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What is in the eye of preservice teachers while instructing? An eye-tracking study about attention processes in different teaching situations

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Abstract Professional vision research lacks behind regarding the investigation of attention processes in teaching action. In this study, eye movements of preservice teachers were assessed by mobile eye-tracking technology (MET). Eye movements of $N = 7$ preservice teachers while teaching in standardized instructional situations (M-Teach) and while teaching in classroom were recorded and analyzed with regard to fixation frequency and fixation duration. According to assumptions of expertise research, the results show that preservice teachers strongly differ in their focus of attention. Furthermore, they show that preservice teachers distribute their attention only over a few pupils while teaching. The findings provide important implications with regard to the question how to support attentional processes even at an early stage of professional development, for example by observing own MET videos.

Keywords Eye-tracking · Teacher Attention · Professional Vision · Teacher Education · Video

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Wohin blicken Lehramtsstudierende beim Unterrichten? Eine Eyetracking Studie zu Aufmerksamkeitsprozessen in unterschiedlichen Lehrsetting

Zusammenfassung Die Untersuchung von Aufmerksamkeitsprozessen aus der Perspektive der Handelnden beim Unterrichten ist in der Forschung zur Professionellen Unterrichtswahrnehmung bisher weitgehend unberücksichtigt. In dieser Studie werden daher die Blickbewegungen von Lehramtsstudierenden mit Hilfe von mobilem Eyetracking (MET) untersucht. Während des Unterrichtens in standardisierten Lehrsettings (M-Teach) sowie im Klassenunterricht wurden die Blickbewegungen von $N = 7$ Studierenden aufgezeichnet und Fixierungshäufigkeit und -dauer analysiert. Entsprechend der Annahmen aus der Expertiseforschung zeigt sich, dass Lehramtsstudierende große interindividuelle Unterschiede im Fokus ihrer Aufmerksamkeit aufweisen und diese vorrangig auf einzelne Lernende richten. Die Ergebnisse liefern wichtige Implikationen für die Frage wie Aufmerksamkeitsprozesse bereits zu Beginn der Ausbildung, zum Beispiel durch das Beobachten eigener MET-Videos, geschult werden können.

Schlüsselwörter Eye-tracking · Lehreraufmerksamkeit · Professional Vision · Lehrerausbildung · Video

1 Introduction

In university-based initial teacher education it is payed more and more attention to the development of preservice teachers' professional vision (Wiens et al. 2013; König et al. 2014; Seidel and Stürmer 2014). With the concept, skills are defined with regard to identifying what is important within a complex classroom setting, and to then make a connection between identified events and broader teaching and learning principles by interpreting what is observed (van Es and Sherin 2002). Professional vision is used as an indicator for describing knowledge representations that prepare effective teaching action within the classroom (Berliner 1991; Palmer et al. 2005; Sherin 2007). In this vein, Kersting and colleagues, for example, have shown that a distinct professional vision is closely related to teachers own teaching practice and instructional quality (Kersting et al. 2012). However, professional vision is not seen as innate; rather it is described as a set of skills which develop over time as (future) teachers learn to perceive classroom events and arrive at meaningful interpretations of their perception based on the acquirement of conceptual knowledge about effective teaching and learning (Seidel and Stürmer 2014; Wolff et al. 2016). Dewey (1965) already pointed out that knowing what to look for and knowing how to interpret it constitutes a crucial part of expertise. Also Grossman (Grossman et al. 2009) mentioned – in comparing different professions – that learning to see and to interpret the relevant elements of practice constitutes a crucial part of professional development.

In teacher education, videotaped classroom situations are used as prompts to elicit preservice teachers' knowledge and to assess their professional vision skills (Seidel and Stürmer 2014; Steffensky et al. 2015; Stürmer and Seidel 2015). Furthermore, researchers and teacher educators have been more and more successful in designing instructional principles for supporting the development of professional vision skills based on learning with video, showing in the video the observers' own teaching or that of others (Star and Strickland 2008; Seidel et al. 2013; Yeh and Santagata 2015). A comparison with other forms of reflection about classroom teaching shows that video-based reflections results in more differentiated and content specific professional vision skills und enables preservice teachers to achieve higher levels of deep conceptual understanding (Rosaen et al. 2008; Rich and Hannafin 2009; Baechler et al. 2013).

Although, videotaped classroom situations constitute an innovative tool to study and support preservice teachers' professional vision, preservice teachers' processes of attention are investigated in the current approaches when they observe themselves or another person while teaching. They take an observer perspective from "outside of the situation" with a more or less predefined cutout and focus (i. e. teacher) on the classroom events. As Sherin et al. stated (2008), the view from outside of an situation might represent a somewhat different view of what one sees when the same person is within the situation (Sherin et al. 2008). Furthermore, the assessed processes of attention are detached from the requirement to actually act within the complexity of classroom events. Processes of attention – for example while teaching – "in the moment demands" of classroom action were mostly neglected in previous professional vision research, but could be seen as a promising supplement and resource for professional vision research and teacher education (Sherin et al. 2008).

