1   Through the eyes of the teacher

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Abstract

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

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

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 Informationand 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

66 years, whereas experts were considered to have professional experience of 10 years or more

67 (Messner & Reusser, 2000).

Procedure/ Data collection

69 **Set up.** For this study, scripted mini-lessons with n = 2 experts and n = 6 novices

70 were recorded in the mobile Lab of the Empirical School and Classroom Research at the

71 University of Leipzig. The subjects were divided into groups of four, so the study was

72 conducted on two different sessions. All participants were asked to hold a 10-minute lesson.

73 The duration of each appointment was approximately 2h: per group 10min briefing, 4 x

74 10min mini-lessons, 10min technical preparation and follow-up and 4x 10min transition

75 points between the lessons and answering questionnaires.

76 One person from the group of 4 acted as a teacher, the other three subjects acted as

77 the class. The subjects, who represented the class, were given behavioral instructions in a

78 pre-written script to simulate typical events and disruptions in the classroom (e.g. putting

79 their heads on the table, chatting, looking at their mobile phones, etc.).

80 The lesson disruptions were displayed as instructions during the lesson for all

81 "students" but not the teacher. In order to avoid learning effects, the disruptions in each

82 lesson were distributed pseudo-randomly over the short teaching phase. In addition, the

83 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.

98 **Eyetracking data.** A binocular Tobii Pro Glasses 2 eye-tracker consisting of a

99 wearable head unit and a recording unit was used to record the eye movements of all 8

100 participants. The head unit is a measuring device with different sensitive sensors. A

101 high-definition scene camera captures a full HD video and an integrated microphone

102 records the surrounding sounds. Infrared light illuminators support the eye tracking

103 sensors which record the eye orientation. The videos were recorded with a sampling rate of

104 50 Hz and a video resolution with 1920 x 1080 at 25 frames per second. The scene camera

105 has a field of view of 90 deg. in 16:9 format (82 deg. horizontal and 52 deg. vertical) and

106 has a frame dimension of 179 x 159 x 57mm (width x depth x height). The Tobii Pro

107 Glasses Controller software was used to record and calibrate the eye movements.

Coding/ Data preparation/ Reliability

109 **Questionnaire Data.** The evaluation after each mini-lesson was conducted using

110 paper questionnaires. Time needed to complete the questionnaire was about 5 minutes.

111 The scales on the quality of teaching are a validated questionnaire (Helmke et al., 2014).

112 Whereas the scales on the teacher's presence behavior were derived from the research

113 literature (Brophy, 1986; Kiel, Frey, Weiß, & Weiss, 2013; Kounin, 2006; Marzano, 2007;

114 Nolting, 2012) and were used in the pilot for the first time. The questionnaire is 4-point

115 Likert scale (1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree). Data

116 was obtained from N = 32 subjects (students n = 24, teachers n = 8).

117 The following scales were assessed:

118 (1) Classroom management

119 (2) Positive climate and motivation

120 (3) Clarity and structuredness

121 (4) Activation and support

122 (5) Presence: posture/gaze

123   (6) Presence: voice

124   (7) Presence: verbal and non-verbal intervention

125   (8) Natural behaviour

126   Table 2 provides an overview over the mean, the standard deviation, the range,

127 Cronbach's Alpha and the Skewness & Kurtosis of all scales for the teachers'

128 self-assessment.

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

130 ## should be reversed.

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

132 ## Some items (ks_sichtbar) were negatively correlated with the total scale and

133 ## probably should be reversed.

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

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

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

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

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

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

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

143 ## should be reversed.

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

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

## Some items ( pi_nonverbal ) 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

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

184   Table 3 provides an overview over the mean, the standard deviation, the range,

185 Cronbach's Alpha and the Skewness & Kurtosis of all scales for the students' perception of

186 the teacher's behaviour in class.

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

188 ## should be reversed.

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

190 ## Some items (phb_stand) were negatively correlated with the total scale and

191 ## probably should be reversed.

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

Table 2

Scale analysis for teachers' self-assessment

scale	N items	M	SD	Min	Max	Skewness	Kurtosis	Cron
Activation and support	3	2.46	1.14	1	4	0.10	1.65	0.85
Clarity and structuredness	2	2.81	0.91	1	4	-0.17	2.17	-0.76
Classroom management	4	2.44	0.88	1	4	0.19	2.38	0.83
Natural behaviour	3	2.83	0.76	2	4	0.28	1.84	0.90
Positive climate and motivation	6	2.85	0.87	1	4	-0.49	2.65	0.78
Presence: posture/gaze	7	2.70	1.01	1	4	-0.44	2.15	0.85
Presence: verbal and non-verbal intervention	3	2.75	0.79	1	4	-0.07	2.48	-0.75
Presence: voice	3	2.79	0.72	2	4	0.32	2.03	0.77

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193  ## Warning in alpha(stud.pvni.wide[, -1]): Some items were negatively correlated with th

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	N items	M	SD	Min	Max	Skewness	Kurtosis	Cron
Activation and support	3	2.64	1.13	1	4	-0.32	1.73	0.48
Clarity and structuredness	2	3.58	0.68	1	4	-1.75	6.09	0.62
Classroom management	4	3.18	0.91	1	4	-0.87	2.86	0.75
Natural behaviour	3	3.43	0.67	2	4	-0.74	2.46	0.85
Positive climate and motivation	6	3.41	0.83	1	4	-1.40	4.29	0.82
Presence: posture/gaze	7	3.24	0.89	1	4	-1.05	3.31	0.59
Presence: verbal and non-verbal intervention	3	3.18	0.81	1	4	-0.66	2.70	0.20
Presence: voice	3	3.60	0.60	2	4	-1.18	3.36	0.71

