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Teachers' visual focus of attention in relation to students' basic academic skills and teachers' individual support for students: An eye-tracking study

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ABSTRACT

This study investigated how teachers' visual focus of attention is associated with students' basic academic skills and teachers' individual support for students in basic academic skills in authentic classroom settings. Teachers' ($N = 46$) visual focus of attention in the classroom was measured with mobile eye-tracking, and students' ($N = 879$) literacy and math skills were tested in Grade 1. The results revealed that teachers' visual focus of attention in terms of fixation counts correlated with students' basic academic skills and teachers' individual support for students in literacy and math. Two case studies showed that teachers' visual focus of attention varied among students with different teacher-reported individual support. It might indicate that the number of students with high teacher individual support in the classroom could influence how evenly teachers are able to distribute their attention. The practical implications of our findings suggest that it is essential to ensure the appropriate distribution of students who require greater individual support so these students can receive more of the teachers' visual focus of attention in the classrooms.

1. Introduction

The classroom is a complex environment that requires teachers to provide individual focus of attention to influence students' learning and ensure effective instruction (Blomberg et al., 2011). A teacher's selective visual focus of attention is known to be a prerequisite for the teacher's noticing of relevant classroom events and thereby, interpreting the classroom events based on their professional knowledge of teaching and learning (Sherin & van Es, 2005). It can be very challenging for teachers to focus immediate visual attention on all students who require individual academic support (van den Bogert et al., 2014). In the early school years, particularly Grade 1, the emphasis of learning is on students' basic academic skills in literacy and math (Lerkkanen et al., 2016). Therefore, teachers must identify students who need more individual support to develop their basic academic skills. This phenomenon is often connected to the term "evocative effect," which refers to an adult's response arising from children's characteristics, such as behavior or academic performance (Nurmi et al., 2012). Previous research has found that students' academic performance evokes teachers' instructional support in the classroom (Huber & Seidel, 2018; Nurmi et al., 2012; Silinskas et al., 2015) to improve their literacy (Connor et al., 2004) and math skills (Curby et al., 2009). However, less is known about the extent to which teachers' visual focus of attention affects the variation of teacher's individual support for students in relation to the development of their basic academic skills. In addition, there is a lack of studies that have utilized eye-tracking methodology to investigate the links between teachers' visual focus of attention and students' basic academic skills and teacher individual support for students in elementary school classrooms. This study used an exploratory approach to investigate, first, whether students' basic academic skills and teachers' individual support for students were associated with teachers' visual focus of attention in Grade 1 classrooms. Second, a case study design was used to explore in-depth the variations in teachers' visual focus of attention in two example classrooms: one classroom scoring higher than average and another classroom scoring lower than average in the teacher's individual support for students in math.

1.1. Teachers' visual focus of attention

There are multiple unpredictable events happening simultaneously in the classroom that require teachers to notice and be selective with their visual focus of attention (Sherin & van Es, 2005). Accordingly, the

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concept of *teacher's professional vision*, first introduced by Goodwin (1994), was further developed to provide a deeper insight into teacher's professional competence that included their ability to *notice* relevant classroom events and provide *knowledge-based reasoning* for the noticed information in the classroom (Seidel et al., 2011; Seidel & Stürmer, 2014). Eye-tracking technology has been used in this regard to study teachers' noticing in terms of moment-to-moment changes in teachers' visual focus of attention on students and in relation to teachers' pedagogical actions (Jarodzka et al., 2020; McIntyre & Mainhard, 2020; Tatler et al., 2014). Recent studies have involved mobile eye-tracking for in-depth investigation of teacher's noticing through their selective focus of visual attention toward classroom events while watching teaching videos (Codreanu et al., 2021; McIntyre et al., 2021; van den Bogert et al., 2014) or while teaching in an authentic classroom setting (Dessus et al., 2016; Goldberg et al., 2021; Haataja et al., 2019; Huang et al., 2021; McIntyre & Foulsham, 2018). Drawing from the existing literature, this study examined the aspect of teachers' noticing through their selective visual focus of attention towards students. The teachers' visual focus of attention is defined as the teacher's gaze on relevant targets (such as students) for processing information present in an authentic classroom setting (van den Bogert et al., 2014), and this can be measured by using eye-tracking indicators of fixation-based metrics, such as total fixation duration, average fixation duration, and fixation counts. In previous studies, fixation has been defined as the duration in eye tracking when the eye is relatively still and provides the ability to process information from the targets in the classroom environment (e.g., Goldberg et al., 2021; McIntyre & Mainhard, 2020; McIntyre et al., 2017; Stahnke & Blömeke, 2021; van den Bogert et al., 2014; Wolff et al., 2016).

