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TEACHER EDUCATION & DEVELOPMENT | RESEARCH ARTICLE

Learning diagnostic skills for adaptive teaching – a theoretical foundation

Sabine Reuker[1]* and Stefan Künzell[2]

Abstract: Diagnostic abilities required during the on-going process of teaching include perception, interpretation and decision-making skills. They are regarded as important prerequisites for adaptive teaching. To teach these skills, several teacher education programs have been developed. However, a theoretical foundation is still missing. Here, we introduce a model for learning these diagnostic skills. With this model, we derive guiding principles for designing a framework using video analysis in teacher education programs. We show that some implications of this model have already been integrated in current programs. However, we also present new aspects. In particular, reflection on unexpected events might be a good way to enhance teacher education programs.

Subjects: Teacher Education & Training; Newly Qualified Teachers; Teacher Training; Teachers & Teacher Education

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PUBLIC INTEREST STATEMENT

Physical Education (PE) teachers have to perform many tasks, such as correcting technical or tactical errors, moderating social processes, promoting health, and ensuring safety. These tasks take place in class, where many events occur simultaneously and quickly. In order to best prepare teachers for these challenges, they must learn to observe the various events in class and to decide which to focus their attention on. This is important because only those who notice and understand what is going on can react appropriately and support the students in the best possible way. In this article, we present a model that explains how to learn these skills. Based on this model, consequences for teacher education are derived. This leads to a guiding framework for learning diagnostic skills through video analysis.

Keywords: teacher education; diagnostic competence; video analysis; learning; knowledge

1. Learning diagnostic skills for adaptive teaching—a theoretical foundation

In class, many events occur at the same time, are often accompanied by overlapping tasks, and take place rapidly. This situation is illustrated by the following response of teacher L06 to the question of what he noticed as significant in an observed Physical Education (PE) lesson. This question was part of a broader research project to identify teachers' professional vision while observing and analyzing videotaped teaching sequences (Reuker, 2017a, 2017b):

I observed a game called board-ball, in a clearly defined area. The area was marked with cones. They played 3:3 with two substitutes. Remarkably, there was a girl who wasn't involved in the game at all. One boy in a yellow shirt also attracted my attention. He was running around with outstretched arms, sometimes running towards a player in order to defend him, but the player already had a defender. What else? Many passes over the heads of the others, crowds of players, offense players often stayed in the shadow of the defense, few movements into the open space. Nevertheless, the group was engaged in the game. There were differences according the rules about allowed steps. Some made four, five, or six steps, others only a few steps with the ball. There was no referee; pupils played autonomously. Once, two players lay on the ground and it was no problem at all. There was no protest when the game continued. This was clear evidence of good cooperation (L06, 116ff.; translated by the authors).

This response elucidates the complexity of perception. When describing his first impressions, the teacher focuses on organizational aspects (e.g., the field marked with cones) as well as on social and tactical processes (e.g., cooperation, movements into the open space). In so doing, he considers individuals as well as the class as a whole. These different attentional foci can be attributed to the diverse teaching tasks a PE teacher must fulfill: for example, correcting technical or tactical errors, moderating social processes, initiating thought processes, promoting health and safety, giving advice, and evaluating pupils (e.g., Armour, 2010). Furthermore, the situation is never the same twice, and many events occur unexpectedly. Thus, rather than establishment of routines, teaching requires a flexible application of knowledge. Sherin et al. (2008) describe this teaching demand as "on-the-fly decision-making" (p. 27), which requires the ability to observe and interpret students' behaviors and learning processes. In the field of mathematics, Sherin et al. (ibid.) specify that "rather than carefully follow a pre-planned lesson [...] Teachers must be able to quickly diagnose students' thinking, decide whether or not to pursue an unexpected tangent, and continually assess the progress of an on-going lesson" (p. 27). Jacobs and Empson (2016) refer to "*responsive teaching*" (p. 185) when they describe this type of teaching, conceptualized as continually adjusting instructions "in response to children's [...] thinking, instead of being determined in advance" (p. 185). More generally, continual monitoring of the various events that happen in class and deciding where to focus one's attention within this complex array of environmental stimuli are tasks central to teaching, because teachers can only react appropriately and provide pupils with the best support possible if they first notice and understand what is going on. In sum, these skills are important prerequisites for *adapting teaching* to diverse requirements and thus for meeting diverse learning needs (Choppin, 2011). Their meaning for the aforementioned diverse teaching tasks is broadly accepted (e.g., Reuker, 2017a, 2017b; Barnhart & Van Es, 2015; Blomberg et al., 2011; Choppin, 2011; Rosaen et al., 2008; Seidel et al., 2011; Sherin & Van Es, 2009; Van Es & Sherin, 2008, 2010). However, researchers use slightly different terms and concepts that will be described in the following section.

