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Through Teachers' Eyes: An Eye-Tracking Study of Classroom Interactions

Abstract: Selective attention to classroom events is an important part of classroom management and teachers' decision-making in the classroom. The present study investigates selective attention to classroom events in the context of teacher education. The study participants were junior ($n = 43$) and senior pre-service teachers ($n = 46$) and experienced in-service teachers ($n = 17$). Their eye movements were explored as objective measures of selective attention while watching video sequences from structured, semi-structured and low-structured classroom situations. The analyses revealed significant differences in the perception of classroom events across the career cycle, especially in semi-structured situations when disruptive behaviour occurs. More experienced teachers encountered a lower number of shorter fixations, which supports the hypothesis of information reduction. Senior pre-service teachers, who had passed a teaching practicum and a classroom management course, seemed to use different professional vision patterns from those of less experienced junior pre-service teachers.

Keywords: professional vision, teacher training, pre-service teachers, in-service teachers, classroom interactions, classroom management, eye-tracking

UDC: 37.091.12

Scientific article

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Introduction

The perception and cognitive processing of classroom interactions are an important part of teachers' classroom management skills (Dessus et al. 2016; van den Bogert et al. 2014). Classroom management (including monitoring and managing classroom events, rules and routines) and learning support (including cognitive activation and the structuring of content) are important dimensions of instructional quality. Classroom management is considered a content-independent aspect of instructional quality, while learning support is content or subject specific (Steffensky et al. 2015). Being content independent, classroom management skills can be studied across subject specializations. Teachers with effective classroom management are able to maintain a productive learning environment (O'Neill and Stephenson 2011). However, novice teachers often need support in terms of the development of classroom management and discipline techniques (O'Neill and Stephenson 2011; van Bogert et al. 2014).

Effective classroom management and discipline techniques require a set of cognitive scripts: a) identification, i.e. selective attention and the visual and initial cognitive processing of classroom events; b) interpretation, i.e. knowledge-based reasoning; and c) intervention, i.e. decision-making related to taking an action at a specific moment. Whereas intervention and interpretation techniques have been studied and relevant training in them has been provided (Martin and Shoho 2000; Martin et al. 2006; Nelsen and Gfroerer 2017; O'Neill and Stephenson 2011; Tauber 2007), in recent years, attention has also focused on the process of identifying and ability to determine the relevant classroom moments in order to understand the whole cycle of teachers' professional vision and reasoning.

Based on studies by Lefstein and Snell (2011), Sherin and van Es (2009) and others, the concept of professional vision can be defined as a teacher's ability to notice relevant classroom interactions for teaching and learning and to interpret them on the basis of scientific theories and reasoning. Teachers' professional vision of classroom management changes and develops as they progress from bachelor to master pre-service teachers and go on to become expert in-service teachers

(Gold and Holodyski 2017). However, regardless of career level, professional vision related to classroom management may also be affected by personality variables and emotional arousal when facing critical or challenging moments in the classroom (Tobin et al. 2016)

Researchers often use video sequences to examine teachers' noticing and visual perceptions of classroom events (Blomberg et al. 2011; Carter et al. 1988; Gaudin and Chalies 2015; Minaříková et al. 2015; Sherin and van Es 2009). Some authors (van den Bogert et al. 2014; Yamamoto and Imai-Matsumura 2013; Wolff et al. 2016) have implemented eye-tracking technology to get a deeper insight into the processes of teachers' selective attention. Eye-tracking technology offers insights into human attention and decision-making processes; as such, eye-tracking data have the potential to provide important information about teachers' behavioural patterns and cognitive processes in everyday classroom situations (Beach and McConnel 2019).

The history of eye-tracking technology dates back to 1879 (Rakoczi 2012), when French ophthalmologist Javal observed the naked eye (without any specific technology) and discovered that the human eye does not move smoothly across text when reading. An eye makes quick movements called saccades and short pauses in movement (the suppression of saccades) called fixations. The results of studies conducted in the 1960s revealed that the number and length of such fixations depend on the participant's interest and attention focus (Yarbus 1967). In other words, fixations are the periods of time when new information is acquired, while no information is retrieved by the brain during saccades (Frutos-Pascual and Garcia-Zapirain 2015; Rayner 2009). Eye-tracking technology can provide objective and quantitative evidence of an individual's visual and attentional processes (Duchowski 2002). This capacity is being widely used in diverse research contexts and scientific disciplines, including studies of the perceptual mechanisms of expert performance in various professions (Haider and Frensch 1999; Gegenfurtner et al. 2011).

Based on the meta-analysis of data from 1899 participants, Gegenfurtner et al. (2011) characterized and evaluated three theories that can explain the differences in professional vision and gaze patterns between experts and novices. The theory of long-term working memory (Ericsson and Kintsch 1995) assumes that expertise extends the ability to process information. Experienced participants process information more quickly, which can be reflected in shorter fixation durations. The information-reduction theory (Haider and Frensch 1999) assumes that experts learn to select relevant information. They neglect task-irrelevant information and focus on task-relevant information. This ability leads to fewer fixations of a shorter duration on task-redundant areas and more fixations of a longer duration on task-relevant areas. The holistic model theory (Kundel et al. 2007) explains the hypothesis of extended visual span. Based on this approach, experts should be able to extract information from widely distanced and parafoveal regions, which can be observed as longer saccade lengths and shorter times to their first fixations on task-relevant areas. These theories offer a framework for the further investigation and understanding of the development of professional

vision because each explains different aspects of visual processing within the professional domain.