In this vein, mobile eye-tracking technology (MET) provides the opportunity to capture attentional processes while teaching. With MET researchers are able to record and videotape the eye movements of preservice teachers while they act within the classroom. By using this data in supporting preservice teachers' professional vision development, first studies show that self-related cognition can be reduced and the focus of reflection can be changed towards students when watching own teaching with MET videos (Cortina et al. 2015, n.d.).

However, as MET technology is quite a young field, an important question is, whether eye movements while teaching constitute a part of attentional processes indicating teaching expertise and thus, could be conveyed to preservice teachers' education in order to facilitate skill acquisition in professional vision. Findings from expertise research using stationary eye-tracking technology reveal systematic differences in experienced teachers' and novice teachers' eye movements when they look at pictures showing classroom situations or when they observe videotaped classroom events. These studies show that novice teachers in comparison to experienced teachers have difficulties to focus their attention on relevant information in the classroom and to distribute their attention across pupils according to the requirements of supporting effective teaching and learning processes (van den Bogert et al. 2013; Yamamoto and Imai-Matsumura 2015). However, a replication of previous findings regarding preservice teachers' attentional processes while teaching and using MET constitutes a desideratum.

When it comes to assess preservice teachers' eye movements while teaching, a second critical aspect has to be pointed out: There are only a few opportunities in the context of university-based teacher education for preservice teachers to experience real teaching in classroom. In response to this challenge, the implementation of standardized teaching situations (such as micro teaching) into teacher education programs is seen as an innovative tool to study and support preservice teachers' professional development towards effective classroom practice (Grossman et al. 2009; Seidel et al. 2015). First studies show that such standardized teaching situation constitute a suitable approach to capture preservice teachers' initial teaching skills in a valid way (Seidel et al. 2015). The question – however – arises whether in standardized teaching situations preservice teachers' eye-movements constitute an indicator for professional processes of attention while teaching.

Against this background, we investigate in a first explorative approach 1) whether preservice teachers eye movements while teaching in standardized teaching situation at university correspond to the characteristics of novice teachers' attentional processes pointed out by previous eye-tracking studies, in which eye-movements of experienced and unexperienced teachers' were compared while they observe teaching. Furthermore, we 2) study whether the assessed eye movements of preservice teachers in standardized teaching situations show similarities to those while teaching in a real classroom. With this study, we aim to provide an important foundation for further explorations with regard to study eye movements while teaching as part of attentional processes indicating teaching expertise (i. e. expert/novice comparison in standardized teaching situations). In turn, this could be transferred to preservice teachers' education in order to facilitate the acquisition of professional vision while teaching.

1.1 Eye movement tracking as indicator of professional expertise in teaching

The approach to use attention processes as indicator for expertise in a certain domain is not a new one (Berliner 1988; Palmer et al. 2005). In many domains, expert performance also comprises attentional skills, that is, the ability to perceive the relevant out of irrelevant information in complex, highly visual stimuli and to draw inferences based upon the perceived information (Jarodzka et al. 2010). Experts have well-organized and structured schemata of concepts in their domain (Chi et al. 1982). In the teaching context the cognitive structure allows them, for example, to apply their knowledge to the highly varied and amorphous set of phenomena that occur simultaneously within the classroom (Borko 2004; Sherin et al. 2011). In using video observation and assessing what and how (future) teachers recall classroom situations, expertise research has shown that experienced teachers are more capable of identifying critical classroom events and classifying and interpreting these events (Palmer et al. 2005). They recognize the patterns of an observed situation with regard to its meaning for student learning and thus are more capable of predicting students' achievement levels than novices (Berliner 2001; Seidel and Prenzel 2007). In contrast, novice teachers mainly describe what happened in the classroom (Hammerness et al. 2002), have difficulties focusing on students' (rather than on teachers') actions, and tend to view lessons merely as chronological but disconnected sequences of events (Borko et al. 2008; Kersting 2008; Sherin and van Es 2009).

MET technology allows to extent previous research about attentional skills by the investigation of eye movements. Eye movements represent a person's cognitive focus on environmental information (Cortina et al. 2015) and provide insights into the processes of information selection (Gegenfurtner and Seppanen 2013). For example, studies from different domains (i. e. arts, chess) using eye-tracking technology supported findings by Glaser and Chi (1988) who have shown that experts process relevant environmental information faster than novices. By comparing the eye movement of experts and novices while looking at fixed pictures it is demonstrated that experts' gazes on relevant information have a higher density and frequency (Antes and Kristjanson 1991; Charness et al. 2001). Jarodzka and colleagues found similar findings when showing people dynamic stimuli (Jarodzka et al. 2010).

