

Design Research with a focus on content-specific professionalization processes: The case of noticing students' potentials

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Abstract. *This mainly methodological paper presents a specific approach of design research, called 'Design Research for teachers with a content-specific focus on professionalization processes'. Its three main characteristics are: (1) 'for many' rather than 'with some' teachers, (2) content-specificity, and (3) focus on teachers' processes. The approach and some typical outcomes are exemplified by the case of a project which fosters secondary teachers to notice students' mathematical potentials. The case is discussed with respect to general issues.*

Keywords. *Design Research for Teachers' Professional Development, Qualitative Research on Professionalization Processes, Noticing, Mathematical Potentials.*

1. ADOPTING DESIGN RESEARCH FOR TEACHERS

1.1 Design research as established research methodology with big variety

Design Research is a widely established research methodology for enhancing and investigating students' learning. It is especially strong when two aims are to be combined: (1) designing learning arrangements for classrooms and (2) investigating the initiated learning processes and contributing to local instruction theories (Bakker & van Eerde, 2015). Although design research approaches share common characteristics (e.g., interventionist, theory generative, iterative, ecologically valid, and practice-oriented, cf. Cobb et al., 2003), a big variety of approaches exists (cf. the 52 case studies documented in Plomp & Nieveen, 2013). These approaches differ in their reasons for doing design research, their types of results, their intended roles of the results for educational innovation, their scales, and their background theories (cf. Prediger, Gravemeijer, & Confrey, 2015a). Our Dortmund research group follows a topic-specific approach which allows to account for different mathematical topics in detail (Prediger & Zwetschler, 2013) with a focus on learning processes (ibid.; Prediger et al., 2015a). This approach is now adapted to designing and researching environments for teachers' professional development.

1.2 Adopting design research *for many* teachers, not only *with some*

Zawojewski et al. (2008) suggested extending the research methodology of Design Research from students to teachers' professional development (PD) "in order to understand both, how teachers develop in their practice and how to design environments and situations to encourage the development of that practice" (Zawojewski et al., 2008, p. 220). Meanwhile, many teacher educators have described impressing individual professionalization effects of *design research with teachers*, for the exclusive minority

of teachers privileged to be part of design research teams (Smit & van Eerde, 2011; Bannan-Ritland, 2008). Although this is without doubt the most intensive PD setting, it is not realizable for scaling up, since many teachers have no access to intensive collaboration with researchers. However, scaling up for reaching many teachers throughout whole Germany is the critical long-term goal for the first and third authors' work in the DZLM, the German National Center for Mathematics Teacher Education (Rösken-Winter, Hoyles & Blömeke, 2015).

Thus, this article suggests complementing the approach of design research *with some* teachers by *design research for many teachers*, taking into account that professional development for scaling up requires well-founded, robust designs for classrooms and PD courses (Burkhardt, 2006; Swan, 2007). Whereas the individual PD work of *researchers* with a selected group of teachers can be based on spontaneous, intuitive decisions in deep discussions, a robust design for PD conducted by *other facilitators* also needs to be grounded on a solid theoretical base, to anticipate possible challenges of the content to be learnt and typical professionalization processes. This calls for the next two characteristics, content-specificity and process-focus.

1.3 Content-specificity and focus on teachers' professionalization processes

So far, the growing body of research on conditions and effects of PD is mainly focused on *pedagogical principles* for PD programs (e.g., Timberley et al., 2007). But for robust designs for scaling up, also a good theoretical base for the *content* of the PD course itself is relevant, which cannot be taken for granted (Prediger, Quasthoff, Vogler, & Heller, 2015b). Specifying what teachers should learn in which perspective about a certain content (e.g. a mathematical topic or noticing students' difficulties) usually refers to the current state of research on classroom practices or teachers' professional knowledge for this content. This reference can be substantiated by also taking into account typical teachers' perspectives, which can be reconstructed when qualitatively investigating content-specific professionalization processes.