The theoretical Classroom Management Script model developed by Wolff et al. (2020) showed that teachers' expertise can influence perception, interpretation, and response to events connected to students in the classroom. Recent eye-tracking studies have shown that expert teachers show improved noticing of classroom events through faster recognition of relevant information (Gegenfurtner et al., 2020; Keller et al., 2021; van den Bogert et al., 2014), improved monitoring of students, and better judgment accuracy regarding student assessment in the classroom when compared with novice teachers (Kosel et al., 2021). The Classroom Management Script model suggested that teachers' visual focus of attention is complex and could follow both top-down and bottom-up processes simultaneously when they concentrate on student-related issues to provide individual attention. For instance, top-down processes could involve teachers' prior knowledge related to students' academic skills and perceived individual support for students, whereas bottom-up processes could involve the students' actual behaviors and other physical characteristics of students guiding the teachers' gaze in the classroom (Wolff et al., 2020). The present study focused on investigating teachers' top-down processes involving students' academic skills and teacher-perceived individual student support, which could influence teachers' visual focus of attention during lessons.

Teachers' visual focus of attention can vary based on students' academic skills and actual behaviors in the classroom. For example, teachers gazed more on secondary school students who needed adaptive pedagogical action (Seidel et al., 2020) and gazed longer when providing guidance to students who struggled, showed less interest, and did not concentrate during academic activities (Dessus et al., 2016; McIntyre et al., 2017; Seidel et al., 2020; Yamamoto & Imai-Matsumura, 2013). Teachers also focused more visual attention on individual students while providing feedback on their answers during classroom interactions (Cortina et al., 2015). Additionally, teachers seemed to focus more visual attention on students who showed disruptive behavior (Wolff et al., 2016; Yamamoto & Imai-Matsumura, 2013) and interactive behavior, such as asking the teacher questions or explaining their answers to the teacher (Goldberg et al., 2021). Therefore, teachers need to engage with students to improve learning and influence a group or individual students through monitoring, interaction, and support whenever required in the classroom (Seidel & Stürmer, 2014; van Es & Sherin, 2008). Recent eye-tracking studies have acknowledged that immediate attention and decisions related to individual student's achievement and understanding have been considered a challenging task for secondary school teachers (Cortina et al., 2015; Dessus et al., 2016; Goldberg et al., 2021; Haataja et al., 2019; Seidel et al., 2020; Wolff et al., 2016; Yamamoto & Imai-Matsumura, 2013) and higher education teachers (Prieto et al., 2017); however, there are limited studies concerning how teachers' visual focus of attention is related to students' basic academic skill levels and teachers' individual support for students in literacy and math at the beginning of elementary school.

1.2. Students' basic academic skills and teachers' individual support for students

Literacy and math are basic academic skills that students must acquire during their early school years. Students who struggle with developing basic academic skills in these years are more likely to struggle with academics in the future (Aunola et al., 2004). Therefore, teachers should support students' individual learning of basic literacy and math skills during their first school year (Lerkkanen et al., 2016). It has been found that students' academic performances evoke teachers' responses, such as individualized support and adaptive instructions (Nurmi et al., 2012; Pakarinen et al., 2011). Previous observational studies have shown that teachers provide more individual support to students who struggle with reading skills (Ruotsalainen et al., 2020) and adapt instruction based on the students' literacy skill level (Connor et al., 2009). In addition, students' low performance in reading and math in the fall of Grade 1 has been associated with increased teacher support in the spring of Grade 1 (Nurmi et al., 2012; Silinskas et al., 2015). In the present study, teachers' individual support for students was defined as teachers' perception of the amount of support they provide in literacy and math to a student compared with other students in the class.