When it comes to the teaching context, studies which investigated eye movements while observing videotaped classroom situations with the focus on classroom management, provide first insights into experienced and novice teachers attentional processes. The studies show that novice teachers in comparison to experienced teachers have difficulties to *focus their attention* on relevant information in the classroom and to *distribute their attention* across pupils according to the requirements of supporting effective teaching and learning processes. Van den Bogert et al. (2013) for example compared 20 experienced secondary school teachers with 20 secondary school student-teachers. They were shown short video fragments in which the camera was directed at the pupils. Participants were asked to identify classroom management issues in the video that either demanded their immediate attention or did not require immediate attention. With regard to the distribution of attention, the authors found that experienced teachers checked up on pupils more regularly and were able to distribute their attention with regard to fixation frequency of their gazes evenly across the classroom. The ability to monitor all pupils in the classroom is regarded as an important aspect of effective teaching as it constitutes a prerequisite for the recognition of the relevant needs for learning of each individual in the classroom (i. e. Cortina et al. 2015). A second difference in experienced and unexperienced teachers' distribution of attention is pointed out by Yamamoto and Imai-Matsumura (2015). They found that the higher fixation duration of eye movements on individual pupils showed by experienced teachers is related to the identification of aspects in pupils that occur as relevant for the learning processes in classroom, (misbehaving pupils in situations that are relevant for learning processes). With regard to the focus of attention, the studies from van den Bogert et al. (2013) as well as Wolff et al. (2016) reveal that unexperienced teachers in comparison to experienced teachers more frequently focus on non-relevant information regarding classroom management. Furthermore, the results of previous eye-tracking studies imply some general characteristics of unexperienced teachers' eye movements: Student-teachers showed a higher variance in the frequency and fixation duration of their eye movements than experienced teachers (Wolff et al. 2016) and experienced teachers processed visual information faster (van den Bogert et al. 2013).

As stated above, the studies in the teaching context that have been conducted so far capture eye movements while observing teaching, but not while teaching. The question arises to what extent the findings regarding preservice teachers' eye movements could indeed be conveyed to their attentional processes while own teaching.

A first study using MET is provided by Cortina et al. (2015). The authors compared 12 teacher pairs: 12 experienced teachers with their 12 student teachers who taught the same class. With regard to the distribution of attention, they analyzed the ability to monitor the classroom. The authors found that the student teachers other than the experienced teachers distributed their attention across a few pupils. This study provides first evidence regarding expert-novice differences in eye movements while teaching and thus, with regard to the assumption that eye movements constitutes a crucial part of attentional processes which indicate teaching expertise.

1.2 Investigating eye movement in pre-service teachers' own teaching

To investigate eye movement in teaching action is a quite novel approach which faces several challenges. Conducting MET studies in the ecological context of classrooms – like the study of Cortina and colleagues – still could be seen as an extensive undertaking, especially with regard to comparable conditions for studying attentional processes. Furthermore, researchers have to take into account that the few real teaching experiences of preservice teachers within university-based teacher education are characterized as highly complex and challenging. This might distort the actual, systematic view on their attentional processes in action.

In this vein, a new innovative approach in university-based teacher education is, to come back to the idea to provide simulated "training" situations in the low-stake environment of a university (Seidel et al. 2015). Such simulated situations are typically implemented in the educational programs of other professions like in pilot or medical education to support university students in acquiring complex competencies such as landing an aircraft (Landriscina 2011; Al-Kadi and Donnon 2013). Also, within initial teacher education a quite positive effect of simulated "training" situations in the form of micro teaching was found with regard to pupils' learning outcome (Hattie 2008). Regarding the current understanding of professional teacher learning as the acquisition of complex teaching competencies to be applied variably to different teaching situations, such teaching situations are characterized and designed as so-called approximations of practice. The Approximation-of-Practice (AoP) framework provides a model for the integration of acquiring professional knowledge and professional practice (Grossman et al. 2009). Most importantly, it demonstrates that the acquisition of a professional practice requires more than one's teaching practice in classrooms and the procedural training of certain skills. Rather, it is characterized by the context-based, reflective interplay of professional knowledge acquisition as well as the organization and integration of this knowledge. Because classroom teaching is a highly complex and dynamic process, university-based teacher education has to draw on authentic representations of practice, which illustrate relevant elements of the real job and enable preservice teachers to link their knowledge to multiple contexts of practice. It has to decompose the complexity of teaching practice in crucial parts in order to help preservice teachers in understanding what constitutes effective teaching practice. In this vein, professional educators can help preservice teachers learn to attend the essential elements of practice and then to enact them, for example by a series of approximations to practice (i. e. simulated situation), which increase in complexity (Grossman et al. 2009). Although, such situation are decomposed with regard to their representation of practice, they still have to allow participants to experience the authentic nature of teaching (Shavelson 2012).

