"HELPING LEARNERS" – PRE-SERVICE MATHEMATICS TEACHERS' CONCEPTIONS OF LEARNING SUPPORT THROUGH THE LENS OF THEIR SITUATED NOTICING – A VIGNETTE-BASED STUDY

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Learning support is a key aspect of the teaching profession. In particular, promoting mathematics-related learning is a goal when mathematics teachers respond to students' questions or comments during their work on tasks. "Helping" learners in this sense should be (A) adaptive to the learner's needs and (B) carry the potential to elicit further learning - both core aspects of learning support informed by a teacher's noticing in the interaction with the learner. Pre-service teachers' noticing in this area can be assumed to be still under development and there is hence a need of empirical studies investigating the learning support they suggest to provide. Consequently, this paper presents results from a vignette-based study with n=116 pre-service teachers, providing insight into their difficulties and also perspectives for improvement.

INTRODUCTION

Mathematics teachers should be able to help learners in building mathematical knowledge and in using such knowledge for solving tasks. "Help" in this sense can be described as individual *learning support* (e.g. Krammer, 2009; cf. Schnebel, 2013). A reaction to the learner should at least (A) take into account the specific individual needs of the learner (i.e., *adaptiveness aspect* of learning support) and (B) carry the potential of facilitating and/or eliciting further individual learning (i.e., *progress aspect* of learning support). Providing individual learning support hence requires mathematics teachers to analyse the learner's mathematical thinking in order to identify potential individual difficulties, in order to find stimuli for further learning and understanding in an adaptive way and to communicate them to the learner. Such *analysing* (Dreher & Kuntze, 2015) can be understood in the framework of teacher noticing (Amador et al., 2021; Choy, 2014; Fernández, & Choy, 2020) as a *knowledge-based reasoning* process (Sherin et al., 2011; Berliner, 1991; Dreher & Kuntze, 2015). Accordingly, the teacher has to notice possible difficulties in the student's understanding, such as incomplete conceptual knowledge, for instance, and to identify a reaction which can support the individual learner to build up or strengthen the mathematical knowledge needed. For this complex and multi-step process, professional knowledge (Shulman, 1986; Kuntze,

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2012, cf. Kuntze, Dreher, & Friesen, 2015) is needed, including *content knowledge* (CK) and *pedagogical content knowledge* (PCK).

All in all, being able to provide effective individual learning support in classroom situations can be seen as a key aspect of mathematics teacher expertise. The requirements of adaptiveness and (content-specific) progress as introduced above show that the particular classroom situation plays a key role – also for research which aims at finding out about how competent teachers are in providing individual learning support. Vignette-based research can help to investigate such situation-specific noticing and to respond to a need of empirical studies in this area. In particular, evidence about *pre-service* teachers' analysis and their ability of providing adequate learning support is highly relevant, in order to find out about professional development needs and to describe pre-service teachers' growth empirically.

Consequently, this paper focuses on whether and how pre-service teachers can provide learning support in a learning situation in the context of divisibility, which is a content area from the pre-service teachers' training in a university course. Through the lens of the pre-service teachers' noticing, i.e. analysis and their suggested learning support, the results can also give insight into how they conceive of "help" to learners.

THEORETICAL BACKGROUND

There is a large consensus that mathematics teachers' reactions to learners' questions or comments should support them in their further learning (e.g. Krammer, 2009; Schnebel, 2013), such reactions should hence respond adaptively to learners' needs and provide them with stimuli for their further construction of mathematical knowledge and understanding. Research about teachers' noticing and analysis (e.g. Sherin, Jacobs, & Philipp, 2011; Amador et al., 2021; Choy, 2014; Fernández, & Choy, 2020; Dreher & Kuntze, 2015; cf. Kersting et al., 2012) has focused continuously on aspects of mathematics teacher expertise related to these requirements: in such research, the teachers' situation-adaptive knowledge-based reasoning and decision-making related to possible situated reactions is typically in the focus. Methodologically, related empirical studies mostly use representations of practice (Buchbinder & Kuntze, 2018), i.e. vignettes (Skilling & Stylianides, 2020; Kuntze et al., in press), for eliciting the teachers' noticing. Beyond a situated scope, there are studies which describe ways of inferring from teachers' situated noticing to more general aspects of their expertise (e.g. Kersting et al., 2012; Friesen & Kuntze, 2016).