²⁰⁵ The individual items of a scale are further represented in graphs.
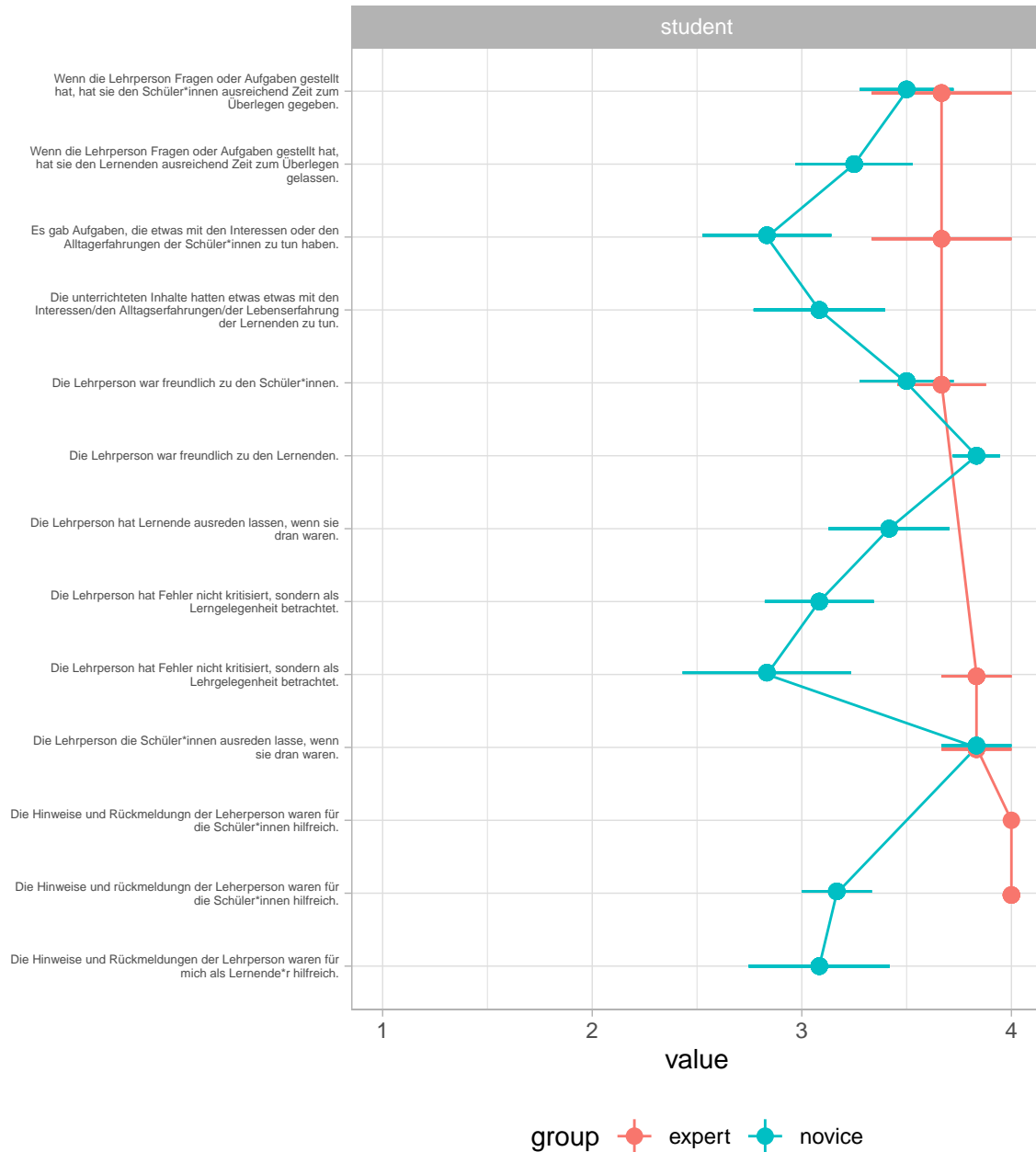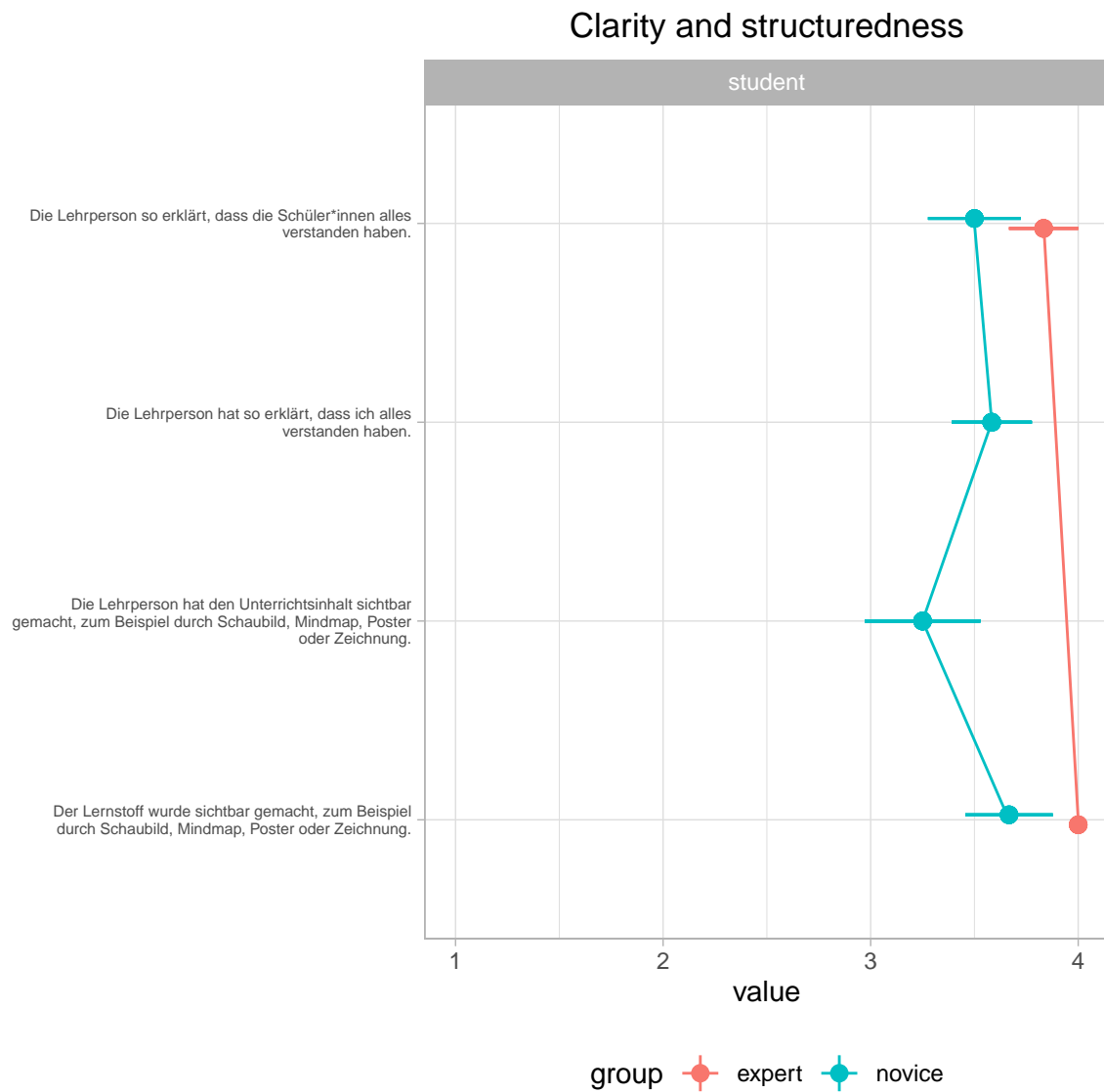
²⁰⁶ (1) Classroom management

