How Do Kindergarten and Primary School Children Justify Their Decisions on Planning Science Experiments?

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Abstract: The ability to test questions and assumptions autonomously by systematic manipulation of variables in an experiment is a central aspect during designing and conducting scientific investigations. It is unknown if children already use the control of variable strategy (CVS) as their argumentation strategy for designing experiments. We compare which argumentation strategy children use to justify their decisions on planning science experiments. Primary school children more often chose non-confounded experiments compared to kindergarten children.

Introduction

Scientific thinking includes problem-solving procedures like formulating research questions, generating hypotheses, designing and conducting investigations and interpreting data as part of inquiry competences (Harwood, 2004). The ability to test questions and assumptions autonomously by systematic manipulation of variables in an experiment (Control of Variable Strategy; CVS) is a central aspect during designing and conducting scientific investigations (Klahr & Nigam, 2004).

Psychological studies have shown that children at the pre- and primary school age already can learn the basics of CVS and can in an easy way distinguish between confounded and non-confounded experiments (Sodian & Mayer, 2013). But is not known if children use the CVS as their argumentation strategy for designing experiments. They might also use another strategy, for example, a normative reference (Walton, Reed, & Macagni, 2013). Students need not only be able to distinguish between confounded and non-confounded experiments, but they need to be able to justify their decisions. It is possible that children choose the right answer and refer correctly to the CVS in their argumentation, but it may also happen that they choose the right answer by chance.

The research questions of this study are as follows:

RQ1: Which argumentation strategies do children in kindergarten and primary school apply?

RQ2: Having chosen a non-confounded experiment how often do children apply a wrong argumentation strategy?

Method

21 kindergarten children and 22 primary school children participated in the study. Kindergarten children`s mean age was 5.28 years (*SD* = .72) and 33.3% of the children were boys. The mean age of the primary school children was 9.18 years (*SD* = .501) and 54.5% were boys.

To assess children`s scientific thinking and argumentation strategies we introduced a scientific question of an everyday situation and showed the children confounded and non-confounded experiments to answer the question. The children had to decide which experiment is the best way to answer the question. Afterwards, we asked the children why they had chosen the respective experiment. We also asked the primary school children to design their own experiments to given scientific questions and justify their design. All tasks were constructed based on existing tasks (Sodian et al., 1991, Bullock & Ziegler, 1999, Schwichow, Christoph, Boone, & Härtig, 2016). The reliability of the scale for planning experiments was $\alpha = .67$ (primary school children; 12 items) and $\alpha = .73$ (kindergarten children 16 items).

We also assessed data about children's general cognitive skills (CFT, Weiß & Osterland, 2013). The knowledge of the kindergarten children was assessed by interviews, the knowledge of the primary school children with a paper-and-pencil test.

Open answers were coded into a categorization scheme (see Edelsbrunner & Deiglmayr, 2017) which has been complemented with additional categories. The complete data were coded independently by two trained coders who reached high inter-rater reliability (Cohen's kappa = .83). The scheme has seven main categories: tautological reasoning, normative reasoning, outcome-based reasoning, precise hint to experimental variation,

precise and correct hint to one factor, precise and correct hint to two or more factors, not possible to categorize. The categories “precise hint to experimental variation, precise and correct hint to one factor, precise and correct hint to two or more factors” were coded as right answers because the children showed a basic understanding of the CVS.

Results

Kindergarten and primary school children both used all argumentation strategies. Answers like “I don`t know” were excluded from the analyses. To compare kindergarten and primary school children we report percentages. The kindergarten children used a normative reasoning more often than the school children. Kindergarten children also mentioned more often a precise hint to one factor. Primary school children more often used tautological reasoning strategies and more often gave a hint to two or more factors.

There were also differences in the argumentation strategies in combination with right or wrong answers and argumentation strategies. Primary school children more often chose the right answer (68.94%) compared to kindergarten children (23.81%). Primary school children often did not use an argumentation strategy referring to the CVS (62.63%). If Kindergarten children chose the right answer, they used almost always the right argumentation strategy (83.33%).

There was a significant correlation between the general cognitive abilities and the skill “planning experiments” for primary school children ($r = .56$, $p = .006$) and also for kindergarten children ($r = .66$, $p = .006$).

Discussion

The results show that children in early years can already identify or plan non-confounded experiments but for primary school children it is difficult to use the right argumentation strategy. As children are able to use the CVS, one possible implication for the daily work in kindergartens and primary schools could be that teachers and educators should foster that children justify decisions with the CVS. For future research, it would be interesting to investigate how to support the teachers and educators in this task. We will increase the overall number of participants within the next few months to present more robust results at the conference.

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