For successful noticing, teachers need to draw on their professional knowledge (Shulman, 1986); their instruction-related views, which are also considered as components of their professional knowledge (Kuntze, 2012), can interfere in this process. For providing adaptive learning support, both CK and PCK is needed in order to mathematically analyse requirements of a task, a learner's thinking, and possibilities to provide learning support (Vondrová & Žalská, 2013). In the noticing process, teachers can draw on professional knowledge components from different levels of

situatedness (Dreher & Kuntze, 2015; Kuntze, 2012). Figure 1 gives a model-like overview of noticing related to providing learning support in the sense of the framework introduced above. In an analysis cycle as described in Kuntze and Friesen (2018), the task requirements, the learner's thinking (Fernández et al., 2018), and potential difficulties or needs of the learner have to be analysed against the background of the teacher's professional knowledge and situation-related observations. Based on this analysis cycle and again drawing on professional knowledge, possible reaction(s) have to be identified and a reaction which corresponds to an optimal adaptive learning support (Hardy et al., 2019) has to be chosen.

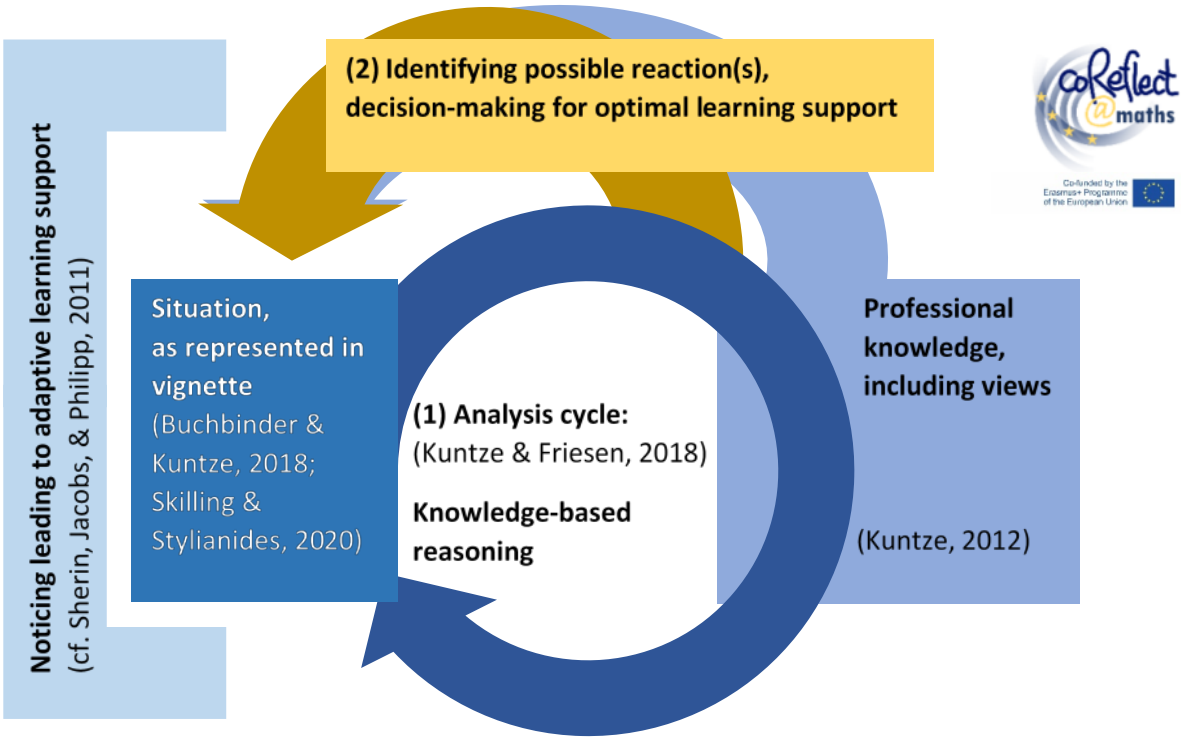

Figure 1: Model-like overview of noticing related to providing learning support.

