

Through the eyes of the teacher

Mandy Klatt¹, Dr. Gregor Kachel^{1, 2}, Dr. Christin Lotz¹, & Prof. Dr. Anne Deiglmayr¹

¹ Leipzig University

² Max-Planck University for Evolutionary Anthropology

Author Note

The Ethics Advisory Board of Leipzig University has dealt with the research project and has come to the conclusion that there are no objections to the implementation of this research project. The Ethics Advisory Board points out that the scientific and ethical responsibility for the implementation of the project remains with the project director.

Correspondence concerning this article should be addressed to Mandy Klatt, Egelstraße 2a 04103 Leipzig. E-mail: mandy.klatt@uni-leipzig.de

Abstract

12

13 This document is a supplement to the paper and shows first graphs findings from the pilot
14 study.

15 *Keywords:* Professional Vision, Expert-Novice-Paradigm, Eye-Tracking

16 Word count: 1949

Through the eyes of the teacher

State of research

Teaching and classroom management are multidimensional settings in which teachers have to respond immediately to events as they develop (Barnes, 2004). The different interests and abilities of students must be managed in a way that maximizes the active learning time of students and minimizes disruptions whilst teaching. Learning to develop such classroom management skills and to teach effectively is a complicated and complex process (Wolff, Jarodzka, & Boshuizen, 2017).

During teaching, teachers must be able to select from a variety of visual and acoustic impressions to focus their attention on the essential and to distinguish between relevant and irrelevant events. This ability is called professional vision and is a key component of teacher expertise and successful teaching (Barth, 2017). Eye tracking technology has become a reliable means to study teachers' visual focus of attention (Bogert, 2016; Pouta, Lehtinen, & Palonen, 2020; Wolff, Jarodzka, & Boshuizen, 2017)

Educational research has repeatedly shown that there are differences between experienced and novice teachers in terms of perception and behavioral competencies (Barth, 2017; Bogert, 2016; Wolff, Jarodzka, & Boshuizen, 2017). For example, experts direct their attention more often and more evenly to all students, whereas novices only direct their attention to some students. The frequency and duration of fixations as eye movement are decisive (Stuermer, Seidel, Mueller, Häusler, & Cortina, 2017). Mobile eye-tracking technology has also shown that experienced teachers distribute their focus more efficiently to solve tasks (Jarodzka, Scheiter, Gerjets, & Van Gog, 2010). Furthermore, in contrast to novices, experts are able to focus their attention on the entire class and guide the class while giving feedback to individual students and answering questions (Cortina, Miller, McKenzie, & Epstein, 2015).

Research questions

The aim of the pilot study was to investigate whether there are differences in how expert and novice teachers manage scripted classroom disruptions. The disruptions were experimentally varied using a previously written script. Thus, our aim was to find out whether differences in the allocation of attention between expertise groups can be detected in this controlled context.

In order to answer this question, the hypothesis was formulated that teachers with more professional experience not only notice more disruptions but also notice them faster. In the hypothesis, therefore, it is necessary to check what has already been shown in the research literature: In complex teaching situations, experts have a more structured and elaborate professional knowledge than novices in order to perceive and interpret relevant events and to act appropriately (Berliner, 2001; Lachner, Jarodzka, & Nückles, 2016).

Methods

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study.

Participants

For the sample recruitment of the subjects ($N = 8$, experts $n = 2$, novices $n = 6$), schools in the city of Leipzig in Saxony were contacted. The institutions as well as the subjects were informed in detail about the aim and intention of the study in advance. Participation in the study was voluntary and only took place after written consent has been given.

The selection of the subjects was based on extreme groups, whereby professional experience is the crucial criterion for the selection of experts or novices. Novices were recruited as teachers who have been working in the teaching profession for no more than 3

Table 1

Demographic Information and Teaching Experience

| group | N | Male | M age | Min age | Max age | SD age | M exp. | Min exp. | Max exp. | SD exp. |
|--------|---|------|-------|---------|---------|--------|--------|----------|----------|---------|
| expert | 2 | 1 | 47.50 | 44 | 51 | 4.95 | 20.00 | 15.00 | 25.00 | 7.07 |
| novice | 6 | 2 | 25.67 | 20 | 33 | 4.89 | 0.68 | 0.00 | 1.50 | 0.68 |

years, whereas experts were considered to have professional experience of 10 years or more (Messner & Reusser, 2000).

Procedure/ Data collection

Set up. For this study, scripted mini-lessons with $n = 2$ experts and $n = 6$ novices were recorded in the mobile Lab of the Empirical School and Classroom Research at the University of Leipzig. The subjects were divided into groups of four, so the study was conducted on two different sessions. All participants were asked to hold a 10-minute lesson. The duration of each appointment was approximately 2h: per group 10min briefing, 4 x 10min mini-lessons, 10min technical preparation and follow-up and 4x 10min transition points between the lessons and answering questionnaires.

One person from the group of 4 acted as a teacher, the other three subjects acted as the class. The subjects, who represented the class, were given behavioral instructions in a pre-written script to simulate typical events and disruptions in the classroom (e.g. putting their heads on the table, chatting, looking at their mobile phones, etc.).

The lesson disruptions were displayed as instructions during the lesson for all “students” but not the teacher. In order to avoid learning effects, the disruptions in each lesson were distributed pseudo-randomly over the short teaching phase. In addition, the order of the data collection was taken into account in the analyses and variance caused by

84 order was controlled.



Figure 1. Example for set up during a mini-lesson

85 **Questionnaire data.** After each mini-lesson, the students answered items on the
 86 teaching quality using a validated questionnaire (Helmke et al., 2014) and scales on the
 87 teacher's presence behavior (students $n = 24$). In addition, the teacher was asked to give a
 88 self-assessment on his/her classroom management by completing the questionnaire after
 89 each mini-lesson (teachers $n = 8$).

90 **Behavioral data.** The speech, sounds and voices were recorded with an audio
 91 recorder installed in the middle of the Lab. Movements, facial expressions and gestures of
 92 the subjects were recorded by four cameras from different angles. One camera was installed
 93 to film the class from the side. Two more cameras were installed on the blackboard and at
 94 the end of the Lab to film the teacher and class from the front and back. Furthermore, the
 95 fourth camera was installed in such a way that only facial expressions and gestures of the
 96 teacher were recorded, which enables a semi-automated analysis of the movement
 97 sequences.

Eyetracking data. A binocular Tobii Pro Glasses 2 eye-tracker consisting of a wearable head unit and a recording unit was used to record the eye movements of all 8 participants. The head unit is a measuring device with different sensitive sensors. A high-definition scene camera captures a full HD video and an integrated microphone records the surrounding sounds. Infrared light illuminators support the eye tracking sensors which record the eye orientation. The videos were recorded with a sampling rate of 50 Hz and a video resolution with 1920 x 1080 at 25 frames per second. The scene camera has a field of view of 90 deg. in 16:9 format (82 deg. horizontal and 52 deg. vertical) and has a frame dimension of 179 x 159 x 57mm (width x depth x height). The Tobii Pro Glasses Controller software was used to record and calibrate the eye movements.

Coding/ Data preparation/ Reliability

Questionnaire Data. The evaluation after each mini-lesson was conducted using paper questionnaires. Time needed to complete the questionnaire was about 5 minutes. The scales on the quality of teaching are a validated questionnaire (Helmke et al., 2014). Whereas the scales on the teacher's presence behavior were derived from the research literature (Brophy, 1986; Kiel, Frey, Weiß, & Weiss, 2013; Kounin, 2006; Marzano, 2007; Nolting, 2012) and were used in the pilot for the first time. The questionnaire is 4-point Likert scale (1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree). Data was obtained from N = 32 subjects (students n = 24, teachers n = 8).