Previous eye-tracking studies have shown that cues such as student academic skills and behavior influence teachers' visual focus of attention. For example, teachers showing greater judgment accuracy of student's cognitive and motivational characteristics used combinations of students' diagnostic cues (Schnitzler et al., 2020) and monitored individual students regularly (Kosel et al., 2021). In addition, teachers who showed greater judgment accuracy in assessing students had increased fixation counts and shorter average fixation duration on students (Schnitzler et al., 2020), possibly indicating improved information processing. Even though students' basic academic skills and teachers' individual support for students have been studied, there is little research on how teachers' visual focus of attention might be related to students' literacy and math skills and the amount of individual student support offered by the teacher in these subject areas. In particular, little is known concerning whether variations in students' basic academic skills and teachers' perceptions of individual student support are related to teachers' visual focus of attention in the classroom.

1.3. Aim of the study

The aim of this study was to investigate teachers' visual focus of attention in relation to students' basic academic skills and teachers' individual support for students in literacy and math in authentic classroom settings using mobile eye-tracking technology. In the classroom context, there is a need to investigate whether teachers provide selective focus of attention to students by noticing student cues, such as their basic academic skills, and how this is related to teachers' individual support for students. To gain a deeper understanding, we used case studies to examine the variations in teachers' visual focus of attention in two example classrooms: one classroom scoring higher than average and another classroom scoring lower than average in teachers' individual support for students in math.

The research questions for this study are as follows:

1. To what extent is teachers' visual focus of attention associated with students' basic academic skills (literacy and math) and teachers' individual support for students in these skills?
2. How are students' math skills and teachers' individual support for students in math skills reflected in teachers' visual focus of attention in classrooms characterized by high and low teacher individual support for students?

The present study was conducted in Finland, where students begin their nine years of elementary school at seven years of age. The students are placed in schools based on the school's proximity to their homes. It is mandatory for teachers to have a master's degree in education to teach in elementary school. Typically, in elementary school, the same teacher teaches the same class and most of the subjects for several years. Most schools in Finland are public schools that follow a national core curriculum for basic education designed by the Finnish National Board of Education (Finnish National Agency for Education, 2014).

2. Methods

2.1. Participants and procedure

In the present study, 46 Finnish Grade 1 teachers (44 female, 2 male; $M_{age} = 44.84$ years, $SD = 9.10$) and 879 students ($M_{age} = 7.28$ years, $SD = 0.47$) participated from 31 schools within seven municipalities in Central Finland, including rural and urban areas. The teachers' average work experience was 16.35 years ($SD = 9.45$, $Min_{exp} = 0.50$, $Max_{exp} = 39$), and the average class size included 19.22 students ($SD = 4.36$, $Min_{cs} = 7$, $Max_{cs} = 25$). All teachers held a Master of Education degree and were qualified as class teachers. The parents' responses indicated that 41.7 % had completed high school followed by vocational school degree or college level training; 27.5 % had completed polytechnic school or a bachelor's degree; 27.1 % had completed a master's degree; and 3.7 % had completed a doctoral degree.

This study was part of a larger follow-up focusing on the role of teacher and student stress on teacher–child interactions (Lerkkanen & Pakarinen, 2016-2022). In the present study, teacher's eye-tracking video data were used to study teachers' visual focus of attention. Previously, the same eye-tracking video dataset from Grade 1 had been used in studies different from the present one, such as studies on teachers' visual focus of attention in relation to teacher stress, teacher's professional vision, and educational dialogue (Chaudhuri et al., 2021; Muhonen et al., 2020, 2021, 2022). However, the topic of the present study, teachers' visual focus of attention in relation to student's basic academic skills and teachers' individual support for students in literacy and math, has not been investigated previously. In 2017, approval from the university's ethics committee was received before the commencement of the study (Finnish Advisory Board on Research Integrity [TENK], 2013). The data for the present study were collected during the spring semester of 2018. Teachers were invited by phone or email to participate in the study. Participation in this study was voluntary, and written consent was obtained from the teachers and students' parents before data collection. The data restoration was carried out according to the university's ethical committee and the European Union's General Data Protection Regulation guidelines.

