Promoting and investigating teachers’ professionalization processes towards noticing and fostering students’ potentials: A case of Content-Specific Design Research for Teachers

Susanne Prediger, Susanne Schnell, & Kim-Alexandra Rösike

Abstract. The chapter presents the research format of content-specific Design Research for teachers. It is exemplified by a specific PD content, namely “noticing and fostering students’ mathematical potentials”. The PD content requires further specification of what exactly teachers have to learn and a PD design for promoting teachers’ professionalization in this PD content. By conducting and analyzing design experiments in PDs, the PD content is further specified and the PD design is iteratively refined in order to take the teachers’ learning pathways into account. Some typical outcomes of the analysis are presented, in particular teachers’ typical perspectives while noticing and fostering students’ potentials.

Noticing and fostering students’ mathematical potentials is a major task for every mathematics teacher. However, it is still neglected in professional development (PD), and even underdetermined what teachers need to learn for fulfilling this task. In this article, we take the example of this PD content to illustrate what Design Research for teachers can mean as well as how it informs the finer specification of what teachers should learn and how they can learn it. For this, we briefly introduce the main ideas of the research approach Design Research for Teachers in Section 1 and the background of the concrete PD Design Research project in Section 2. Section 3 presents exemplary design and research results which are discussed with respect to general methodological issues of the research approach in Section 4.

1. Adopting Design Research for teachers

1.1 Design Research as an 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 and (2) investigating the initiated learning processes as well as 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 content-specific approach which allows to account for different mathematical topics in detail (Prediger & Zwetzschler, 2013) with a focus on learning processes (ibid.; Prediger et al., 2015a). In the last years, this approach was adapted to designing and researching environments for teacher learning in professional development (Prediger, Schnell, & Rösike, 2016; Prediger 2019).

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 impressive individual professionalization effects of Design Research with teachers for the exclusive minority of teachers who are privileged to be part of Design Research teams (Smit & van Eerde, 2011; Bannan-Ritland, 2008). Although this is without doubt a very intensive PD setting, it is not realizable for scaling up, since many teachers have no access to such an intensive collaboration with researchers. However, scaling up for reaching many teachers throughout whole Germany is the critical long-term goal for the authors’ work in the DZLM, the German National Center for Mathematics Teacher Education (Rösken-Winter, Hoyles, & Blömeke, 2015).

Thus, Prediger, Schnell, and Rösike (2016) have suggested 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, which allows to anticipate possible challenges of the content to be learnt and teachers’ 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 about a certain content (e.g. a mathematical topic or noticing students’ difficulties) is of course an a priori task before starting the PD. It usually refers to the current state of research on classroom practices or teachers’ professional knowledge for this content. However, the further refinement
of the content is also an empirical task as the original content must be restructured with respect to typical teachers’ perspectives, which can be reconstructed when qualitatively investigating content-specific professionalization processes.

In their review 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 & Zwetzschler, 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 Zwetzschler (2013) for PD Design Research by Prediger, Schnell, and Röske (2016). 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 (d) developing contributions to local theories on professionalization processes.

![Figure 1: Working areas and results of Content-Specific Design Research for Teachers](image-url)
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 on the teacher level). The project addresses secondary school mathematics teachers who intend to develop their competences of 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 of the classroom program.* The DoMath classroom program aims at fostering students’ mathematical potential. Specifically, it addresses (often underprivileged) students “who can achieve a high level of mathematical performance when their potential is realized to the greatest extent” (Leikin, 2009, p. 388), but have not yet been identified as talented (Suh & Fulginiti, 2011). Thus, the program adopts a broader conceptualizing of mathematical potential as (i) *potentially hidden*, appearing not only in constantly good performances, but also situationally and in ‘seeds’, which have to be fostered in order to be fully realized, (ii) *dynamic*, so that it can be fostered over different situations rather than as a stable naturally given talent, and (iii) *participatory*, referring to approximately 20% of all students rather than the top 2% or 1% (Schnell & Prediger, 2017). According to a literature review, mathematical potential can be identified by five different facets (cf. Table 1, cf. Leikin, 2011; Sheffield, 2003).