The following scales were assessed:

- (1) Classroom management
- (2) Positive climate and motivation
- (3) Clarity and structuredness
- (4) Activation and support
- (5) Presence: posture/gaze

(6) Presence: voice

(7) Presence: verbal and non-verbal intervention

(8) Natural behaviour

Table 2 provides an overview over the mean, the standard deviation, the range, Cronbach's Alpha and the Skewness & Kurtosis of all scales for the teachers' self-assessment.

```
## Warning in alpha(self.cs.wide[, -1]): Some items were negatively correlated with the  
## should be reversed.
```

```
## To do this, run the function again with the 'check.keys=TRUE' option
```

```
## Some items ( ks_sichtbar ) were negatively correlated with the total scale and  
## probably should be reversed.
```

```
## To do this, run the function again with the 'check.keys=TRUE' option
```

```
## Warning in sqrt(Vtc): NaNs wurden erzeugt
```

```
## Warning in cor.smooth(r): Matrix was not positive definite, smoothing was done
```

```
## Warning in cor.smooth(R): Matrix was not positive definite, smoothing was done
```

```
## Warning in cor.smooth(R): Matrix was not positive definite, smoothing was done
```

```
## Warning in cor.smooth(R): Matrix was not positive definite, smoothing was done
```

```
## Warning in alpha(self.pvni.wide[, -1]): Some items were negatively correlated with th  
## should be reversed.
```

```
## To do this, run the function again with the 'check.keys=TRUE' option
```



```
145 ## Some items ( pi_nonverbal ) were negatively correlated with the total scale and
146 ## probably should be reversed.
147 ## To do this, run the function again with the 'check.keys=TRUE' option

148 ## Warning in sqrt(Vtc): NaNs wurden erzeugt

149 ## Warning in cor.smooth(r): Matrix was not positive definite, smoothing was done

150 ## Warning in alpha(self.p.wide[, -1]): Some items were negatively correlated with the t
151 ## should be reversed.
152 ## To do this, run the function again with the 'check.keys=TRUE' option

153 ## Some items ( pi_nonverbal ) were negatively correlated with the total scale and
154 ## probably should be reversed.
155 ## To do this, run the function again with the 'check.keys=TRUE' option

156 ## Warning in cor.smooth(R): Matrix was not positive definite, smoothing was done

157 ## Warning in cor.smooth(R): Matrix was not positive definite, smoothing was done
158
159 ## Warning in cor.smooth(R): Matrix was not positive definite, smoothing was done
160
161 ## Warning in cor.smooth(R): Matrix was not positive definite, smoothing was done
162
163 ## Warning in cor.smooth(R): Matrix was not positive definite, smoothing was done
164
165 ## Warning in cor.smooth(R): Matrix was not positive definite, smoothing was done
166
167 ## Warning in cor.smooth(R): Matrix was not positive definite, smoothing was done
```

```
## Warning in cor.smooth(R): Matrix was not positive definite, smoothing was done

## Warning in cor.smooth(R): Matrix was not positive definite, smoothing was done

## Warning in cor.smooth(R): Matrix was not positive definite, smoothing was done

## Warning in cor.smooth(R): Matrix was not positive definite, smoothing was done

## Warning in cor.smooth(R): Matrix was not positive definite, smoothing was done

## Warning in cor.smooth(R): Matrix was not positive definite, smoothing was done

## Warning in cor.smooth(R): Matrix was not positive definite, smoothing was done

## Warning in cor.smooth(R): Matrix was not positive definite, smoothing was done

## Warning in cor.smooth(R): Matrix was not positive definite, smoothing was done
```

Table 3 provides an overview over the mean, the standard deviation, the range, Cronbach's Alpha and the Skewness & Kurtosis of all scales for the students' perception of the teacher's behaviour in class.

```
## Warning in alpha(stud.ppg.wide[, -1]): Some items were negatively correlated with the
## should be reversed.

## To do this, run the function again with the 'check.keys=TRUE' option

## Some items ( phb_stand ) were negatively correlated with the total scale and
## probably should be reversed.

## To do this, run the function again with the 'check.keys=TRUE' option
```

Table 2

Scale analysis for teachers' self-assessment

| scale | M | SD | Min | Max | Skewness | Kurtosis | Cronbach's a |
|--|------|------|-----|-----|----------|----------|--------------|
| Activation and support | 2.46 | 1.14 | 1 | 4 | 0.10 | 1.65 | 0.85 |
| Clarity and structuredness | 2.81 | 0.91 | 1 | 4 | -0.17 | 2.17 | -0.76 |
| Classroom management | 2.44 | 0.88 | 1 | 4 | 0.19 | 2.38 | 0.83 |
| Natural behaviour | 2.83 | 0.76 | 2 | 4 | 0.28 | 1.84 | 0.90 |
| Positive climate and motivation | 2.85 | 0.87 | 1 | 4 | -0.49 | 2.65 | 0.78 |
| Presence: posture/gaze | 2.70 | 1.01 | 1 | 4 | -0.44 | 2.15 | 0.85 |
| Presence: verbal and non-verbal intervention | 2.75 | 0.79 | 1 | 4 | -0.07 | 2.48 | -0.75 |
| Presence: voice | 2.79 | 0.72 | 2 | 4 | 0.32 | 2.03 | 0.77 |

```

193 ## Warning in alpha(stud.pvni.wide[, -1]): Some items were negatively correlated with the t
194 ## should be reversed.
195 ## To do this, run the function again with the 'check.keys=TRUE' option

196 ## Some items ( pi_direkt ) were negatively correlated with the total scale and
197 ## probably should be reversed.
198 ## To do this, run the function again with the 'check.keys=TRUE' option

199 ## Warning in alpha(stud.p.wide[, -1]): Some items were negatively correlated with the t
200 ## should be reversed.
201 ## To do this, run the function again with the 'check.keys=TRUE' option

202 ## Some items ( phb_stand ) were negatively correlated with the total scale and
203 ## probably should be reversed.
204 ## To do this, run the function again with the 'check.keys=TRUE' option