The teachers filled in questionnaires on background information, and they rated their individual support for students in their classrooms. The assessment of students' basic academic skills in literacy was conducted as an individual test, and the math assessment was conducted as a group test on a regular school day by trained research assistants. The teachers filled in a questionnaire concerning their individual support for each participating student in literacy and math. The purpose of this questionnaire was to obtain an overall assessment of teacher's individual support for a student, rather than focusing solely on the day of eye-tracking data collection. It is important to note that since the same teacher teaches all subjects in Grade 1, they were able to rate individual support for students in both literacy and math.

The teachers' visual focus of attention in authentic classroom settings was investigated using mobile eye-tracking technology. The eye-tracking videos of teachers were recorded during the second lesson of the normal school day using Tobii Pro Glasses 2 (Tobii AB, Danderyd, Sweden) for a period of 20–25 min starting from the beginning of the lesson. The lesson structure and content were not predetermined, and the teachers had the freedom to carry out their tuition based on their preferences and the typical agenda of the school day. These recordings consisted of 22 math lessons, 20 literacy lessons, and four activity-based lessons (for example, art and crafts, and a Saint Valentine's day activity). The four activity-based lessons were included in the larger data since these lessons had references to components of literacy and math. In addition, math and literacy lessons also included activities at different stages of the lesson to ensure a multimodal learning approach for students. In Grade 1, it is typical for teachers to practice integration and multidisciplinary learning across subjects since both literacy and math are equally considered as basic foundational academic skills (Finnish National Agency for Education, 2014). To ensure appropriate data quality, a 3-point calibration of the eye-tracking glasses was conducted by two trained research assistants before each recording. The course of the lesson, the seating plan in the classroom, and the materials used during the recording were also noted. In the present study, the Tobii Pro Glasses 2 (see Tobii AB, 2018) that was used had the following features: four cameras for corneal reflection and pupil tracking with scene camera resolution of 1920 × 1080 pixels at 25 frames per second. The visual angle of the scene camera was 82 degrees horizontal and 52 degrees vertical. The frame dimensions were 179 × 159 × 57 mm. For further investigation using the case study design, two classrooms in which math lessons were taught during eye-tracking recording were selected: one with more overall high teachers' individual support for students and one with overall low teachers' individual support for students in math.

2.2. Measures

2.2.1. Teachers' visual focus of attention

Teachers' areas of interest (AOIs) were identified as the targets where teachers looked during the lesson using Tobii Pro Analyser software v. 1.128. In the present study, during the manual fixation mapping process, AOIs such as the students, instructional materials (such as materials required for teaching and learning), and non-instructional materials (areas such as walls, tables, curtains, windows, etc.) were considered as the targets where teachers focused their visual attention. Drawing from previous research showing that manual coding was best suited when the total dwell time on a target was required to answer the research question (Holmqvist et al., 2015), we decided to use manual mapping of the teachers' eye-gaze behavior in the form of fixations in the eye-tracking recordings using a coding criterion. However, in the present study, only students were considered for further analysis of the teachers' visual focus of attention. Only those eye-tracking video recordings with 70 % and above gaze sample percentages were selected for the study to ensure that one or both eyes were detected during 70 % of the recording's duration. Based on the coding criteria, screenshots of the video recordings were used to define the AOI in the eye-tracking videos. The coder started manual gaze mapping when the teacher first looked at a student AOI in the classroom and ended coding when the teacher took off the mobile eye-tracking glasses. The two coders who were assigned to code the eye-tracking videos held master's degrees in teacher education and had experience collecting eye-tracking recordings in authentic classroom settings. The intercoder reliability was checked by double coding 20 % of the videos from the whole dataset. Double coding agreement ranged from 84.80 % to 94.03 %.