<table>
<thead>
<tr>
<th>Cognitive facet</th>
<th>Meta-cognitive facet</th>
<th>Personal &amp; affective facet</th>
<th>Communicative &amp; linguistic facet</th>
<th>Social facet</th>
</tr>
</thead>
<tbody>
<tr>
<td>• conceptual understanding</td>
<td>• planning</td>
<td>• mathematical self-concept</td>
<td>• complex argumentation</td>
<td>• cooperative skills</td>
</tr>
<tr>
<td>• procedural fluency</td>
<td>• monitoring</td>
<td>• commitment</td>
<td>• deep discursive involvement</td>
<td>• social involvement</td>
</tr>
<tr>
<td>• adaptive (logical) reasoning</td>
<td>• evaluating</td>
<td>• creativity</td>
<td>• etc.</td>
<td>• etc.</td>
</tr>
<tr>
<td>• finding pattern</td>
<td>• etc.</td>
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<tr>
<td>• generalizing</td>
<td>• etc.</td>
<td>• etc.</td>
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*Table 1:* Excerpt of facets of mathematical potential
Cognitive activities in the exploration process:

- Arguing
- Systematizing
- Conjecturing
- Trying Out
- Capturing

Increasing epistemic demands

Figure 2: Stair number exploration as example for a self-differentiating, open-ended problem

The instructional design therefore builds upon whole-class enrichment settings with rich, self-differentiating open-ended problems (Sheffield, 2003). One example for such an open-ended problem is the so-called Stair Number Exploration (cf. Figure 2).

These kind of open-ended problems intend to allow teachers to notice early seeds of students’ potentials in the rich situations and to adaptively foster the noticed situative potentials by supportive interactions.

Structure of the PD program. Based on the DoMath classroom program, the DoMath PD program spans over several months and professionalizes teachers 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, 2017). The preparation includes their own mathematical inquiries as well as anticipating students’ ideas. The typical “sandwich structure” of the PD program is illustrated in Figure 3.
modes on students and the necessity of a 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 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 for fostering the fragile situative potentials (cf. Figure 4 for the intended professionalization trajectory which corresponds to a hypothetical learning trajectory in other Design Research approaches, cf. Prediger et al., 2015a).

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 were 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 (with 23 teachers in 3 whole-day PD sessions of two days each, over 6 months). During each design experiment cycle, the PD sessions and classroom teaching experiments (cf. Figure 3) were investigated in so-called mini-cycles of Design Research for immediately refining the program. Analyses of teachers’ discussions and their subsequent implementation of activities in classroom informed the design of the following PD sessions, so that overall the relatively vague intended trajectory matured into a more detailed model for noticing students’ potentials (Schnell & Prediger, 2017). Later, this refinement of the underlying content-specific theory will allow pursuing the long-term aim to develop a PD course for scaling up to a national level with facilitators within the DZLM.

Methods for data gathering. The data collection includes video recordings of classroom teaching experiments and all PD sessions (cf. Figure 3). In order to capture teachers’ perspectives, data from group discussions were complemented by interviews with single teachers. These individual interview sessions in which video clips are analyzed allow deeper insights into the individual professional visions of the teachers.

Methods for data analysis. The qualitative methods for analyzing transcripts from the video data aimed at (1) specifying demands and challenges in teachers’ noticing and (2) reconstructing individual pathways in professionalizing the noticing. For this, video
data of PD sequences in which teachers discussed the potential of students were selected and analyzed by means of the sensitizing subconstructs of professional vision (I – III) and the theoretically derived facets for identifying potentials (Table 1) in an inductive-deductive procedure. Comparing the sequences of the video clip selected by the teachers (I: selective attention) with a pre-analysis of the clips conducted by the research team (cf. Rösike & Schnell, 2017) was used to identify the challenges in noticing potential. Next, the selected sections were interpreted and carefully discussed in terms of the underlying perspective on potential (inductively specifying the PD content, cf. Figure 4 and Figure 5). 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 videos in Cycle 2).