```

Table 3

Scale analysis for students' perspective

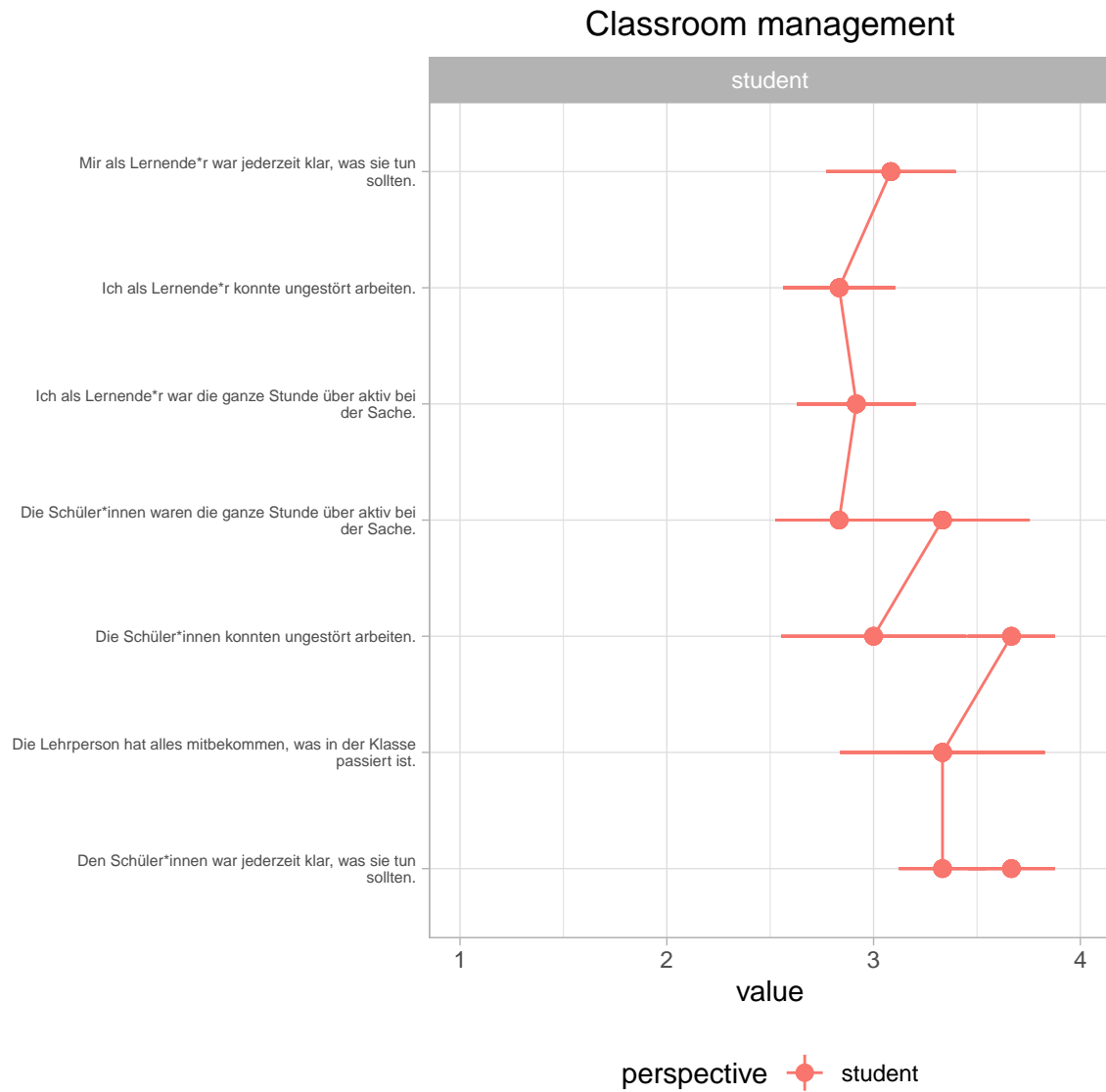
| scale | M | SD | Min | Max | Skewness | Kurtosis | Cronbach's a |
|--|------|------|-----|-----|----------|----------|--------------|
| Activation and support | 2.64 | 1.13 | 1 | 4 | -0.32 | 1.73 | 0.48 |
| Clarity and structuredness | 3.58 | 0.68 | 1 | 4 | -1.75 | 6.09 | 0.62 |
| Classroom management | 3.18 | 0.91 | 1 | 4 | -0.87 | 2.86 | 0.75 |
| Natural behaviour | 3.43 | 0.67 | 2 | 4 | -0.74 | 2.46 | 0.85 |
| Positive climate and motivation | 3.41 | 0.83 | 1 | 4 | -1.40 | 4.29 | 0.82 |
| Presence: posture/gaze | 3.24 | 0.89 | 1 | 4 | -1.05 | 3.31 | 0.59 |
| Presence: verbal and non-verbal intervention | 3.18 | 0.81 | 1 | 4 | -0.66 | 2.70 | 0.20 |
| Presence: voice | 3.60 | 0.60 | 2 | 4 | -1.18 | 3.36 | 0.71 |

205

The individual items of a scale are further represented in graphs.

