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# An analysis of a kindergarten teacher's choices and justifications regarding teaching of a mathematical activity

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*This paper aims to increase the insight into kindergarten teachers' justification of their teaching. The study was done in a context with mathematical activities developed by the researchers in collaboration with the teachers. This is a context we consider as rich to reveal their choices and justifications made in advance of and during the teaching of a mathematical activity. Data from a semi-structured, post-teaching stimulated recall interview based on an activity with 5-year-old children was analysed employing the Knowledge Quartet proposed by Rowland et al. (2005). We identify seven choices made by the kindergarten teacher that reveal aspects of the kindergarten teacher's knowledge-in-action and knowledge-in-interaction. She adapts the activity through questions, comments, particularities within the activities, and use of artefacts. Thus, she nurtures the children in their mathematical learning process.*

*Keywords: Knowledge Quartet, Mathematics teaching in kindergarten, Teacher's choices, Teacher's justifications.*

## Introduction

The aim of the current study is to reveal insights regarding the choices kindergarten teachers (KTs) make during the teaching of mathematical activities in kindergarten and the justifications they provide with respect to these choices. Research has shown that high quality early childhood programs carry the potential of improving children's early learning. Moreover, intervention programs have shown to positively effect children's learning of mathematics (Clements & Sarama, 2011; Stehler et al., 2013). The current study draws on data collected as part of the research conducted within the Agder Project<sup>1</sup> (AP). The AP is a research and development project, designed as a randomized control trial with an experimental group and a control group, with the intention to even out differences between children as they enter school. The AP thus bares characteristics of an early childhood intervention program. In the project focus was on nurturing 5-year-old children in their development within four competence areas (social skills, self-regulation, literacy, and mathematics) that research has shown to significantly contribute to children's school readiness. In the AP, researchers designed mathematical activities in close collaboration with participating kindergarten teachers (KTs); activities that the KT's taught with the group of 5-year-olds from their own kindergarten.

The mathematical activities were designed based on two main principles, playful learning (Hirsh-Pasek et al., 2009) and inquiry (Wells, 1999; see also Breive et al., 2018 for further details with

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respect to the design). The current study thus takes as point of departure these two principles when researching the teaching of mathematical activities in the kindergarten context. Research has documented that emphasis on playfulness in engaging with mathematics in the early years is particularly important with respect to long-lasting effects (Marcon, 2002; Singer et al., 2009). Research has also documented that adopting an inquiry approach to mathematics learning is promising regarding children's learning of mathematics (Breive, 2019; Wells, 1999)

A huge amount of research has been conducted with respect to mathematics teachers' knowledge regarding mathematics and mathematics teaching. These studies are drawing on well-known frameworks such as Mathematical Knowledge for Teaching (cf. Ball et al., 2008), the Teaching Triad (cf. Jaworski, 1994), and the Knowledge Quartet (cf. Rowland et al., 2003; 2005). However, the number of studies analysing kindergarten teachers' practice is more scarce. Mosvold et al. (2011), drawing on the framework of Ball et al. (2008), analysed mathematics teaching in Norwegian kindergartens. They found that they needed to adjust the theoretical framework slightly to make it fit with the kindergarten setting. Breive (2019) also analysed mathematics teaching in a Norwegian kindergarten setting, and she revealed insights into the subtleties of KT's practice. However, these studies drew on observational data to reveal insights into the KT's mathematics teaching. We, on the other hand, draw on interview data associated with a taught mathematical activity to reveal glimpses into one KT's choices and justifications for her choices in the activity. Through this approach, we seek a more personal view upon mathematics teaching in kindergarten. Our approach is to some extent in line with the study of Sæbbe (2019), as he, building on the work of Ball et al. (2008), also drew on interview data immediately following observations of mathematics teaching in kindergarten. Nevertheless, our foci on choices and justifications for choices deviate from Sæbbe's, as he discussed whether KT's practice may be characterised as teaching, whether it is mathematical, and the challenges and demands for KT's competence. Moreover, our study deviates from Sæbbe's as we adopt a complementary, theoretical framework in our study, the Knowledge Quartet (Rowland et al., 2003; 2005). As such, our study is theoretically in line with Hundeland et al. (2017), who also drew on this quartet in their analysis of a KT's practice. To our knowledge, the Knowledge Quartet has not been used as an analytical framework to analyse interviews before. Thus, our study represents a novel attempt to scrutinise a KT's choices and justifications for her choices in the activity.

