expression nursery teacher.

Results of the research of belief domain confirm that beliefs are behind teachers' behaviour in their classroom and act as a filter to indications of curriculum (Leder, Pehkonen & Toerner 2002). We can see this in the description of beliefs of Furinghetti and Pehkonen (2000, p.8): "Beliefs form a background system regulating our perception, thinking and actions; and therefore, beliefs act as indicators for teaching and learning". Skott (2001) also describes the consistency between beliefs and practice. Ngan Ng, Lopez-Real & Rao (2003) revealed in their study the strong influence of beliefs especially for kindergarten teachers. They noticed that there were more consistencies between beliefs and practices in kindergarten teachers compared with primary grade teachers. The big influence of prior knowledge, attitudes, emotions and individuals' understanding is also emphasized by the representatives of the cognitive-constructivist psychology of learning (Seel 2003) and the neurobiology (Roth 1997).

The construct "belief" consists of different components. One component is the view of mathematics. Mathematics as a science has different dimensions. According to Grigutsch, Raatz & Toerner (1998), there are four different aspects. Grigutsch et al. conducted an empirical study with over 300 math teachers and validated four aspects through different statistical tests: formalism, scheme, application and process. The aspect of formalism characterizes mathematics strictly by logical and precise thinking in exactly defined subject terminology with exact reasoning. Mathematics as a collection of calculation acts and -rules, which precisely indicates how to solve problems, describes the aspect of scheme. The aspect of application describes that mathematics has a practical use or a direct application. Mathematics also can be seen as problem-related process of discovery and understanding. Freudenthal (1982) describes the aspect of process very clearly, by defining mathematics as human activity in contrast to ready-made mathematics.

Next to the different aspects of mathematics, the belief about how mathematics should be learned and taught influences our exposure to children and to mathematics. Here, two contrasting positions can be described: "The assumption that the goal of mathematics instruction is to transmit knowledge to students and the view that students construct mathematical knowledge by active reorganizing their cognitive structures" (Cobb 1988, p. 87). The constructivist view of learning is generally accepted in mathematics education. Many research reports and even official documents represent a view of children who actively construct mathematics.

In conclusion it is obvious that the emotions and conceptions of kindergarten teachers about mathematics and mathematics education are important factors which influence their actual practice of doing mathematics in kindergarten. It is important to know some aspects of their conceptions and emotions related to mathematics education when discussing basic and advanced training of kindergarten teachers.

DESIGN

A questionnaire survey was conducted in the Karlsruhe area[3] with 589 kindergarten teachers (Benz 2008) in order to evaluate the conceptions of kindergarten teachers. With the questionnaire it was examined, which attitudes, experiences and prior knowledge kindergarten teachers have concerning “mathematics” and “mathematics education”.

At the beginning of the year 2007, 550 questionnaires were distributed in kindergartens, of which 281 were returned. Moreover, 308 prospective kindergarten teachers of 2 vocational schools were surveyed. Of the 589 respondents, 554 were female and 35 were male. None of the kindergarten teachers that were working in a kindergarten at the time of the survey had had “mathematics in kindergarten” as part of their vocational education. Only the prospective kindergarten teachers who started to work after 2008, dealt with the topic of “mathematics in kindergarten” during their education to be a kindergarten teacher. The gradual changes in the education policy led to changes of the curricula.

The single items of the questionnaire were differently constructed. In the first part, the kindergarten teachers could express their feelings towards mathematics in mulitple answers. In later questions, they could give their agreement to single statements on “mathematics”, “learning of mathematics” and “mathmatics in kindergarten” with the help of a rating scale from 1 (does not apply at all) to 4 (applies completely). Which competences children should gain in kindergarten was asked in “open questions”. “Open” questions were used in order not to restrict or influence the answers too much.

