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# Noticing the relevance of subject matter in typical teacher tasks – a situated learning intervention for preservice teachers

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*Preservice mathematics teachers (PSTs) often struggle to make connections between the formal mathematics required in university teacher education and the school-level mathematical content they will later be teaching. This leads to negative beliefs about their professional education and often alienation from mathematics itself. Based on the hypothesis that prospective teachers underestimate the mathematical demands of their future profession, a situated learning intervention based on the Four Component Instructional Design (4C/ID) framework was designed. This paper describes the development of an 11-week intervention aimed at improving the PSTs' noticing of subject matter as well as their views on subject matter knowledge as a teacher resource. Selected results of the quasi-experimental study are briefly described.*

*Keywords: Preservice teacher education, situated learning, knowledge base for teaching, noticing, beliefs.*

## Introduction

Domain knowledge has been shown to be a prerequisite of expert performance (Glaser & Chi, 1998) and, accordingly, knowledge of mathematics is considered to be a foundational part of successful mathematics pedagogy (Ball, 1988). The positive effects of teacher knowledge on cognitive activation and student achievement have been shown empirically (Baumert & Kunter, 2011).

While there thus exists a broad consensus among researchers and teacher educators on the importance of subject matter knowledge, the actual levels of knowledge PSTs exhibit have often been discussed as a cause for concern (Harrell & Eddy, 2012). Teachers without a solid mathematical knowledge base tend to also exhibit negative views about their professional education, their own perceived competency, as well as about mathematics itself (Pieper-Seier, 2002; Hine, 2015).

Many PSTs experience mathematical content courses at university to be excessive in scope and quite unrelated to their future profession (Mischau & Blunck, 2006). One reason for this could be that prospective teachers misunderstand what will be required of them later on (Becher & Biehler, 2015). PSTs' initial views on the (non-)importance of subject matter knowledge may be further cemented if practical experiences as student teachers are not adequately mentored to point out mathematical considerations when making teaching decisions (Strong & Baron, 2004), thus highlighting connections to the student teachers' mathematical knowledge.

The intellectual trickle-down hypothesis (Wu, 2011) that PSTs will automatically be able to apply formal mathematics knowledge to teaching situations seems questionable. In fact, even well-chosen teaching methods for conveying academic mathematical knowledge may, in fact, hinder the transfer of such knowledge to other situations – a phenomenon known as the *transfer paradox* (van Merriënboer et al., 2017). These findings suggest that a more situated approach to teaching mathematical subject matter may improve PSTs' skills in applying their mathematical knowledge and influence their beliefs about the relevance of subject matter knowledge for the work of teaching.

This research project set out to systematically study the effects of a situated learning intervention using a quasi-experimental design. The main dependent variables of interest were the PSTs' beliefs regarding the relevance of content courses for their future profession, and their ability to consider mathematical aspects of teaching situations, conceptualized as *noticing of subject matter*, a specialized, content-focused facet of a teacher's professional vision (cf. Goodwin, 1994).

## **Theoretical framework**

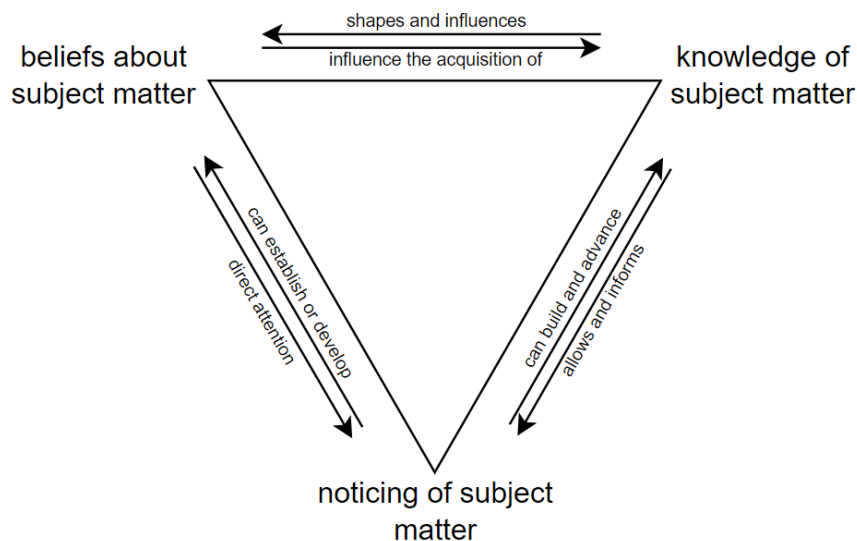
Within the subject-specific knowledge types, content knowledge (CK) is typically contrasted with pedagogical content knowledge (PCK; Shulman, 1986) – CK is understood to be domain knowledge which is not specific to teaching and simultaneously the basis upon which PCK, knowledge about how learners may best attain domain knowledge, is built. (The terms content knowledge and *subject matter knowledge* are used interchangeably in this paper.)