3. Exemplary design and research results in the DoMath project

In the following section, we present exemplary insight into some results of the Design Research project focusing on teachers’ professional development: Regarding the design, we briefly discuss two of the design elements implemented, evaluated and successively adapted over the course of the design cycles. In terms of the research results, we discuss obstacles in the teachers’ professionalization process which lead to refinements of the local theory for noticing and fostering students’ mathematical potential. As both types of results are intertwined, they are described first before being illustrated by an exemplary analysis of a transcript.

3.1 Design Results

Design element video clips from participants’ classrooms

In line with other professionalization approaches (e.g. Sherin & van Es, 2009; Empson & Jacobs, 2008), the project uses video clips from the participating teachers’ classrooms which are intensively discussed by groups of teachers. The collective video analysis aims at promoting discussions among the teachers, in which they deepen their own understanding of mathematical potential by collectively negotiating which student utterances or actions can be interpreted as situational seeds of potential and which interactions by the teachers could have possibly lead to fostering them (for a detailed description of a video clip cf. Rösike & Schnell, 2017). Even though the analysis takes place in a laboratory setting to allow for in-depth inquiries, the clips are taken from real classroom activities to facilitate the transferability of acquired noticing skills into the teachers’ everyday practice. The clips are selected by the research team in terms of student interactions showing high levels of cognitive activities, productive discussions or other seed of mathematical potential. However, the captured working processes are often non-linear and can be interspersed with less productive phases or incorrect approaches, which allow for a large variety of analytic perspectives.
Design elements focus question and diagnostic categories

The collective discussion of classroom video clips allows for a variety of settings such as letting the teachers pick relevant scenes themselves vs. pre-picked scenes or developing an analysis focus during the meeting vs. pre-given focus questions (cf. van Es & Sherin, 2006). Results of van Es and Sherin (2006) point out that a less focused discussion enables the teachers to adopt more diverse perspectives with a broader scope of different aspects that are considered. A pre-given focus question, on the other hand, leads to a narrower perspective with insights on a more in-depth level e.g. into student thinking. Both – the narrow as well as the broad perspective - are valuable for a comprehensive account of the classroom interactions.

In the project DoMath, the first video club meetings in Design Experiment Cycle 1 did not immediately aim at directing teachers’ noticing of potential. Instead, the first goal was to identify in-service-teachers’ conceptions of mathematical potential as a starting point to complement the theoretically derived facets and aspects (cf. Table 1). However, teachers kept a deficit-oriented mode for a long time, which hindered them to see any seeds of mathematical potential at all. Thus, after the first mini cycles, we introduced the focus question “What kind of potentials can you discover in the students’ processes?” which was repeated by the researchers throughout the discussion session. Furthermore, to facilitate the focus on potential under the cognitive facet (cf. Table 1), additional scaffolding material was provided which included didactical categories for grasping typical cognitive processes when working on open-ended tasks. For example, the Stair Number Exploration in Figure 2 was discussed together with the categories for cognitive activities in Figure 2.

As the following analysis will exemplify, the effect of the focus question and categories was substantial in the second cycle: from the first PD session on, the second teacher group adopted a more process perspective in mainly non-deficit modes. The categories allowed the teachers to focus their attention on the processes rather than the products and give them a language to distinguish different moments in a refined way.

3.2 Exemplary Research Results: Extending the landscape of diagnostic perspectives and their relation to fostering

To illustrate perspectives and obstacles during a typical collective discussion of the video clips, we present short excerpts from the PD Session 2 in Cycle 2. Afterwards, we condense the findings into the developed perspective model for noticing and fostering potentials.

Functioning of focus questions and categories

In following transcript, the teachers watch a video clip – complemented by the transcript – of four students working on the Stair Number Exploration in Figure 2 which was recorded in a Grade 8 classroom taught by the participating teacher Katharina.
Next, they are asked to comment the scene spontaneously and make sense of the students’ (non-linear) exploration process in groups of two or three. Lastly, the facilitator and researcher (the second author) asks them to focus on mathematical potential, which is then discussed in the whole group. The transcript was translated from German and simplified marginally to enhance the readability. All names are pseudonyms.