We followed the fixation metrics explained by Holmqvist et al. (2015). One fixation typically lasted 200–300 milliseconds. The fixation metrics, such as total fixation duration, average fixation duration, and fixation counts for each student, were obtained after coding the eye-

tracking recordings to investigate teachers' visual focus of attention. Total fixation duration, and average fixation duration metrics were measured in milliseconds (ms), and fixation count was represented by an integer. The total fixation duration and average fixation duration on a target suggested that the longer the fixation duration on a target, the deeper was the information processing. The fixation counts or the number of fixations on a target showed the noticeability and importance of a specific target; for example, higher fixation counts indicated greater importance of the target. Another eye-tracking study determined that shorter fixation durations and a greater number of fixations on task-relevant areas indicate improved information processing and selective focus of attention (Gegenfurtner et al., 2011).

2.2.2. Students' basic academic skills

Students' basic academic skills were measured in literacy and math. First, literacy skills were measured using the "ARMI– Luku- ja kirjoitustaidon arviointimateriaali 1. Luokalle" test battery (Lerkkanen et al., 2006) translated as "Literacy assessment material for 1st grade" is a Finnish tool for assessing reading accuracy in Grade 1. The test consisted of increasingly difficult words ranging from 2- to 16-syllables. The research assistant showed one word at a time (20 words in total) to each student individually, and the student read each word aloud. The sum of correct responses to the items determined the total score out of a maximum score of 20. Cronbach's alpha of the ARMI test battery was 0.61.

Second, math skills were measured using the Basic Arithmetic Test (BAT; Aunola & Räsänen, 2007). BAT is a 28-item timed test of three minutes where students are presented with arithmetic operation questions in addition (14 items, e.g., 2 + 1 =? and 3 + 4 + 6 =?) and subtraction (14 items, e.g., 4–1 =? and 20–2–4 =?). Students are required to perform basic calculations with speed and accuracy. The number of correct items determines the sum score out of a maximum score of 28. Cronbach's alpha of the BAT was 0.84. For further analysis, both the test scores were standardized, and investigated in relation to teachers' visual focus of attention indicators. However, for in-depth investigation using two case studies, only students' math test scores were considered.

2.2.3. Teachers' individual support for students

Teachers rated the need for instructional support for each individual student using nine questions related to teachers' support in (a) reading, (b) writing, and (c) math. For literacy (six items), teachers rated individual support provided to each student during a single day in reading words, reading fluency, reading comprehension, writing words, word-level spelling, and writing text. For math (three items), teachers rated individual support provided to students in number counting, basic math problems, and verbal math problems. The teacher rated each student on the basis of the individual support they offered in literacy and math learning on a typical school day compared with the other children in the classroom on a 5-point scale: 1 = Substantially less than other students, 2 = Somewhat less than other students, 3 = An equal amount as other students, 4 = Somewhat more than other students, and 5 = Substantially more than other students (Silinskas et al., 2015). For further analyses, scores obtained from items related to teachers' individual support for students in reading and math were standardized and investigated in relation to teachers' visual focus of attention indicators. However, for in-depth investigation using two case studies, only teachers' individual support for students in math was considered. The Cronbach's alphas for items indicating individual support in literacy and math were 0.97 and 0.94, respectively. In addition, Pearson's correlation showed a negative association between students' basic academic skill level and teachers' individual support for students in literacy ($r = -0.425$, $p = .003$) and math ($r = -0.287$, $p = .056$).