In our study, we draw on the so called M-Teach situations which have been developed within the teacher education program of the Technical University of Munich and which have been shown to be a valid tool to capture preservice teachers' first teaching skills (Seidel et al. 2015). The M-Teach situations focus on the standardized assessment of preservice teachers' actions, including planning, performing, and self-reflection with regard to structuring and supporting learning as relevant teaching and learning components. In order to provide situations with reduced complexity, preservice teachers were asked to teach a small group of four simulated learners (1:4). The M-Teach situations had a reduced instruction time of 20 min; 40 min were allotted for planning, and 10 min for reflection afterwards. To ensure that the preservice teachers' prior knowledge is comparable and that the teaching settings could be implemented in a variety of teacher education programs, the teaching focus lay on two instructional topics: (1) teaching strategies for a tactical game (Monopoly); (2) finding the most advantageous ticket in Munich's public transport system. The topics are generic in nature and unrelated to school subjects, but constitute relevant issues for preservice teachers' personal lives and are regarded as motivating. Preservice teachers receive a standardized instruction task, which encouraged them to focus on goal clarity and teacher support in their teaching. Furthermore, they receive an introduction to the teaching setting, and information regarding their diverse learner group. Information is also provided on the available teaching material. In order to ensure authentic and comparable conditions, trained students acted as simulated diverse learners. The acting scripts are based on diverse student profiles, as identified in a large national video study (Seidel 2006) and which take into account differences in student characteristics with regard to cognitive and motivational-affective characteristics. Four different student profiles are implemented in the two M-Teach situations: a *strong profile* (high pre-requisites with regard to cognitive abilities, prior knowledge, self-concept, and interest); an *underestimating profile* (high cognitive abilities and knowledge, low self-concept, intermediate level of interest); an *uninterested* profile (mixed cognitive abilities, low interest); and a *struggling profile* (low cognitive ability, knowledge, and self-concept). In the acting scripts background information about each profile are provided. The information refers to the cognitive and motivational-affective characteristics (i. e. "Susi is not interested in the topic") as well as observable behavioral indicators which are related to those characteristics as pointed out by video studies (i. e. "Susi is often sidetracked in the classroom, for example by playing with her cell phone"). In a training situation, students were taught to play their role of learner with regard to observable behavioral indicators. However, they were also trained to keep up an authentic situation by being adaptive in their behavior with regard to the learning environment that the teaching preservice teachers provided. With regard to the fidelity of the M-Teach situation, a study with acting preservice teachers, simulated learners and experts who observed the situations showed that the teaching settings constitute an authentic teaching experience (Seidel et al. in press). In a study with 89 participants it has been shown that the performances of preservice teachers were distributed from a mainly low/medium skill level to a high skill level in some students. Furthermore, preservice teachers' skills to supporting student learning and structuring a teaching unit in the M-Teach situations were highly correlated with their teaching skills when teaching in a real classroom (Seidel et al. 2015). Thus, the M-Teach situations could be seen as a valid environment to capture preservice teachers teaching skills in action. However, the question arises whether such standardized situations are also suitable to represent preservice teachers' professional vision in action.

1.3 Research questions

With this explorative study, we aim to investigate eye movements while teaching as part of attentional processes indicating teaching expertise, which could be conveyed to preservice teachers' education in order to facilitate the acquisition of professional vision. Therefore, we use a new approach as twofold: First, to study preservice teachers' eye movements while teaching with MET in standardized teaching situations. Second, to align the eye movements while teaching in such situations with previous findings from eye-tracking research capturing eye movements while observing teaching as well as with eye movements while teaching in the classroom. Previous research has shown that novice teachers have difficulties to focus their attention on relevant information in the classroom and to distribute their attention across pupils according to the requirements of supporting effective teaching and learning processes. For this reason, we address the following research questions:

1. *On what do preservice teachers focus their attention while teaching in M-Teach situations?*
   As the M-Teach situations are reduced in their complexity, we assume that preservice teachers focus their attention mainly to the simulated learner. However, according to findings from expertise research, we hypothesize great variance and rapidly changeovers in preservice teachers' eye movements.
2. *How do preservice teachers distribute their attention while teaching in M-Teach situations across the simulated learners?*
   According to findings that have been shown with fixed eye-tracking technology so far, we assume that preservice teachers' struggle in distributing their attention evenly across the four simulated learner.
3. *Are there similarities for focus and distribution of attention while teaching in the M-Teach situations and in the real classroom?*
   As attention process constitute an indicator for professional development, we hypothesize similarities in preservice teachers' eye movements while teaching in both teaching settings.

2 Methods

2.1 Sample

The study is based on a subsample of a full cohort of preservice teachers from the teacher education program of the Technical University of Munich (TUM). The program focuses on training preservice teachers to teach mathematics and science at secondary school (Gröschner and Seidel 2012). In the program university-based courses for preservice teachers are accompanied with short internship phases (two till three weeks) at school. The full cohort participated in their third year of the study program (winter term 2013) in the context of one university-based course in the M-Teach situations. At this point the cohort has already gathered some teaching experiences by passing three internships in schools and classrooms. Within the sample, preservice teachers were asked to voluntarily participate in the eye-tracking study. In total seven preservice teachers ($n = 5$ female) participated in the MET condition while teaching in the M-Teach situations (age: $M = 22.19$, $SD = 2.03$; semester: $M = 4.61$, $SD = 1.27$). Out of this subsample four preservice teachers also used MET while teaching in a real classroom. Therefore, they went back to their internship school and taught a class they had already been acquainted with the year before during their internship.