For the purpose of this study, beliefs are conceptualised according to Philipp (2007) as “psychologically held understandings, premises, or propositions about the world that are thought to be true” (p. 259). Beliefs, especially those formed early in life (as beliefs about teaching and learning typically are), tend to be fairly robust to change, and due to their implicit nature, can only be studied indirectly, suggesting methodological triangulation (Pajares, 1992). PSTs' beliefs regarding mathematics courses in tertiary education have been specifically studied by Isaev and Eichler (2017), whose questionnaire was also employed to assess the participants' *beliefs about subject matter* in the study at hand.

If PSTs deem much of the mathematics studied at university unrelated to their future tasks as teachers, and teacher educators arrive at a different judgment, this may be a sign that the same teaching tasks are perceived differently by novices and experts. *Teacher noticing* has been prominent in mathematics education research in the past years (Sherin et al., 2010). For this study, *subject matter noticing* – the noticing of mathematical aspects in teaching tasks – was conceptualised as a three-part skill (cf. Jacobs et al., 2010), comprising perceiving specifically mathematical features of a task, interpreting those mathematical features within the context of the task, and deciding how to act (considering those features) when fulfilling the task.

Expertise studies (Glaser & Chi, 1998) have not only shown the close connection between domain knowledge and expert performance, but also between expert performance and particular ways of perceiving situations. Furthermore, our perception of events may be influenced by the beliefs we hold, which in turn are often based on (our perceptions of) past experiences (Pajares, 1992). Thus, the triad of subject matter knowledge, beliefs about subject matter knowledge, and the noticing of subject matter knowledge can be thought of as a set of interdependencies as portrayed in Figure 1 on the following page.

These reciprocal dependencies make the assumption plausible that improvement in either one of these corners will be difficult to achieve as long as the others remain unchanged. It is for this theoretical reason as well (aside from the fact that situated learning environments may allow for a resolution of the transfer paradox) that a holistic intervention strategy was chosen, interleaving the revision, reflection and application of existing domain knowledge when attending to teacher tasks.



**Figure 1: Dependencies between noticing, beliefs and knowledge, figure by author**

## Research questions

(Note: The methods section of the paper will provide a detailed description of the intervention.) The main research questions of the study were:

- Which effect does the situated intervention have on the PSTs' beliefs and noticing skills?
- Which connection – if any – exists between changes in PSTs' beliefs and changes in their noticing skills as a result of the situated intervention?
- How do the effects of the situated intervention compare to the effects of gaining practical experience (of similar scope) as mentored student teachers?

## Methods

In order to investigate the questions stated above, a quasi-experimental design was chosen, collecting data over the course of an entire academic year (2021/22). In both semesters, the 11-week intervention was implemented as a “seminar in mathematics education” that was attended by students in the secondary teacher accreditation programme. At the beginning and at the end of each semester, a questionnaire was administered to the participants ( $n = 46$ , total across both semesters). This questionnaire was also filled out at both timepoints by students of a control group ( $n = 29$ , total) taking the accompanying class to the mandatory “teaching practice” for Master’s students.

The questionnaire consisted of four text vignettes to evaluate the participants’ noticing of subject matter, Isaev and Eichler’s (2017) questionnaire concerning beliefs regarding subject matter (18 Likert scale items; as an example: “I will use university mathematics in many situations after finishing my university studies”), eight single choice subject matter questions relating to the content of the noticing vignettes, as well as some items to collect demographic and educational information. The noticing, beliefs and knowledge sections of the questionnaire were identical at the pre-test and post-test. Each of the four text vignettes of the noticing part of the questionnaire was accompanied by two open questions, the first of which asked the participants to list all of the mathematical content they deemed relevant to the situation portrayed in the vignette (“Which contents of mathematical knowledge are addressed in this item?”), while the second invited the participants to imagine and describe a specific teaching action in response to the situation (“Imagine you are the teacher and you

would like to address the issues raised by the students during this group activity. Please write down a response as you would give it to your students and provide an explanation for your choice.”) The initially qualitative data from the participants’ open responses was coded and quantified based on coding guidelines based on expert ratings ( $N = 6$ ). Participants’ responses scored between 0 and 5 points per item, depending on how much their perception of content knowledge aligned with that of the expert consensus. A pilot study was conducted with a group of 14 PSTs in 2020, after which the coding guidelines were improved upon.