Teachers' views related to "helping learners" i.e. to forms of learning support are assumed to influence this process and its results. When a learner struggles with finding a correct solution to a problem, learning support may consist of *directly providing information* such as the task solution, parts of it or a standard solution algorithm or rule, so that the learner can learn from this solution, rule or algorithm. However, learning support may also take the form of *feedback*, for example telling the learner that her/his reasoning is not correct or providing a counter-example, with or without indicating a further pathway for a correct solution. Moreover, rather *procedural* learning support can focus on stimuli to the learner for discovering a correct solution on her/his own, such as encouraging the learner to try out specific strategies or to challenge and check her/his thoughts on her/his own by using example values. A teacher's preference for such different forms of learning support may indicate this

teacher's views about learning support. For pre-service teachers in particular, such views may influence in which direction they develop their professional knowledge and instruction-related experience further (cf. e.g. Kuntze, 2012). In conclusion, mathematics teachers' views can be reflected in their noticing and analysis of vignettes.

RESEARCH INTEREST AND RESEARCH QUESTIONS

In particular for pre-service mathematics teachers – who are in the process of their professional development – relatively little is known from vignette-based empirical studies about how they provide learning support and to which extent they encounter obstacles when having to "help" learners, such as lacking CK. Such vignette-based research can not only indicate potential pre-service teachers' professional development needs, but also inform vignette use in pre-service teacher education and related evaluation research. This corresponds also to the aims of the Erasmus+ project coReflect@maths ("Digital Support for Teachers' Collaborative Reflection on Mathematics Classroom Situations", www.coreflect.eu).

For this reason, this study aims at analysing pre-service teachers' answers to a vignette in the content area of divisibility with respect of the following research questions:

(1) To what extent are pre-service teachers able to provide learning support in a vignette-based setting showing a fictitious situation in the content area of divisibility?

(2) What role does their content knowledge (CK) play in this context?

(3) In which form do they suggest to provide learning support and is it possible to infer to their conceptions of "helping learners" from the findings?

DESIGN AND METHODS

In order to answer the research questions introduced above, a vignette-based questionnaire was designed by the team of co-authors of this paper, using representations of practice (Buchbinder & Kuntze, 2018). For the vignettes, the style of concept cartoons (Samková, 2020) was chosen, in order to be able to present different learners' thoughts and to implement a variety of learning support requirements. The instrument focused on problems from the content area of divisibility, in line with the learning content of the target group. In this way, it could be assured that beyond their prior CK, all pre-service teachers had been given a set of opportunities for CK-related learning in the topic area of divisibility beforehand. One of the vignettes in concept cartoon style is shown in Figure 2. The research instrument with this vignette was administered to n=116 pre-service teachers preparing to teach at primary schools (18% male, all in their first year of studying mathematics) enrolled at a University of Education in southern Germany.

This study is part of a larger set of empirical studies carried out in the framework of the Erasmus+ project coReflect@maths. In the case of the results reported here, more analyses will be carried out in the future on the base of more data, also from groups of Spanish and Czech pre-service teachers who had worked with vignettes from the

questionnaire as well, in the framework of an international research approach in coReflect@maths.

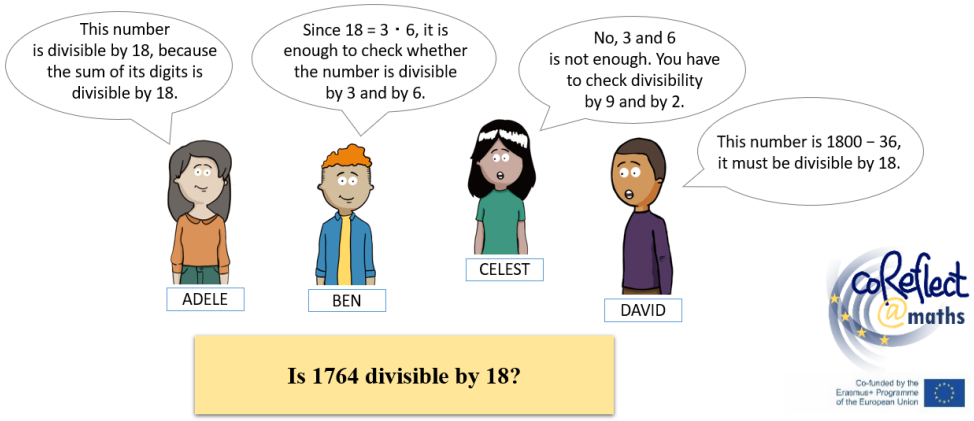

Figure 2: Vignette in the style of a concept cartoon (translated).

