EXPLORING MATHEMATICS TEACHER NOTICING OF WHOLE-CLASS DISCUSSIONS ACROSS CAREER STAGES

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Research on teacher noticing highlights differences between novice and expert teachers, yet little is known about early career and intermediate expertise levels and how these expertise-related differences emerge in central teaching tasks and content areas. Facilitating whole-class discussions represents a central teaching task, such as when fostering flexible strategy use. This study examines expertise-related differences in mathematics teachers' noticing in observed video scenes of whole-class discussions on flexible strategy use in Grade 1 using Epistemic Network Analysis. The preliminary results show no substantial differences between intermediate and expert teachers but between beginning teachers and the other two expertise groups regarding their noticing focus and the cognitive structures underlying their noticing processes.

TEACHER NOTICING AS COMPONENT OF TEACHER COMPETENCE AND EXPERTISE

Across different conceptualisations of teacher professionalisation – summarised as expertise and competence paradigms – teacher noticing is ascribed a central role for high quality teaching. Conceptualisations referring to the competence paradigm frame teacher noticing as a competency comprising the facets of perception, interpretation, and decision-making, which mediates between teachers' knowledge and their instructional actions (Blömeke et al., 2015). Accordingly, teacher noticing describes how professional knowledge is enacted in concrete teaching tasks (Sherin, Jacobs, & Philipp, 2011). Studies demonstrate that higher noticing skills are associated with improved student learning outcomes and better student performance (Blömeke, 2022).

The expertise perspective of teacher noticing examines differences between teachers at various career stages, with the aim of providing insights for teacher education and professional development (Seidel et al., 2024). Drawing on expertise research (Berliner, 2001), expertise is understood as the ability to perform consistently at a high level in a specific domain based on well-organized, domain-specific knowledge, efficient information processing, and pattern recognition. Research on teacher noticing shows that novice and expert teachers differ in their noticing (e.g., Stahnke, 2024), attributing these differences to different mental representations that teachers build of observed classroom scenes as indicators for their disciplinary knowledge and complex, interconnected knowledge structures (Berliner, 2001; Seidel et al., 2024).While such noticing skills are less pronounced among novice teachers compared to experts (e. g.

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Stahnke, 2024), little is known about early career teachers' noticing and at what stages these noticing processes develop towards expert-level noticing.

Recent work (Kaiser et al., 2025) focuses on the common roots of both paradigms and integrates both by proposing a heuristic expertise including a competence-oriented perspective. Building on this idea, the present study addresses teacher noticing following the competence paradigm by understanding teacher noticing as teachers' perception of relevant aspects in the classroom, their interpretation of these aspects by drawing on their professional knowledge, and their decision-making in terms of alternative actions and strategies to respond to the observed situation (Blömeke et al., 2015). Drawing on the expertise paradigm, this study examines noticing processes among mathematics teachers of various levels of expertise to characterise differences in noticing (Seidel et al., 2024).

TEACHER MOVES IN FACILITATING WHOLE-CLASS DISCUSSIONS ON FLEXIBLE STRATEGY USE

In (early) mathematics education it is a major goal that students learn to solve arithmetical problems by applying various strategies insightfully, efficiently, and flexibly (e.g. Verschaffel, 2024). Flexible strategies are based on using number relations and known number facts to derive the solution, which implies the acquisition of strategies and their insightful and flexible use (Verschaffel, 2024). Studies emphasise that teachers need to draw the students' attention on relations between numbers and between strategies by posing cognitively activating questions to promote students' thinking and reflection (Rechtsteiner & Rathgeb-Schnierer, 2017), especially in whole-class discussions.

Generally, teachers shape students' access to the learning content by following criteria for high quality mathematics teaching (Prediger et al., 2022) and initiating and guiding whole-class discussions through questions and targeted discussion prompts, referred to as *teacher moves* (Webb et al., 2019). These teacher moves (e.g., *framing*, *orchestrating*, and *representing content*) enable teachers to orchestrate learning by coordinating, comparing, and relating different strategies within classroom discourse (Shaughnessy et al., 2021).