2.2 Research design

The research design for the participating teachers in the MET condition was the same as for the rest of the participating cohort. In the context of a research course, the students of the cohort first participated in the research project. In the second half of the semester, the instructors explained the research design, the background and methods used in this study in order to help the students understand basic principles of research in teacher education. The participation in the research study included teaching a small-group in the M-Teach events. In this context, the participating students came to the research team at a fixed appointment. The M-Teach events comprised a planning, teaching and reflection phase. In the planning phase, the preservice students were given the topic of teaching (tactical game, public transportation system) and they had 40 min to prepare teaching the topic to a diverse learner group of four students. In order to prepare they were given all necessary teaching material (game/information on transport system, flip chart, pens, etc.). After 40 min they were asked to go to the next room in which four students (as simulated learners) were waiting for them. The teaching phase comprised 20 min of instruction. In these 20 min the preservice teachers in the MET condition were wearing the mobile eye-tracking device (SMI – SensoMotoric Instruments) and their gazes were recorded. In addition, the teaching setting was recorded with a fixed digital video camera standing in the back. The four simulated learners always sat in the same order at a table (the strong and underestimated profile in the front, the uninterested and weak profile in the back). The blackboard was assembled in front of the table (see Fig. 1). For the subsample of four students being recorded in the classroom, two digital video cameras were used in addition to wearing the MET device.

The MET device integrates in real time data of the location of preservice teachers' right pupil and the current visual field. The system consists of a pair of glasses containing infrared recording device and a small digital camera. A cable transmits the data to a recording unit that the preservice teachers wore in a small pack around the hips. With the MET device preservice teachers' fixations are recorded which are assumed to be a necessary condition for cognitive processing of visual information

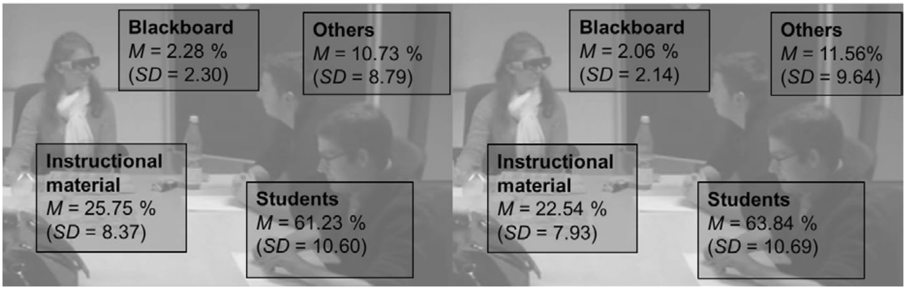

Fig. 1 Percentage ratio of fixation frequency and duration of total fixation scores per AOI

(Cortina et al. 2015). The fixations represent gaze-points which fall within a by the system predefined radius and show a certain duration.

The MET glasses look like regular glasses and are easy in her weight. Preservice teachers were able to move around in the M-Teach situations or classrooms in a completely free way. First experiences with the MET system in school classrooms have shown that pupils start to forget about the MET glasses after a few minutes (Cortina et al., submitted). Before recording preservice teachers eye movements in our study, we additionally explained the system and provided time to get familiar with wearing the glasses. In the classroom the pupils also had the opportunity to ask questions about the MET device.

2.3 Analysis of MET data

Prior to eye-tracking data analysis, we defined so called Areas of Interest (AOIs). We coded the AOIs with the SMI software in the MET videos. For both teaching settings (M-Teach and classroom), we marked four AOIs that could be assumed to be the main components in both settings: "blackboard", "instructional material", "students" and an "others" category (see Fig. 1). This procedure is necessary for assigning each fixation to an AOI, which allows the eye-tracking software to compute the desired metrics like fixation frequency and fixation duration.

With regard to our first research question, we were interested in preservice teachers' focus of attention while teaching in the M-Teach situations. Therefore, we analyzed how often and for how long preservice teachers' gazes at an AOI. Although, preservice teachers had a predefined timespan of 20 min for teaching, the total number of fixations (M = 2534.43, SD = 486.41) as well as duration of fixation (M = 518,720.71 ms, SD = 121422.12 ms) varied between students. Therefore, we calculated the percentage ratio of fixation frequency and duration per AOI with regard to preservice teachers' total fixation scores. Regarding the question how often preservice teachers switched their focus between the four AOIs, we summarized each fixation to AOI events (M = 495.00, SD = 209.91) and analyzed the time and the combination between occurring AOI events.

To answer our second research question – how do preservice teachers distribute their attention while teaching in M-Teach situations across learners – we only concentrated on data of the defined AOI "students". In a first step, we were interested in preservice teachers' skills to monitor the four learners. Therefore, we ranked the scores for total fixation frequency per learner (regardless the simulated profile the learner represents) for each participating preservice teacher in descending order. This method is suggested by van den Bogert and colleagues (2013) for receiving insights into the distribution of gazes' frequency across the four learners by plotting these data. In a second step, we calculated for each preservice teacher how long he or she in total gazed at each simulated learner. This analysis provides insight into the question how the preservice teachers attend to students with a certain profile.

Regarding our third research question, – detecting similarities in preservice teachers' eye movements while teaching in the standardized teaching situations and in the classroom – we analyzed the focus and distribution of preservice teachers' attention while teaching in the classroom in the same way like we did for the eye movements while teaching in the M-Teach situations. However, as the classrooms in which the preservice teachers taught, constitutes a different setting as the M-Teach situations, we only concentrate on aspects which allow in some ways comparisons. Regarding the focus of attention, we again calculated the percentage ratio of fixation frequency and duration per AOI with regard to total fixations scores (total number of fixations $M = 6886.25$, $SD = 718.53$, total duration of fixation $M = 1{,}439{,}613.25$ ms, $SD = 265{,}861.36$ ms). We compared preservice teachers' data in both teaching settings regarding their focus of attention by using the non-parametric Wilcoxon test. As preservice teachers taught different classes, the distribution of attention over the learners is hardly to compare. However, in order to receive first insights in preservice skills to monitor their pupils, we ranked the scores for total fixation frequency per pupil in descending order and displayed the first 10 ranks for each preservice teacher.