Classroom management
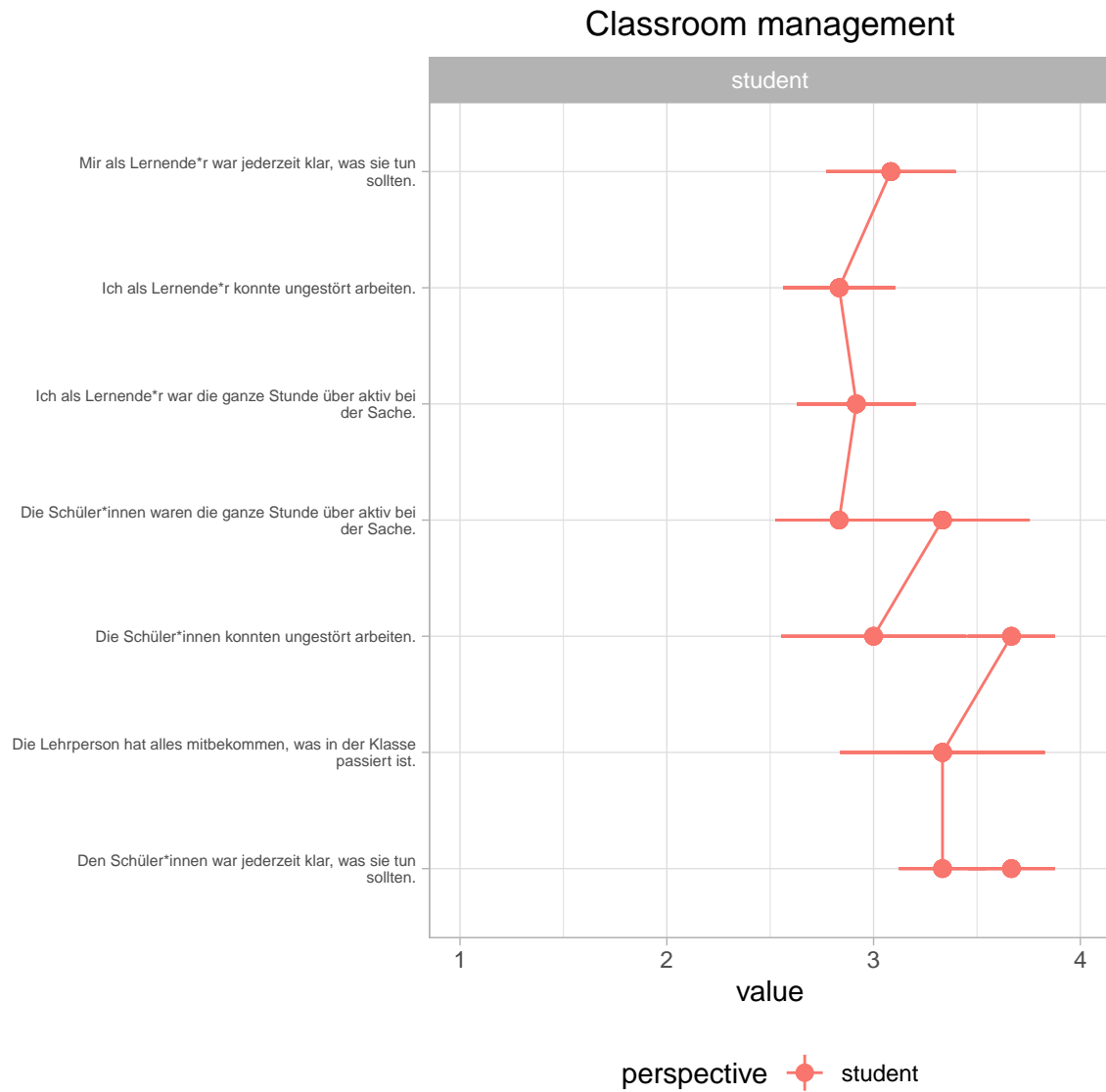
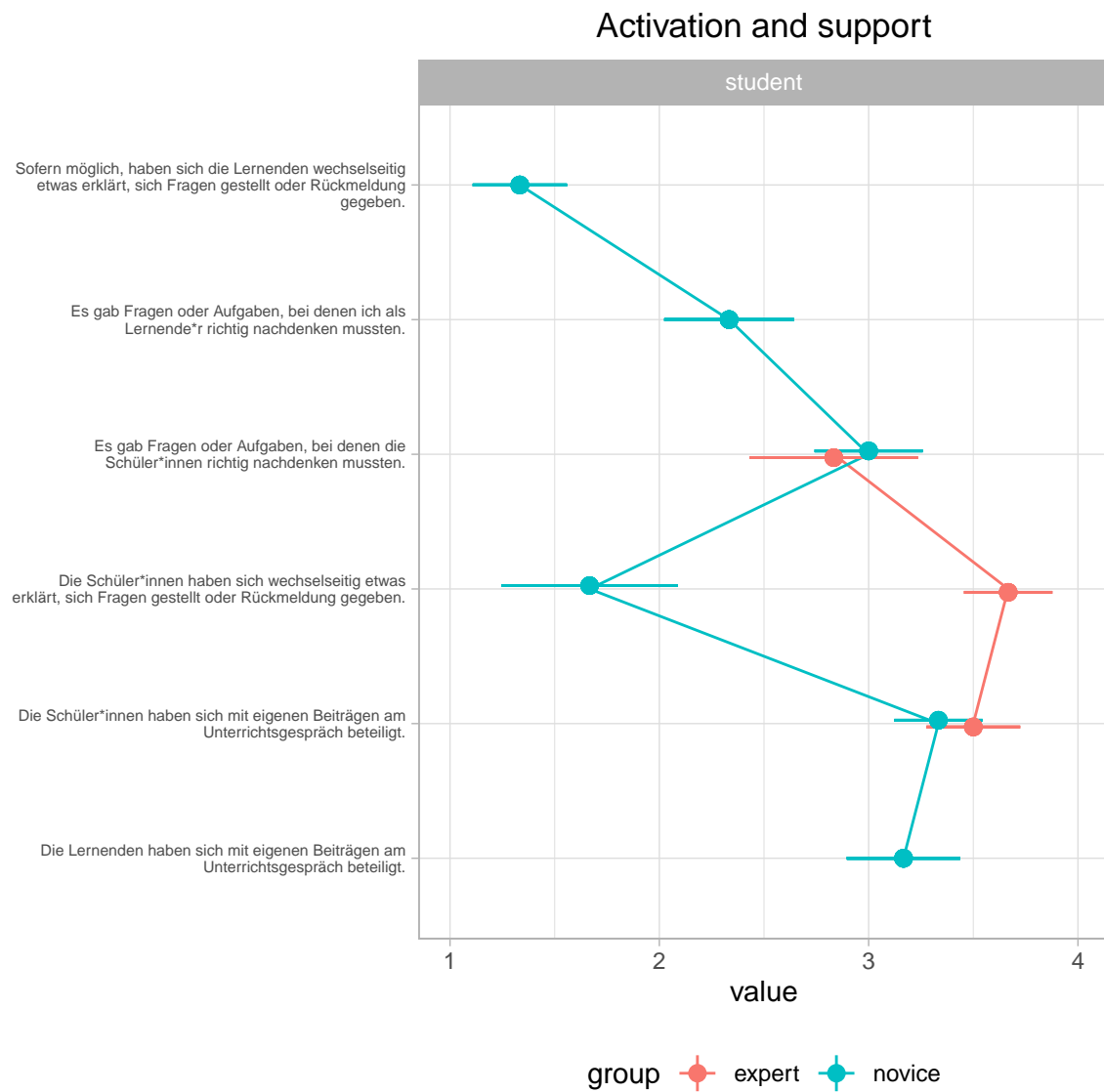(2) Positive climate and motivation