206

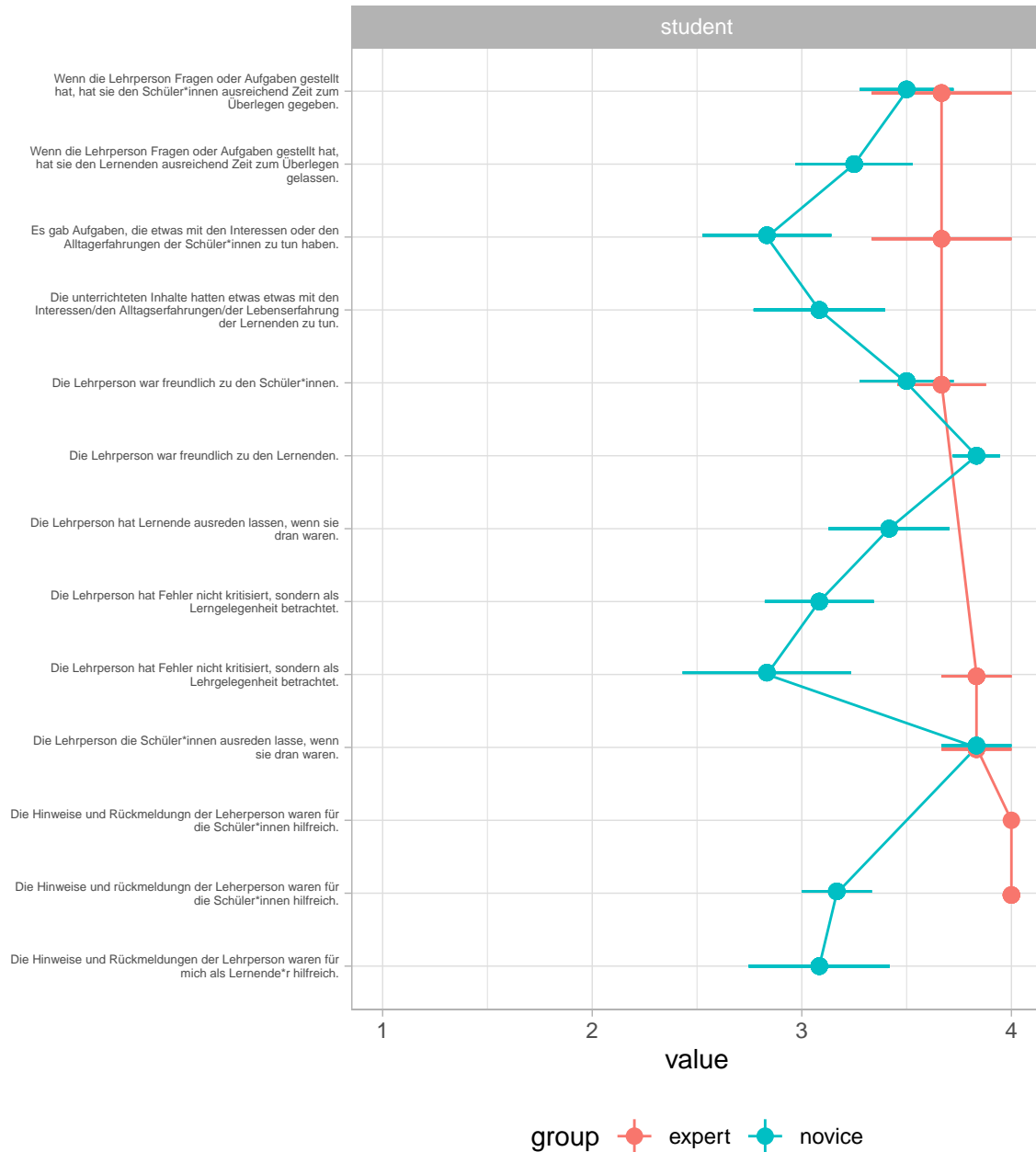
(1) Classroom management



208

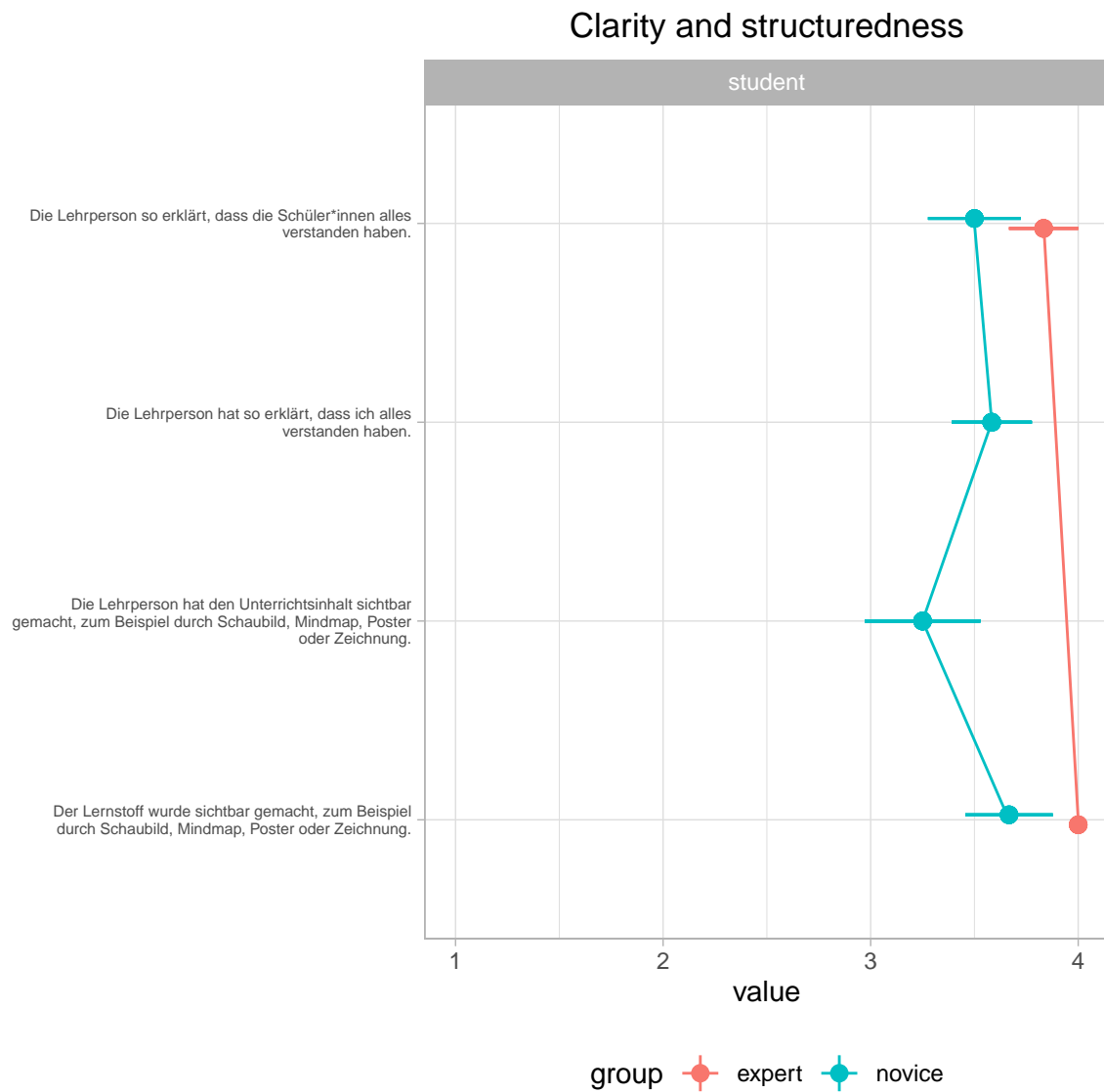
(2) Positive climate and motivation

Positive climate and motivation

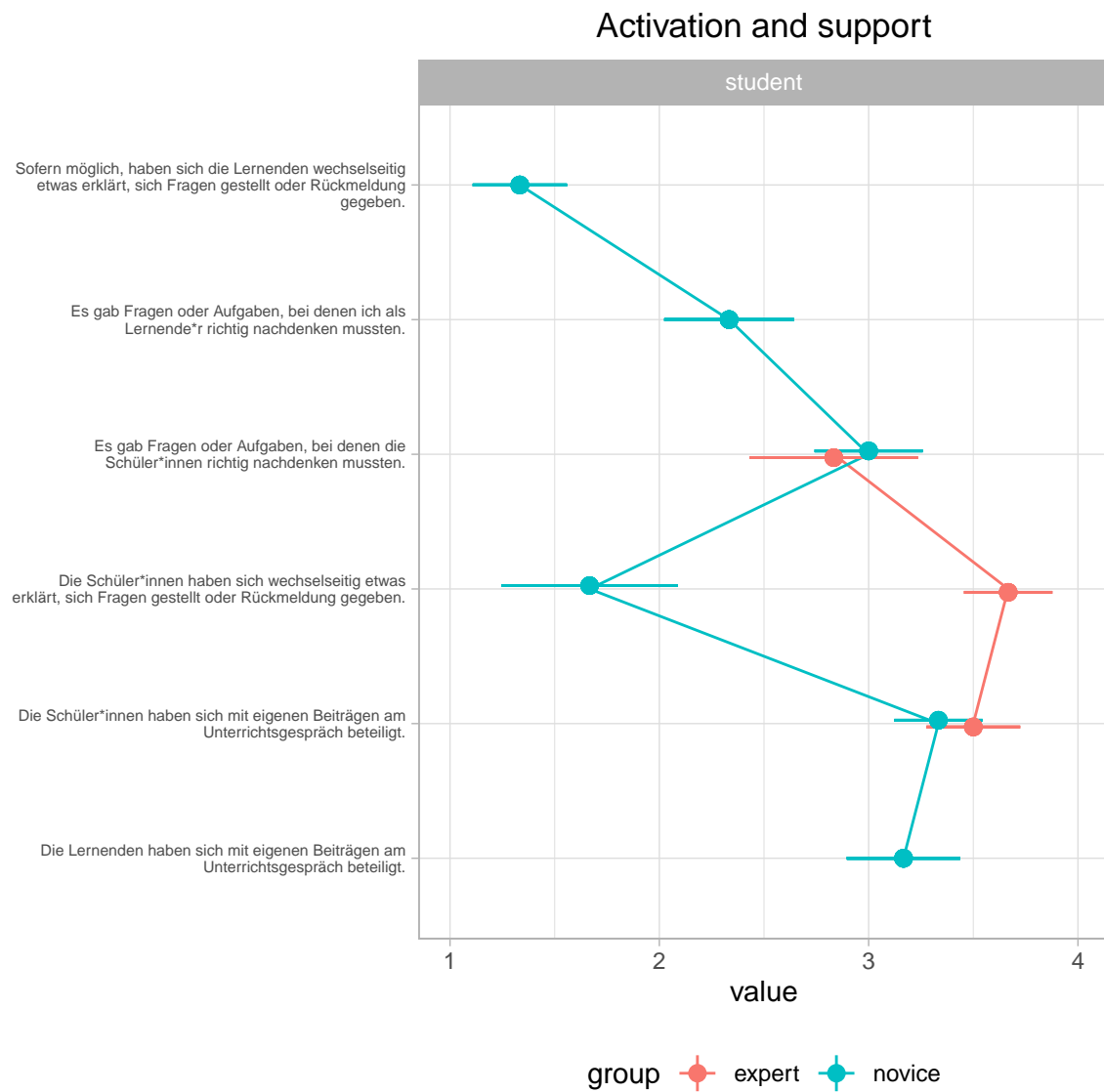


209

210 (3) Clarity and structuredness



212 (4) Activation and support