3 Results

3.1 Preservice teachers' focus of attention in M-Teach

Regarding the question on what preservice teachers focus their attention while teaching in M-Teach situations, Fig. 1 represents the average of preservice teachers' fixation frequency and fixation duration for each defined AOI. These descriptive findings illustrate that preservice teachers most frequently gazed on the simulated learners, followed by the instructional material. Also with regard to fixation duration, preservice teachers spent the longest time spans on the learners, again followed by the instructional material. However, when taking the high standard deviation into account, the results indicate strong intra-individual differences between preservice teachers.

When analyzing the switchover between AOI events, we found that preservice teachers' eye movements skip between the AOI "students" and "instructional material" ($M = 45.31$, $SD = 18.21$) and between individual students ($M = 36.02$, $SD = 17.01$). Thereby, preservice teachers change their focus of attention (AOI) in average every $M = 1.48$ ($SD = 0.66$) second.

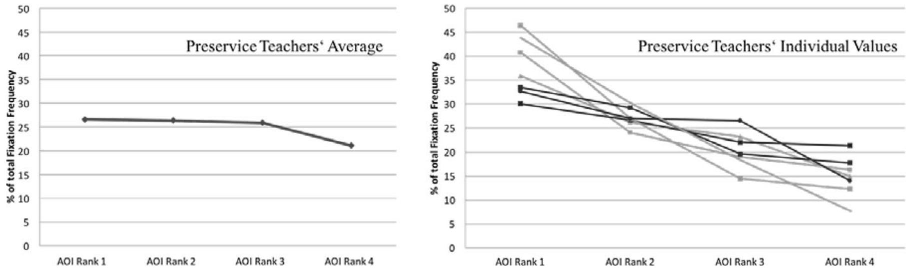

Fig. 2 Ranked scores for total fixation frequency per learner in M-Tech setting in descending order

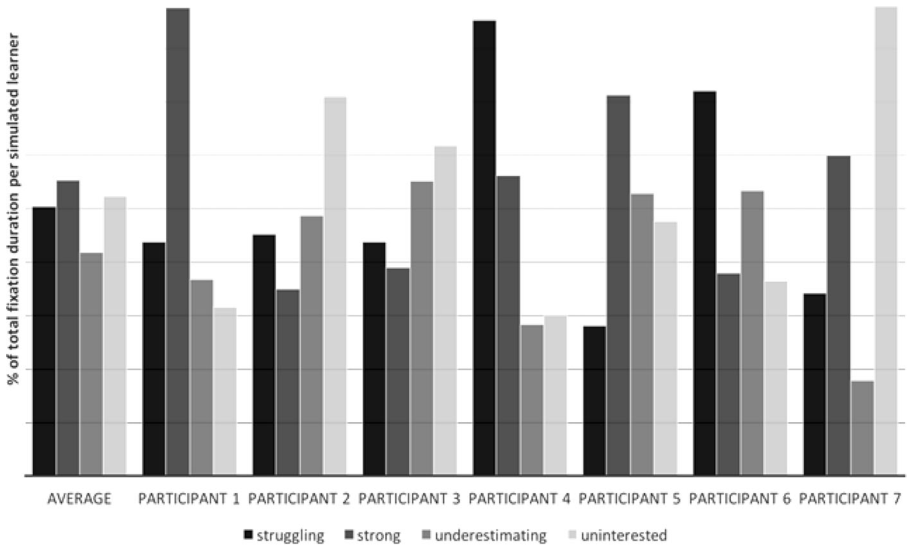

Fig. 3 Fixation Duration per simulated Learner Profile

3.2 Preservice teachers' distribution of attention in M-Teach

In a second step, we analyzed how preservice teachers distributed their attention across the simulated learners. Therefore, we focused on the question how evenly they distribute their attention across the four learners and for how long they gazed in total to each simulated profile. Fig. 2 illustrates the skills of preservice teachers to evenly monitor four learners. The graphs show the ranked scores for total fixation frequency per learner in descending order. An even distribution of gazes across learners would be illustrated by four nearly identical plotted ranks. With regard to preservice teachers' average of fixation frequency, it seems like preservice teachers distributed their attention quite evenly across all four learners (left graph). All four ranks are close to each other. However, taking into account the individual scores of each participant (right graph) high variability is demonstrated, with some preservice teachers being quite even in their distribution of attention while others show large differences between the four ranks.