210   (3) Clarity and structuredness
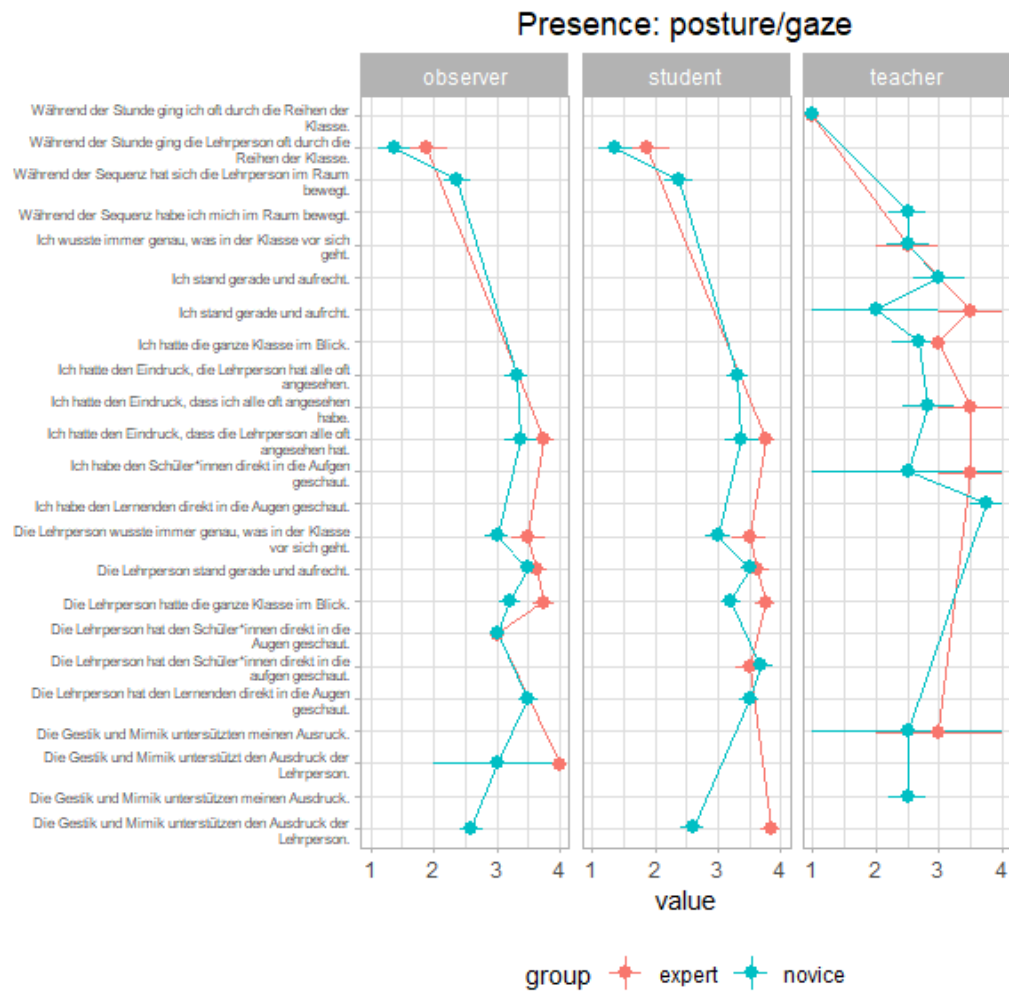

211

212 (4) Activation and support