2.3. Analyses

First, using IBM SPSS Statistics 27 (IBM, Armonk, NY, USA), Pearson correlation analysis was conducted to investigate the association between teachers' visual focus of attention and students' basic academic skills and teachers' individual support for students in literacy and math using classroom aggregates across the whole sample of 46 classrooms. Second, two example classrooms with math lessons were selected for the case study based on teachers' ratings of individual support for students in math skills: one with high teacher individual support for students in math and the other classroom with low teacher individual support for students in math. The classroom characterized by high teacher individual support for students in math had a higher-than-average teacher individual support score than the overall score of the 46 classrooms in this study, whereas the classroom characterized by low teacher individual support for students in math had a lower teacher individual support score than the average of the whole sample in math. In-depth investigations of the selected teacher's visual focus of attention were conducted in three phases. First, the Mann–Whitney *U* test was used to examine the differences in teachers' visual focus of attention (in terms of the eye-tracking variables) between two classrooms with math lessons shown in the eye-tracking recordings, one characterized by high and the other by low teacher individual support scores in math. Second, in the two selected classrooms, the Mann–Whitney *U* test was again used to examine differences in teachers' visual focus of attention metrics between two student groups characterized by their high and low teacher-reported individual support scores in math skills, respectively. Third, a visual representation of teachers' visual focus of attention was created using the variables of fixation counts, academic skills, and teachers' individual support for students in math. In case study classrooms, the teachers' fixation counts indicated the number of times the teacher fixated on a student to process information during their math lessons.

3. Results

3.1. Teachers' visual focus of attention in relation to students' basic academic skills and teachers' individual support for students in literacy and math

The first research question concerned the extent to which teachers' visual focus of attention was associated with students' basic academic skills and teachers' individual support for students in literacy and math. Descriptive information related to the classroom aggregates of the study variables can be seen in Table 1. As shown in Table 2, Pearson correlation analysis showed that teachers' fixation counts negatively correlated with students' basic academic skills in literacy ($r = -0.47$, $p < .001$) and math ($r = -0.31$, $p < .05$). In addition, fixation counts positively correlated with teachers' individual support for students in literacy ($r = 0.41$, $p < .001$) and math ($r = 0.33$, $p < .05$). However, no other associations were found between the other eye-tracking metrics and

Table 1
Descriptive information on students' basic academic skills, teachers' individual support for students, and teachers' visual focus of attention in 46 classrooms.

	Mean (*SD*)	Min	Max
Students' Basic Academic Skills			
Literacy[b]	18.68 (2)	6.67	20
Math[b]	9.84 (2.15)	4.33	14.20
Teachers' individual support for students (rated 1–5)			
Literacy[b]	2.91(0.46)	1.94	4.33
Math[b]	2.68 (0.43)	1.55	4.22
Teachers' visual focus of attention			
1. Total Fixation Duration[a] (s)	26.99 (11.91)	10.62	72.64
2. Average Fixation Duration[a] (s)	0.40 (0.11)	0.21	0.87
3. Fixation Counts[a]	62.89 (24.16)	27.64	134

[a] Per student in the classroom.
[b] Per classroom.

Table 2
Pearson correlations between teachers' visual focus of attention and teachers' individual support for students and students' basic academic skills in 46 classrooms.

	Teachers' individual support for students		Students' basic academic skills	
	Literacy	Math	Literacy	Math
Teachers' visual focus of attention				
1. Total Fixation Duration	0.212	0.193	−0.185	−0.217
2. Average Fixation Duration	−0.085	−0.017	0.091	−0.083
3. Fixation Counts	0.414**	0.336*	−0.477**	−0.314*

** $p < .001$.
* $p < .05$.

student-related variables.

3.2. Two teachers' visual focus of attention in high and low teachers' individual support classrooms

To answer the second research question, using a case study design, we investigated in what way student's basic academic skills and teachers' individual support for students in math were reflected in teachers' visual focus of attention during math lesson. Further investigation involved identifying two classrooms, one characterized by high teacher's individual support and one characterized by low teacher's individual support for students in math. A Mann–Whitney *U test* was used to investigate how the three eye-tracking metrics, namely, total fixation duration, average fixation duration, and fixation counts, varied between the two teachers during a math lesson in the two respective classrooms. The test showed statistically significant differences in teachers' visual focus of attention, particularly in average fixation duration, teachers' individual support for students, and basic academic skills in math (see Table 3). More detailed descriptions of the two classrooms are presented in Figs. 1 and 2. In these visual representations of the case study, teachers' visual focus of attention and teachers' individual support for students and students' basic academic skills have been demonstrated in terms of fixation counts. This use of fixation counts was based on the earlier findings of the present study that showed teachers' fixation counts were associated with students' basic academic skills and teachers' individual support for students in math (see Table 2).