After gathering the data, mixed ANOVAs were carried out. In order to make the results more robust (due to small simple size not all statistical prerequisites were fulfilled for each subgroup), the non-parametric Mann-Whitney U test and the Wilcoxon signed rank test were additionally calculated.

### **Description of intervention design and development of materials**

The intervention was designed following the guidelines of the situated Four Component Instructional Design (4C/ID) framework as laid out by Merriënboer and Kirschner (2017). The four design components of 4C/ID are *learning tasks*, *supportive information*, *procedural information*, and *part-task practice*, the latter being an optional component for recurrent task aspects in which a high level of automaticity is necessary. Since active reflection on possibly unexpected mathematical aspects of teaching stood at the centre of the intervention to be designed, any highly automatised mathematical aspects of teaching (e.g. routinely scanning solutions or students’ statements for errors in arithmetic or basic algebra) were set aside. The design process therefore focused on providing and interleaving the first three components.

The core of the framework are learning tasks designed to authentically reflect real-life tasks of, in our case, mathematics teachers. The real-life tasks of teachers can be conceptualised as a profile of requirements that educators are expected to meet (Prediger et al., 2022). Various real-life tasks of mathematics teachers were initially considered as a basis for the learning tasks. In order to recreate the typical situations a mathematics teacher may find themselves in as realistically as possible, three tasks were chosen:

- choosing, adapting and utilising exercises
- providing explanations and giving illustrative examples
- evaluating student solutions and giving feedback

These tasks all fall under the category of “lesson preparation”/“follow-up work” that is often undertaken outside the classroom, in the teacher’s office or home – conditions which could be more easily mimicked within the university building.

In line with the principle of scaffolding, within each of the three task-based thematic sections, four levels of independence were distinguished:

- oral worked-example, incomplete solutions (modelling by expert)
- well-structured group tasks, completed in class (independence level 1)
- well-structured group tasks, completed at home (independence level 2)
- relatively open individual tasks (independence level 3)

In order to limit the scope of subject matter, the seminar was chosen to focus on topics in analysis. Four main concepts within the field of analysis – all of which are central to Austrian school curricula

– were identified: function, limit, derivative and integral. Each section, centered on one real-life task of teachers, was designed to contain a variety of learning tasks exploring each of these mathematical concepts.

Figure 2 shows an example of a text vignette from section two (providing explanations) at independence level 2. It illustrates some design principles that were employed in the creation of learning tasks.

Two of your students are having a discussion they can't resolve and ask you for help:

A: "My tutor explained that integration is the opposite of differentiation, like minus is the opposite of plus, and division of multiplication."

B: "Yes, but if you count 5 *plus* 1, and then *minus* 1, you're back at 5. But if I, look: differentiate  $x^2$ , we get  $2x$ , but when I integrate  $2x$ , that's  $x^2 + c$ , is what we wrote down."

A: "Yes, sure, but that basically doesn't *matter*, that  $c$ . You can tell it's basically the same.  $x^2$  becomes  $2x$ , becomes  $x^2$ ."

B: "... plus  $c$ . We're supposed to also write down  $+c$ ."

A: "Yes, but it's still the reversal of differentiation, if it's the same except for that ' $+c$ '."

B: "I don't get it. Why are we supposed to write  $+c$  at all, then, if it doesn't matter anyway..."

You'd like to provide a clarifying answer. Work through the following prompts:

1. Which basic ideas and aspects of mathematical concepts is this discussion primarily about? Describe them specifically with regard to this exchange.
  - 2a. What was your first intuition when reading this dialogue? In which ways are student A and student B each "right", which of their statements are problematic?
  - 2b. Consult your own study materials (textbooks, scripts, notes) in order to precisely clarify the question: *Are integration and differentiation inverse operations?* In which ways do you have to modify or expand your initial assessment?
3. Write down a response to the two students that clarifies the question at the students' mathematical level. (Feel free to include sketches or examples you would give for illustration purposes.)
4. Why might the transfer of the concept "inverse operation" known from arithmetic operations like addition and multiplication into this new domain be difficult? (Tip: Think about the kinds of "input" arithmetic operations work with and the kind of "output" they generate. What's the case when you consider the operations of integration and differentiation?)

**Figure 2: learning task used in the intervention (translated by the author from German; slightly abridged)**

relevant mathematical concepts and make an initial evaluation of the observed student utterances.