The concept of expert vision was adopted by educational researchers, who aimed to analyse the visual patterns of pre-service or novice and expert teachers because »the added value of eye-tracking is that it can be used to study aspects of teachers' perception and cognition that are not accessible to conscious thought, and therefore do not show up in verbal reports« (van den Bogert et al. 2014, p. 215). According to Yamamoto and Imai-Matsumura (2013), no relationship exists between teaching experience and the ability to notice students' negative behaviour. They found that teachers who noticed students' misbehaviour fixated on target students more frequently and for longer. According to van den Bogert et al. (2014) and Wolff et al. (2016), more teaching experience leads to a different way of processing and reasoning with regard to classroom events. Based on the eye-tracking study conducted by Wolff et al. (2016), expert teachers are able to select relevant information from a situation and develop faster and more accurate conclusions. Eye-tracking studies of classroom management and professional vision often discuss the hypothesis of differences between novice and experienced teachers (Jarodzka et al. 2021; Lachner et al. 2016; McIntyre et al. 2017).

The aim of this study is to analyse vision data from pre-service and in-service teachers to understand the development of professional vision across career levels. Our goal is also to investigate the differences in vision patterns among junior pre-service teachers, senior pre-service teachers and experienced in-service teachers in different classroom situations and to evaluate the three theories mentioned above. We propose the following hypotheses:

More experienced teachers will process the information from classroom situations more quickly, which will be manifested in shorter fixation durations (the theory of long-term working memory; Ericsson and Kintsch 1995).

More experienced teachers will be able to select relevant information from the complex classroom context, which will be manifested in a lower number of fixations (the information-reduction theory; Haider and Frensch 1999).

More experienced teachers will be able to extract information from widely distanced and parafoveal regions of the classroom, which will be manifested in shorter times to their first fixations (the holistic model theory; Kundel et al. 2007).

Method

Participants

The study participants (N = 106) were 43 junior pre-service teachers, 46 senior pre-service teachers and 17 experienced in-service teachers. The average age of the teachers in the sample was 25.29 (SD = 7.16, min = 19, max = 55). Most of the participants were female (n = 95). At the time of data collection, the pre-service teachers were enrolled in the teacher training programme for secondary school teachers (for pupils from 11 to 19 years of age) at Comenius Universi-

ty in Bratislava, Slovakia. The junior pre-service teachers were recruited during their introductory psychology courses. They were in their second year of teacher training, which means that they had only passed introductory courses in psychology, pedagogy and their teaching subject. The senior pre-service teachers were in their final (fifth) year of training. At the time of data collection, they had passed a teaching practicum and a course on classroom management. The expert teachers were teaching at the lower or higher secondary school level (for pupils from 11 to 19 years of age). They had at least seven years of teaching experience. They were recruited via university contact lists. All the participants took part in the study voluntarily, without any financial or material reward. We treated all the participants in accordance with the American Psychological Association ethical guidelines (APA 2002) and GDPR regulations.

Test environment and procedure

The participants watched classroom videos on a computer screen while their eye movements were tracked and recorded. The testing room was equipped with 20 computers with eye trackers and headphones and twenty 24 monitors with 1920 x 1200 px screen resolution, which enabled multiple studies with identical conditions to be carried out at the same time. The eye movements were recorded using Tobii X2-60 eye trackers with a sampling frequency of 60 Hz. The participants took part in the study in eight groups; standardized conditions were implemented for each round of testing, including the light conditions and the video and sound quality, as well as the initial instruction and support.

Prior to the start of the test, the participants were informed of the procedure and purpose of the study. Subsequently, the eye-tracker calibration procedure was carried out, and the calibration of each participant was checked individually by a team member; only then could the participants start the session. All the participants watched the same four classroom videos in a random order. They were instructed to use headphones during this process. At the end of the session, they were debriefed and had the opportunity to ask questions about the procedure. The procedure was tested in a pilot study with 15 participants.