Previous studies have shown that substantial insights into KT's accounts of their teaching practice may be revealed through interview data (Erfjord et al., 2012; Hundeland et al., 2011). The current study draws on this experience as interview data from one volunteering KT from the AP has been analysed. This KT was selected based on the following procedure: The 42 participating KT's in the experimental group were, during the intervention year, invited to accept an invitation from the team of researchers who are the authors of this paper as well as teachers in the professional in-service program the KT's were part of. 12 of the KT's, randomly selected from the 42, accepted the invitation to be observed during their implementation of designed activities as well as a post-teaching interview. The particular KT in this paper was selected from one of these 12, at no other basis than an initial judgment that the activity was conducted as planned (that nothing unfortunate happened like sickness, external need for change in plans etc.). The interview of this selected KT has been analysed in order to address the following two research questions:

1. What choices does a kindergarten teacher make in her teaching of a mathematical activity?
2. What justifications does the kindergarten teacher provide regarding her choices in teaching the mathematical activity?

The KT taught an activity called ‘The secret bag’. An analysis of the mathematical discourse emerging in this activity is communicated elsewhere (Hundeland et al., 2020). The activity encompasses reasoning with respect to two-dimensional and three-dimensional geometrical shapes, firstly displayed for all and secondly located in an in-transparent fabric bag. The KT and the children first discussed features of and connections between these shapes. Then, having the shapes into the bag, one child at a time tactilely felt and reasoned what shape the picked one was.

### **The Knowledge Quartet (KQ)**

Rowland et al. (2005) describe mathematics and mathematics teaching and the mathematics teacher’s subject matter knowledge regarding these areas through four dimensions. These dimensions are called Foundation, Transformation, Connection, and Contingency, hence the label ‘The Knowledge Quartet’. This label not only signifies that there are four dimensions of mathematics teachers’ knowing, but also that these dimensions are intertwined – as a quartet. These dimensions emphasize the situations during mathematics teaching in which one may observe the mathematics-related knowing of the teacher.

*Foundation* is the dimension directed towards the use of propositional knowledge. That is, in the current study in what ways the KT, in her interview responses, reveals relevant knowledge of mathematics and mathematics education as well as her view regarding the goals of mathematics education and ways children appropriate mathematics. The analytical contributory codes used were: “awareness of purpose; identifying errors; overt subject knowledge; theoretical underpinning of pedagogy; use of terminology; use of textbook; reliance on procedures” (Rowland et al., 2005, p. 265).

Within the KQ there are two dimensions addressing knowledge-in-action. *Transformation* refers in the current study to the KT’s choices of representations, demonstrations, and use of examples, e.g. geometrical shapes, and how these are revealed in interview responses. Basically, this dimension concerns in what ways the KT shows evidence of appropriately transforming the mathematics for the children’s learning. The analytical contributory codes used were: “choice of representation; teacher demonstration; choice of examples” (Rowland et al., 2005, p. 265). *Connection* refers in the current study to how the KT makes connections between the activity involved mathematical concepts and procedures, i.e. features of geometrical shapes and their relations, as well as ways to challenge the meaning of these concepts and ideas. The analytical contributory codes used were: “making connections between procedures; making connections between concepts; anticipation of complexity” (Rowland et al., 2005, p. 265).

The fourth dimension is called *Contingency* - a dimension of knowledge-in-interaction. This dimension encompasses the nature of adult-child interactions and responses, and in the current study as how the KT responds appropriately, take advantage of emerging opportunities for learning, make the activity her own, and to what degree she deviates from her set foci and goals. The analytical

contributory codes used were: “responding to children’s ideas; use of opportunities; deviation from agenda” (Rowland et al., 2005, p. 266).

According to Rowland et al. (2003), “the quartet is comprehensive as a tool for thinking about the ways that subject knowledge comes into play in the classroom” (p. 97). Nevertheless, we will analyse the KT’s answers in a post-teaching stimulated recall interview and align her responses with the relevant dimension(s) and associated codes.

### **Semi-structured interviews**

Semi-structured interviewing is a commonly used method of data collection (Bryman, 2016; Kvale, 1996). Characterising features of semi-structured interviews are (non-exhaustive): 1) A list of questions is prepared; 2) The respondent may elaborate the response; 3) There is no strict order of the questions; 4) New, non-prepared questions may be asked; and 5) All prepared questions are asked.