In question 2b, subject matter knowledge as presented at university is explicitly suggested as a resource to verify the PSTs' first assessment of the mathematical situation. The prompt is phrased in a value-neutral way – students should look to academic mathematics as a helpful tool to answer subtle questions, instead of an authority determining whether they did "badly" or "well" as a student/teacher.

Question 3 then asks the PSTs to perform a typical teacher task based on these mathematical considerations. In this item, an extra prompt is then given to take the content analysis even further and consider the subject matter of inverse operations from a mathematical perspective that can shed light on another typical teaching task (anticipating children's difficulties).

## Results

A significant interaction effect between the factors **group** (intervention IG, control CG) and **time** (pre-test  $t_1$ , post-test  $t_2$ ) was found for “noticing of subject matter”,  $F(1,73) = 14.468$ ,  $p < .01$ ,  $\eta_p^2 = .165$ . Posthoc pairwise comparisons show that this is accounted for by the IG’s higher noticing scores at  $t_2$  compared to the CG’s noticing scores at  $t_2$ . Neither **group** nor **time** alone showed significant effects on this variable. No significant changes occurred to the PSTs’ beliefs about subject matter knowledge.

The results of the non-parametric tests are in line with the positive results yielded by the mixed ANOVA in the case of subject matter noticing. According to the Mann-Whitney U test, the noticing scores of the IG at  $t_2$  are significantly ( $p < .01$ ) higher than the noticing scores of the CG at  $t_2$ . The Wilcoxon signed rank test shows that the noticing scores of IG participants were significantly ( $p < .01$ ) higher at  $t_2$  than they were at  $t_1$ .

## Discussion

The findings suggest that the situated intervention was helpful in allowing preservice teachers to advance their sensitivity to subject matter aspects of everyday teacher tasks. The results are in line with earlier research showing that noticing as a skill can be trained (Jong et al., 2021), however, this had not yet been shown for the *noticing of subject matter*. Despite this, the participants’ beliefs about the relevance of mathematics as experienced at university seem to have remained stable – a somewhat disappointing result, which is, at the same time, not too surprising as beliefs are conceptualised as rather stable and have been found to be difficult to change (Philipp, 2007; Pajares, 1992).

Several explanations for a lack of significant change in this variable are possible: The PSTs’ beliefs may have become too ingrained at the time these (almost exclusively Master’s) students participated in the intervention. It is also possible that small to moderate effects do exist but could not be detected with the comparatively low number of participants in each group (power analysis shows that only effects with effect sizes of at least  $f(U) = 0.33$  would have yielded significant results).

Based on the overwhelmingly positive feedback received by the researcher both verbally as well as in the reflection pieces the participants were asked to submit at the end of the course – in which many PSTs claimed to have found the seminar very helpful in illustrating practical uses of university level content knowledge during teaching – the null result is still surprising. One explanation (and critique of the validity of the methods of data collection) could be that the beliefs questionnaire used in the study did not assess the type of beliefs relevant to the research questions as they had been intended.

Many of the Likert scale items in the questionnaire are worded in a way that may have prompted the PSTs to rate how relevant to their future profession they considered *the subject matter courses they had received at university* to be. (As a researcher, I had been more interested in their opinion on the *kind of advanced mathematics* studied at university and whether they considered being proficient in such mathematics to be important as a teacher, rather than an evaluation of the usefulness of the specific classes they had attended.) The participants’ responses often stressed that this situated type of learning was much more useful to them than the more traditional subject matter courses they had received earlier in their studies. As such, even if their beliefs toward the applicability of subject matter knowledge itself *had* changed for the better, they may still have felt the same way toward “university

mathematics” as it had been presented to them – or felt even worse about it. As one participant put it: “If anything, this seminar made me even more angry at the curriculum”.

Thus, future research needs to pay attention to the instruments of data collection and use methodological triangulation in order to improve the validity and relevance of its results. Furthermore, because of the non-randomised design, selection effects of the PSTs who chose to participate in such a seminar cannot be disregarded. It would also be advisable to investigate whether a general sensitivity for noticing subject matter was gained that can then be transferred to other domains, as the noticing questionnaire shared the invention’s focus on topics in real analysis.