Stimulus video sequences

Classroom videos show »the complexity, simultaneity, immediacy, and unpredictability of real classroom situations« (Dutke et al. 2018, p. 371). Consequently, authentic classroom videos were used as stimulus material for this eye-tracking study. The videos were recorded in two state schools at the lower secondary level of education (the pupils were aged from 11 to 13). Parents and teachers gave their informed consent for recording the lessons and for using the recordings for the purposes of eye-tracking research and the further training of pre-service teachers. During the lessons, a static camera was placed in front of the class to simulate the

way the teacher commonly viewed the class; the researcher was not present in the classroom during the lessons. The stimulus sequences were selected from six hours and five minutes of recordings based on the reports of three independent expert coders. The selected sequences (15 minutes and 15 seconds) represented three types of situations based on the level of discipline in a classroom and the occurrence of disruptive incidents: a) a structured situation (sequence 1), where pupils were working on their tasks while being supervised by the teacher with a minimal level of disruptive behaviour; b) semi-structured situations (sequences 3 and 4), where pupils were completing a test while several pupils were acting inappropriately (clowning around, commenting, shouting, turning round, etc.); and c) a low-structured situation (sequence 2), where pupils were supposed to be watching an educational film but most of the class were not paying attention to it (instead they were talking, some pupils were moving around, etc.). The participants watched all four sequences in a random order. They were instructed to observe the sequences and then provide written comments on what they saw, i.e. a free-viewing task was applied as defined by Gegenfurtner et al. (2011). The participants watched the situations without any specific instructions.

Areas of interest (AOIs)

Classroom videos are a dynamic stimulus, which means that the objects (pupils) can move, change places, etc. Consequently, for each video sequence, several areas of interest (AOIs) were defined as dynamic polygons and key frames corresponding to a certain point on the timeline of the video sequence (Kurzahls and Weiskopf 2013). These key frames copied the movement and activity of groups of pupils in the classroom. AOIs were defined based on the analysis of video sequences carried out by three expert coders and the qualitative analysis of clusters from a pilot study with 15 participants realized prior to the testing. The coders watched the video sequences and identified individual pupils or groups of pupils with off-task or disruptive behaviour. Based on the inter-coder agreement, the AOIs were defined. They covered 22.01% to 27.76% of the recorded area. Van den Bogert et al. (2014) applied a similar approach to defining AOIs in teachers' professional vision research.

Data analysis

For the purpose of this study, the quantitative and qualitative participant-based (Kurzahls et al. 2017) analysis of eye-tracking data was performed. The recordings of eye movements were processed automatically in Tobii Studio 3.4.8, which allows the calculation of eye-movement metrics from dynamic AOIs. Fixations were calculated using an I-VT filter with a velocity threshold of 30 degrees/second. Interpolation was enabled up to a maximum gap length of 75 ms without noise reduction. An average eye gaze position was used. The window

length for the velocity calculator was 20 ms. Short fixations below 60 ms were discarded. Adjacent fixations within 75 ms and 0.5 degrees were merged. Five eye-movement metrics were collected as variables for further data analysis (see Table 1) based on the theories of professional vision mentioned above. With regard to the different sizes of individual AOIs, for further analysis, we normalized the number and duration of individual AOIs based on the area.

Variable	Variable definition
Fixation duration (FD) per AOI	Duration of each individual fixation within an AOI measured in seconds (the theory of long-term working memory).
Total fixation duration (FD) of all the AOIs	Duration of fixations within all the AOIs per media measured in seconds.
Fixation count (FC) per AOI	The number of times the participant fixated on an AOI (information reduction theory).
Total fixation count (FC) of all the AOIs	The number of times the participant fixated on all the AOIs per media.
Time to first fixation (TFF) per AOI	Time before each individual fixated on an AOI measured in seconds (holistic theory).

Table 1: List of the eye-movement variables and their definitions

Results

Fixation duration (Theory of long-term working memory)

The duration of each individual fixation within an AOI is measured in seconds; it is operationalized as a measure of the amount of attention paid to a given AOI. As the fixation duration data were not normally distributed, a non-parametric Kruskal-Wallis test was used to analyse differences in the fixation durations among all three groups of participants. The comparison of the fixation durations of all the AOIs per sequence across career levels did not reveal significant differences among the groups (see Figure 1 and Table 2). The average length of the fixations per sequence ranged from .288 seconds to .302 seconds among the junior pre-service teachers, from .261 seconds to .275 seconds among the senior pre-service teachers and from .265 seconds to .280 seconds among the in-service teachers. The most consistent fixation durations across the groups were found in sequence 2, which represented a low-structured classroom situation with several pupils behaving disruptively or inattentively. The junior pre-service teachers tended to fixate longer than their more experienced colleagues in all four types of classroom video sequence. The experienced in-service teachers tended to fixate on predefined AOIs for shorter periods of time than the pre-service teachers, and the junior pre-service teachers experienced longer fixations than the senior pre-service teachers. This trend was significant in eight AOIs of the semi-structured situations (sequences 3 and 4), in one AOI in the structured situation (sequence

1) and in one AOI in the low-structured situation (sequence 2), which displayed different types of classroom behaviour.