2. Diagnostic skills for adaptive teaching—different terms and concepts

One of the first concepts that highlighted these skills is the concept of *professional vision*. Referring to the explanations of Goodwin (1994), who emphasized the importance of professional vision in other professional domains, Sherin and Van Es (e.g., Sherin & Van Es, 2005, 2009; Van Es & Sherin,

2002, 2010) established this concept in the field of teacher education by conducting numerous studies. Initially, they identified two mutually influential processes as important teaching requirements: First, teachers must be able to separate important and unimportant events and decide where to focus their attention in complex classroom situations, described as *selective attention*. Second, and relatedly, teachers must be able to give these events meaning by interpreting them from a teaching perspective, described as *knowledge-based reasoning*. Since then, the concept of professional vision has been extended to include a third process, described as the ability to *respond* to the analyzed events (e.g., Barnhart & Van Es, 2015). Referring to this concept, some researchers use different terms, such as *professional perception* (Seidel et al., 2010). Sometimes the term *noticing* is used synonymously with professional vision (Van Es & Sherin, 2010). This is partially confusing because some authors define noticing only as an aspect of attention (e.g., Star & Strickland, 2008), whereas others define noticing as a process that includes attention, reasoning, and deciding how to respond (e.g., Barnhart & Van Es, 2015; Jacobs & Empson, 2016; Jacobs et al., 2010).

Referring to a teacher competence model drawn by Blömeke et al. (2015), the three aspects of perception, interpretation, and decision-making are termed *situation-specific skills* that mediate between what teachers know and how they act (e.g., Santagata & Yeh, 2016; Stahnke et al., 2016). Accordingly, these situation-specific skills build an important link between teachers' dispositions and performance, as they are influenced by cognitive, motivational, or affective traits and give "rise to observed behavior in a particular real world situation" (Blömeke et al., 2015, p. 11).

In the competence-theoretical discourse, the skills of perception, interpretation and decision-making are described as diagnostic competence[1] (Artelt & Gräsel, 2009). Here, a basic distinction is made between performance and learning process diagnostics. The diagnostic skills presented here are to be understood in the sense of process diagnostics, which takes place during on-going teaching, e.g., to adapt tasks to different requirements (Reuker, 2018; Schrader, 2013).

When we speak of *process diagnostic skills* in the following, we refer to the aforementioned three skills: the skill to *perceive* teaching events and decide where to pay attention, the skill to *interpret* and give events a meaning from a teaching perspective and the skill to *decide how to respond* to the analyzed events to support learning processes.

Despite slight differences, authors agree that developing these skills is an important topic in teacher education because it enables teachers to move beyond a habitual response towards new, responsive forms of teaching. Blomberg et al. (2011) even indicate that this is one of the key purposes of university teacher education. Rosaen et al. (2008) consider these abilities to be an essential requirement for changes in teacher behavior. Some empirical findings and theoretical principles regarding learning diagnostic skills are presented in the next section.

3. Insights into the development of process diagnostic skills

Especially in the context of the concept of *professional vision*, several studies have demonstrated that attending, reasoning and decision-making abilities are attributes of teacher professionalization by examining differences between groups with different expertise (e.g., Reuker, 2011, 2017a, 2017b; Blomberg et al., 2011; Jacobs et al., 2010). Moreover, standardized instruments to verify professional vision have been developed (e.g., Kersting, 2008; Seidel et al., 2010; Stürmer et al., 2016). Researchers have also investigated how professional vision can be developed by evaluating the effects of different teacher education programs. For example, Sherin and Van Es (Sherin & Van Es, 2005, 2009; Van Es & Sherin, 2010) provided evidence for the suitability of video clubs in which groups watch and discuss videotapes of teaching situations. Other researchers investigated the influence of differently conceptualized university-based courses and confirmed that video-based approaches serve as an appropriate method for developing professional vision (Michalsky, 2014; Stürmer, Könings et al., 2013). However, they note that there are individual differences due to entry levels (Stürmer et al., 2016; Stürmer, Seidel et al., 2013). Other studies focused on special