In their research survey on PD research, Goldsmith et al. (2014) emphasize the need to focus on teachers' professionalization *processes* rather than only on quantitatively measurable effects. Even if they have not found much research on processes yet, they collect indications that teacher learning "is often incremental, nonlinear, and iterative, proceeding through repeated cycles of inquiry" (ibid, p. 20). As the research gap is even bigger for *content-specific* research results, it is a major aim of the approach presented here to provide fine-grained insights into teachers' processes of professionalization on different specific PD contents. For this aim, the most appropriate approach is the adaptation of topic-specific design research with a focus on learning processes (elaborated for classrooms in Prediger & Zwetschler, 2013; Prediger et al. 2015a). Adapted to the level of teachers, we call it *Design Research for teachers with a focus on content-specific professionalization processes*.

1.4 Four intertwined working areas for PD Design Research

Figure 1 shows the four working areas that are *iteratively* connected in the design and research process, adapted from Prediger and Zwetschler (2013) for PD design research. The four working areas comprise (a) specifying and structuring PD goals and contents in hypothetical intended professionalization trajectories, (b) developing the specific PD design, (c) conducting and analyzing design experiments in PD settings, and (4) developing contributions to local theories on professionalization processes.

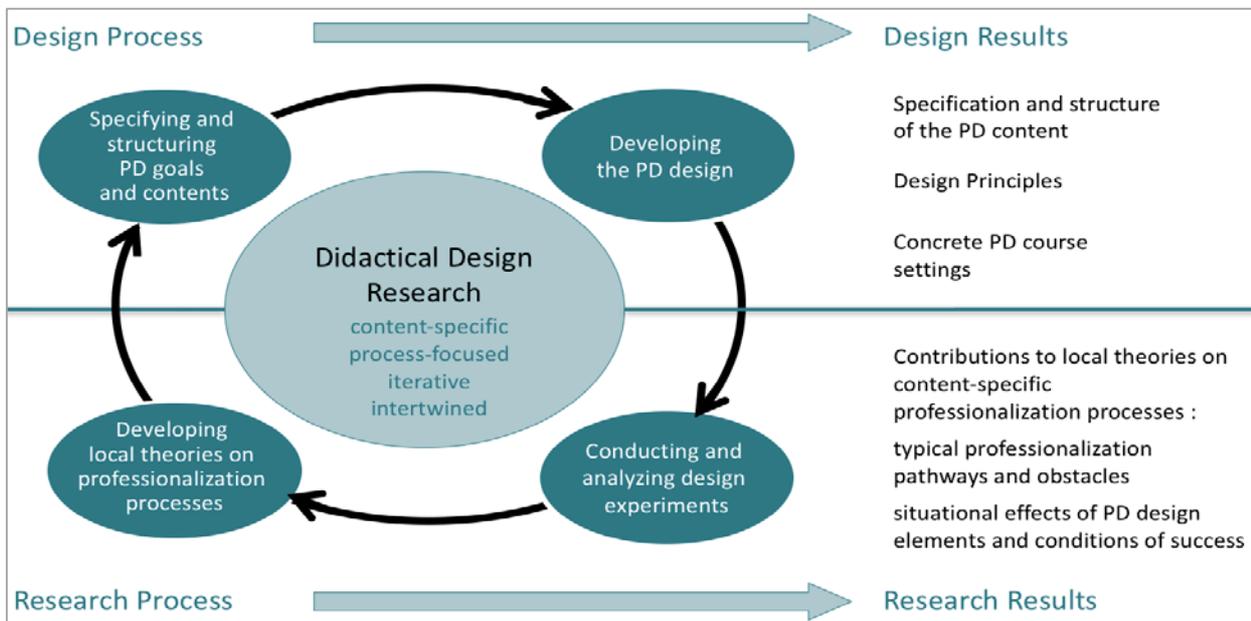


Fig. 1: Working areas and results of Design Research for teachers with a content-specific focus on professionalization processes

The areas are *intertwined* in the sense that each cycle builds upon results of previous cycles across the areas. Corresponding to the two general aims of Design Research, design results and research results have equal importance: The design results comprise the PD course settings as well as their backgrounds, a specified and structured PD content and refined design principles. The local theories are developed to underpin the concrete products and to be generalized by accumulation over several projects. Contributions to local theories on content-specific professionalization processes can be expected with respect to typical individual pathways and obstacles, means for support in the PD setting as well as their effects and contextual conditions of success.