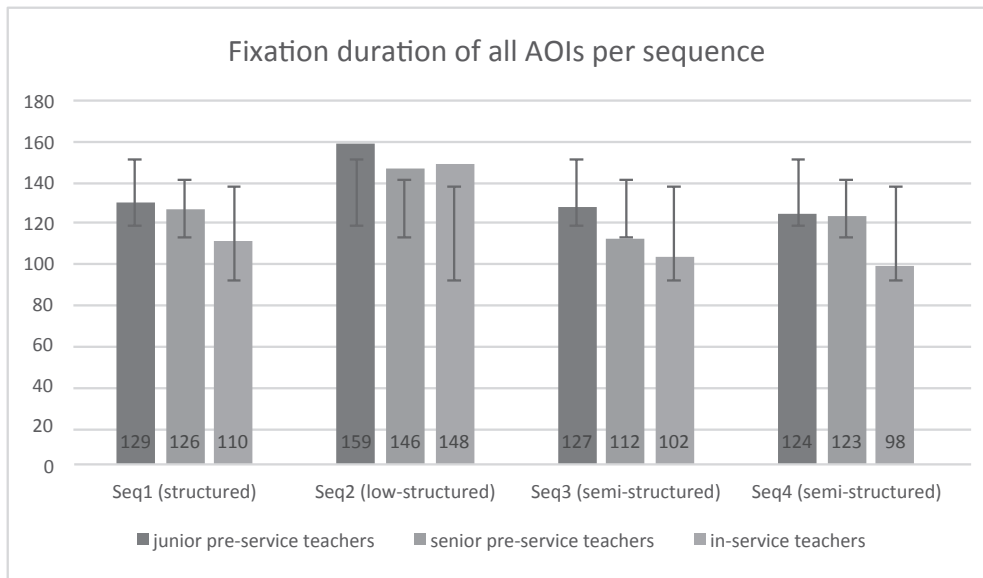


Figure 1: Average fixation durations and standard deviations of all the AOIs per sequence across career levels (in seconds)

In the structured situation (sequence 1), the difference in the fixation duration across career levels was significant (with a medium-sized effect) in AOI 2. One pupil was sitting at the back of the class; his behaviour was not disruptive. For part of the sequence, he was not writing like the other pupils; instead, he was watching something under the desk and seemed not to be paying attention. In the low-structured situation (sequence 2), we only found a significant difference in one area, AOI 6 (see Table 3), which showed pupils talking together.

In the semi-structured situations, significant differences with medium-sized effects were found in AOIs 5, 7, 8 and 13 (sequence 3) and 2, 6, 8 and 9 (sequence 4). The pupils involved were again sitting at the back of the class. They were not the main sources of disruptive behaviour in the classroom. In AOI 8 of sequence 3, a boy was hitting his desk while completing a test, and his neighbour slapped his hand. In AOI 7 of sequence 3, a girl was turning to her neighbour during the test and later threw a pen to a boy at the front of the classroom. In AOIs 8 and 9 in sequence 4, two boys were talking together during the test, rocking back and forth on their chairs and turning around. In AOI 6 of this sequence, a girl had turned around and was talking to a classmate. All these examples of classroom behaviour from semi-structured situations can be classified as disruptive or as breaking school rules.

		Seq1 AOI 2	Seq2 AOI 6	Seq3 AOI 5	Seq3 AOI 7	Seq3 AOI 8	Seq3 AOI 13	Seq4 AOI 2	Seq4 AOI 6	Seq4 AOI 8	Seq4 AOI 9
Junior pre- service teachers (n = 43)	M	.72	4.28	1.17	2.67	2.52	.41	.86	2.08	3.17	6.89
	SD	.72	2.00	.80	1.63	1.39	.24	.66	1.37	1.18	3.45
	Md	.59	4.15	1.16	2.66	2.14	.37	.74	2.10	3.23	7.00
	Var	.51	4.04	.64	2.65	1.94	.06	.43	1.87	1.40	11.87
	Kurt	20.86	1.35	3.82	.92	.97	-.44	-.27	.44	-.26	.40
	Skw	3.97	.67	1.23	.90	1.11	.52	.54	.67	-.31	.40
Senior pre- service teachers (n = 46)	M	.58	4.02	1.58	1.76	1.73	.47	1.05	2.28	2.91	6.52
	SD	.69	1.87	1.02	1.08	.92	.30	.72	1.40	1.38	3.12
	Md	.39	3.93	1.53	1.67	1.56	.44	1.14	1.91	2.64	6.08
	Var	.48	3.50	1.05	1.16	.85	.09	.51	1.95	1.89	9.70
	Kurt	14.88	1.35	.39	3.15	2.82	-.61	-.84	1.41	1.97	2.13
	Skw	3.25	.79	-.48	1.35	1.26	.38	.29	1.10	1.30	1.18
In-service teachers (n = 17)	M	.30	2.98	1.03	1.62	1.66	.30	.53	1.26	2.17	4.38
	SD	.28	1.36	.83	1.01	1.30	.29	.51	1.57	1.27	2.44
	Md	.32	2.76	.76	1.54	1.46	.27	.41	.87	2.07	4.63
	Var	.08	1.85	.69	1.02	1.69	.09	.26	2.47	1.61	4.63
	Kurt	-1.66	-.06	1.20	1.55	.31	7.44	-.91	9.90	-.79	-.64
	Skw	.29	.46	1.04	.83	.86	2.34	.65	2.89	.36	-.05
Total	M	2.02	3.96	1.33	2.10	2.04	.42	.90	2.04	2.90	6.35
	SD	2.26	1.90	.93	1.39	1.25	.28	.68	1.44	1.31	3.25
	Md	1.65	3.86	1.22	1.79	1.77	.37	.74	1.77	2.77	5.94
	Var	.44	3.60	.86	1.94	1.56	.08	.47	2.07	1.73	10.58
	Kurt	27.36	1.29	.56	2.20	1.77	.11	-.55	1.26	.60	1.04
	Skw	4.29	.78	.81	1.28	1.21	.72	.50	1.05	.51	.73
Kruskal- Walis test	H	10.82	6.86	6.12	9.88	10.44	6.75	6.89	10.27	7.95	7.73
	p	.004	.036	.047	.007	.005	.034	.032	.006	.019	.021
	η^2	.086	.047	.040	.077	.082	.046	.047	.080	.058	.056
	d	.612	.445	.408	.576	.598	.440	.447	.591	.495	.485