Table 1 Preservice Teachers Focus of Attention in Both Teaching Settings

	M-Teach (%)	Classroom (%)	*p* (Wilcoxon)
Fixation Frequency			
AOI: Instructional Material	30.24 (6.98)	12.30 (7.11)	0.07
AOI: Blackboard	0.70 (0.98)	23.93 (8.60)	0.07
AOI: Others	7.87 (3.45)	13.76 (8.56)	0.14
AOI: Students	61.19 (9.52)	50.01 (10.34)	0.27
Fixation Duration			
AOI: Instructional Material	26.41 (7.89)	10.26 (6.18)	0.07
AOI: Blackboard	0.65 (7.89)	23.03 (7.59)	0.07
AOI: Others	8.63 (3.45)	13.00 (9.00)	0.07
AOI: Students	64.30 (9.51)	53.76 (9.64)	0.14
Fixation Frequency/Duration			
Time in seconds between AOI events	1.48 (0.66)	0.72 (0.19)	0.07

Standard deviation in parentless

A closer look at the fixation duration per simulated learner profile of each participant (Fig. 3) also shows that most preservice teachers spent most attention to one simulated learner profile. Thereby, it is quite different between the preservice teachers with which student profile they interact for the longest time. Taking for example participant 1: most of the time he or she gazed at the simulated learner with the strong profile. In comparison, participant 7 shows the highest fixation duration on the uninterested student profile.

3.3 Similarities between MET in M-Teach and classrooms

Keeping the question in mind whether M-Teach situations constitute a valid representation of practice to capture eye movements proximal to real teaching demands, we analyzed in a third step preservice teachers' focus and distribution of attention while teaching in real classrooms. As the four classrooms in which the participants taught were quite different, direct comparisons could hardly be provided. However, testing differences of preservice teachers' focus of attention on the described AOI in both settings and displaying the ranks of how they distribute their attention across pupils, constitutes a first insight into similarities of attentional processes. Table 1 represents the results of the non-parametric Wilcoxon test regarding preservice teachers' focus of attention in both settings. The test implies no significant differences between preservice teachers' focus of attention in both teaching settings. Although, there are some trends for differences: preservice teachers seem to gaze more often on the blackboard in classrooms than they do in the M-Teach situations. Furthermore, they seem to change their focus of attention (time between AOI events) faster in the classroom than in the standardized teaching situations.

Regarding preservice teachers' skills to monitor pupils in the classroom, the ranked scores for total fixation frequency per learner in descending order shows a similar picture than in the M-Teach situations (see Fig. 4). It seems that preservice teachers mainly distribute their attention across a few pupils (rank 1–5). However, the

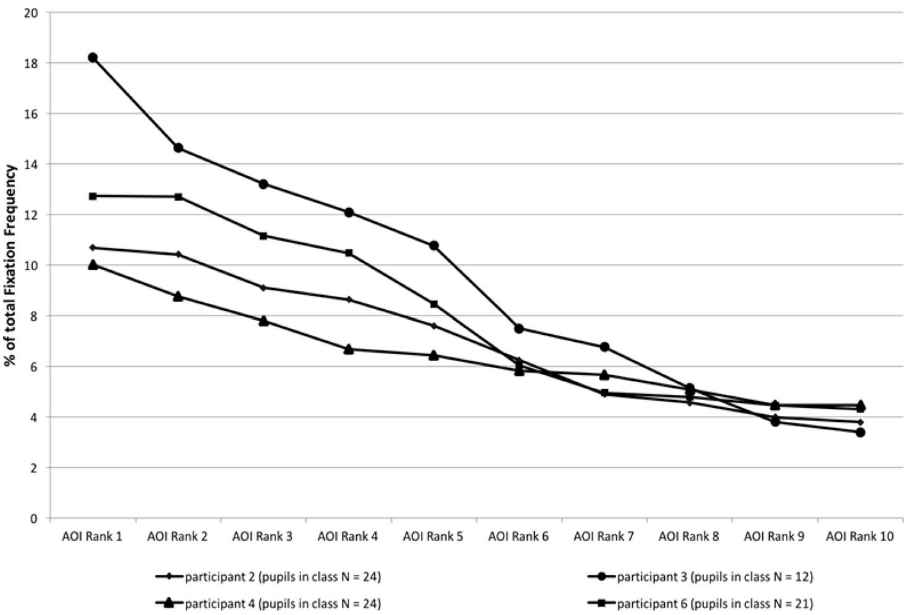

Fig. 4 Ranked scores for total fixation frequency per learner in classroom setting in descending order (first 10 ranks)

illustration also implies relevant intra-individual differences. Taking participant 3 as example, he or she most frequently gazed at one pupil by teaching in total 12 learners in the classroom. In contrast, participant 4 taught 24 pupils, but was able to distribute the attention quite evenly across a larger group of learners.