213

Figure 2. (5) Presence: posture/gaze
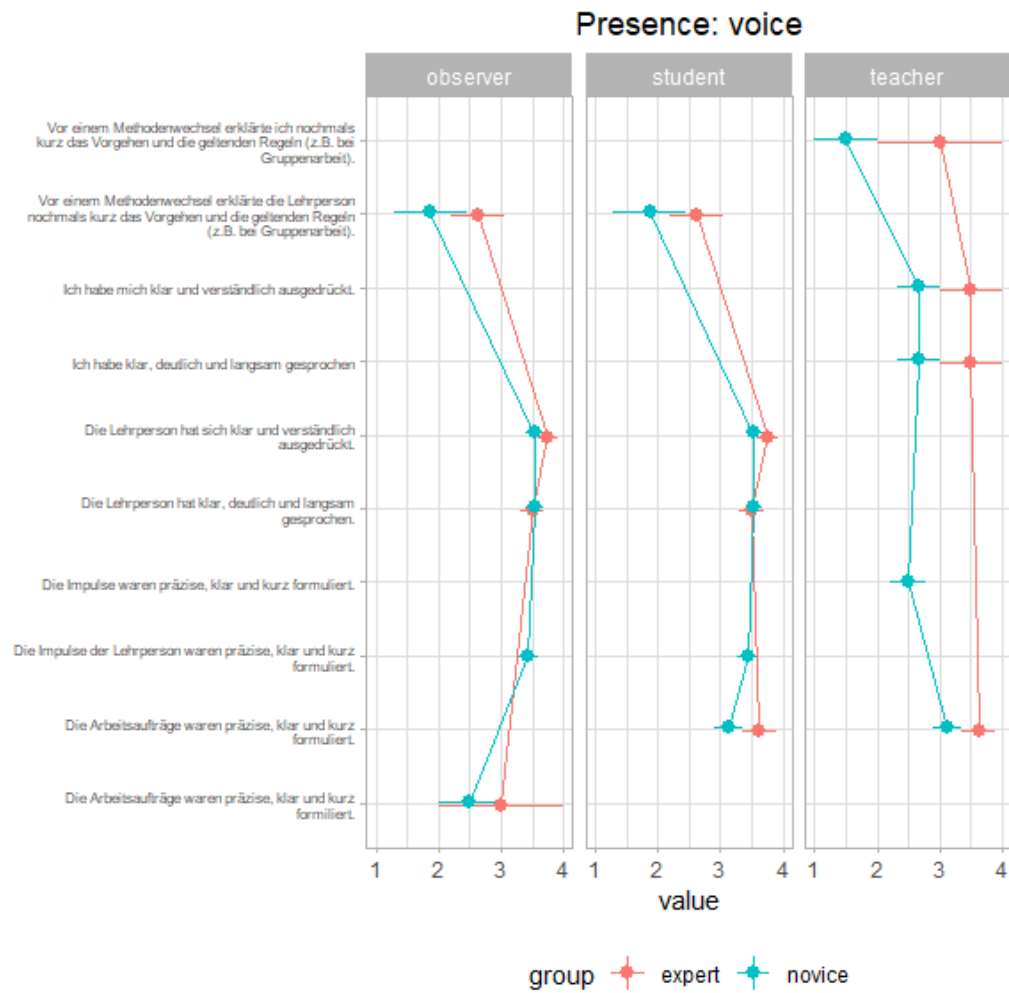