RESULTS

Feelings about mathematics are better than their reputation

In the questionnaire, four adjectives were given, that could be seen as emotionally neutral (*useful, important, abstract, useless*). Four emotional positive items (*challenging, interesting, clearly understandable, fascinating*) and four negative adjectives concerning emotions (*confusing, frightening, boring, incomprehensible*) were listed too. Table 1 set out the results from the questionnaires.

useful	63%	confusing	35%	frightening	15%
important	59%	incomprehensible	24%	clearly understandable	9%
challenging	52%	abstract	21%	boring	7%
interesting	40%	fascinating	19%	useless	3%

Table 1: Feelings towards mathematics in percentages

[3] There are kindergarten teachers working in the city of Karlsruhe (280 000 inhabitants) and also kindergarten teachers who are working in suburbs and villages around Karlsruhe.

Adjectives that could be described as neutral feelings with a positive value judgement, like useful and important, were chosen more frequently than any other terms. This is in contrast to the often cited public bad images of mathematics. The next most frequently chosen words were *challenging* and *interesting*. This concerns adjectives, which could be linked to positive feelings. Then follow two negative feelings like *incomprehensible* and *confusing*. *Incomprehensible* expresses that mathematics cannot be understood at all, while *confusing* can relate to a part of mathematics. This could be the reason why *confusing* was chosen more often than *incomprehensible.*

Thus, it must be noted that, concerning mathematics, positive emotions are more often predominant than negative emotions. Still, it is not to underestimate that one third of all kindergarten teachers regard mathematics as confusing.

Schematic view of mathematics prevails

The kindergarten teachers got a variety of statements where they could show their agreement in a multilevel rating scale from 1 (does not apply at all) to 4 (applies completely) in order to see which aspect prevails. In each case, 5 answers could be related to the aspect of scheme and formalism (e.g. mathematics demands formal accuracy), the aspect of process (e.g. solving problems is a main part of mathematics) and the aspect of application (e.g. mathematics trains abilities that are useful in everyday life). In order not to confront the kindergarten teachers with too many items the aspect of scheme and the aspect of formalism were jointed together. Grigutsch et al. (1998, 45) pointed out a very strong correlation between these two factors: “The formalism and scheme aspects positively correlate with one another and represent both aspects of a static view of mathematics as a system. They stand in opposition to the dynamical view of mathematics as a process”[4].

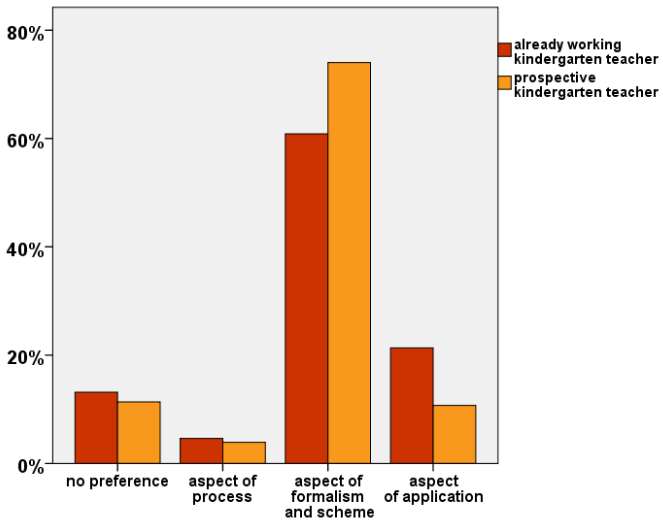
The mean values of every aspect for every person were calculated[5]. Then it was looked on which aspect the kindergarten teachers preferred. The results can be seen in Figure 1. 68% of all kindergarten teachers, agreed mostly to statements of the aspect of scheme and formalism. 16% agreed mostly to the aspect of application and only 4% agreed mainly to the aspect of process. For the remaining 12%, one prevailing aspect could not be determined.

Currently employed kindergarten teachers responded differently to these questions than did pre-service teachers. The pre-service kindergarten teachers were more likely to choose the aspect of scheme and formalism. Kindergarten teachers who are currently employed are more are more likely to choose the aspect of application.