## References

- Ball, D. L. (1988). Unlearning to teach mathematics. *For the Learning of Mathematics*, 8(1), 40–48. <https://www.jstor.org/stable/40248141>
- Baumert, J., & Kunter, M. (2011). Das mathematikspezifische Wissen von Lehrkräften, kognitive Aktivierung im Unterricht und Lernfortschritte von Schülerinnen und Schülern [Teachers’ mathematics-specific knowledge, cognitive activation and student progress]. In M. Kunter, J. Baumert, W. Blum, U. Klusman, S. Krauss, & M. Neubrand (Eds.), *Professionelle Kompetenz von Lehrkräften. Ergebnisse des Forschungsprogramms COACTIV* (pp. 163–192). Waxmann.
- Becher, S., & Biehler, R. (2015). Welche Kriterien legen Lehramtsstudierende (Gym) bei der Bewertung fachmathematischer Veranstaltungen zu Grunde? [Which criteria do (secondary) preservice teachers employ when evaluating content courses?] In F. Caluori, H. Linneweber-Lammerskitten, & Chr. Streit (Eds.), *Beiträge zum Mathematikunterricht 2015* [Contributions to maths teaching 2015] (pp. 116–119). WTM.
- Glaser, R., & Chi, M. T. H. (1998). Overview. In M. T. H. Chi, R. Glaser, & M. J. Farr (Eds.), *The Nature of Expertise*. Psychology Press. <https://doi.org/10.4324/9781315799681>
- Goodwin, C. (1994). Professional Vision. *American Anthropologist*, 96(3), 606–633. <https://doi.org/10.1525/aa.1994.96.3.02a00100>
- Harrell, P. E., & Eddy, C. M. (2012). Examining mathematics teacher content knowledge: Policy and practice. *Policy Futures in Education*, 10(1), 103–116. <https://doi.org/10.2304/pfie.2012.10.1.103>
- Hine, G. (2015). Self-perceptions of pre-service mathematics teachers completing a Graduate Diploma of Secondary Education. *Issues in Educational Research*, 25(4), 480–500.
- Isaev, V., & Eichler, A. (2017). Measuring beliefs concerning the double discontinuity in secondary teacher education. In T. Dooley & G. Gueudet (Eds.), *Proceedings of the Ninth Congress of the European Society for Research in Mathematics Education (CERME10)* (pp. 2916–2923). DCU Institute of Education and ERME.
- Jacobs, V. R., Lamb, L. L. C., & Philipp, R. A. (2010). Professional noticing of children’s mathematical thinking. *Journal for Research in Mathematics Education*, 41(2), 169–202. <https://www.jstor.org/stable/20720130>
- Jong, C., Schack, E. O., Fisher, M. H., Thomas, J., & Dueber, D. (2021). What role does professional noticing play? Examining connections with affect and mathematical knowledge for teaching



- among preservice teachers. *ZDM – Mathematics Education*, 53(1), 151–164. <https://doi.org/10.1007/s11858-020-01210-5>
- Merriënboer, J. J. G. van, & Kirschner, P. A. (2017). *Ten steps to complex learning: A systematic approach to four-component instructional design*. Routledge.
- Mischau, A., & Blunck, A. (2006). Mathematikstudierende, ihr Studium und ihr Fach: Einfluss von Studiengang und Geschlecht [Mathematics students, their studies and their subject. Effects of study programme and gender]. *Mitteilungen der Deutschen Mathematiker-Vereinigung*, 14(1), 46–52. <https://doi.org/10.1515/dmvm-2006-0022>
- Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research*, 62(3), 307–332. <https://doi.org/10.3102/00346543062003307>
- Philipp, R. A. (2007). Mathematics teachers' beliefs and affect. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning: a project of the National Council of Teachers of Mathematics* (pp. 257–315). National Council of Teachers of Mathematics.
- Pieper-Seier, I. (2002). Lehramtsstudierende und ihr Verhältnis zur Mathematik [Preservice teachers and their attitudes towards mathematics]. In W. Peschek (Ed.), *Beiträge zum Mathematikunterricht 2002* [Contributions to maths teaching 2002] (pp. 395–398). Franzbecker.
- Prediger, S., Roesken-Winter, B., Stahnke, R., & Pöhler, B. (2022). Conceptualizing content-related PD facilitator expertise. *Journal of Mathematics Teacher Education*, 25(4), 403–428. <https://doi.org/10.1007/s10857-021-09497-1>
- Sherin, M., Jacobs, V., & Philipp, R. (Eds.) (2010). *Mathematics teacher noticing: Seeing through teachers' eyes*. Routledge. <https://doi.org/10.4324/9780203832714>
- Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4–14. <https://doi.org/10.3102/0013189X015002004>
- Strong, M., & Baron, W. (2004). An analysis of mentoring conversations with beginning teachers: suggestions and responses. *Teaching and Teacher Education*, 20(1), 47–57. <https://doi.org/10.1016/j.tate.2003.09.005>
- Wu, H. (2011). The mis-education of mathematics teachers. *Notices of the AMS*, 58(3), 372–384.