2. THE CASE OF DOMATH, A PD DESIGN RESEARCH PROJECT ON NOTICING STUDENTS' POTENTIALS

For illustrating the approach, we briefly give some insights into the dual design research project DoMath (working on student and teacher level, here focused to the teacher level). The project addresses secondary school mathematics teachers who intend to develop their competences for noticing and fostering students' mathematical potential. Due to space limitations, we focus mainly on noticing rather than fostering.

2.1 Goals, structure, and background of the DoMath PD program

Goals and structure. The DoMath program for classrooms adopts a wide, dynamic and participatory conceptualization of mathematical potentials (Schnell & Prediger, 2016, following Leikin, 2009), addressing specifically those (often underprivileged) students not yet identified as talented. The classroom instructional design therefore builds upon whole class enrichment settings with rich, self-differentiating open-ended problems (ibid.). Teachers become sensitized to notice students' potentials in the rich situations and to adaptively foster the noticed potentials by facilitating supportive interaction.

PD programs in DoMath span over several months in action and reflection settings of material-based video clubs (Sherin & van Es, 2009). In the PD sessions, teachers reflect on classroom video-clips and student products stemming from their teaching experiments with the jointly prepared whole class enrichment settings (Rösike & Schnell, in press). The preparation includes their own mathematical inquiries as well as anticipating students' ideas. The typical structure of the PD program is visualized in Figure 2.

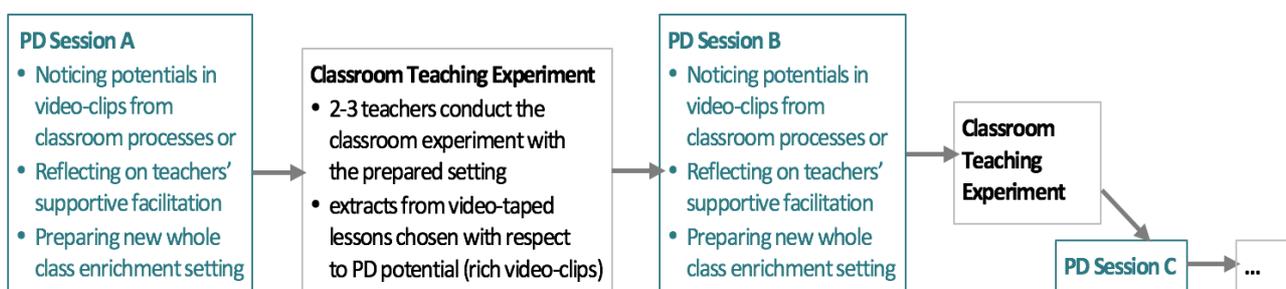


Fig. 2: Structure of the PD program with sessions and intermediate classroom experiments

Background. The general PD content *noticing* has been characterized in several research studies: They emphasize the need for teachers to overcome deficit-oriented modes on students and the necessary shift from product- to process-oriented perspectives (Empson & Jacobs, 2008). By the construct of professional vision, Sherin and van Es (2009) conceptualize noticing by three subconstructs, (I) selective attention, (II) knowledge-based reasoning underlying the actions and (III) interpreting specific events in terms of broader pedagogical principles.

In the specific case of noticing students' mathematical potentials with a dynamic and participatory conceptualization of potential, all three subconstructs are important. For uncovering hidden potentials, the process perspective in a non-deficit-oriented mode is hypothesized to be an important precursor for extending the selective attention and widening the repertoire of possible actions (cf. Fig. 3 for the intended professionalization trajectory which corresponds to a hypothetical learning trajectory in other design research approaches, cf. Prediger et al., 2015a).