aspects of interventions, such as the importance of an observation framework (Santagata, 2009; Santagata & Angelici, 2010) or the type of video material observed (e.g., one's own teaching or that of others; see Seidel et al., 2011). Rosaen et al. (2008) compared video-supported reflection to memory-based reflection and concluded that the former enabled participants to reflect more thoroughly. Overall, there is consensus that teaching programs can support the development of professional vision. Herein, the use of video footage that supports reflection of teaching situations is recognized as an effective approach (for an overview, see Stahnke et al., 2016).

This view is substantiated by the concept of *reflective practice*, which focuses on deliberate reflection on experience as an essential tool for professional development (e.g., Schön, 1983). "In this way teachers become skilled professionals rather than mindless technicians" (Barnhart & Van Es, 2015, p. 84), or as Rodgers (2002) notes, teachers "become more able to respond thoughtfully in the moment" (p. 232). To explain the process of Berliner (2001, 2004) refers to an expertise model that characterizes professional development as the acquisition of declarative and procedural knowledge. According to his view, with increasing teaching expertise, underlying knowledge grows progressively more crosslinked and context-bound, which finally leads to expert knowledge that is practical, tacit, and contextualized. He assumes that this process is initiated by deliberate practice, but notes the need for external support, at least at the beginning of development. However, the concrete learning process and the method of support remains open (Berliner, 2001, 2004). Other researchers highlight the necessity of cognitively activating individuals to develop knowledge, and thus professional vision, using video-based reflection (e.g., Seidel et al., 2011; Sherin, 2004; Sherin & Han, 2004; Sherin & Van Es, 2005, 2009; Van Es & Sherin, 2002, 2010).

The perspective of knowledge development as an active process can be theoretically supported by constructivist theories of learning (e.g., Fosnot, 1996; Light, 2008; MacPhail et al., 2013). In constructivist theories, learning is understood to be a process of knowledge construction requiring active confrontation. In psychological constructivism, new knowledge and meaning are constructed through interpretation and exploration referring to current knowledge and past experience, whereas social constructivism highlights that knowledge emerges from social interactions by sharing and discussing ideas collectively. Light (2008) uses the term *complex learning theories* to underscore the similarities of different approaches and to focus on common aspects of constructivist theories: learning is an active and ongoing process that unfolds in social interactions and involves processes of subjective interpretation. Fosnot (1996) adds two more aspects that are important for learning in the context of the constructivist paradigm: contradiction and reflexivity. Whereas contradiction facilitates rethinking, reflexivity drives the learning process. Based on these theoretical foundations, reflection is supported by various authors as an important process for personal development (e.g., Dewey, 1933; Schön, 1983). In the context of teacher education, reflection as a prerequisite for learning, primarily using video analysis, is widely unquestioned (e.g., Brophy, 2004; Van Es & Sherin, 2010). However, watching videos is not effective in itself; a framework is needed to guide video analysis (e.g., Berliner, 2001; Santagata & Angelici, 2010; Seidel et al., 2013; Star & Strickland, 2008; Van Es & Sherin, 2002). Barnhart and Van Es (2015) even argue that not "providing guidance in what should be analyzed [...] results in superficial learning and may even be mis-educative" (p. 84). Santagata (2009) confirms that a detailed conception of the video analysis framework, such as formulation of guiding questions and tasks, is necessary to understand learning. However, the specific guiding framework appropriate for teaching programs using video-supported reflection in teacher education remains controversial (e.g., Gelfuso, 2016; Hiebert et al., 2007; Sherin, 2004). Van Es and Sherin (2010) argue that "despite an increased focus on teacher noticing in recent years, little is known about the development of teachers' ability to notice and how to effectively support this development" (p. 157). We agree, and would extend this statement by additionally suggesting that a theoretical foundation that explains this learning process is essential to substantiate such a framework. However, a theoretical foundation of learning process diagnostic skills is still lacking.