Table 2: Descriptive statistics of fixation duration in seconds (normalized per AOI based on its size)
 Note: Only AOIs with significant differences across career levels are displayed. Interpretation of d: small effect size ($0.20 \leq d \leq 0.49$), moderate effect size ($0.50 \leq d \leq 0.79$) and large effect size ($d \geq 0.80$).

Fixation count (Information reduction theory)

The fixation count measures the number of times a participant fixated on an AOI; it is operationalized as a measure of the frequency of attention paid to a given AOI. As the fixation count data were not normally distributed, we again used a non-parametric Kruskal-Wallis test to analyse differences in the fixation counts among all three groups of participants. The comparison of the fixation counts of all the AOIs across career levels in the three sequences did not reveal significant differences among the groups (see Figure 2 and Table 3). In sequence 4, where the in-service teachers had the lowest number of fixations, the difference was significant ($p = .02$; $d = .491$). Similarly to the fixation durations, we only observed a significant difference in one AOI in the low-structured situation (sequence 2, AOI 6). The highest numbers of fixations were found among the senior pre-service teachers. The AOIs in which we observed significant differences in the number of fixations showed pupils in peripheral parts of the classroom who were moving or talking. More fixations among senior pre-service teachers reveal a tendency to scan the classroom and check up on pupils regularly. Senior pre-service teachers seem to use different viewing patterns compared to their less experienced colleagues. They check what is happening more frequently, especially with regard to pupils in the peripheral parts of the classroom.

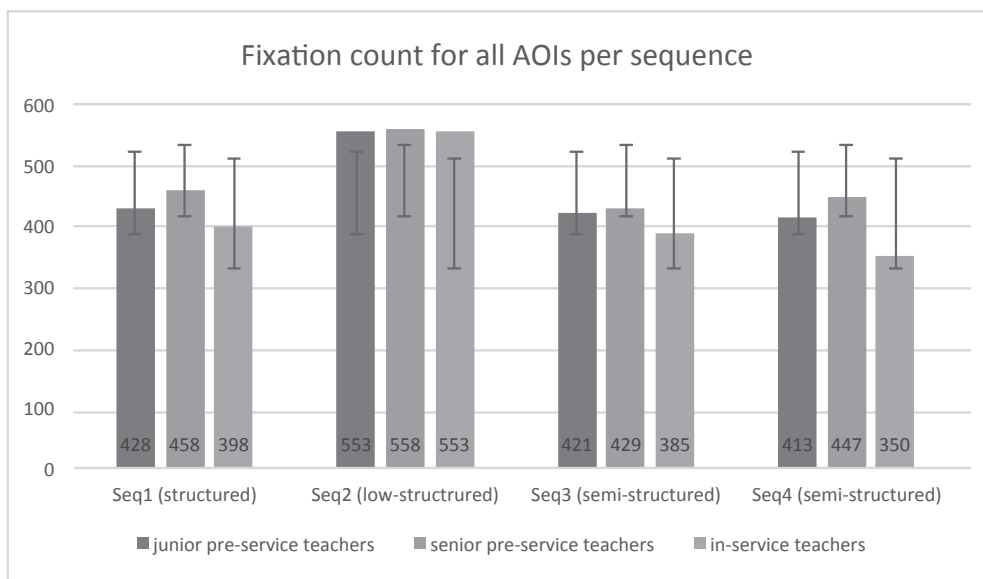


Figure 2: Average numbers (fixation counts) and standard deviations of all the AOIs per sequence across career levels