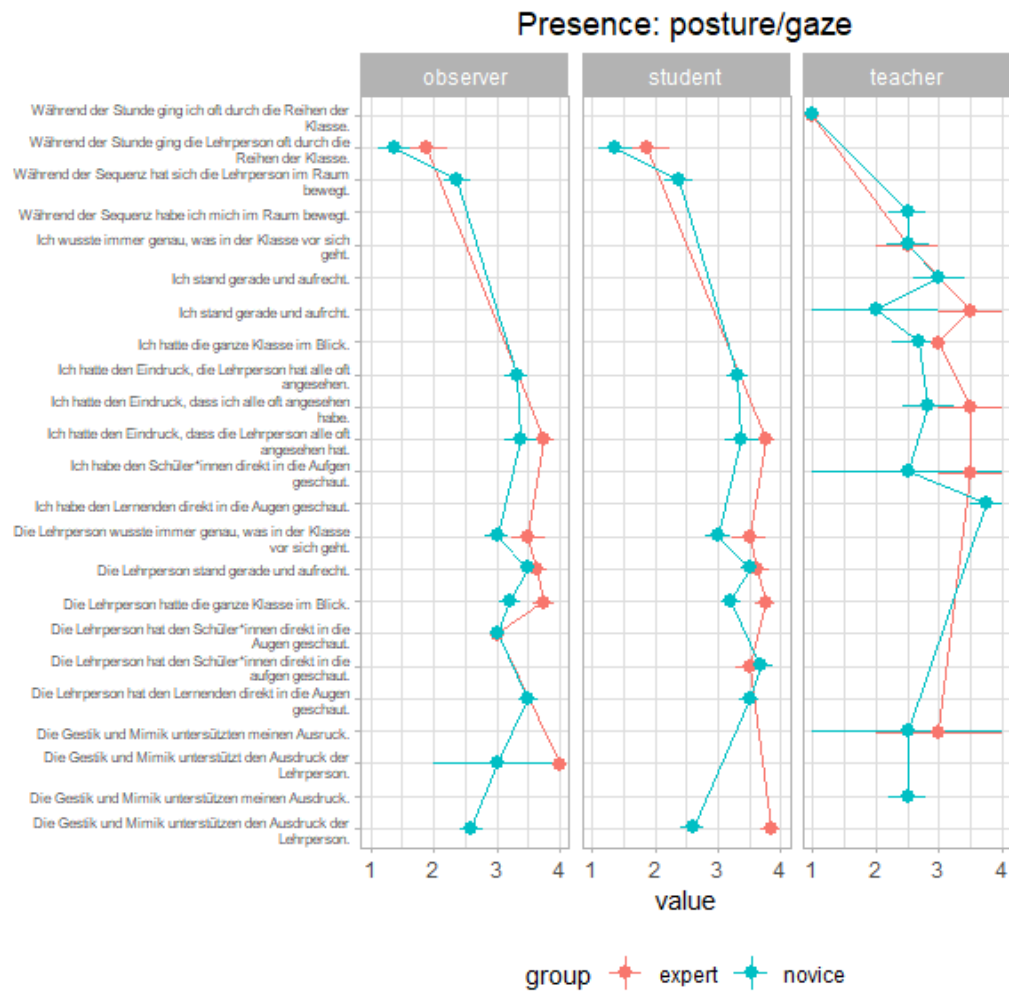


Figure 2. (5) Presence: posture/gaze

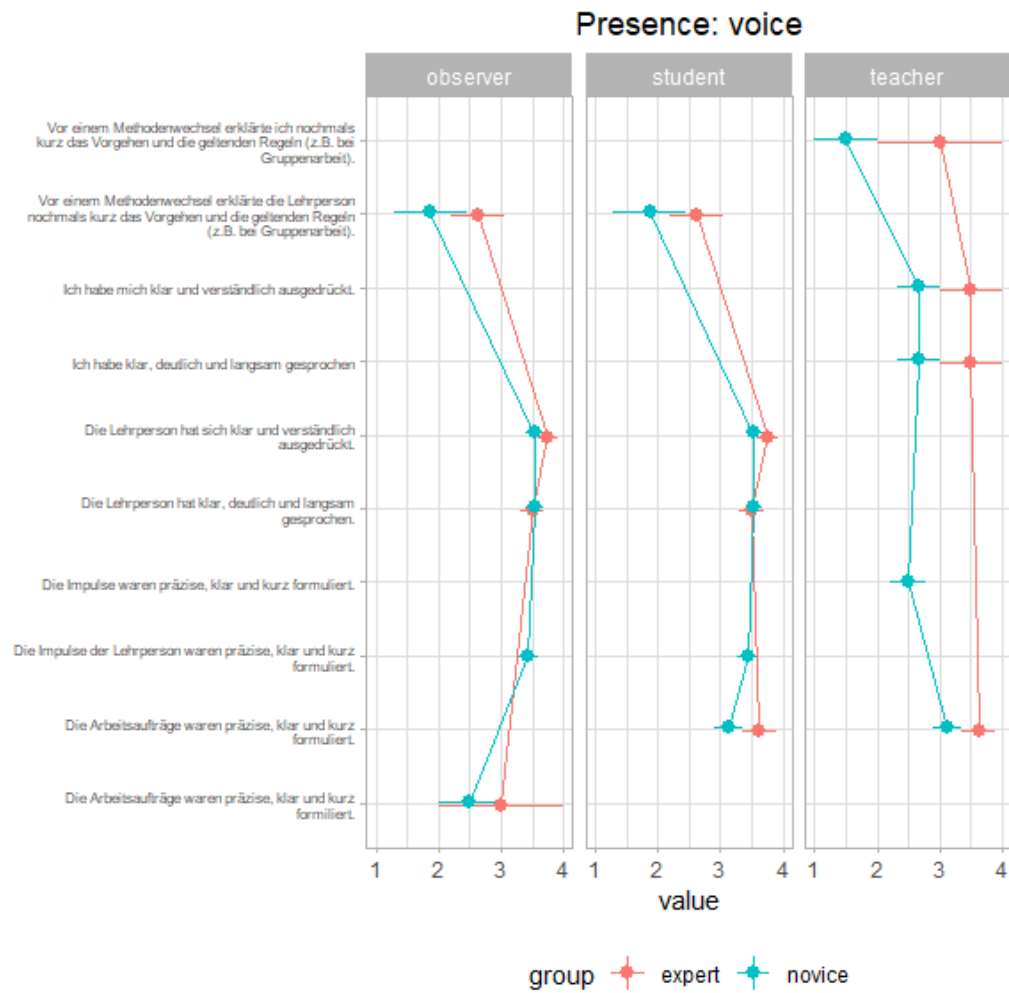


Figure 3. (6) Presence: voice

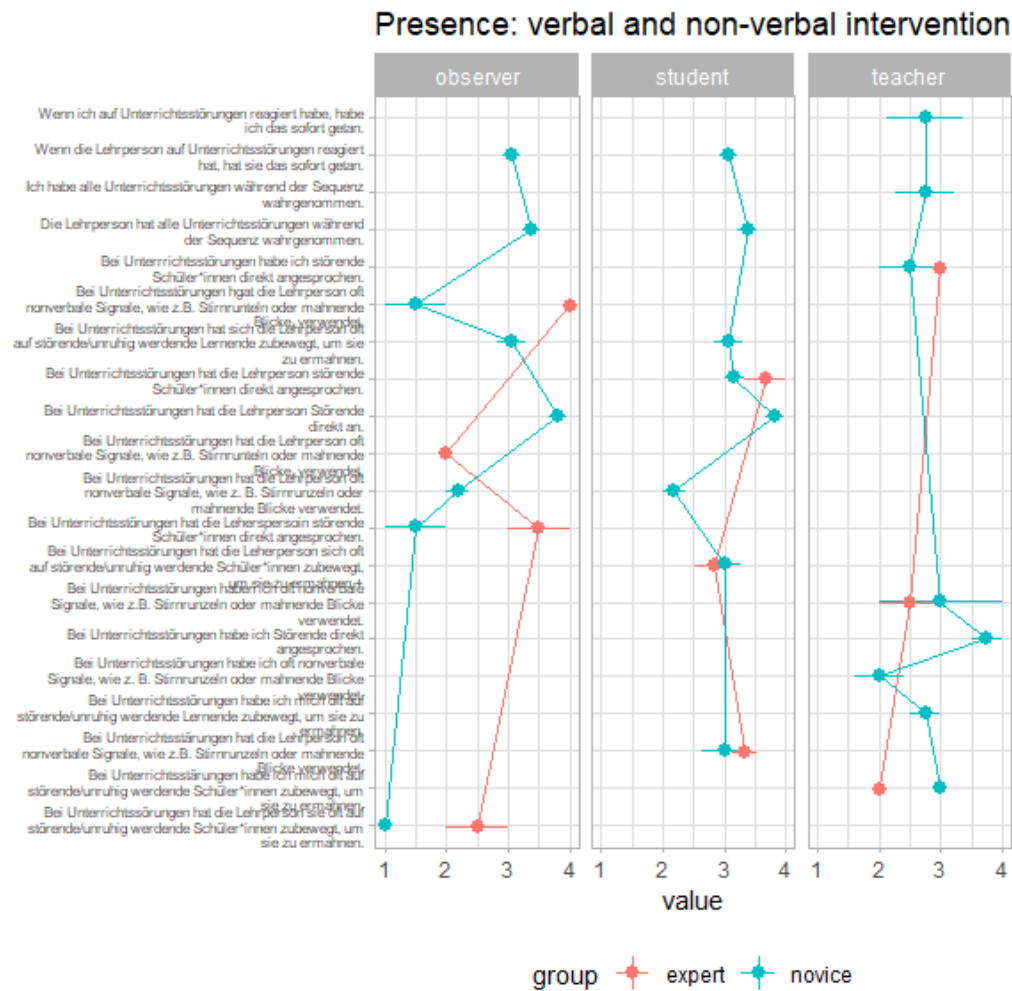
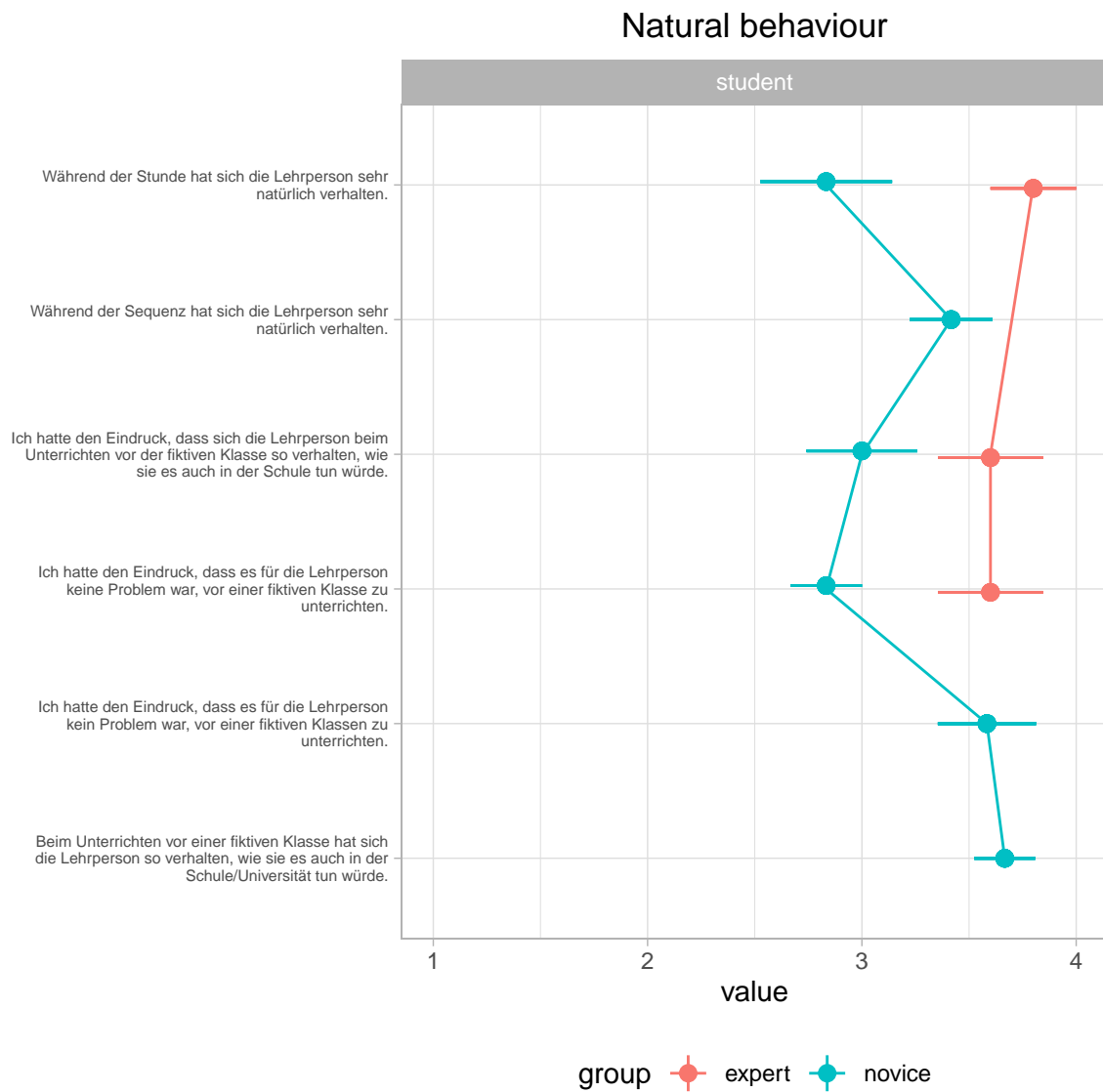


Figure 4. (7) Presence: verbal and non-verbal intervention