In the following section, we introduce a model of learning process diagnostic skills inspired by theories that refer to the domain of action theory and motor learning. First, we illustrate the model's suitability by comparing an example from the domain of sports with an example from the domain of teaching.

4. Learning process diagnostic skills: towards a theory

Why should a theory that examines action and is successfully applied in the sports domain (e.g., Hoffmann et al., 2004; Koch et al., 2004; Kröger & Roth, 2005) be seminal for teacher education? A closer look reveals many similarities between sports and teaching. First of all, sportspersons as well as teachers must practice, prove, and develop themselves in situations characterized by complexity, that is, many events taking place simultaneously and immediately (for classroom situations, see Doyle, 1986). Thus, in both domains, people must continuously monitor many different events, decide where to focus their attention, and choose one action from among several options. In most cases, this process takes place under time pressure. For example, a sportsperson who plays football must notice the tactical line-up, the itineraries of teammates and opponents, their strengths and weaknesses, and will, say, decide to pass the ball to a teammate as one out of several other options. A teacher who is teaching in class must notice the students' behavior and learning processes, whether pupils are attendant, bored, overstrained, interested, or distracted, and will, say, decide to ask a question as one out of several other options. Second, in both domains, these decisions are intentional, that is, actions are goal-directed. In sports and classroom situations, goals are hierarchically structured. An overall goal can be achieved by striving for several subgoals (Reuker et al, 2018). These subgoals may emerge in concrete situations and must be specified or changed on the fly. For example, the football player may decide that ball possession is a more successful subgoal than a kick. The teacher may decide that involving all students is more important than finishing the content in time (for examples in teaching situations, see Schoenfeld, 2011). Third, decisions are characterized by an appreciable amount of uncertainty due to the complex nature of personal interactions, which involve "predicting, interpreting and assessing others' thoughts, emotions, and behavior" (for the teaching domain, see Helsing, 2007, S. 1318).

Because of these analogies between sportspersons' and teachers' tasks, we propose a model closely related to current action theory that could serve as a foundation for understanding how to learn process diagnostic skills. We will first give a short overview of the basic idea of action theory, the ideo-motor principle. Then, we present our model, which is based on a branch of action theory that addresses learning to notice in concrete situations.[2]

Modern action theory is grounded in an idea that reaches back to Lotze (1852), Carpenter (1852), and James (1890) (for a historic overview, see Stock & Stock, 2004). These early scientists reasoned about what processes evoke a voluntary action and concluded that the "idea" of the action's effect activates the "motor" system. Consequently, Carpenter (1852) termed it the "ideo-motor principle" (p. 153). The ideo-motor principle is in sharp contrast to the behavioristic idea that responses are exclusively activated by stimuli. Therefore, during the heyday of behaviorism, the ideo-motor principle was paid little heed. With the advent of connectionism, the ideo-motor principle experienced a revival (Jordan & Rumelhart, 1992). During the course of this Hoffmann (1993, 2003) developed a concept of learning based on the ideo-motor principle: the anticipatory behavior control concept. This concept is especially seminal as a foundation for a theory of learning process diagnostic skills because it explains the noticing of situations in an action context. The model we present here is based on this concept, with some terms adapted to the pedagogical terminology and some modifications borrowed and integrated from related theories (e.g., Kawato, 1999; Wolpert et al., 2001; Wolpert & Kawato, 1998). Three considerations are fundamental in our model: a) Noticing serves action. In accordance with Hoffmann (1993), we assume that noticing is driven by the goal to execute an action that is appropriate to the specific situation. In other words, a reason and a need for learning to notice are only present if such learning is relevant for the success of the action. b) Action emerges from an interaction between the intended effect and the noticed situation. The noticing of the situation and the intention are not independent