		Seq1 AOI 2	Seq1 AOI 10	Seq2 AOI 6	Seq3 AOI 5	Seq3 AOI 13	Seq4 AOI 1	Seq4 AOI 2	Seq4 AOI 6	Seq4 AOI 16
Junior pre-service teachers (n = 43)	M	2.24	9.11	4.34	4.41	1.51	3.01	3.28	7.28	4.53
	SD	1.76	3.56	1.46	2.53	.97	2.81	2.28	4.50	2.62
	Md	1.98	9.20	4.19	4.47	1.29	2.70	3.29	6.88	4.48
	Var	3.09	12.70	26.45	6.38	.93	7.91	5.18	20.28	6.85
	Kurt	10.09	-.03	.42	.97	.94	4.40	-.29	.51	-.88
	Skew	2.56	.38	.73	.48	1.15	1.71	.44	.76	.21
Senior pre-service teachers (n = 46)	M	2.11	9.91	4.25	5.99	1.87	3.54	4.31	8.66	5.01
	SD	2.88	3.05	1.78	3.09	1.02	2.93	2.64	4.46	2.53
	Md	1.32	9.47	4.12	6.30	2.04	2.70	4.69	8.03	4.69
	Var	8.27	9.33	27.20	9.57	1.05	8.56	.99	19.92	6.38
	Kurt	23.71	-.07	-.05	-.69	-.42	2.83	-.27	1.11	-.52
	Skew	4.33	.36	.26	-.07	.08	1.44	.39	.78	.50
In-service teachers (n = 17)	M	1.23	7.43	5.21	4.21	1.06	1.60	2.41	4.44	3.11
	SD	1.21	3.76	2.78	3.90	.92	1.48	2.52	4.83	2.30
	Md	1.10	6.54	5.06	3.66	1.07	1.58	2.11	3.44	2.88
	Var	1.47	14.16	21.97	15.20	.84	2.19	6.37	23.31	5.29
	Kurt	-1.19	.64	.49	5.16	4.76	1.41	6.33	9.12	-1.14
	Skew	.54	.64	.49	1.94	1.75	1.01	2.17	2.75	.38
Total (N = 106)	M	2.02	9.19	4.44	5.06	1.59	3.03	3.59	7.45	4.52
	SD	2.26	3.46	1.87	3.11	1.02	2.77	2.55	4.71	2.59
	Md	1.65	9.07	4.33	4.88	1.40	2.70	3.29	6.88	4.05
	Var	11.96	5.13	27.14	9.64	1.03	7.65	6.52	22.21	7.65
	Kurt	27.36	-.10	1.35	.71	-.11	3.70	.03	.74	-.64
	Skew	4.29	.26	.71	.24	.65	1.63	.64	.86	.34
Kruskal- Wallis test	H	6.77	6.32	6.76	9.94	10.24	7.17	8.85	14.40	6.02
	<i>p</i>	.034	.042	.034	.006	.007	.028	.012	.001	.049
	η^2	.046	.042	.046	.077	.080	.050	.067	.120	.039
	<i>d</i>	.441	.418	.440	.578	.590	.460	.534	.740	.403

Table 3: Descriptive statistics of fixation count

Note: Only AOIs with significant differences across career levels are displayed.

Interpretation of *d*: small effect size ($0.20 \leq d \leq 0.49$), moderate effect size ($0.50 \leq d \leq 0.79$) and large effect size ($d \geq 0.80$).

Time to the first fixation (Holistic theory)

The time to the first fixation refers to the amount of time (in seconds) before the participant in question fixated on an AOI for the first time. These metrics can be analysed by means of cross-sectional comparison (similarly to the fixation duration and fixation count above), or they can be used to analyse the scan paths and the order in which the participant fixated on individual AOIs. Cross-sectional comparison revealed significant differences with a moderate effect size within six AOIs, where less experienced participants fixated on these AOIs earlier than their more experienced colleagues (Table 4). These AOIs represented students in peripheral parts of the classroom, despite them attracting the attention of the pre-service teachers more quickly than that of the in-service teachers. The experienced teachers fixated more quickly on the AOIs in the low-structured situation; however, these differences were not significant.

		Seq1 AOI 2	Seq1 AOI 8	Seq2 AOI 7	Seq4 AOI 1	Seq4 AOI 3	Seq4 AOI 16
Junior pre- service teachers (n = 43)	M	23.25	3.08	3.73	37.56	10.62	53.08
	SD	23.79	2.95	8.43	38.59	10.68	.93
	Md	17.73	2.25	1.72	16.85	8.11	52.85
	Var	565.95	8.73	71.63	1489.29	113.99	.864
	Kurt	9.17	7.34	31.58	.48	9.59	14.72
	Skew	2.61	2.47	5.50	1.18	3.03	3.69
Senior pre- service teachers (n = 46)	M	33.58	2.02	6.69	31.75	15.15	53.77
	SD	52.60	1.83	28.34	37.01	22.50	5.44
	Md	11.83	1.54	1.79	14.75	7.48	52.83
	Var	2766.30	3.33	802.94	1369.70	506.29	29.60
	Kurt	5.12	2.99	42.58	5.21	11.08	41.04
	Skew	2.44	1.69	6.51	2.44	3.06	6.35
In-service teachers (n = 17)	M	57.98	8.58	5.93	65.97	36.33	76.34
	SD	49.10	18.03	6.39	48.32	51.09	52.70
	Md	34.85	3.89	3.53	34.85	12.05	53.06
	Var	2410.28	324.92	40.77	2410.28	2610.15	2776.99
	Kurt	-.74	11.58	2.81	-.74	2.01	2.84
	Skew	.76	3.38	1.87	.76	1.83	2.08
Total (N = 106)	M	34.64	3.61	5.18	38.17	18.67	57.85
	SD	45.48	7.25	18.84	39.80	26.73	24.03
	Var	2068.03	52.61	354.93	1584.12	714.29	577.61
	Kurt	5.91	53.58	86.26	2.17	9.80	30.23
	Skew	2.45	6.81	8.99	1.56	2.95	5.55
Kruskal-Wallis test	H	9.01	9.19	8.52	8.06	11.32	8.09
	<i>p</i>	.011	.010	.014	.018	.003	.018
	η^2	.068	.07	.063	.059	.09	.059
	<i>d</i>	.54	.548	.52	.50	.631	.501