214 (8) Natural behaviour



216 In addition, we plotted all scales. Graph provides boxplots and individual data for
217 experts and novices.

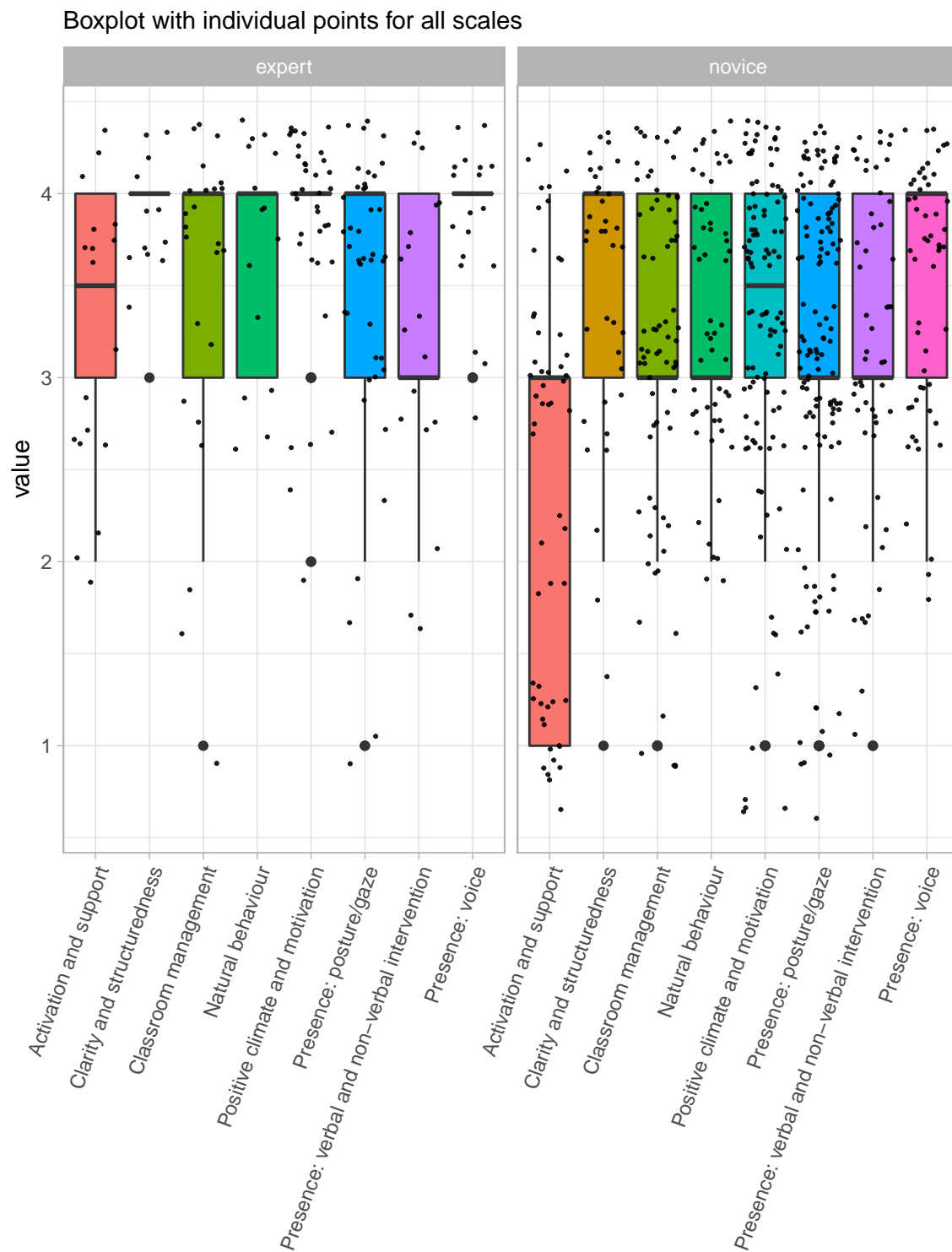


Figure 5. (#fig:boxplot scales) Boxplots and individual data for experts and novices