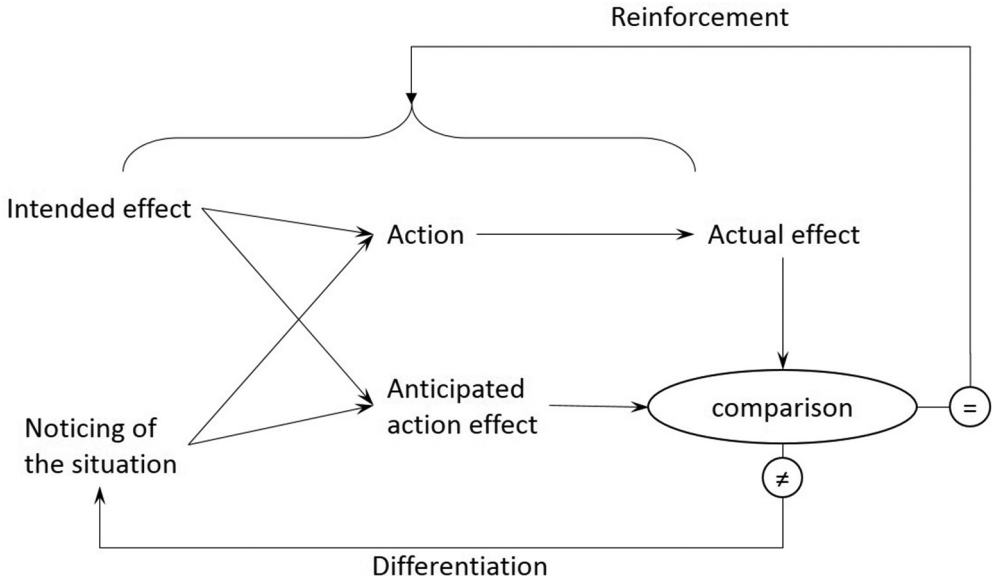

Figure 1. A model of learning noticing inspired by the anticipatory behavior concept of Hoffmann (2003) and Wolpert and Kawato (1998). Action emerges from the interaction of the intended effect and the noticed situation. Simultaneously, anticipation of the sensory consequences of the action, that is, the action effect, emerges internally. The actual effect and the anticipated effect are compared. Hoffmann (2003) suggests two learning mechanisms. In the case of consonance (=) the association between noticing, intention, and action is reinforced. Dissonance between the actual and anticipated effect (≠) leads to a differentiated noticing of the situation (more details in the text).

processes. c) The learning process is a result of the comparison of the anticipated and actual effect of an action.

The model of learning noticing is shown in Figure 1. According to this model, the trigger for voluntary action is the imagining of an intended effect to be achieved by the specific action. This is complemented by noticing the specific situational context. Thus, noticing is understood as a selective attentional process that is relevant to accomplishing the intended effect, that is, that is focused on *action-relevant situations*. Subsequently, the situational context and the intended effect simultaneously evoke the specific action and anticipation of the specific action's effect. The action then leads to an actual effect in the environment. This actual effect is compared to the previously anticipated effect. The learning process is now dependent on the results of this comparison. On the one hand, if there is sufficient consonance between the anticipated and the actual effect, the situation–action–effect associations will be reinforced (depicted by = in Figure 1). On the other, if there is insufficient consonance between the anticipated and the actual effect (depicted by ≠ in Figure 1), something has been gone differently than anticipated. This missing consonance is the trigger for a change in the situation–action–effect associations. Hoffmann (1993) considers inappropriate noticing of the situation as the reason for dissonance—in other words, the missing consonance between the anticipated and the actual effect activates a differentiated noticing of the situational context. However, we do not assume that the process of noticing is necessarily effortful and time-consuming, but may rather be a process that emerges in the concrete situation. We illustrate the learning mechanism originally invented by Hoffmann (1993) with an example from the domain of sports.

Let us assume you are a moderate table tennis player and play with your friends once in a while. You are familiar with returning your friend's serve. Therefore, you notice the movements your friend makes while executing the serve (noticing the situation) and you intend to return the serve, let's say, with a stroke to return the ball on the longline side of the opponent's field (intended effect). Simultaneous to initiating your movement, you anticipate that your stroke will carry the ball longline on the other side of the net (effect anticipation). This frequently happens, and the association between noticing the situation, action, and anticipation is reinforced. Now you happen to be playing against a table tennis expert. She serves the ball with a spin, which you have never

experienced before. So as before, you notice the opponent's movement, initiate your movement, and anticipate the ball will land on the longline side of the opponent's table half. However, the ball rebounds from your paddle in a surprising angle and lands far out behind the table. In this case, the anticipated effect does not match the actual effect. So you must learn noticing: What is the difference between your friend's serve and the serve of the expert? Note that this learning mechanism is not constrained to sports, but is also valid for most fields of perceptual learning. Hoffmann (1993) argues that this differentiation in noticing the situation is the reason for the development of terms. In our example, it will be the term "spin," and, to extend the example further, the terms topspin, sidespin, slice, and so on.