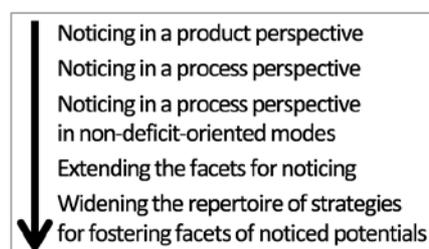


Fig. 3: Intended professionalization trajectory

2.2 Project design in three iterative cycles with mini cycles

Overall project design. The DoMath PD program is developed and investigated in an ongoing PD design research project in the described approach (cf. Section 1) from 2014 to 2018. Three iterative cycles of design experiment series are conducted in 2014/15 (with 5 teachers in 6 PD sessions over 12 months), 2015/16 (with 20 teachers in 6 PD sessions over 10 months) and 2016/17 (planned with 20 teachers in 2-3 longer PD sessions over 6 months). Between the PD sessions of one design experiment cycle, mini cycles of investigating processes allow immediate refinement of the program. During the mini-cycles of the first two cycles, the relatively vague intended trajectory matured into a more detailed specification of a model for noticing students' potentials (Schnell & Prediger, 2016). Later, this refinement of the underlying content-specific theory will allow pursuing the long-term aim to develop a PD course for scaling up with facilitators within the DZLM.

Methods for data gathering. Most classroom teaching experiments and all PD sessions are videotaped, as well as some individual video sessions between the third author and 1-3 teachers each. The individual video sessions complement the data from group discussions during PD sessions as they allow deeper insights into the individual professional visions.

Methods for data analysis. Based on the sensitizing subconstructs of professional vision (I – III) and theoretically derived facets for identifying potentials (in Fig. 3), the interpretative methods for analyzing transcripts from the video data aimed at developing a category system (1) for specifying demands and challenges in teachers' noticing and (2) for reconstructing individual pathways in professionalizing the noticing. The excerpts presented here stem from the ongoing analysis of professionalization contents and pathways of design experiment cycle 2 and are based on 33 hours of video material (13 h PD sessions, 16 h of their classroom interactions, 4 h individual discussions of video).

2.3 Exemplary insights into teacher's diagnostic perspectives

Effect of the design element Video. As described by others (e.g. Sherin & van Es; 2009; Empson & Jacobs, 2008), analyzing videos in the PD sessions turned out to be a design element which successfully initiates the shift from product perspectives (focusing only on the outcome of student work) to process perspectives (focusing on the richness of processes even if the outcomes stay incomplete, cf. Fig. 3). The shift also seems to be stable in the teachers' classrooms.

Effect of the design element Focus Question. As the teachers of the first mini cycles kept deficit-oriented modes for a long time, we revised the program starting by analyzing videos with a focus question "What kind of potentials can you discover in the processes of the students?". The effect of the focus question was substantial in the second cycle: from the first PD session on, the second teacher group adopted a process perspective in mainly non-deficit modes.

Accounting for obstacles and teachers' perspectives. However, the process perspective did not automatically lead to focusing hidden potentials and searching for strategies to foster them. Instead of thinking about strategies to foster uncovered seeds of situational potential, the teachers showed and discussed mainly strategies to help students to solve the open-ended problems. In consequence, the noticing mainly focused on students' processes of coping with the task (or why they could not cope well). This can be illustrated by the following excerpts of data:

After watching a video clip of two female students working on an open task about several derivatives (grade 12), Sonja, one of the video-watching teachers in the third PD session, says

Sonja Where they have problems is with verbalizing what they found out – especially mathematically correct verbalizing. So, I think they did understand the principle, but [... not the relevant pattern behind it].
And well, you have to justify or formulate it in a more differentiated way.

(Cycle 2, PD Session 3, Clip 'Derivatives', transcript line 78, min. 16:48)

Within her analysis of the video-clip, Sonja points out what the girls would have needed to accomplish the problem. She emphasizes what they reached and the discursive obstacles they need to overcome. Sonja's perspective is an instance of what we researchers later decided to call the *process-coping perspective* (see below): Although already overcoming purely deficit-oriented modes and focusing on processes, Sonja does not yet focus on potentials. As our teachers often adopt this perspective, we needed to include it into the model and consider it as rational choice, since it is teachers' responsibility to support the students in coping with the task (or their acquisition of competences or knowledge). Hence, it is also a direct successor of the product perspective.

