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# Teachers' Conceptions of Algebra and Knowledge of Task Purposes

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## Background of the study

Teachers are the key stakeholders of the prekindergarten-12<sup>th</sup> grade algebra reform and their conceptions about algebra is utmost important. Stephens (2008) working with elementary preservice teachers found that they held narrow conceptions of algebra centered around symbols and symbol manipulation. This study aimed to investigate in-service teachers' conceptions of algebra and their knowledge of task purposes across three tasks that focused on equivalence and equations, functional thinking, and variable.

## Theoretical framework

Kaput (2008) defined two core aspects of algebra as “a) algebra as systematically symbolizing generalizations of regularities and constraints” “(b) algebra as syntactically guided reasoning and actions on generalizations expressed in conventional symbol systems” (p. 11). This framework was used in the study to help categorize teachers' conceptions of algebra.

The second framework used in the study was Mathematical Knowledge for Teaching (MKT) (Ball, Thames, & Phelps, 2008). This study investigated teachers' knowledge of task purposes (their awareness to engage students in algebraic thinking) which can be categorized under the pedagogical content knowledge (PCK) of the MKT framework across three tasks that focused on algebra.

## Methods

The study was conducted with five female mathematics teachers who were working at the same school with the first author. Three teachers were teaching at the primary and middle school levels and two were teaching at the middle school level. Semi-structured individual interviews were conducted. The interview protocol comprised of three parts and developed based on Stephens (2008), and a functional thinking task was taken from Blanton et al. (2015). The first part included demographic information. The second part focused on understanding teachers' conceptions of algebra including the open-ended question “How would you describe what algebra is to someone who has never heard of it before?” This part also included three tasks. Teachers were asked the possible aims of the task. Also, teachers were asked to categorize the tasks as algebraic or not with their justifications. The last part included two student solutions provided to each of the three tasks. Participants were asked to categorize these student solutions as algebraic or not by explaining their reasoning.

The coding was conducted according to a coding scheme that was developed in previous studies (see Alapala, 2018; Stephens, 2008). The second author coded a randomly selected 20% of the data

What number goes in the box?

$$37 + 54 = \square + 55$$

and the agreement between the coders was found as 80%. The disagreements were resolved, and changes were reflected to the analysis.

**Figure 1: Task 1**

## **Results and discussion**

When teachers were asked the possible of aims of each task, their awareness regarding the opportunities to engage students in algebraic thinking varied from task to task. For instance, in Task 1 (see Figure 1) while four teachers focused on having students find the unknown using a computational approach, one teacher focused on the relationship between numbers in her response. When they were asked how they would describe what algebra is to someone who has never heard of it before, the majority of the teachers focused on the presence of an unknown or an equation in their responses. Teachers' categorizations of tasks as algebraic or not providing their justifications revealed a similar finding. They mentioned surface features such as the presence of an unknown or an equation in their categorizations. For instance, all teachers categorized Task 1 as "algebraic" because of the presence of an unknown or an equation. T4 said "I think it is an algebra task because there is an unknown. We didn't say  $x$ ,  $y$  but we used an empty box." Lastly, teachers' categorizations of student solutions indicated that the majority of the teachers ranked student solutions that included manipulations and equations as "algebraic" while they ranked solutions that focused on the structure of the equations and patterns as "non-algebraic." For example, in Task 1, while all teachers rated the student response who used a computational approach to find the unknown as "algebraic," only one teacher rated the response that focused on the relationships between numbers (indicating relational thinking) as "algebraic." Therefore, even though teachers demonstrated some awareness regarding the opportunities the tasks can offer in terms of algebraic thinking (PCK regarding algebra), their conceptions were mostly aligned with Kaput's (2008) manipulation of formalisms. This was similar in Stephens (2008). Given what teachers see as "algebra" could be foregrounded in the classroom, researchers should pay further attention to teachers' conceptions of algebra and pose tasks and hypothetical student responses that help uncover these conceptions.

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