From a teacher noticing perspective and in the context of flexible strategy use, choosing a teacher move involves perceiving relevant aspects of students' different contributions about their strategy use, interpreting them on the basis of professional knowledge, and shaping the ongoing whole-class discussion in an adaptive way (e.g., by linking learners' different use of strategies through emphasising commonalities and differences). It can be assumed that teachers differ in terms of which aspects of facilitating whole-class discussions on flexible strategy use they perceive in a given teaching situation, how they interpret them, and what alternative moves they see. However, research on noticing regarding specific teaching tasks in a content-specific way is rare. Addressing this gap, the present study investigates teacher noticing

focusing the flexible strategy use in Grade 1 as well as the situational teaching task of facilitating whole-class discussions. To capture differences in teacher noticing, the study includes three groups of teachers with beginning, intermediate, and expert teachers and employs Epistemic Network Analysis (ENA) (Shaffer & Ruis, 2017) to examine the mental representations that teachers build of observed classroom scenes. Based on this, the following research questions are posed:

Research Question 1: How do beginning, intermediate, and expert teachers notice classroom scenes focussing on facilitating whole-class discussions on flexible strategy use in Grade 1, and which alternative moves do they propose?

Research Question 2: How do beginning, intermediate, and expert teachers differ in terms of their epistemic networks, representing the knowledge structures that underly their noticing of the classroom scenes?

RESEARCH DESIGN

Data collection and procedure

The sample of this study consists of ten beginning, intermediate, and expert primary school mathematics teachers (N = 30). Expert teachers are defined as mathematics teachers who have substantial professional experience (M_{exp} = 21.05; SD = 8.85; Ericsson, 2018) and additional responsibilities in mathematics education, e.g. as a facilitator. Intermediate teachers have substantial professional experience (M_{exp} = 17.29; SD = 7.13) in teaching without any further responsibilities. Beginning teachers had finished their teacher education program and were currently in the middle of induction phase (M_{exp} = 1.25 years, SD = 0.54). Three video excerpts from videotaped classroom scenes were used in an on-action design as stimuli and presented to the teachers in individual interviews. The video scenes depict plenary phases of reflection or introduction focusing flexible strategy use in Grade 1 in which 43 teacher moves occur (17 *framing*, 15 *teacher-led directing*, 7 *orchestrating*, 4 *content-focused steering the whole-class discussion*). *Framing* includes initiating and concluding discussions, preparing a supportive learning environment, managing the classroom, and securing students' contributions. *Teacher-led directing* includes (repeating) impulses and questions, commenting on students' statements, posing leading questions, and guiding the discussion step-by-step. *Orchestrating* the whole-class discussions includes encouraging students to react to and build on others' contributions (e.g., different strategies), linking and relating different ways of calculating arithmetical problems, and using prompts to elicit, deepen, and address learners reasoning and justifications about their strategy use. *Content-focused steering* highlights key elements for understanding and maintaining a focus in the learning objective (e.g., to discover different strategies and explain why they are suitable and effective for the specific task). In the questions following the viewing of the videos, all three noticing facets (perceiving, interpreting, decision-making) were addressed.

Data analysis

Data were analysed using qualitative content analysis following Kuckartz & Rädiker (2023) using MAXQDA 2024 (VERBI Software, 24.4.0). Teachers' statements were first coded with respect to perceived teacher moves into four areas: *framing, teacher-led directing, orchestrating*, and *content-focused steering the whole-class discussion* (adapted from Shaughnessy et al., 2021). Teachers' responses concerning their interpretations of the perceived teacher moves and their suggestions for alternative moves were coded using categories related to quality dimensions of teaching mathematics adapted from Prediger et al. (2022): *conceptual understanding, organisation, student focus and adaptivity, cognitive activation*. In addition, the analysis captured whether teachers' interpretations indicated that the observed discussion facilitation was evaluated as effective or ineffective with respect to the respective quality dimension and whether interpretations/decisions were general or specific related to the learning content of flexible strategy use in Grade 1.