5. How to design a framework for learning process diagnostic skills using video analysis

With the model presented above, we advocate a theoretical foundation for learning process diagnostic skills in teaching. We suggest that learning these skills is based on comparison between the anticipated and actual effects of teaching actions. However, one central difference between actions in sports and the process of teaching must be considered. Whereas in sports an action's overall goal is generally given by the rules of the game (e.g., to score a point), teaching addresses diverse overall goals. Helsing (2007) describes teaching as "inherently uncertain due to its lack of a knowledge base or technical culture" (p. 1317) and concludes that this results in "little consensus about the goals or methods of good teaching" (p. 1317). Thus, in teaching situations, there are multiple perspectives that could have relevance to action. For example, if it is important for a teacher to ensure a quiet learning atmosphere, noticing off-task behavior might become relevant for his/her action. A teacher more concerned with promoting individual learning might focus his/her attention on learning difficulties to be able to give pupils the best support possible. Because of the diverse overall goals of teaching, different subgoals might be suitable and reasonable. Therefore, contrary to the domain of motor learning, in learning to teach, processes cannot be evoked exclusively during the ongoing lesson but rather require reflection and external support. A forum for negotiation is needed to reveal the diverse goals and perspectives present and to develop a repertoire of alternative actions.

The importance of reflection for developing new insights is supported by various authors who consider reflection a process that moves a person from experience of a situation to a deeper understanding (e.g., Dewey, 1933; Schön, 1983). In the context of developing professional vision, the working group led by Sherin and Van Es (Sherin & Van Es, 2005, 2009; Van Es & Sherin, 2002, 2010) supports a model of professional development based on the idea of engaging in a cycle of negotiations about teaching situations (e.g., understanding lessons, views of student learning, knowledge of mathematics). We believe that our suggested model offers a suitable orientation for a framework that guides these cycles of negotiations. We will show that some implications of this model are already integrated in the aforementioned frameworks, while others offer new inspiration for teacher education programs. We first suggest some guiding principles derived from our model that should be considered when selecting the video sequences used as the subjects of the negotiations.

5.1. Guiding principles for the selection and application of video sequences

According to our model, a teacher education program for process diagnostic skills should address four aspects: the intended effect, the situation, the action, and the anticipated effect. Thus, videos must show teaching situations in which the initial situation, the teacher's action, and the action's effect are observable. Because one suggested learning mechanism requires dissonance between an anticipated and an actual effect, teaching situations that show unexpected turns are especially suitable. Stopping the video at certain times allows people to identify the four different aspects. Therefore, the first stop should be just before the teacher's action. The participants in the teacher education program should be prompted to describe the situation and reflect on the teacher's intended effect. The second stop should be right after the teacher's action, upon which participants should anticipate the effect of the teacher's action on the concrete, previously described

situation. The third stop should be after the participants observe the actual effect of the teacher's action.

5.2. Guiding principles for questioning within a guiding framework

As mentioned previously, watching videos is not effective in itself, but rather requires a guiding framework. Below, we propose three key issues derived from our model that should be considered when developing process diagnostic skills through video analysis, focusing on *action-relevant perception* in concrete situations:

5.2.1. Reflecting on intended effects on the concrete situation

A guiding framework should integrate reflection regarding intended effects by asking participants, what could be an intended effect in the perceived situation? This focus is based on the idea that intentions must be specified in concrete situations to professionalize selective attention. Furthermore, the discussion of possible intentions should be responsive—that is, participants should refer to what they see by describing what they notice, and should explain their considerations by referring to overarching educational principles and theories of teaching and learning.

When we speak of intentions, we do not mean the overall goal of improving students' learning, but rather modified subgoals as they play out in concrete situations. These might be the intended effect of moving forward in the learning process, and may be changed depending on interpretation of a perceived error as either a slip or a serious misunderstanding. Schoenfeld (2011) calls it the "reprioritization of goals" (p. 8), one important basis for the "moment-by-moment choices" (p. 10) teachers make as they teach. Additionally, he claims that goal prioritization is "fundamentally shaped by the individuals' orientations" (p. 45), influencing their perception and interpretation of situations.