Table 4: Descriptive statistics of time to the first fixation

Note: Only AOIs with significant differences across career levels are displayed. Interpretation of *d*: small effect size ($0.20 \leq d \leq 0.49$), moderate effect size ($0.50 \leq d \leq 0.79$) and large effect size ($d \geq 0.80$).

Frame and colleagues (2019) consider scan paths in combination with eye-tracking metrics to be a powerful tool for eye-tracking data analysis. A scan path can be characterized as an eye movement track (Sun et al., 2018) or the order in which a participant fixates on individual AOIs. The inspection of visual attention maps showed only minor differences across career levels, and aggregat-

ed maps for larger groups of participants provided us with information on which AOIs attracted the most visual attention in a given career group and how the visual attention was distributed. In combination with the time to first fixation metrics, the order of the AOIs fixated on was formed to model a scan path for each career group. The inspection of these scan paths showed differences across the groups. To begin with, all the groups fixated on the same AOI, but then we observed different orders when scanning the classroom. The in-service teachers tended to scan the central part of the classroom first, and then they fixated on the peripheral areas, while the pre-service teachers tended to skip to the peripheral areas earlier than their more experienced colleagues. This trend may support the assumption of holistic perception among experts, but it needs further investigation.

Discussion

Dessus and colleagues (2016) consider gaze patterns as being mainly related to teachers' experience. Studies on expertise in visual processing, however, do not provide consistent results (Gegenfurtner and Seppänen 2013). Yamamoto and Imai-Matsumura (2013) found no difference in teaching experience between teachers who were aware and those who were unaware of students' misbehaviour. According to van den Bogert et al. (2014) and Wolff et al. (2016), more teaching experience leads to the ability to select relevant information in the classroom and reach swifter and more precise conclusions. The aim of this study was to investigate the gaze patterns among three career levels of teachers and to evaluate the three theories of expertise vision within the teaching professional domain. Based on the hypotheses of information reduction, long-term working memory and holistic theory (Gegenfurtner et al. 2011), the cognitive processing of visual stimuli related to the professional domain is influenced by professional experience. The comparison of junior and senior pre-service teachers' eye-tracking data shows differences in visual patterns between the groups. It seems that not only in-service expertise, but also pre-service training experiences, may lead to changes in the cognitive processing of classroom dynamics. Teachers' professional vision and selective attention to classroom management changes as they progress from bachelor to master pre-service teachers and go on to become expert in-service teachers (Gold and Holodynski 2017).

According to the theory of long-term working memory (Ericsson and Kintsch 1995; Gegenfurtner et al. 2011), experts process professional information faster, which is manifested in shorter fixations. Like van den Bogert et al. (2014), we found that more experienced teachers process visual information from the classroom more quickly. In our sample, the in-service teachers had the shortest fixations and the junior pre-service teachers the longest. This trend was significant within ten AOIs. Based on the information-reduction theory (Haider and Frensch 1999; Gegenfurtner et al. 2011), experts fixate on task-redundant areas less often. We found significant differences in the number of fixations within eight AOIs

across career levels. However, in this case, the senior pre-service teachers appeared to have the highest numbers of fixations. Tobin et al. (2016) described the emotions and physiological changes experienced while teaching a lesson. These may contaminate cognitive processing while teaching and also when observing a critical or challenging situation. Senior pre-service teachers seem to be more sensitive to these stimuli when transitioning into service, which may cause the differences in their visual attention and processing of a situation. Their number of fixations was higher than those observed among junior pre-service teachers and experienced in-service teachers. Senior pre-service teachers tended to return to individual AOIs more frequently, which may be a sign of sensitivity towards classroom dynamics.

The trend of shorter and fewer fixations among more experienced teachers, however, was more evident in the semi-structured situations. With regard to the low-structured classroom situation, with many simultaneous instances of misbehaviour, all three groups of participants seemed to have consistent numbers and lengths of fixations. The differences across career levels seem to depend on the stimulus situation. The differences are more significant if the situation is semi-structured and contains elements of disruptive or inattentive behaviour. If our participants could easily locate the source of challenging behaviour, they usually focused their visual attention on the relevant pupil or pupils. If the pupils were working in a structured manner, the participants tended to fixate on pupils in the classroom more evenly. However, in the low-structured situation, with several possible sources of misbehaviour, the participants tended to scan the classroom to locate the sources.