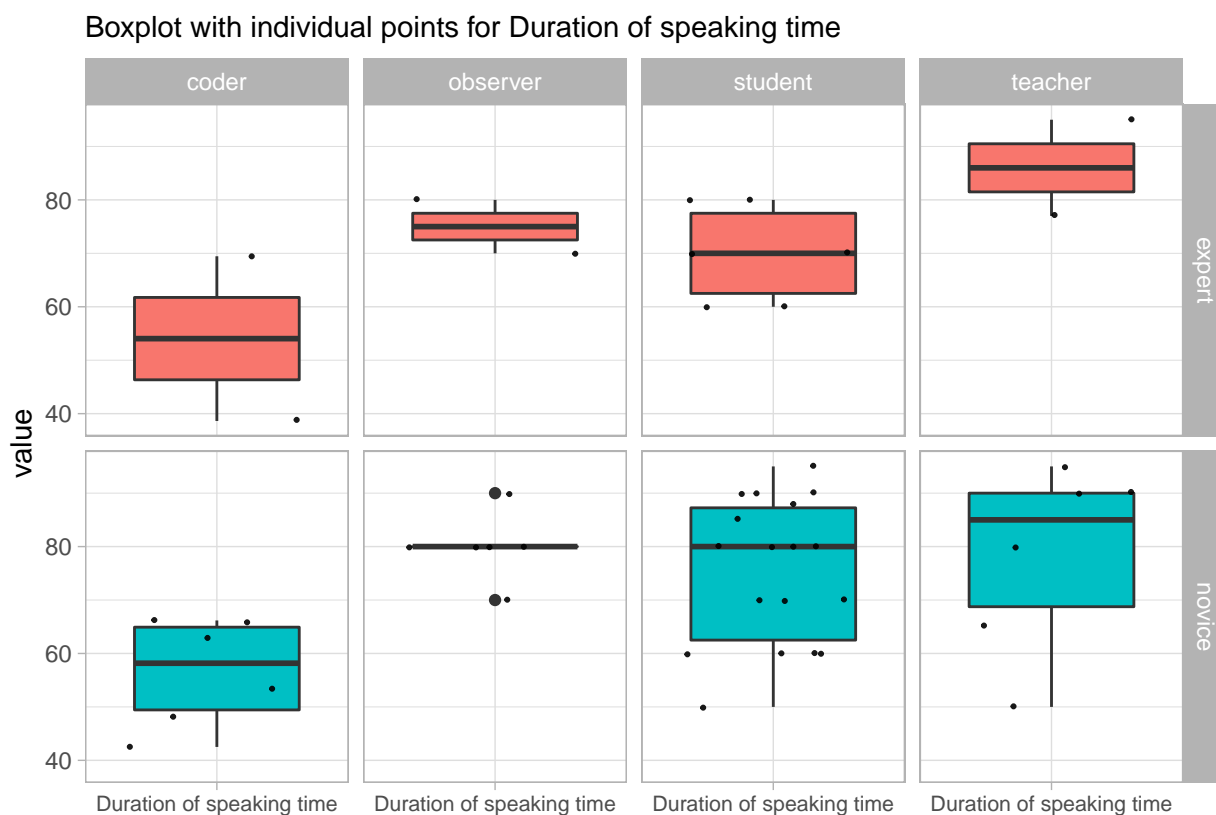
Behavioral Data. The recorded lessons were coded in a post-hoc procedure with the coding software MAXQDA by previously trained raters (Kuckartz & Rädiker, 2019). The following coding scheme was developed:

- phase - lesson begin, state event: teacher starts the lesson with a noise, talk, taking a position in class
- phase - lesson end, state event: teacher finishes the lesson with a noise, talk, taking a position in class
- phase - organization/transition points, state event: any situation that does not imply effective learning time (fetching chalk, working material, organizing desks, opening windows, printing work results etc.)
- phase - single, state event: any individual student activity on a given task (reading, writing, drawing etc.)
- phase - group, state event: any student activity on a given task together in a group of at least 3 students (reading, writing, drawing etc.)
- phase - class discussion, state event: discussion in class, teacher talks to class/individual/group
- phase - pair: state event: any student activity on a given task together in a team of 2 students (reading, writing, drawing etc.)
- phase - teachers lecture, state event: any teacher's presentation on a certain topic which maybe supported by a PPP, PREZI, notes on board, OHP etc.
- phase - other, state event: not categorizable
- phase - break, state event: e.g. drinking, relaxation exercises

- 240 • phase - external interruption, state event: external interruptions (e.g. fire alarm,
241 technical problems, other teachers coming into the room)
- 242 • speaking time - teacher, state event
- 243 • speaking time - students, state event
- 244 • disruption - chatting with neighbor, state event (perceived/ not perceived, reacted:
245 verbal, non-verbal/ not reacted)
- 246 • disruption - asking a question, state event (perceived/ not perceived, reacted: verbal,
247 non-verbal/ not reacted)
- 248 • disruption - yelling, state event (perceived/ not perceived, reacted: verbal,
249 non-verbal/ not reacted)
- 250 • disruption - looking at phone, state event (perceived/ not perceived, reacted: verbal,
251 non-verbal/ not reacted)
- 252 • disruption - staring out of window, state event (perceived/ not perceived, reacted:
253 verbal, non-verbal/ not reacted)
- 254 • disruption - drawing, state event (perceived/ not perceived, reacted: verbal,
255 non-verbal/ not reacted)
- 256 • disruption - head on table, state event (perceived/ not perceived, reacted: verbal,
257 non-verbal/ not reacted)
- 258 • disruption - clicking pen, state event (perceived/ not perceived, reacted: verbal,
259 non-verbal/ not reacted)
- 260 • disruption - drumming hands, state event (perceived/ not perceived, reacted: verbal,
261 non-verbal/ not reacted)

- disruption - walking around, state event (perceived/ not perceived, reacted: verbal, non-verbal/ not reacted)

First, we coded the speaking time of the teacher and the students to compare all perspectives: coder, observer, students, teacher. The graph below shows the result of the coded speaking duration compared to the estimated speaking duration assessed with the questionnaire.



Eyetracking Data. The Tobii Pro Lab 2 software was used to analyze the teachers' visual attention during each mini-lesson. The software allows for non-screen based recordings of a participants' attention while moving in real-world settings. The recordings of the glasses contain both HD-video from the subjects' perspective as well as the respective gaze data mapped onto the video. In order to map multiple recordings to AOIs, we first imported the eye-tracking recordings into the Tobii Pro Analyzer software. Second, we created dynamic Areas of Interest (AOI) manually to plot the gaze data. Once the

AOIs are created, the gaze recordings of multiple recordings can be mapped and analyzed in aggregated form. Tobii Pro does not allow to do AOI based analyses within Pro Lab. So we exported a tsv. file to do further analyses in the software R.

Gaze relational index (GRI).

The GRI is a measure of visual expertise in information processing. This metric is calculated as the ratio of mean fixation duration to fixation count. The GRI is higher for novices than for experts. (Gegenfurtner et al., 2020)

Table 4

Number and Duration (in msec) of Fixations

| Participant | Variable | Fixation Number | Fixation Duration | M Duration Fixation | TOI | GRI |
|-------------|----------|-----------------|-------------------|---------------------|------------|------|
| 01_01_D | Expert | 803.00 | 316,571.00 | 394.00 | 781,978.00 | 0.49 |
| 01_02_A | Expert | 1,070.00 | 385,812.00 | 361.00 | 838,026.00 | 0.34 |
| 01_03_B | Novice | 617.00 | 374,315.00 | 607.00 | 744,444.00 | 0.98 |
| 01_04_C | Novice | 769.00 | 384,537.00 | 500.00 | 723,922.00 | 0.65 |
| 02_01_A | Novice | 569.00 | 101,541.00 | 178.00 | 729,762.00 | 0.31 |
| 02_02_B | Novice | 1,140.00 | 520,431.00 | 457.00 | 730,565.00 | 0.40 |
| 02_03_C | Novice | 1,048.00 | 469,018.00 | 448.00 | 737,604.00 | 0.43 |
| 02_04_D | Novice | 613.00 | 438,655.00 | 716.00 | 747,729.00 | 1.17 |