4 Discussion

The skills to perceive the relevant out of irrelevant information in the complex setting of a classroom and to arrive at meaningful interpretations of the selected information constitutes a crucial part of teacher expertise (van Es and Sherin 2002; Grossman et al. 2009). As previous research mainly used the observation of video-taped classroom situations to study and support such skills, we aimed with this study to offer first insights concerning the nature of preservice teachers' attention processes as part of professional vision in action (Sherin et al. 2008). Therefore, we studied preservice teachers' eye movements while teaching by using MET. As recent research has shown, eye movements can be used to compare attentional processes of expert and novice teachers when observing teaching (van den Bogert et al. 2013; Wolf et al. 2016). However, the question arises whether such processes could be replicated with regard to preservice teachers' attentional processes while teaching and not observing teaching and could also be conveyed to teacher education with the longer-term objective to facilitate skill acquisition in professional vision. As preservice teachers have only few opportunities for teaching in the real classroom within initial, university-based teacher education and standardized conditions for investigating attentional process are barley given with regard to their first teaching experiences, we focused on preservice teaching in a standardized simulated teaching (M-Teach) event as a form of approximation-of-practice (Grossman et al. 2009). Previous research comparing teaching performance in M-Teach with teaching in classrooms indicates that preservice teachers initial teaching skills are quite validly captured within such approximations-of-practice (Seidel et al. 2015). However, to focus on preservice teachers' attentional processes is a new approach. In this vein, we were in a first explorative approach interested to what extent we were able to replicate previous findings of expertise research about novices in preservice teachers' eye movements while teaching in the M-Teach situation and whether we find similarities with their attentional processes while teaching in the classroom. We see in this study an important foundation for further explorations with regard to study eye movements while teaching as part of attentional processes indicating teaching expertise, for example to compare eye movements of experienced and unexperienced teachers under standardized conditions in the M-Teach situations.

Findings of previous eye-tracking research using stationary technologies reveal that novice teachers have difficulties to *focus their attention* on relevant information in the classroom and show a higher variance within their group than experienced teachers (van den Bogert et al. 2013; Wolf et al. 2016). Although, we found that preservice teachers focused in the M-Teach situation more frequently on the simulated learners, we also found high standard deviations between them as well as a short time between the switchovers of gazes from one AOI to another. In line with previous findings is the result that the preservice teachers more frequently skipped their attention between the simulated learner and their instructional material. Thus, our results in the M-Teach situations goes align with findings regarding preservice teachers' eye movements when observing teaching on a picture or in a video. In addition, the comparison of MET between M-Teach and classroom teaching indicate similarities regarding the focus of attention in both situations. These results provide additional insights into preservice teachers cognitive focusing and selection on and of classroom information (Cortina et al. 2015; Gegenfurtner and Seppanen 2013). However, further research has to show how preservice teacher process the information, for example when rapidly switching between students and instructional material. We see a promising approach in showing preservice teachers' their MET videos and use the "think-aloud" method to study in more detail the extent to which relevant information in the teaching settings are processed (cf. Cortina et al. n.d.).

A second prominent result from expertise research is that preservice teachers have difficulties to *distribute their attention* evenly across pupils and to align eye movements with regard to fixation duration to the learning relevant requirements of individual pupils (van den Bogert et al. 2013; Yamamoto and Imai-Matsumura 2015). Regarding preservice teachers' attentional processes while teaching in the M-Teach situations, we found similar results. Even when teaching only four learners, preservice teachers in this study show the highest fixation frequency on one simulated learner; meaning a low ability of preservice teachers to monitor all the learners. One might assume that preservice teachers' more often gaze on learners who require more attention (i. e. struggling or uninterested profile). However, our results also indicate substantial differences in attentional processes between preservice teachers with regard to the kind of focused simulated student profile (strong, struggling, uninterested, underestimating). However, the results do not provide insights into the interactions between the preservice teacher and the learners preceding the gazes. The results only illustrate differences between preservice teachers' attention on learners in a standardized teaching setting, which implies different teacher-learner interactions. For this reason, further analyses will be applied in order to investigate the interrelationships between gazes and pre- as well as subsequent verbal interactions. One might assume that preservice teachers, for example, react in their attentional processes to the learning relevant needs of individual pupils (i. e. learners who have difficulties). However, research has shown for example, a high variability in teachers' ability to judge learners with regard to their cognitive characteristics (Südkamp et al. 2012). In this vein, studying the interaction on which the eye movements are based on, seems to be a promising approach for providing further insights into preservice teachers' professional vision in action. Furthermore, we regard the investigation of individual characteristics (cognitive and motivational-affective) in relation to teacher-learner interaction as valuable addition in order to study the differences in gaze patterns.

Regarding the question whether eye movements while teaching as part of attentional processes indicate teaching expertise, which could be conveyed to preservice teachers' education in order to facilitate the acquisition of professional vision, the results of our explorative study could be interpreted twofold. First, the findings provide first indications for a replication of previous results by using this new methodological approach. However, further indicators for preservice teachers' professional development are required to ensure the validity of the identified attentional processes. In this vein, it seems also worthy to analyze the relation between preservice teachers teaching skills in action and their professional vision in action. Second, the results regarding high variability among preservice teachers confirm once again that novices need instructional support in learning to focus on relevant information in classroom and to distribute their attention across pupils according to the requirements of supporting effective teaching and learning processes. We see in the use of the MET videos a worthy supplement to the current approaches in professional vision research. As Cortina and colleagues have shown, the focus of preservice teachers' reflection can be changed towards learners when watching own teaching with MET videos (Cortina et al. 2015, n.d.). However, research in this field is still in its beginnings and requires further approaches focusing on the questions how to implement MET data into university-based teacher education for fostering professional vision and teaching action.

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