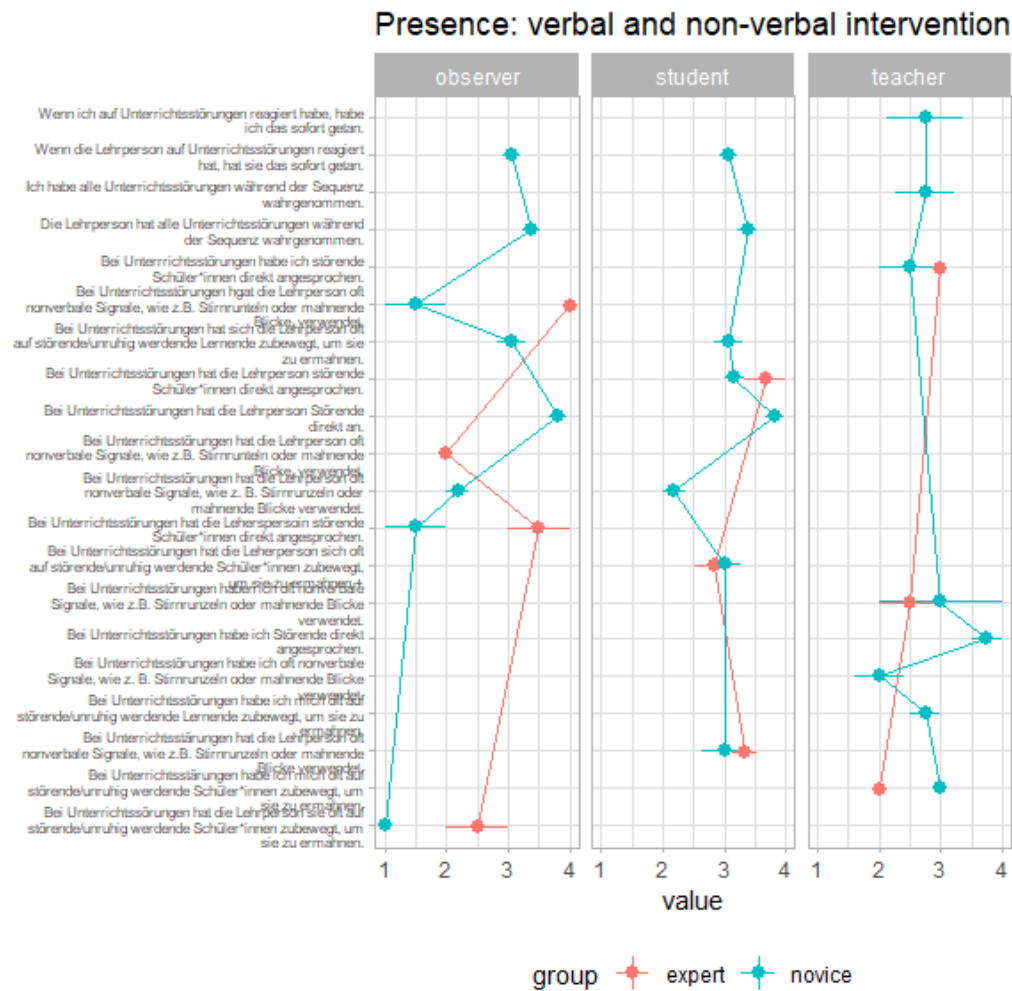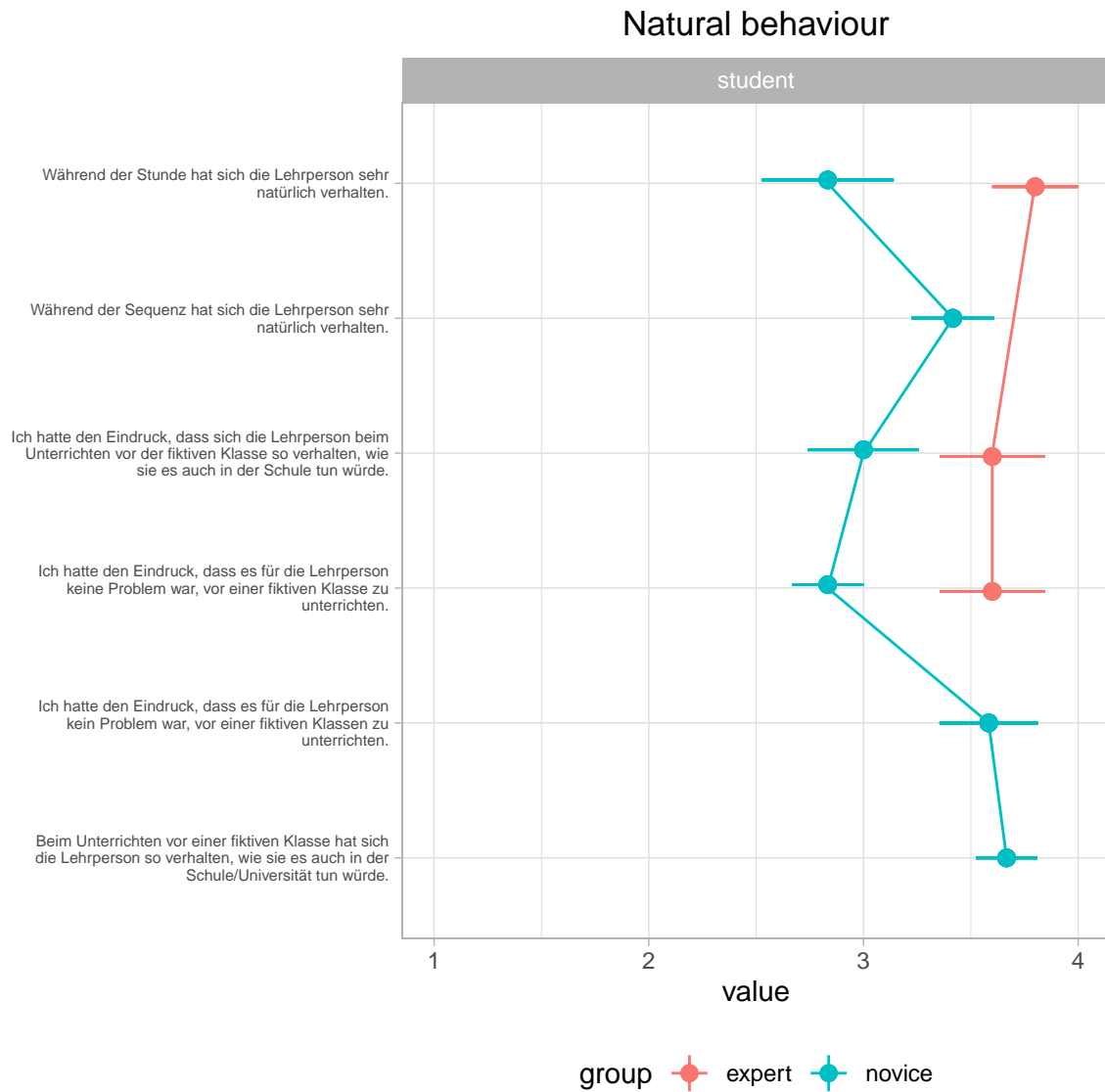
Figure 3. (6) Presence: voice