We are aware of the deficits of qualitative interviews when it comes to trustworthiness, as people tend to rationalise on their thinking rather than trying to tell what they are/were thinking in interview settings. However, one of the authors both observed the taught activity as well as conducted the interview immediately after the activity. Extensive collaboration between the researcher(s) and the KTs was also established in the AP. These aspects add to the trustworthiness of the KT’s answers with respect to choices made and the justifications for these choices.

In the current study we particularly analyse a post-teaching stimulated recall interview. Designing our interview in this way is in line with how Rowland et al. (2005) designed their interview when developing the framework of the Knowledge Quartet. Furthermore, we designed our interview paying close attention to the codes behind the four dimensions of the Knowledge Quartet. Thus, we were formulating our questions aiming to address the particular codes in order to implicitly address the four dimensions. For example, we asked the question “What was the intention behind the activity?”, to address the code ‘awareness of purpose’.

### **Context and participant**

The current study analyses a semi-structured interview with the KT, immediately following her teaching of a mathematical activity, ‘The secret bag’. The activity was designed based on the principles of playful learning and inquiry. The written description of the activity encompassed an intention of the activity with respect to participating children’s possibilities for making mathematical experiences, suggestions for preparations, and suggestions for how to implement that activity including mathematical questions and prompts to use.

### **Results**

Despite the collaborative design of the mathematical activities, including explicit intentions and suggestions for implementation of the activity, the KT was left with a lot of freedom regarding how to teach the activity in detail. Each interview was analysed based on the following procedure: Initially, as mentioned above, the interview guide was collaboratively developed by the three researchers adaptive to the codes behind the four dimensions of the KQ. The conducted interviews were transcribed, and individually we analysed the transcripts, marked the statements and selected illustrative statements for the choices made. After the individual analysis, we met, shared and

discussed our outcomes and found that we strongly agreed on the outcomes and the respective statements. Finally, the statements were translated to English and added to our analysis section. From this analysis of the post-teaching stimulated recall interview, we identified seven novel choices that the KT made prior to and during her teaching. We have grouped them according to the dimensions of the KQ.

### **Choices and justifications associated with Foundation and Connection**

With respect to these dimensions, we asked questions about the intentions behind her activity, whether the intentions were achieved, her emphases on making connections between involved mathematical concepts, decisions about sequencing. The KT communicated the following choices:

1. She wanted to promote a particular mathematical focus and mathematical learning purpose of the activity.
2. She was conscious of the design and order of elements engaged with in the activity.
3. She was conscious of what mathematical questions to ask each of the children.

Even though the written description of the mathematical activity encompassed an intention, the KT explained that she made explicit choices in line with her intention. With respect to 1): “I wanted to emphasize a mathematical discussion concerning the features of the geometrical shapes”; “I wanted to let the children come up with answers, to give them time to think, to let them philosophize”; “I have twisted the activity a bit, made it my own”. With respect to 2): “I wanted the children first to engage with the geometrical shapes that I brought, and then for them to recognize geometrical shapes in their environment”; “I wanted the children to experience the shapes in two different learning arenas”. With respect to 3): “There are substantial differences amongst the children. Thus, I do not ask them questions with equal difficulty”; “If I am to include mathematics into the children’s play, it is important to ask the good questions”. These choices testify that 1) the KT consciously decides and is aware of the mathematical learning purposes of the activity; 2) the KT consciously decides on the organisation of the activity; 3) the KT consciously decides on the mathematical foci through her questioning; and 4) the KT anticipates the mathematical complexity involved in the activity. Thus, we argue that these choices exemplify an operationalisation of the dimensions of Foundation and Connection. The KT draws on her propositional knowledge both with respect to mathematics and mathematics education and establishes connections between the purpose of the activities and the children by adapting the inherent mathematical difficulty.

With respect to the first choice above, the KT argued that she wanted to nurture a discussion amongst her children concerning the characteristics of two-dimensional and three-dimensional shapes. Furthermore, she wanted her children to use visual, auditive and tactile senses to make mathematical experiences from the activity. Concerning the second choice, the KT argued that she followed the written activity quite closely, but also that she had prepared extra material for the children to engage with. She argued that her activity was flexible in its own right, offering her possibilities to both make it easier and to develop the activity further. Justifications for the third choice were as follows. The KT argued that the mathematics questions ought to be adapted to each child’s level of competency and that it is important to know each child’s competency in order to ask appropriate questions.

Appropriate questions are furthermore needed to make the activity successful in terms of participation and mathematical learning opportunities.