Table 3
Mann–Whitney U test results showing difference between classroom of high teacher individual support classroom (HTISC) and classroom of low teacher individual support classroom (LTISC).

	Mean (*SD*)		Median (*Mdn*)		*U*	*p*
	[a] HTISC	[b] LTISC	[a] HTISC	[b] LTISC		
Teachers' visual focus of attention						
Total fixation duration	17.14 (12.34)	11.91 (7.40)	14.61	10.46	192.50	0.212
Average fixation duration	485.07 (129.65)	350.36 (115.59)	479.50	330.50	248.50	0.002*
Fixation count	32.93 (20.08)	33.45 (20.08)	28.50	28	152.50	0.962
Teachers' individual support for students						
Literacy	2.79 (1.51)	1.98 (1.41)	2.58	1.50	196.50	0.170
Math	3.03 (1.48)	1.78 (1.04)	3.83	1.66	216.50	0.041*
Students' basic academic skills						
Literacy	19.71 (0.46)	17 (5.83)	20	19	208.00	0.083
Math	12.07 (4.54)	9.50 (4.75)	11.50	9	224.00	0.023*

* $p < .05$.
[a] $n = 14$ students present.
[b] $n = 22$ students present.

3.2.1. One teacher's visual focus of attention in the classroom of high teacher's individual support for students

The teacher in this classroom was 41 years old, with 17 years of work experience, including 10 years in the current workplace at the time of data collection. Out of the class size of 23, seven students did not have parental permission to participate in the study, and two students were absent. Therefore, there were 14 students (10 boys and 4 girls) present during the math lesson at the time of the eye-tracking recording. The teacher reported that 57.14 % of the students needed higher-than-average teacher individual support in the classroom, and 42.8 % needed lower-than-average teacher individual support. However, 78.57 % of the students had a higher-than-average math skill level, and 21.42 % of the students had lower-than-average math skills, compared with that of all 46 classrooms. A detailed account of the descriptive information of the students' math skill levels, the teacher's individual support for students in math, and the teachers' visual focus of attention on the students during the first 20 min of a math lesson is shown in Appendix 1. In this classroom, the average score of the teacher's individual support for students in math ($M = 3.03$, $n = 14$) and average math skill scores ($M = 12.07$, $n = 14$) were higher than the average score (see Table 1) of all 46 classrooms in the sample. On average, from the high teacher individual support group in math, a student received 13.42 s of total fixation duration, 426.5 ms average fixation duration, and 28.5 fixation counts, whereas a student from the low teacher individual support group in math received 22.12 s of total fixation duration, 563.16 ms average fixation duration, and 38.8 fixation counts from the teacher.

The Mann–Whitney *U* test within the classroom of high teacher's individual support for students showed that only average fixation duration ($U = 8.00$, $p = .03$) out of the three fixation metrics used in this study varied significantly between the students with higher and lower teacher individual support for students in math: high teacher individual support students ($Mdn = 415.40$, $n = 8$) received less teachers' visual focus of attention (measured with average fixation duration) compared with low teacher individual support students ($Mdn = 526.50$, $n = 6$). Additionally, students' math skills ($U = 5.00$, $p = .01$) varied between high teacher individual support students ($Mdn = 10$, $n = 8$) and low teacher individual support students ($Mdn = 15$, $n = 6$). In the same classroom, teacher individual support for students in math skills ($U = 48.00$, $p = .002$) also varied significantly between high teacher individual support students ($Mdn = 4.16$, $n = 8$) and low teacher individual support students ($Mdn = 1.49$, $n = 6$).