Another example of this type of goal-orientated, on-the-fly decision-making is found in the study of Sherin and Han (2004). They investigated learning that occurred in a series of long-term video club meetings to professionalize mathematics teachers through discussion and analysis of classroom situations. In the transcripts of these meetings, one teacher commented on his teaching decision to discuss a graph in more detail rather than move on as planned due to the emergence of the subgoal "to have students talking about their ideas and in class" (p. 169). Sherin and Han argue that in the beginning, when discussions focused on goals, they "quickly turned the conversation away from student thinking and towards a focus on the teacher's actions" (p. 173–174). Throughout the meetings, teachers developed a stronger focus on student thinking, even when discussing specific goals, that is, teachers discussed goals with particular attention to the specific situation. According to our model, we concretize that this is not only "an emphasis on relating the teachers' actions to what the participants understood about student thinking" (p. 178) but rather an emphasis on responsive reflection on the intended effect. We suggest that this focus should be highlighted explicitly in a guiding framework. Thus, in addition to prompting teachers to analyze sequences by mentioning noteworthy events, giving evidence of their noticing, and interpreting the events (e.g., Sherin & Van Es, 2005; Van Es & Sherin, 2008, 2010), the subject of noteworthy events should first be reflected upon by discussing what has relevance to attaining the intended effect.

5.2.2. Reflecting on differences between the anticipated and actual effects of teachers' actions

Using the aforementioned stopping technique, in the second step, participants should reflect on the anticipated and actual effects by answering two questions: What do you expect to happen after the teacher's action in the concrete situation? and after the next stop of the video, what actually happened after the teacher's action? Again, consideration of the anticipated and actual effects should be responsive, that is, situational and theoretically founded. The key reflection point is comparison of the anticipated effects and the actually observed effects, and determination of whether they are consonant or dissonant. Here, "consonance" and "dissonance" do not indicate a perfect match or a complete mismatch, but rather express personal assessments of whether the anticipated effect occurred (consonance) or something unexpected happened (dissonance).

The potential of this dissonance to foster learning is also highlighted in the field of educational research (e.g., Gelfuso, 2016; Rosaen et al., 2008; Sherin, 2002). Sherin (2002) notes the importance of unexpected or innovative comments from students, as they "have emerged as a key trigger for teacher learning during instruction" (p. 145) by prompting teachers to rethink their knowledge. The "value of uncertainties and disruptions as rich sides of learning" is also highlighted by Rosaen et al. (2008, p. 348). Referring to Field and Latta (2001), who argue that "the possibility of becoming more experienced arises only when something happens to us beyond what we anticipate" (p. 887), Rosaen et al. (2008) presume that learning takes place if teachers make connections between experiences and knowledge by reflecting on teaching situations initiated by dissonance.

Thus, a guiding framework should integrate reflection on possible causes of dissonance by asking participants what was overlooked in the concrete situation. According to our model, this key question focuses on unnoticed hints that indicate the unexpected turn, which is the reflection on noticing in the initial situation. Extending our model, reflection on the appropriateness of the actions to obtain the anticipated effect could be included as well by asking the participants what action would lead to the anticipated effect in the observed situation.

In some guiding frameworks, a focus on anticipated effects is already integrated. For example, the working group around Seidel (Seidel & Stürmer, 2014; Seidel et al., 2011) evaluated professional vision by prompting participants to describe precisely what they had noticed, explain its importance by linking the processes to prior knowledge and educational understanding, and predict what might happen as a result of the observed situation. However, Seidel et al. did not suggest comparing the anticipated and actual effect, so the differences in noticing the situation remained unconsidered. Hiebert et al. (2007) proposed a framework for learning to teach by studying teaching that fosters attention to cause-effect relationships between teaching and learning. Teachers are prompted to focus on assessing whether students achieve the learning goals, and how and why the instruction does or does not affect this achievement. This approach is close to our suggestion of reflection on dissonance between anticipated and real effects. In contrast to our perspective, it is more concerned with generally unpacking learning goals into specific subgoals, and less with identifying the diverse subgoals that emerge in concrete situations, that is, the focus is more goal-orientated than effect-orientated.