41 Facilitator: Let’s bring it all together. What did you notice? Where are the potentials, which cognitive activities do you see? (…)

42 Julia: I go first. The first part, the first 43 seconds. It seems like they try something systematically. Though, in our opinion, Kai is quite dominant. And Lukas is still stuck at understanding [the task]. In between he yells ‘no, again, again, again’, he is not there, yet. And in the end ‘ah yes, you can do it with 7, that’s correct’. So he is a bit behind the others and as I said, Kai dominates it all. Until there is the first conjecture after 43 seconds. (…)

46 Svenja: In our group, we wondered if the students were on the same page regarding if they look at stairs with two steps or stairs with three steps. When you only read the transcript, we got the feeling that one thinks about stairs with three steps in the beginning and another about stairs with two steps and they are not on the same page. Later, they agree with each other: when the first conjecture is verbalized, then they find each other and notice that they have to get on the same page. (…)

While the facilitator’s focus question in Line 41 addresses the mathematical potential in the scene, the teachers Julia and Svenja mainly concentrate on understanding and evaluating how the students cope with the problem. Both point out deficits in the group working process as one student is lost and the others are perceived to talk about different things in the beginning. This perspective of evaluating if the task is addressed correctly by the students is quite prominent in everyday classrooms, as the teacher has to make sure that everyone is able to understand and work on the given assignment. Svenja’s last sentence can be understood as a more positive evaluation as she points out how the students overcome their difficulties themselves, thus taking a more non-deficit-oriented stance.

48 Sophie: I find that they begin quite quickly to systematize and justify. When they find out that all uneven numbers work, they all confirm each other one after the other. They say ‘then you always have stairs’ in line 23 [of the transcript] for example (…) and again in line 33. Confirms ‘because you only have one step’, which is for them already a justification that all uneven numbers work. And then they continue immediately: next you have to mathematize the even numbers. Here, they are also very fast to try and find a generalization. (…)

55 Svenja: [Referring to the given categories of typical activities in exploration processes] I think they always jump a step up and then another and then one back and then again one up. They always get a step further and then one step back until they justify it at some point. Not on the first pages [of the transcript], I wouldn’t say they justify mathematically correct yet, written or in any other way. At least they did go many steps up, as you said (to Merle), but also down. It’s a constant movement. Nothing written down and never staying in the same spot, but always moving. (…)

These statements by Sophie and Svenja show that they now apply the previously introduced categories for exploration processes (in Figure 3) as a lens to interpret the
students’ working process, which leads them to an inquiry of their cognitive activities. Thus, the design element focus question and categories seems to successfully initiate the analysis of more in-depth level of student thinking. Furthermore, Svenja comments on the complexity and non-linearity of the process which surfaces only by the design element video clip. The diversity of aspects and perspectives mentioned by the teachers shows the potential of the selected video clips for activating teachers’ diverse diagnostic processes.

While the statements above seem to be non-deficit oriented, it remains unclear if the teachers already perceive the situational mathematical potential. Thus, the researcher reminds the group of the focus question.

72 Facilitator: Did you notice anything else where you would say ‘There is something I would call potential. Something is happening which is mathematical potential for me’? (…) 

73 Emma: Me and my colleague, we first had the impression that Tom just listens in the beginning. And I tried to find out if he works on the task or if he thinks about something else. And then we read the transcript and my colleague found out that we have to look more closely, because Tom is always structuring a bit. He lets others think and calculate and then he gives a small summary of what the others did. I find that pretty interesting. I wouldn’t have thought so while watching the scene, but by looking so closely… It is really the case, Tom is not absent or lazy and letting the others calculate, but he seems to do something completely different. He thinks about what is the common thing which they all just discovered and then he summarizes it in a structured way. I find that super interesting to discover.