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

214 (8) Natural behaviour

215

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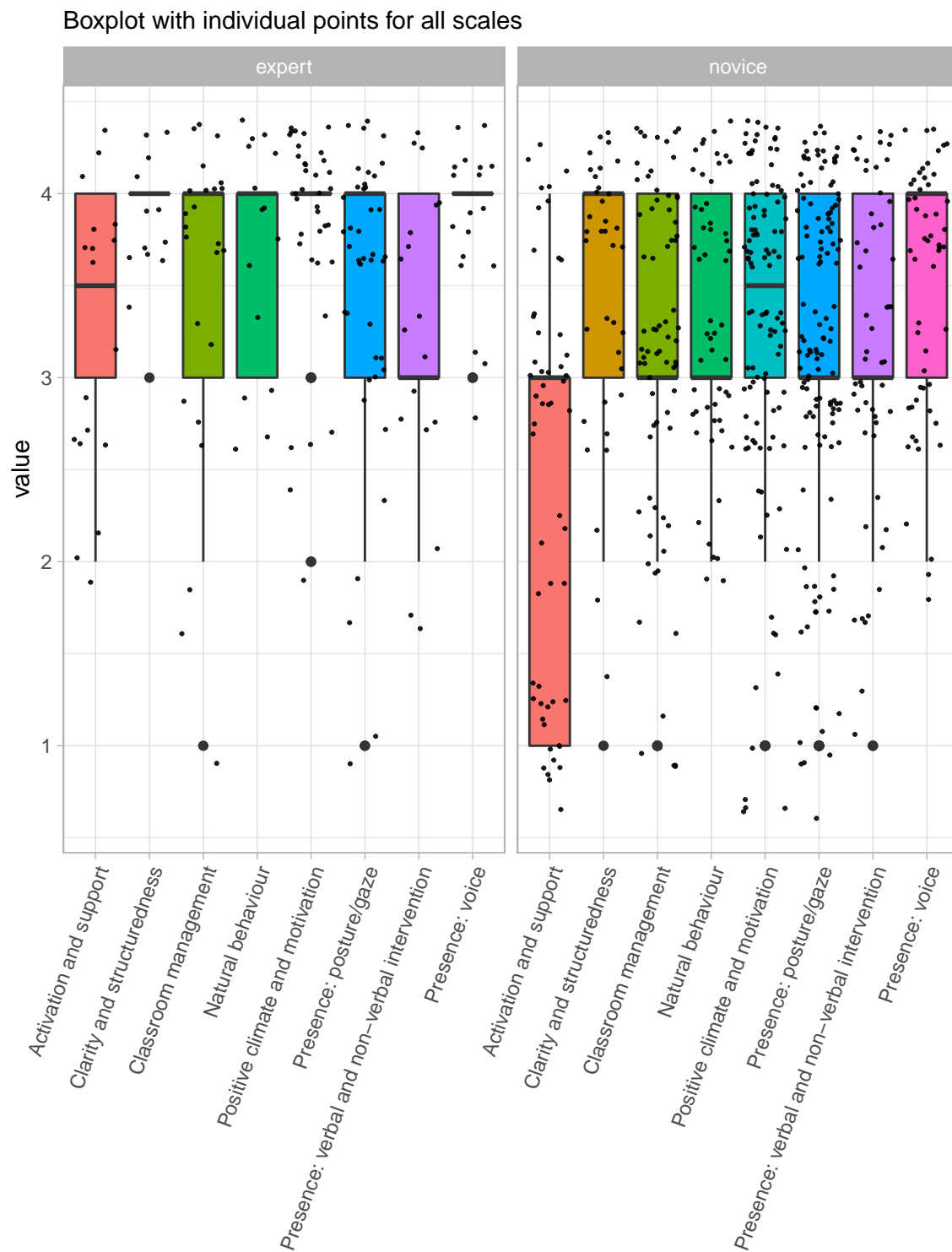
217   experts and novices.

Boxplot with individual points for all scales

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

218   **Behavioral Data.**   The recorded lessons were coded in a post-hoc procedure with

219   the coding software MAXQDA by previously trained raters (Kuckartz & Rädiker, 2019).

220   The following coding scheme was developed:

221   • phase - lesson begin, state event: teacher starts the lesson with a noise, talk, taking a
222   position in class

223   • phase - lesson end, state event: teacher finishes the lesson with a noise, talk, taking a
224   position in class

225   • phase - organization/transition points, state event: any situation that does not imply
226   effective learning time (fetching chalk, working material, organizing desks, opening
227   windows, printing work results etc.)

228   • phase - single, state event: any individual student activity on a given task (reading,
229   writing, drawing etc.)

230   • phase - group, state event: any student activity on a given task together in a group of
231   at least 3 students (reading, writing, drawing etc.)

232   • phase - class discussion, state event: discussion in class, teacher talks to
233   class/individual/group

234   • phase - pair: state event: any student activity on a given task together in a team of 2
235   students (reading, writing, drawing etc.)

236   • phase - teachers lecture, state event: any teacher's presentation on a certain topic
237   which maybe supported by a PPP, PREZI, notes on board, OHP etc.

238   • phase - other, state event: not categorizable

239   • phase - break, state event: e.g. drinking, relaxation exercises

- phase - external interruption, state event: external interruptions (e.g. fire alarm, technical problems, other teachers coming into the room)

- speaking time - teacher, state event

- speaking time - students, state event

- disruption - chatting with neighbor, state event (perceived/ not perceived, reacted: verbal, non-verbal/ not reacted)

- disruption - asking a question, state event (perceived/ not perceived, reacted: verbal, non-verbal/ not reacted)

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

- disruption - looking at phone, state event (perceived/ not perceived, reacted: verbal, non-verbal/ not reacted)

- disruption - staring out of window, state event (perceived/ not perceived, reacted: verbal, non-verbal/ not reacted)

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

- disruption - head on table, state event (perceived/ not perceived, reacted: verbal, non-verbal/ not reacted)

- disruption - clicking pen, state event (perceived/ not perceived, reacted: verbal, non-verbal/ not reacted)

- disruption - drumming hands, state event (perceived/ not perceived, reacted: verbal, non-verbal/ not reacted)

262   • disruption - walking around, state event (perceived/ not perceived, reacted: verbal,

263   non-verbal/ not reacted)

264   First, we coded the speaking time of the teacher and the students to compare all

265 perspectives: coder, observer, students, teacher. The graph below shows the result of the

266 coded speaking duration compared to the estimated speaking duration assessed with the

267 questionnaire.