[4] The new categories were verified through a factor analysis. 44% of the common variance can be explained with these three factors. Cronbach's alpha for the aspect of formalism and scheme is 0.58, for the aspect of process 0.60 and for the aspect of application is 0.74. For every factor there is a very significant intercorrelation between each of the items of the factor.

[5] The mean value for all kindergarten teachers for the aspect of process is 2.5; for the aspect of application it is 2.7; and the aspect of formalism and scheme it is 3.2.

The low part of kindergarten teachers choosing statements of the aspect of process is probably due to their own experiences in school. Mathematics was not experienced as a lively science, in which problem solving, creating of own solution strategies and personal ideas was common. Grigutsch et al. (1998) show the opposite tendency. They noticed in their study that the aspect which math teachers agreed mostly was the aspect of process. The aspect of application was also highly agreed upon whereas the aspect of scheme and the aspect of formalism was least agreed upon.



Prevailing aspects of mathematics in %		
	Already working N= 281	**Prospective teacher** N= 308
no preference	**13.2**	**11.4**
process	**4.6**	**3.9**
formalism scheme	**60.9**	**74.0**
application	**21.4**	**10.7**

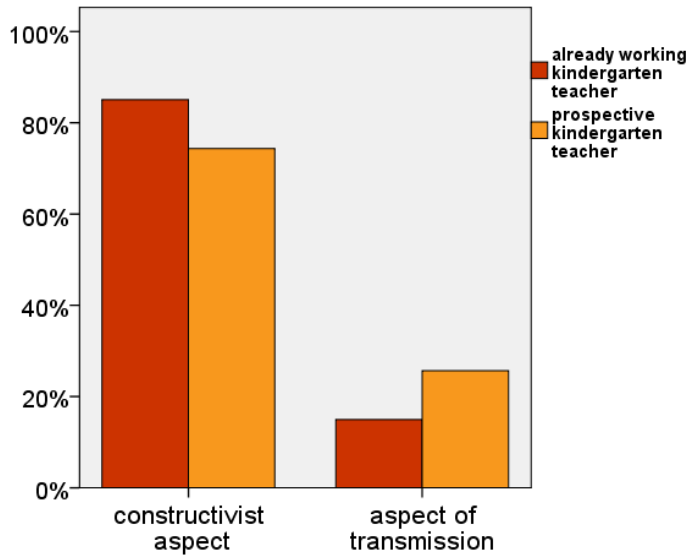
Figure 1: Prevailing aspects of mathematics

Active and constructive learning of mathematics gets high agreement

After the statements of different views about mathematics, the respondents were confronted with statements concerning the acquisition of mathematical knowledge. Thereby, five statements had related to transmission, for example: “mathematics is best learnt when model solutions are demonstrated“ and five statements related to constructivist learning theory, such as “children should discover new knowledge on their own, I just give the hints”[6]. The answers concerning more a view of transmission had a mean value of 2.8. Statements that are based more on constructive learning theories achieved a mean value of 3.3.

As before, after calculating the mean value, the answers of the kindergarten teachers were sorted according to the prevailing aspect. The results can be seen in Figure 2.

[6] The categories were verified through a factor analysis. The scree test showed an extraction of two factors. 41% of the common variance can be explained with these two factors. Cronbach's alpha for the aspect of transmission is 0.57 and for the constructivist aspect it is 0.76. For every factor there is a highly significant intercorrelation between each of the items of the factor.



Prevailing aspects of learning of mathematics in %		
	Already working N= 281	Prospective teacher N= 308
constructivist aspect	85.1	14.9
aspect of transmission	74.4	25.6

Figure 2: Prevailing aspects concerning the acquisition of mathematical knowledge

In doing so, it becomes clear that the kindergarten teachers, which are already working, set a higher value on constructivist aspects and less value to the aspect of transmission. Looking on the mean value of single items the tendency can be demonstrated too. Kindergarten teachers (M=3.32; SD=.75) already agreed more to the constructive statement “mathematical tasks can be solved in different ways” than prospective kindergarten teachers (M=2.98; SD=.86).