To examine group differences in teachers' noticing and to represent them in networks, an ENA was conducted using the ENA Web Tool (Marquardt et al., 2018). In ENA, nodes located closer to the centre of the network share most variance, whereas nodes positioned further apart account for differences between the teacher groups. For each teacher, an individual network was modelled, representing how mental representations were constructed. Edges between nodes indicate the co-occurrences of codes (Shaffer & Ruis, 2017). Using a moving window size of three, the focus was on the co-occurrences of codes within a coded statement and the following two codes, to analyse how teachers built their mental models of the video scenes. For each of the teacher group, ENA is used to model mean networks characterising teacher noticing typical for the expertise group, which are then compared pairwise in a subtraction network. In these networks, nodes with more connections reveal group differences in influential codes, while thicker edges show influential connections in which the groups differ. For presentation purposes, quality dimensions were cumulated into broader categories (general vs. specific and effective vs. not effective interpretations and decisions).

PRELIMINARY FINDINGS

Currently, six cases were evaluated, with two from each teacher group (beginning, intermediate, expert). A total of 182 statements were coded across all cases and videos, with between 18 and 48 segments coded per case and between 4 and 17 segments coded per video and per case.

Beginning, intermediate, and expert teacher noticing

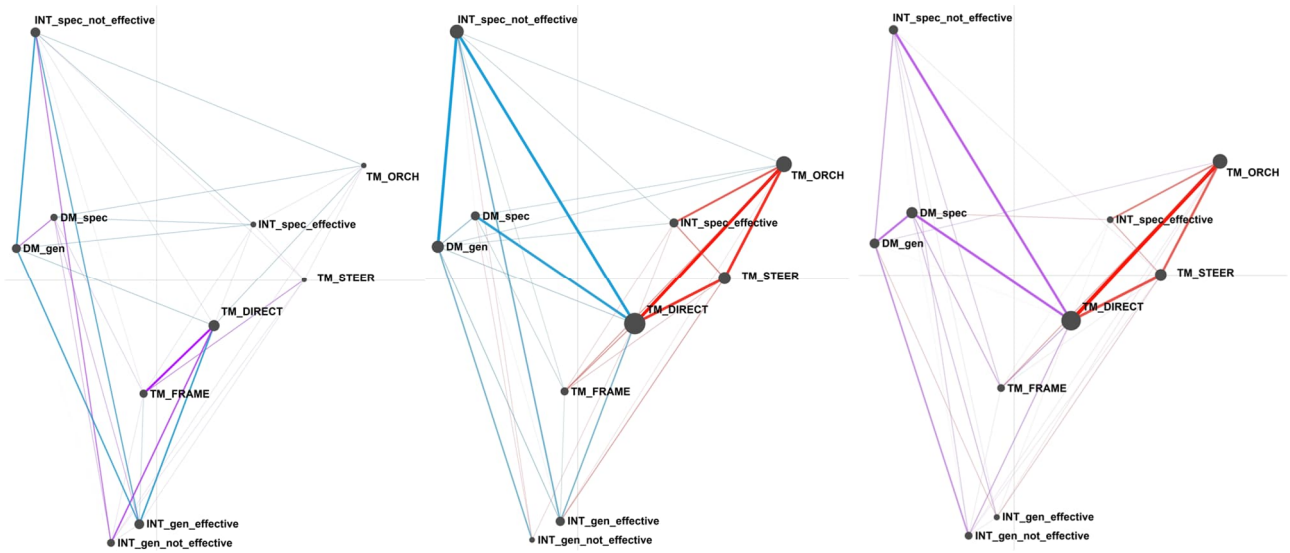
The *expert teachers* primarily focus on teacher-centred teacher moves (*teacher-led directing*), highlighting a step-by-step guiding from the teacher. They also perceive teacher moves about *framing* the discussion and show little to no perception of the teacher moves regarding *orchestrating* or *steering* the discussion. The experts interpret the perceived teacher moves mostly as ineffective in relation to the specific learning