### **Choices and justifications associated with Transformation**

With respect to this dimension, we asked questions about how she adapted the activity to suit the children's mathematical experience, her reasoning with respect to how successful she was in adapting the mathematics, explanations, and use of manipulatives. The KT communicated the following choices:

4. She was conscious of how to engage each of the children in the mathematical activity.
5. She was conscious of how to use manipulatives and other mediating artefacts.

Both these choices signal that the KT is consciously aware of how to best communicate with her children. The KT is careful in how she mathematically approaches each of the children, and she adapts her questions and prompts to each child based on her particular insights regarding each child. "I wanted all children to be able to participate in the mathematical activity"; "There are many ways to engage the children in the mathematics". Furthermore, the KT reveals that she made conscious choices with respect to the various manipulatives she used in the activities, both particularly mathematical manipulatives and other mediating artefacts such as what shapes and number of shapes to include. The KT was also attentive to how she used mathematical language, use of pointing gestures, and displaying artefacts. "I used the fabric bag to introduce some mystery, something exiting, and I used a balloon and some pictures". These choices demonstrate, we argue, that the KT's taught activity was revealing the dimension of Transformation.

Regarding the fourth and fifth choice, the KT argued that all children were actively engaged in the activity. She sought to make them curious about the shapes and used the shapes of artefacts in the room, a brought artefact, and the small plastic shapes to let the children "experience the shapes in two different learning arenas".

### **Choices and justifications associated with Contingency**

With respect to this dimension, we asked questions about how the KT responded to and took advantage of the children's various contributions, whether and why she deviated from her plans for the activity. The KT communicated the following choices:

6. She made choices regarding how to communicate with each of the children.
7. She was attentive to children's comments and made deviations from plans and acted in the moment.

These two choices demonstrate that the KT is particularly aware of how she communicates with the children, especially to what extent and how she responds to the children's questions and initiatives during the activities. "My plans are rarely executed fully. It's about being spontaneous. The children steadily discover new things". "I wanted to let the children come up with answers, to give them time to think, to let them philosophize". The KT was also explicit about the various deviations she made due to the children's contributions, and she explained that she had to act in the moment according to the emerging issues. "I planned to use a game with shapes, made copies for each child. But then I experienced that the mathematical conversation was running smoothly. Introducing the game would

then just disturb them”; “I had to make one the children sit on my lap”; “I saw that the children were engaged in the activity. But after 30 minutes I realized that it was time to finalize”.

With respect to the sixth choice, the KT emphasized to let the children come up with the answers, to let the children philosophise. She also gave the children time to think for themselves for a while, for them to come up with answers. As regards the seventh choice, the KT argued that it was important to her to follow up on the children’s philosophical-mathematical questions. She wanted to discuss what the children were mathematically occupied with, to be spontaneous and flexible and react to the mathematically unexpected. However, she also took actions on the spot with respect to her leadership of the activity.

## **Discussion**

This paper aims to increase the insight into KTs’ justification of their teaching. The study was done in a context with mathematical activities developed by the researchers in collaboration with the KTs, a context we consider as rich to reveal their choices and justifications. We set out to come up with answers to the following two research questions: What choices does a kindergarten teacher make in her teaching of a mathematical activity? and What justifications does the kindergarten teacher provide regarding her choices in teaching the mathematical activity? Findings suggest that the revealed justifications for the teaching choices made, give insights into this KT’s knowledge-in-action and knowledge-in-interaction.

From the analyses of the post-teaching stimulated recall interviews, we argue that the KT made deliberate choices with respect to her teaching of the mathematical activity as well as justifications for these choices. She chose the particular mathematical learning goals for the taught activity, she chose to ask particular mathematical questions and raise mathematical issues for the children to wonder about. She chose various mathematical artefacts and talked attentively with each child in a deliberate way. All these choices were thoroughly justified.

Based on the KT’s revealed justifications for the teaching choices made we argue that the KT made the activities her own, in a way featured by the four dimensions in the Knowledge Quartet (Rowland et al., 2003; 2005). She adapts the activity through questions, comments, particularities within the activities, and use of artefacts. Thus, she nurtures the children in their mathematical learning process.

These insights reveal that the Knowledge Quartet is applicable as an analytical framework for analysing post-teaching stimulated recall interviews of kindergarten teachers. Furthermore, through our elaborations of the KQ dimensions and associated codes in our analyses, significant insights are implicitly revealed regarding a kindergarten teacher’s teaching of mathematics and the issues she has to handle in situ to make the participation in the activity a nurturing mathematical learning process for the involved children.

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