The participating pre-service teachers were first asked to analyse the thinking of the persons in the cartoon (Fig. 2). Then, they were asked to think of a reaction: The key vignette question for the analysis corresponding to the research aims of this paper was "How could you help the student teachers (1) to correct their answers or (2) to improve their argumentation?". In this way, the questions required analysing the vignette learners' thinking and providing the vignette learners with adaptive individual learning support.

The vignette in Figure 2 contains two answers with a mistake (Adele, Ben) and two answers that can be interpreted as incomplete (Celest, David) in the sense that the corresponding argumentations can be improved. As the above-mentioned question requires that "help" should be provided to all persons represented in the vignette, the learning support (A) should fit to the needs of the respective person (*adaptiveness aspect* of learning support) and the (B) "help" should lead further on the content level (*progress aspect* of learning support). Consequently, a top-down coding (cf. Mayring, 2015) was applied according to these two aspects: For each vignette person,

- code (A) describes whether there is an adaptive content-specific connection of the answer with the given vignette person's comment (dysfunctional attempts of adaptive connections with an observable aim of connecting to the cartoon character's thinking were coded as such, e.g. in case of mathematically inadequate connections or (partial) misinterpretations of the cartoon characters' thinking),
- code (B) describes whether the content of the answer could somehow advance the vignette person's learning or understanding.

Additionally, the form of suggested learning support was coded in a bottom-up approach (cf. Mayring, 2015), in which a set of different categories emerged, which will be reported together with the respective frequencies in the results section.

RESULTS

Figures 1 and 2 display results of the coding introduced above and the relative frequencies of the respective categories. Research question (1) focuses on the extent to which the 116 pre-service teachers were able to provide learning support to the four vignette persons. The results indicate that a considerable number of pre-service teachers struggled with CK difficulties, which inhibited both the adaptiveness (code A) and progress aspect (code B) of the individual learning support they suggested. For research question (2), there is more than half of the answers with evidence of CK difficulties, except for answers to David with a lower frequency of CK difficulty codes.

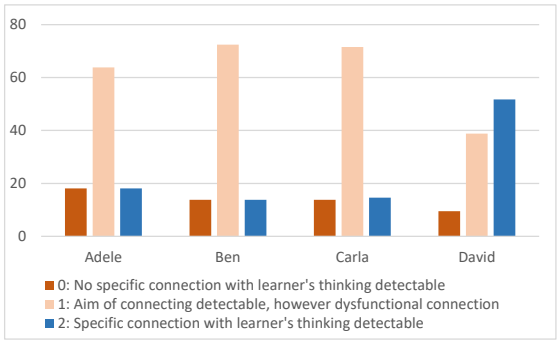

Figure 3: Relative frequencies for Code (A) (in per cent).

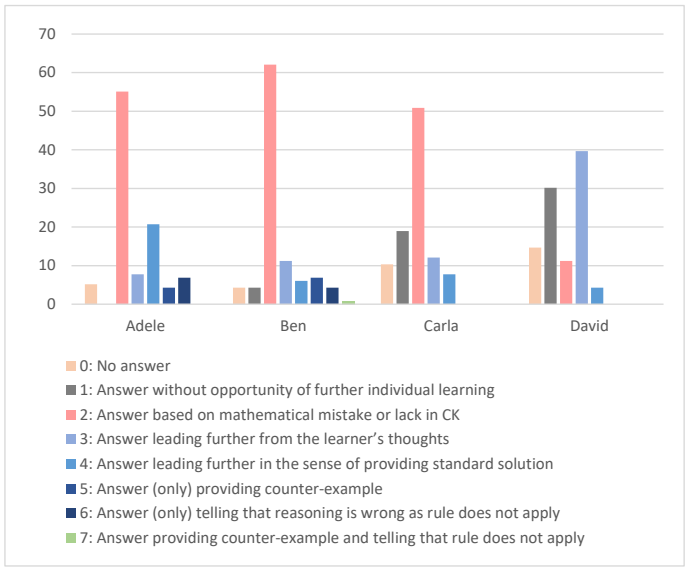

Figure 4: Relative frequencies for Code (B) (in per cent).