Data analysis

We used R [Version 4.0.3; R Core Team (2019)] and the R-packages *dplyr* [R-dplyr], *forcats* [Version 0.5.0; Wickham (2020a)], *ggplot2* [Version 3.3.2; Wickham (2016)], *moments* [Version 0.14; Komsta and Novomestky (2015)], *papaja* [Version 0.1.0.9997; Aust and Barth (2020)], *papayar* (Muschelli, 2016), *psych* [Version 2.0.12; Revelle (2020)], *purrr* [Version 0.3.4; Henry and Wickham (2020)], *readr* [Version 1.4.0; Wickham, Hester, and Francois (2018)], *sjPlot* [Version 2.8.7; Lüdecke (2021)], *stringr* [Version 1.4.0; Wickham (2019)], *tibble* [Version 3.0.4; Müller and Wickham (2021)], *tidyr*

Table 5
Number and Duration (in msec) of Fixations during calibration

| Participant | Variable1 | Fixation Number | Fixation Duration | M Duration Fixation | TOI | GRI |
|-------------|-----------|-----------------|-------------------|---------------------|-----------|--------|
| 01_01_D | Expert | 9.00 | 14,372.00 | 1,597.00 | 16,470.00 | 177.44 |
| 01_02_A | Expert | 10.00 | 10,194.00 | 1,019.00 | 13,335.00 | 101.90 |
| 01_03_B | Novice | 17.00 | 9,234.00 | 543.00 | 10,615.00 | 31.94 |
| 01_04_C | Novice | 14.00 | 15,311.00 | 1,094.00 | 17,224.00 | 78.14 |
| 02_01_A | Novice | 13.00 | 5,157.00 | 397.00 | 17,902.00 | 30.54 |
| 02_02_B | Novice | 12.00 | 10,654.00 | 888.00 | 12,325.00 | 74.00 |
| 02_03_C | Novice | 18.00 | 14,151.00 | 786.00 | 16,494.00 | 43.67 |
| 02_04_D | Novice | 14.00 | 19,128.00 | 1,366.00 | 20,964.00 | 97.57 |

[Version 1.1.2; Wickham (2020b)], and *tidyverse* [Version 1.3.0; Wickham et al. (2019)] for all our analyses.

Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet.

Questionnaire Data.

Behavioral Data.

Eyetracking Data.

Results

Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos

et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet.

Questionnaire Data.

Behavioral Data.

Eyetracking Data.

Discussion

Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet.

References

Aust, F., & Barth, M. (2020). *papaja: Create APA manuscripts with R Markdown*.

Retrieved from <https://github.com/crsh/papaja>

Barnes, D. (2004). The significance of teachers' frames for teaching. In *Teachers and teaching* (pp. 16–38). Routledge.

Barth, V. L. (2017). *Professionelle wahrnehmung von störungen im unterricht*. Springer.

Berliner, D. C. (2001). Learning about and learning from expert teachers. *International Journal of Educational Research*, 35(5), 463–482.

Bogert, N. J. van den. (2016). *On teachers' visual perception and interpretation of classroom events using eye tracking and collaborative tagging methodologies*. Technische Universiteit Eindhoven.

Brophy, J. (1986). Classroom management techniques. *Education and Urban Society*, 18(2), 182–194.

Cortina, K. S., Miller, K. F., McKenzie, R., & Epstein, A. (2015). Where low and high inference data converge: Validation of CLASS assessment of mathematics instruction using mobile eye tracking with expert and novice teachers. *International Journal of Science and Mathematics Education*, 13(2), 389–403.

Gegenfurtner, A., Boucheix, J.-M., Gruber, H., Hauser, F., Lehtinen, E., & Lowe, R. K. (2020). The gaze relational index as a measure of visual expertise. *Journal of Expertise*. East Lansing, Michigan: Michigan State University, 2020, Vol. 3, Iss. 1.

Helmke, A., Helmke, T., Lenske, G., Pham, G., Praetorius, A.-K., Schrader, F.-W., & AdeThurow, M. (2014). Unterrichtsdiagnostik mit EMU. *Aus-Und Fortbildung Der Lehrkräfte in Hinblick Auf Verbesserung Der Diagnosefähigkeit, Umgang*

Mit Heterogenität Und Individuelle Förderung, 149–163.

Henry, L., & Wickham, H. (2020). *Purrr: Functional programming tools*. Retrieved from <https://CRAN.R-project.org/package=purrr>

Jarodzka, H., Scheiter, K., Gerjets, P., & Van Gog, T. (2010). In the eyes of the beholder: How experts and novices interpret dynamic stimuli. *Learning and Instruction*, 20(2), 146–154.

Kiel, E., Frey, A., Weiß, S., & Weiss, S. (2013). *Trainingsbuch klassenführung* (Vol. 3992). UTB.

Komsta, L., & Novomestky, F. (2015). *Moments: Moments, cumulants, skewness, kurtosis and related tests*. Retrieved from <https://CRAN.R-project.org/package=moments>

Kounin, J. S. (2006). *Techniken der klassenführung*. Waxmann Verlag.

Kuckartz, U., & Rädiker, S. (2019). *Analyzing qualitative data with MAXQDA*. Springer.

Lachner, A., Jarodzka, H., & Nückles, M. (2016). What makes an expert teacher? Investigating teachers' professional vision and discourse abilities. *Instructional Science*, 44(3), 197–203.

Lüdecke, D. (2021). *sjPlot: Data visualization for statistics in social science*. Retrieved from <https://CRAN.R-project.org/package=sjPlot>

Marzano, R. J. (2007). *The art and science of teaching: A comprehensive framework for effective instruction*. Ascd.

Messner, H., & Reusser, K. (2000). Die berufliche entwicklung von lehrpersonen als lebenslanger prozess. *Beiträge Zur Lehrerinnen-Und Lehrerbildung*, 18(2), 157–171.

Muschelli, J. (2016). *Papayar: View medical research images using the papaya*

JavaScript library. Retrieved from

<https://CRAN.R-project.org/package=papayar>

Müller, K., & Wickham, H. (2021). *Tibble: Simple data frames*. Retrieved from

<https://CRAN.R-project.org/package=tibble>

Nolting, H.-P. (2012). *Störungen in der schulklasse*. Beltz.

Pouta, M., Lehtinen, E., & Palonen, T. (2020). Student teachers' and experienced teachers' professional vision of students' understanding of the rational number concept.

R Core Team. (2019). *R: A language and environment for statistical computing*.

Vienna, Austria: R Foundation for Statistical Computing. Retrieved from

<https://www.R-project.org/>

Revelle, W. (2020). *Psych: Procedures for psychological, psychometric, and*

personality research. Evanston, Illinois: Northwestern University. Retrieved from

<https://CRAN.R-project.org/package=psych>

Stuermer, K., Seidel, T., Mueller, K., Häusler, J., & Cortina, K. S. (2017). What is

in the eye of preservice teachers while instructing? An eye-tracking study about

attention processes in different teaching situations. *Zeitschrift für*

Erziehungswissenschaft, 20(1), 75–92.

Wickham, H. (2016). *ggplot2: Elegant graphics for data analysis*. Springer-Verlag

New York. Retrieved from <https://ggplot2.tidyverse.org>

Wickham, H. (2019). *Stringr: Simple, consistent wrappers for common string*

operations. Retrieved from <https://CRAN.R-project.org/package=stringr>

Wickham, H. (2020a). *Forcats: Tools for working with categorical variables*

(factors). Retrieved from <https://CRAN.R-project.org/package=forcats>

396 Wickham, H. (2020b). *Tidyr: Tidy messy data*. Retrieved from

397 <https://CRAN.R-project.org/package=tidyr>

398 Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L. D., François, R., . . .

399 Yutani, H. (2019). Welcome to the tidyverse. *Journal of Open Source Software*,
400 4(43), 1686. <https://doi.org/10.21105/joss.01686>

401 Wickham, H., Hester, J., & François, R. (2018). *Readr: Read rectangular text data*.

402 Retrieved from <https://CRAN.R-project.org/package=readr>

403 Wolff, C. E., Jarodzka, H., & Boshuizen, H. P. (2017). See and tell: Differences

404 between expert and novice teachers' interpretations of problematic classroom
405 management events. *Teaching and Teacher Education*, 66, 295–308.