content across all quality dimensions. They state many alternative teacher moves, primarily content-specific alternative moves, as for example: “In the task 8 + 2 + 2, the teacher could have pointed out more clearly where the first addend is and what happened to the second addend” (EXP_1: 134 – 135). *Intermediate teachers* also focus on teacher moves of *directing and framing*. They also interpret these as ineffective in relation to the learning content, however, they primarily mention general alternative moves (For example: “And again, some kind of language support, something the children can work with, because often they lack the words or sentences”, INT 4: 139-140). *Beginning teachers* perceive teacher moves in all four areas and describe teacher moves, where the teacher is facilitating the whole-class discussions through *content-focused steering* and *orchestrating* learners’ statements, in particular, asking in-depth questions about thought processes and encouraging exchange between learners. They interpret these teacher moves as effective regarding the specific learning content (For example: “Through the moderation and targeted questions, the children were able to arrive at the solution and structure and describe their solution process”, BEG 9, 99-100). Overall, the beginning teacher do not interpret as frequently as the other groups and mention few alternative teacher moves.

Differences in teacher noticing according to Epistemic Networks

The comparison between intermediate and expert teachers (Figure 1: left side) shows no differences regarding the position of the centroids of the mean networks. The thin lines indicate similar co-occurrences of codes. However, the experts have greater common co-occurrences of perceived teacher moves (*direct* and *frame*) and interpretations as not effective as well as of general and specific interpretation (stronger purple lines). Differences can be seen in the subtraction networks of the beginning and intermediate (Figure 1: in the middle) and of the beginning and expert teachers (Figure 1: right side). Both subtraction networks show differences in the centroids of the compared mean networks and the co-occurrence of codes. While the beginning teachers (red) show thick lines between all teacher moves (frequent co-occurrence of codes), the intermediate teachers (blue) show more frequent connections between the teacher move *direct*, the interpretation of these as ineffective in relation to the specific learning content and the mention of general alternative actions. The connection between the sub-facets of noticing is apparent within the intermediate and expert teachers. The beginning teachers do not yet show strong connections between the sub-facets in their cognitive structures. Above all, connections to deciding on alternative moves are less frequent than for intermediate and expert teacher.

Figure 1: Subtraction networks of intermediate (blue) and expert (purple) teachers on the left, of intermediate (blue) and beginning (red) teachers in the middle, and of beginning (red) and expert (purple) teachers on the right side. TM = perceived Teacher Move; INT = Interpretation; DM = Decision-making.



DISCUSSION AND CONCLUSION

The reported findings align with prior research demonstrating differences in teacher noticing between expert and novice (beginning) teachers (e.g. Stahnke, 2024) and support assumptions about the role of complex and interconnected knowledge structures in the development of teacher noticing processes (Seidel et al, 2024). Differences were found between beginning teachers and both intermediate and expert teachers, whereas no substantial differences emerged between intermediate and expert groups. This underlines the central role of teaching experience in the development of noticing expertise (Ericsson, 2018). Differences in the statements, coded as effective/ not effective and general/ specific, show that expert and intermediate teachers focus more strongly on the connection to the learning content, recognising how whole-class discussions on flexible strategy support conceptual understanding (specific) and interpreting interactions as rather superficial (not effective for learners' conceptual understanding). Beginning teachers, by contrast, interpret the same scenes (even if perceived as a teacher-led direction) as effective. Thus, expert and intermediate teachers attribute greater importance to facilitating whole-class discussions that focus on insightful and flexible strategy use (Verschaffel et al., 2024), with experts emphasising this clearly in their specific alternative moves. The network analyses reveal differences in how the facets of noticing are interconnected across career stages. While beginning teachers notice a wide range of teacher moves, they struggle to interpret these and to derive alternative moves. In contrast, intermediate and expert teachers show more interpreted noticing processes, linking perceived teacher moves to

interpretations and decisions. Interestingly, intermediate and expert teachers' noticing focus mainly on ineffective teacher moves in the scenes.

These results extend findings on expertise-related differences by situating them within concrete classroom situations and a specific learning content. However, the study is limited by the small number of cases per group and by cumulating the quality dimensions in the network models. Building on the present case analyses, all available cases will be analysed to systematically compare group networks and to further investigate how teacher noticing develops across stages of teaching expertise.

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