The process-coping-perspective often coexists with the *potential indicator perspective* which we have reconstructed when the teacher implicitly poses her- or himself questions like "Which situational indicators for students' potentials can we identify?". For example, the teacher Stephanie analyzed a video clip of four students (grade 8) working on a problem-solving task

Steph That is really a good way of abstraction. They generalize very well at this point. Also, how they stay at it. They know now, they have the odd numbers and now they think about how to adjust the stairs [of numbers]. [...] Thus, they communicate well with one another and then generalize really well. There is a lot of potential.

(Cycle 2, Individual discussion of video clip 'Stair problem', transcript line 45, min. 18:42)

Stephanie also reconstructs steps in the coping perspective, but beyond that, she identifies students' way of abstraction as an indicator for their mathematical potential. At the same time, the way she and some colleagues talk about the students signals that she conceives potential here as students' stable disposition rather than a dynamically emerging and disappearing moment in the situation which requires teacher's efforts to be stabilized.

It was a longer discussion in the research team to reconstruct the backgrounds for these observed obstacles. After having re-analyzed also other transcripts, we realized the need to differentiate the process perspective which is still too vague in the hypothesized learning trajectory (Fig. 3). The result of several reconstructions and discussions was a refined perspective model (Fig. 4) which allows to take into account the teachers' perspective and to structuring of the PD content which was not adequately grasped by the earlier learning trajectory in Fig. 3 (cf. Schnell & Prediger, 2016).

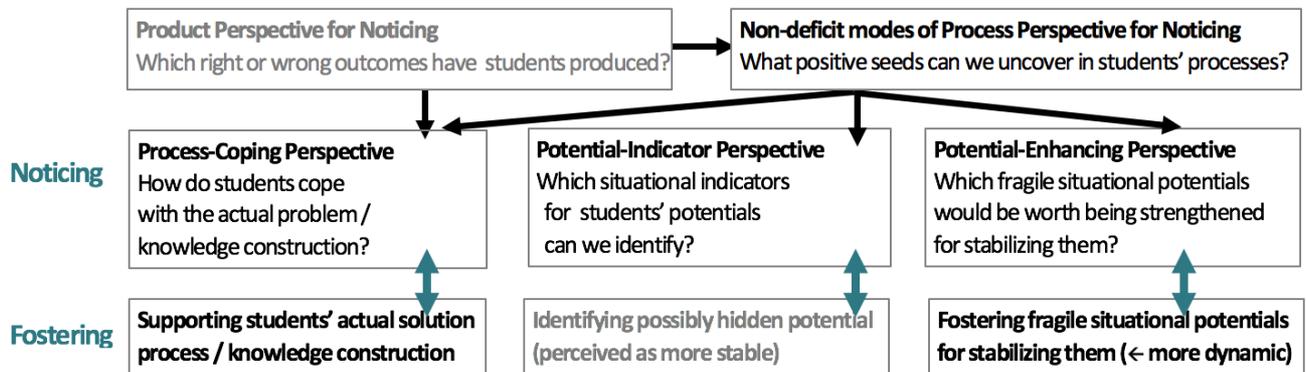


Fig. 4: Refined structure of PD content: Perspective model for noticing and fostering potentials

The last perspective, at which the PD programs aims, is now called the *potential-enhancing perspective*, asking for fragile situational potentials which would be worth to be strengthened in order to stabilize them. This perspective would allow fostering potentials, but in the beginning, teachers rarely adopt this perspective. A condensed fictional prototype of this focus of selective attention would be:

Teach That is really a good way of abstraction, they generalize very well at this point. I tell them how this as a brilliant approach. Hoping, they get used to doing it more often.

Some teachers, especially Henry, can adopt the *potential-enhancing perspective*, and even explain what he should NOT do in order to foster the situational potential:

PD leader [...] Would you have liked to give them an impulse, if you would have been there?

Henry Yes, I do find it great. So I noticed for myself that it works quite well even if I don't give any prompt. I notice that I, as teacher, would have quickly felt the need to say 'oh, look here, what happens here? The three here.' And now I think you sometimes give them too little time so that they can unfold their ideas in peace. That it needs a lot of time [...] Because I find they gave the right impulses themselves.