Research question (3) concentrates on forms of suggested learning support. In particular the results shown in Figure 5 indicate that the pre-service teachers mainly chose forms of presenting or providing information, even if incorrect.

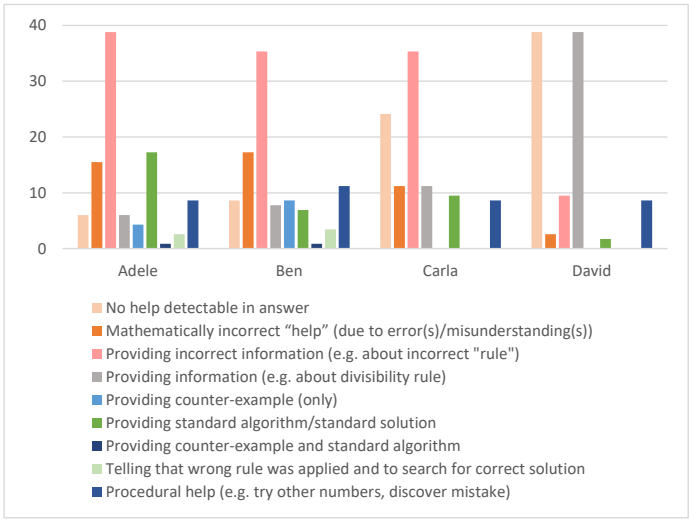

Figure 5: Relative code frequencies for the form of learning support provided (in per cent).

Only in around 10% of the cases, procedural help, emphasising a comparably more active role of the learner, was suggested. The large majority of answers falls into categories that reflect a conception of "help" that consists in providing information about rules, standard solutions, or feedback in the form of counter-examples.

DISCUSSION AND CONCLUSIONS

Even if the evidence should be interpreted with care, given that the sample is not representative for German pre-service teachers, the research questions could be

answered and provide insight into the participants' noticing and professional knowledge, especially as far as CK-related needs for professional development are concerned. More than half of the answers to the cartoon characters Adele, Ben and Carla were marked by CK deficits, so that the ability of providing learning support appears in need of improvement for many pre-service teachers.

As far as forms of learning support are concerned, the data shows a predominance of telling the learners about rules (including attempts with evidence of mathematical, i.e. CK deficits) or standard solutions and algorithms. This might be a consequence of the pre-service teachers still being in a learning process related to divisibility contents, possibly leading them to rather focus on evaluating the vignette persons' thinking and on newly learned rules and standard procedures. The evidence however also might reflect the pre-service teachers' conceptions of "helping learners" through the lens of their noticing: For many of them, "help" might rather consist in directly providing information or hints related to procedures than in stimulating the learner's thinking and activities in the direction of learner-centred experience and reasoning. This differs from conceptions of learning support in literature (e.g. Schnebel, 2013; cf. Krammer, 2009). In this sense, the results also point to needs in the development of pre-service teachers' instruction-related views (cf. Kuntze, 2012). Future further analysis also of additional data from Spanish and Czech pre-service teachers promises further insight here, also on a cross-cultural level.

As far as methodological approaches are concerned, the study highlights the potential of vignettes to elicit mathematics teachers' noticing: On a situation and content-specific level, pre-service teachers' analysis of learners' thinking and decision-making related to learning support can be made accessible to research and evaluation by teacher educators by asking the pre-service teachers to comment on vignettes. In line with the potential of vignette-based formats for pre- and in-service mathematics teacher professional development, the project coReflect@maths will further focus on corresponding research and development needs.

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