74 Christian: He refuses a bit to try out and always stays on a higher level and looks down what the others do. And then he looks up to elaborate on that. (…) 

77 Merle: And in line 85, when they are at the beginning of finding a term. It was about having to subtract six, which was true for the stairs with three steps. And then he says ‘or minus 10’ which is a reproduction, because it was said before, but I think it’s really clever to say it in this moment. Because he says you always have to subtract the base form, and the base form is always different. It can be six, it can be ten. And thus they figure out that they have to subtract [a variable] z.

(Cycle 2, PD session 2, Clip ‘Stair Number Exploration’, min. 82:49 - 99:37)

In line 73, Emma describes how her perception of the student Tom changed: While she was first unsure if he was working on the task at all (i.e. identifying a possible deficit in not being engaged in the working process), the detailed analysis of the transcripts leads her to a quite positive evaluation of Tom as a moderator who repeatedly summarizes, systematizes and thus pushes the exploration process of the group forward. Christian and Merle also point out the high cognitive level of Tom’s contributions. A possible interpretation of these statements is that the teachers were able to achieve a more in-depth level of analysis which leads them to uncover a potential in this situation which they ascribe to Tom. Again, the application of hierarchical categories support them in their positive evaluation. While this potential might have been hidden in the very beginning of the clip, it becomes apparent in the student’s actions later on.
Accounting for obstacles and teachers’ perspectives. The described snapshots from the second PD meeting in the second cycle are prototypical for teachers’ differences and obstacles in changing perspectives: Typically, teachers at first argue from a deficit-oriented mode which is overcome by the focus questions. However, the process perspective does 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 identify and discuss mainly strategies to help students to solve the open-ended mathematical problems. In consequence, the noticing mainly focuses on students’ processes of coping with the task (or why they could not cope well). This can be illustrated in an even more pointed way 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

78 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’, 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 perspectives 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.

This 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:

45 Stephanie: 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 Number Exploration, min. 18:42)

Stephanie also reconstructs steps in the coping perspective, but beyond that, she identifies the 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 indicates that she conceives potential here as students’ stable disposition rather than dynamically emerging and disappearing 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 (Figure 4). The result of several reconstructions and discussions was a refined perspective model (Figure 5) 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 Figure 4 (cf. Schnell & Prediger, 2017).

Figure 5: 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, looking for fragile situational potentials which are worth to be strengthened in order to stabilize them. This perspective allows fostering potentials, but in the beginning, teachers rarely adopt this perspective. Nicole is one of the teachers who adapt potential-enhancing perspective in later stages of the PD as her following utterance shows:

334 Nicole:  I would strengthen their generalizing, because I think, Aishe is practically formulating a kind of rule. “I thought that in this case, you always do such an such…” She is on the way to systematize, to find a rule. And I think, well, … she has potential in that idea and we could work on that.

(Cycle 3, PD Session 1, Day 2, group discussion, min. 2:30:00)

Also Henry starts to adopt the potential-enhancing perspective, and even explains what he should NOT do in order to foster the situational potential:

79 Facilitator: […] Would you have liked to give them an impulse, if you would have been there?
80 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’, min. 14:55)

In total, the research contributed to refining the model as it revealed specifically the following observation on the tight connection between teachers’ noticing and fostering:

- 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. Figure 5).
- 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.

### 3.3 Summarizing and combining the design 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 Figure 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 and their connection to fostering practices. 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 and fostering potentials (cf. Figure 5). 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 and categories are not yet generalizable. Hence, 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 the DoMath 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.

4. Zooming out: Discussing the research approach Design Research

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 Figure 5).

Like every investigation of individual learning pathways, such an analysis always has the risk to be deficit-focused as the intended goal is not reached, devaluing the perspective of the learning teachers. In order to avoid this, the teachers’ perspectives as well as their inner logic and rationalization has to be systematically taken into account. The research goal has to be the search for a synthesis between teachers’ and intended perspectives which leads to overcoming 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 for in-service teachers 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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**References**