Boxplot with individual points for Duration of speaking time

268
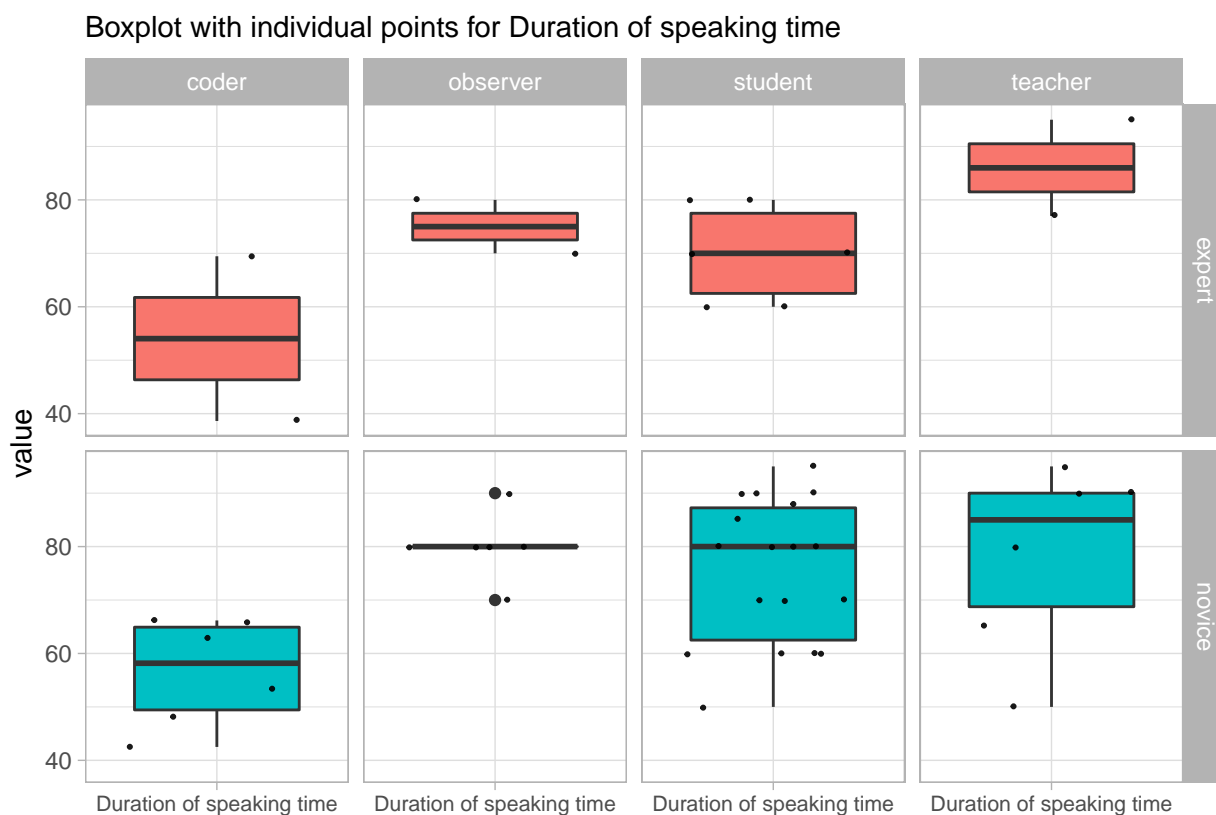
269   **Eyetracking Data.**   The Tobii Pro Lab 2 software was used to analyze the

270 teachers' visual attetion during each mini-lesson. The software allows for non-screen based

271 recordings of a participants' attention while moving in real-world settings. The recordings

272 of the glasses contain both HD-video from the subjects' perspective as well as the

273 respective gaze data mapped onto the video. In order to map multiple recordings to AOIs,

274 we first imported the eye-tracking recordings into the Tobii Pro Analyzer software. Second,

275 we created dynamic Areas of Interest (AOI) manually to plot the gaze data. Once the

276 AOIs are created, the gaze recordings of multiple recordings can be mapped and analyzed

277 in aggregated form. Tobii Pro does not allow to do AOI based analyses within Pro Lab. So

278 we exported a tsv. file to do further analyses in the software R.

279 ### *Gaze relational index (GRI).*

280   The GRI is a measure of visual expertise in information processing. This metric is

281 calculated as the ratio of mean fixation duration to fixation count. The GRI is higher for

282 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

283 ## Data analysis

284   We used R [Version 4.0.3; R Core Team (2019)] and the R-packages *}dplyr*

285 [@}R-dplyr], *corrplot2017* (Wei & Simko, 2017), *forcats* [Version 0.5.0; Wickham (2020a)],

286 *Formula* [Version 1.2.4; Zeileis and Croissant (2010)], *ggplot2* [Version 3.3.2; Wickham

287 (2016)], *Hmisc* [Version 4.4.2; Harrell Jr, Charles Dupont, and others. (2020)], *lattice*

288 [Version 0.20.41; Sarkar (2008)], *moments* [Version 0.14; Komsta and Novomestky (2015)],

289 *papaja* [Version 0.1.0.9997; Aust and Barth (2020)], *papayar* (Muschelli, 2016), *psych*

290 [Version 2.0.12; Revelle (2020)], *purrr* [Version 0.3.4; Henry and Wickham (2020)], *readr*

291 [Version 1.4.0; Wickham, Hester, and Francois (2018)], *sjPlot* [Version 2.8.7; Lüdecke

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

292 (2021)], *stringr* [Version 1.4.0; Wickham (2019)], *survival* [Version 3.2.7; Terry M.

293 Therneau and Patricia M. Grambsch (2000)], *tibble* [Version 3.0.4; Müller and Wickham

294 (2021)], *tidyr* [Version 1.1.2; Wickham (2020b)], and *tidyverse* [Version 1.3.0; Wickham et

295 al. (2019)] for all our analyses.

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301 sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita

302 kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet.

303 **Questionnaire Data.**

304 **Behavioral Data.**

305 **Eyetracking Data.**

Table 6

Number and Duration (in msec) of Fixations Calibration End to Lesson Start

Participant	Variable1	Fixation Number	Fixation Duration	M Duration Fixation	TOI	GRI
01_01_D	Expert	101.00	38,177.00	378.00	53,133.00	3.74
01_02_A	Expert	27.00	6,736.00	249.00	15,502.00	9.22
01_03_B	Novice	57.00	36,378.00	638.00	58,763.00	11.19
01_04_C	Novice	65.00	22,387.00	344.00	39,235.00	5.29
02_01_A	Novice	14.00	2,619.00	187.00	30,195.00	13.36
02_02_B	Novice	46.00	15,851.00	345.00	30,297.00	7.50
02_03_C	Novice	86.00	27,643.00	321.00	42,603.00	3.73
02_04_D	Novice	53.00	27,783.00	524.00	36,204.00	9.89

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

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