5.2.3. Reflecting on situations and action-effects when thinking about possible alternative actions

In the proposed model, the learning process is understood as a reinforcement or change in the situation–action–effect associations. Thus, reflection on alternative actions, as it is becoming more and more prominent in actual teacher education programs using video analysis (e.g., Barnhart & Van Es, 2015; Santagata & Angelici, 2010; Santagata & Yeh, 2016), should refer to the observed situation by asking for situational evidence and explanations. Whereas researchers are strongly interested in identifying levels of sophistication in teachers' responses to emerging events, the link between actions and their effects has not yet been investigated. According to our model, and in addition to the first question, participants should be directed to link actions with effects by being asked what they expect to happen after the actions.

Therefore, in a nutshell, a guiding framework should prompt participants to analyze the initial situation and the intended effects, consider the teacher's actions and their anticipated effects, compare these effects with the actual effects, and in cases of dissonance, look for indications of the unexpected outcome in the initial situation. None of these steps are really new, but together they build a theoretically derived guiding framework that helps to foster process diagnostic skills.

6. Summary and conclusion

Transferring models to different fields is often a source of scientific progress. However, caution is needed, because in most cases not all features of the original problem are transferable to the new domain. Here, we discuss the additional value of applying our model in the conceptualization of teacher education programs, but we also specify some caveats in which the underlying model should be applied cautiously.

Although there are several similarities between action learning and teaching, there are also some differences. First, one feature of the underlying theoretical assumptions from the field of action learning is that they do not reflect external support within the learning process. In our model, and in extension of the underlying action theory, we presuppose that in teaching situations, this process must be supported by conscious reflection on the situation–action–effect associations. This external support is necessary because in the domain of teaching, in contrast to the domain of sports, various goals might be equally suitable and reasonable (Helsing, 2007). Moreover, in extension of action theory, we assume that the learning process is not necessarily bound to one's own experience in a real context, but can also be triggered by observing colleagues acting in a class on video, inferring the intentions and anticipating the effects of others' actions. Although there are some hints at that in action theories (Wolpert et al., 2003), these assumptions should be subject to empirical confirmation.

Second, the anticipatory behavior control concept (Hoffmann, 1993) considers only incorrect noticing as the cause of dissonance between the anticipated and the actual effect. However, it is improbable that *noticing* is the only source of dissonance. Inappropriate *action selection* or even an *inadequate anticipation* process could just as well lead to dissonance. Thus, reflection on alternative actions in concrete situations, as it is becoming more and more prominent in actual teacher education programs that use video analysis (e.g., Barnhart & Van Es, 2015; Santagata & Angelici, 2010; Santagata & Yeh, 2016), may also be an important aspect of developing process diagnostic skills. Because Hoffmann's (1993) concept does not consider any processes for learning anticipation or adaption of the action itself, our paper focuses on noticing and does not attach importance to aspects of learning action or anticipation.

Highlighting the added value of our model, it explains which aspects influence the process of learning process diagnostic skills and thus provides a theoretically founded direction for teaching these skills. We emphasize three features of learning that have thus far not been sufficiently considered. First, we extend existing perspectives in teacher education programs by proposing a stronger focus on learning to notice *action-relevant* situations. The relevance of action is made apparent through comparison of its anticipated and actual effect. Second, our model suggests that noticing is dependent on the teacher's intention, which emerges in the concrete situation. Third, learning is understood as a reinforcement or change of the situation–action–effect associations. With our model, we derive guiding principles for designing a framework using video analysis in teacher education programs. The model thus offers a theoretical foundation that thus far is still lacking. Furthermore, it offers a way to design testable hypotheses to evaluate appropriate design of teacher education programs. We hope that this prompts further empirical investigation of process diagnostic skills.

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Notes

1. So far, there is no generally accepted model for diagnostic competence. Some researchers model diagnostic competence as an independent competence, others as a competence area and still others model it in a more comprehensive understanding (summarised in Reuker, 2018).
2. The term noticing in this model refers to the processes of perceiving, interpreting, and deciding and thus to all three skills, but with an emphasis on the former.

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