According to Gegenfurtner and Seppänen (2013, p. 393), expert performance can be defined as »maximal adaptations to representative tasks within a domain«. A low-structured situation might be a scenario, which is not a representative task. In such a context, experts do not use the same visual processing patterns as in a standard, structured or semi-structured classroom situation. This interpretation supports the assumption that visual expertise is context bound and domain specific (Gegenfurtner and Seppänen 2013). The reasoning within a domain is affected by beliefs about discipline and classroom management (Martin and Shoho 2000; Martin et al. 2006; Tauber 2007). Both pre-service and in-service teachers may hold different theories and beliefs about classroom management, which may influence their cognitive processing and decision-making in the classroom (Tauber 2007).

Based on the holistic model theory (Kundel et al. 2007; Gegenfurtner et al. 2011), experts can extract information from widely distanced areas, which is manifested in shorter times to the first fixation on task-relevant areas. In our sample, we found significant differences in these metrics within six AOIs, but in-service teachers appeared to have longer times to the first fixation than pre-service teachers. Classroom situations are rather complex and often unpredictable (Dutke et al. 2018). As a free-viewing task (Gegenfurtner et al. 2011) was used in our study, specific task-relevant areas were not defined for the classroom situation. Consequently, our data cannot support the holistic model theory. However, we observed

a trend of first scanning the central part of the classroom among experienced teachers and fixating earlier on peripheral areas among pre-service teachers.

Our study aimed to analyse differences in the visual processing of classroom events among pre-service and in-service teachers. Despite achieving this goal, the study has some limitations. Despite the fact that our research sample was larger than those reported in similar eye-tracking studies, we did not succeed in reaching homogenous distribution in all the three sub-samples. Although the participants in all three groups met the sampling criteria, the expert group was smaller than the junior and senior pre-service teacher groups. For the purpose of this study, we grouped the participants based on their levels of expertise, and we did not explore any other potential variables that may affect their vision patterns, such as biological age, gender, subject area or personality variables. Regarding further research, it might be valuable to study vision patterns across subject domains, as subject-specific socializations may lead to distinct sets of shared beliefs and affect professional vision (Blomberg et al. 2011).

Conclusion

In the present study, we analysed the differences in vision patterns across three career levels. Differences were found not only across these levels but also across various classroom contexts. Our data support the theories of long-term working memory and information reduction, but we observed significant differences (both in terms of fixation duration and fixation count), especially in the semi-structured situations. The findings illustrate how visual processing develops across the career cycle. The eye-tracking methodology has the potential to investigate the process of developing professional vision and visual expertise among pre-service teachers. The process of becoming a teacher should be a continuous one and should include professional development throughout all the phases of teacher training. Transition into practice and the induction period are important parts of a teacher's professional life (Alles et al. 2019). At this time, pre-service teachers seem to be more sensitive to classroom dynamics and misbehaviour, and, consequently, it is advisable to implement the results of this study when designing training situations for pre-service teachers. The analysis of vision pattern differences within our sample has some implications for the design of teacher training environments. In accordance with Gegenfurtner et al. (2011), Sun et al. (2018) and Rakoczi (2012), we suggest that eye tracking can work as a powerful learning tool and not only as a research technology. For example, Gegenfurtner et al. (2011) suggest replaying the eye movements of experts to novices as the gaze-following mechanism can be used to model such gaze patterns to learn what to focus on. Future research can examine how these learning interventions can help to develop the professional vision of prospective teachers.

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SKOZI UČITELJEVE OČI: ŠTUDIJA INTERAKCIJ V RAZREDU S SLEDENJEM UČITELJEVEMU POGLEDU

Povzetek: Selektivna pozornost, ki jo učitelj posveča dogajanju v razredu, je pomemben del obvladovanja razreda in učiteljevega odločanja v razredu. Predstavljena študija proučuje takšno selektivno pozornost v razredu v okviru izobraževanja učiteljev. Udeleženci študije so bili mlajši ($n = 43$) in starejši bodoči učitelji ($n = 46$) ter izkušeni učitelji ($n = 17$). Njihovo selektivno pozornost med gledanjem posnetkov strukturiranih, polstrukturiranih in nizko strukturiranih situacij v razredu smo objektivno merili z analizo njihovega premikanja pogleda. Analiza je pokazala pomembne razlike v zaznavanju dogodkov v razredu med učitelji z različno dolgim stažem, zlasti v polstrukturiranih situacijah, kadar pride do motečega vedenja. Bolj izkušeni učitelji so se manjkrat poslužili krajše fiksacije, kar potrjuje hipotezo o informacijski redukciji. Starejši bodoči učitelji, ki so že opravili pedagoško prakso in predmet obvladovanje razreda, so uporabljali drugačne vzorce strokovnega usmerjanja pogleda kot manj izkušeni mlajši bodoči učitelji.

Ključne besede: strokovno usmerjanje pogleda, usposabljanje učiteljev, bodoči učitelji, izkušeni učitelji, interakcije v razredu, vodenje razreda, sledenje pogledu

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