(Cycle 2, Individual discussion 2 of video clip 'Stair problem', transcript line 79-80, min. 14:55)

In total, the refined model specifically includes the following observation: what teachers selectively notice is highly connected to what they intend to foster: As long as the main goal is supporting students' actual processes of working on a given task, it is rational to stay in a process-coping perspective (cf. Fig. 4). The potential-indicator perspective looks at indicators for students' existing potentials displayed in a certain situation. While it is important in our teaching approach, it cannot help fostering

students when potentials are perceived as pre-existing and more stable dispositions. In contrast, sensitive strategies for fostering (still fragile) situational potentials in order to stabilize them in the long run require a potential-enhancing perspective of noticing. It is this perspective which teachers adopt the least often in the beginning of the course and successively learn to adopt during the discussion of fostering strategies. Rather than linear, teachers' navigation during the professionalization process is forward and backward, since they need to coordinate different perspectives at the same time.

2.4 Exemplary design results and research results

By the case of the DoMath project, we can exemplify typical design and research results of typical PD design research projects as listed in Fig. 1.

Research results. Although the existing literature provided consolidated knowledge of the general structure of teachers' noticing and general pedagogical principles for enhancing them (Sherin & van Es, 2009; Blomberg, Renkl, Sherin, Borko & Seidel, 2013), little was known about the specific content, noticing students' hidden mathematical potentials based on our dynamic and participatory conceptualization of potential. Thus, the empirical research on teachers' processes was necessary to iteratively refine a local theory on this PD content and individual pathways to approaching it. First research results are condensed in the *perspective model for noticing potentials* (cf. Fig. 4). It provides a content-dependent language for describing typical professionalization pathways and obstacles. Of course, the reconstructed insights into effects of specific design elements like focus questions are not yet generalizable, their transferability to other contents should be investigated in further research.

Design results. The research results on effects of specific design elements have iteratively influenced the design of PD sessions within the mini cycles and between the big cycles. However, we have only achieved first steps for the long term goal of designing a *PD program with robust materials* that can be used for scaling up, i.e. for facilitators who have not joined our programs themselves. For this purpose, the theoretical foundation is crucial, and in this sense, the *specification and structure of the PD content* based on the perspective model is also an important design result which will guide a manual for facilitators. With respect to pedagogical *design principles*, the project has mainly confirmed existing work (e.g. Blomberg et al., 2013) and found content-specific ways for their realization, a design result which is far from trivial.

3. DISCUSSION

Although design research *with* teachers on the student level is an excellent setting for professionalizing *some* teachers, this paper pleads for extending the approach for reaching *many* teachers. In the presented approach, design experiments take place in PD sessions, not in classrooms alone. PD design research adds to usual PD program development a much more intense, video-based analysis of teachers' professionalization pathways during and between the PD sessions, by own teaching experiments and

their video-based reflection in small groups. The reconstruction of teachers' individual professionalization pathways allows gaining profound insights into the structure of the PD content: in our case, the process perspective had to be split for understanding teachers' pathways (cf. perspective model in Fig. 4).

Like every analysis of individual learning pathways, such an analysis has always the risk to be deficit-focused, devaluing the perspective of the learning teachers. Thus, systematically taking into account the teachers' perspectives and its inner logic invites to search for a synthesis between teachers' and intended perspectives and helps to overcome the risk of deficit-orientation (Prediger et al. 2015b). In our case, we had to accept the process-coping perspective as a natural and important perspective which should coexist with the potential-enhancing perspective.

The methodological control of the interpretative data analysis procedures is paramount for achieving profound empirical results. This means respecting the quality criteria of transparency, intersubjectivity and openness for phenomena outside the theoretical input. However, quality criteria in design research go beyond these classical methodological criteria, as they also comprise relevance and practicability of the design, generalizability of the results by accumulating over several projects and ecological validity of the complete setting (Cobb et al. 2003). For the concrete project, the generalizability of the research results is not yet achieved since the process is only at the beginning. However, its preliminary results are encouraging to pursue this aim.

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