A constructivist conception of learning includes a certain awareness of mistakes: Mistakes are thereby an essential part of the way of learning and a normal aspect of the exploring learning process. They are not a blemish that should be deleted. Only a person, who learns, makes mistakes. The person, who does not make mistakes any longer, has stopped learning. In order to know what kindergarten teachers think about mistakes, there were two items concerning mistakes. The quite low mean values of 2.5 (“The most important thing is to achieve correct results” see figure 3 left) and 2.3 (“avoiding mistakes is important“ see figure 3 right) of the negatively formulated items show a positive attitude towards mistakes.

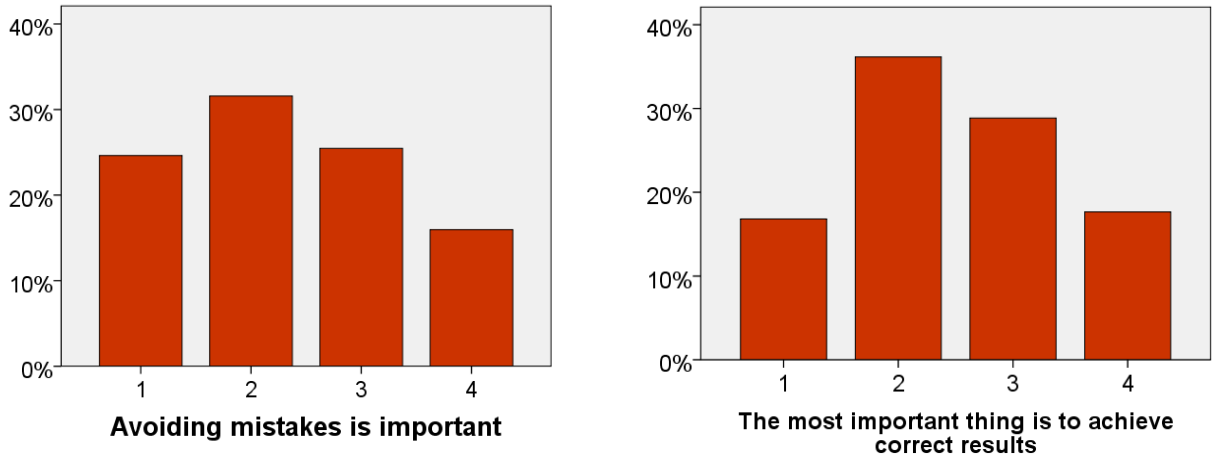


Figure 3: Attitude towards mistakes

But more than 25% of the kindergarten teachers chose “3” of the rating scale and 15% chose the top agreement “4” for both statements. So many kindergarten teachers think that errors should be avoided. This shows that a positive attitude concerning mistakes is not yet completely prevailing for all kindergarten teachers.

Broad spectrum of desired competences

As already mentioned in the introduction, there are not many concrete learning goals with respect to content in many curricula, which children should have acquired at the end of their kindergarten time.

There was an open question about what kindergarten teachers believed that children should learn. The answers were summarized in the following categories. The frequency of statements to each category is illustrated in Table 2 (Percentage of the kindergarten teachers making a statement to the respective content).[7]

counting	48%	reading or writing of numbers	29%
sets	38%	geometry (building, shapes, patterns)	26%
calculating	36%	measures (length, weights, time, volume)	17%

Table 2: Expected competences

The range of content was very broad. Very few kindergarten teachers noticed “nothing” or “mathematics should be learned at school and not in kindergarten”. But most of the kindergarten teachers wrote some competencies. Many content topics from primary school mathematics were mentioned. Counting as well as handling of sets was brought up most often. According to the kindergarten teachers, the children should also already learn simple arithmetic problems, often with the additional comment “embedded in situations” or “with objects”. Mathematical competencies concerning measures were rarely mentioned. This is astonishing, because the reference to everyday activities is very obvious concerning measures.

It makes one thoughtful when reading some statements about very high expected competences of the children such as “conceptual knowledge up to 100”, “numbers up to 100”, “counting up to 100”, “all basic operations like addition, subtraction, division and multiplication”, “multiplication tables”.

CONCLUSION

Due to the illustrated tendencies, the following components seem to be meaningful and essential for a pre-service and in-service teacher education in the area of preschool mathematical education:

[7] One kindergarten teacher wrote: “Numbers are actually not bad, so children should learn numbers in kindergarten”.

Focus on the aspect of process with regard to mathematics

Because most of the kindergarten teachers preferred the schematic view of mathematics, it is important that mathematical components should be included in Kindergarten teachers' education. Kindergarten teachers should have the possibility to make their own mathematical experiences and thus experiencing the aspect of process and problem-solving of mathematics. Similar to an important goal of elementary teacher education, the important goal of mathematical components in and for preschool teacher education is to:

> contribute to breaking a vicious circle. Many (prospective) teachers do not feel confident with mathematics due to their own prior negative learning experiences. Thus, they are likely to perpetuate their limited understanding to their own students. In this context, (prospective) teachers' encounters with mathematics play a crucial role, as they offer opportunities to encourage them to develop a lively relation to the activity of *doing mathematics*. (Selter, 2001, p.198)

Focus on active construction of knowledge with the consequence for doing mathematics with children

Although there was a high agreement to statements which can be referred to a constructivist view of learning, there were quite a lot of mostly prospective kindergarten teachers who showed a higher agreement to statements according to the aspect of transmission. So another important aspect for the basic and advanced kindergarten teacher education are the fundamentals of the cognitive-constructivist learning theory like e.g. the active meaningful construction of the knowledge. It is also important to concretise this with the help of learning environments to provoke children's curiosity and to enable individual exploration. Thereby, an important aspect is the role of the kindergarten teacher as a learning companion, who is able to inspire and support the children's own constructions. In addition to providing learning environments, it is also important that kindergarten teachers can use children's daily experience. Everyday situations can provide rich mathematical experiences quite often. Therefore, kindergarten teachers should develop a view for opportunities of learning mathematics in order to see this in everyday kindergarten activities.

Valuing children's own construction

When children construct their own knowledge, not standardised generalisations and analogies are included. They occur as spontaneous systematic errors. A child which construct the counting sequence, twenty-seven, twenty-eight, twenty-nine, twenty-ten do overextend the pattern it has noticed (e.g. the twenties are formed by combining the term twenty with each number in the single-digit counting series one, two, three …nine, Baroody & Wilkins 2004). As already stated 25% of the kindergarten teachers chose "3" of the rating scale and 15% chose the top agreement "4" for the statements "it is most important to achieve a correct result or "it is important to avoid

mistakes". Therefore it is important that learning mathematics take place in an environment where errors do not have to be avoided. So the valuing of child's own constructions and patterns they have explored is one basic component of pre-service and in-service kindergarten teacher education.

Focus on content regarding learning goals

As could be seen in the open question, the range of learning goals was very broad. Many content topics from primary school mathematics were mentioned, even As Steinweg (2008) mentions, it is essential, to talk about helpful basic competences that help the children in the transition from kindergarten to school. Concerning these basic competences, it is important to keep in mind that the learning goals from school should not transferred into the kindergarten and thus pressurising kindergarten teachers and children. Therefore learning goals should be one aspect of the discussion of mathematics education in the early years.

In summary, the important aim of the early learning of mathematics is that children have the possibility to playfully explore mathematics as a lively science It is the challenge of people involved in mathematics education to provide opportunities for all kindergarten teachers so that they can explore and develop to be learning companions who are creative, curious and imaginative.

In addition to consequences for pre-service and in-service kindergarten teacher education, the research results point out that further research is needed. One aspect to focus on is the first sight minor differences between prospective kindergarten teachers and kindergarten teachers who have practical experiences already. Another question is to investigate the actual practice of doing mathematics in kindergarten. Furthermore it is interesting if at all and how a kindergarten teacher education that focuses on the mentioned components influences the practice.

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