Fig. 1 demonstrates how the teacher's visual focus of attention in terms of fixation counts varied with the teacher's individual support for students and academic performance in math in the high individual support classroom. The fixation counts indicated the number of times fixations occurred in teachers' eye movements to take in information from a student. Among students with high teacher individual support, students 2, 8, 11, and 12 supported findings from the first part of this study showing that teachers gave high visual focus of attention to students with lower academic skills in math and higher teacher individual support. In addition, among students with low teacher individual support, students 6, 7, and 13 seemed to support findings from the first part of this study showing that teachers gave lower visual focus of attention to students with higher math skills and lower teacher individual support than the classroom average. However, there were some exceptions. In fact, despite having lower teachers' individual support scores and higher math scores than the classroom average, students 4 and 14 were fixated on twice as often as the other students. In addition, other exceptions among students with high teacher individual support were students 3, 5, 9, and 10, who received relatively less teachers' visual focus of attention in the form of fixation counts despite their low math skills and high teacher individual support. Another exception was student 1, who scored lower in math skills than the classroom average, had low teacher individual support, and was fixated on fewer times by the teacher.

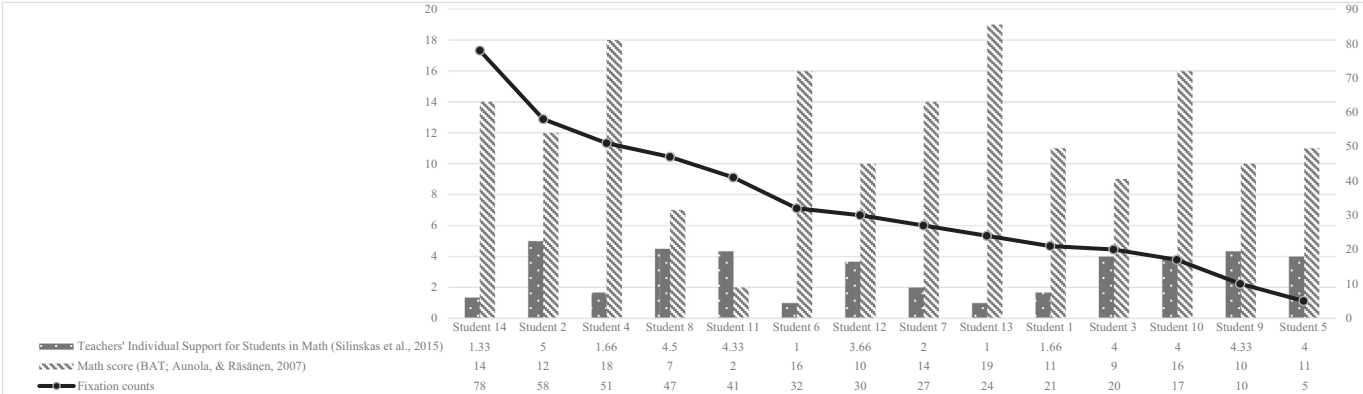

Fig. 1. Teacher's individual support for students, academic performance in math and teacher's fixation counts in high individual support classroom.
Note. Students 2, 3, 5, 8, 9, 10, 11 and 12 have greater individual support requirement in math according to the teacher.

3.2.2. One teacher's focus of attention in the classroom of low teachers' individual support for students

A teacher 50 years of age with 18 years of work experience, including three years and six months in the current workplace, taught a math lesson during eye-tracking recordings in the classroom with low teacher individual support for students' math skills. The low individual support classroom had a class size of 24 students (17 boys, 7 girls), all of whom were seven years of age at the time of data collection. Overall, 22 students (16 boys, 6 girls) were present, and two students were absent at the time of the eye-tracking recording. This classroom had the lowest overall teachers' individual support for students in math skills ($M = 1.78$, $n = 22$) and lower math skills scores ($M = 9.50$, $n = 22$) in relation to the average of the total sample of 46 classrooms (see Table 1). According to the teacher, 13.60 % of the students needed higher-than-average teachers' individual support in math skills, and 86.40 % of students needed lower-than-average teachers' individual support in math skills. Overall, 40.90 % of the students scored higher than average, and 59.10 % of the students scored lower than average in math skills compared with the total sample of 46 classrooms. Descriptive information about the students' math skills, their teacher's individual support for students in math, and the teacher's visual focus of attention on students during the first 20 min of a math lesson are shown in Appendix 2. On average, in this classroom, students in the high individual support group in math received 15.73 s of total fixation duration, 441 ms of average fixation duration, and 35.33 fixation counts during the eye-tracking recording, whereas students in the low individual support group, on average, received 11.31 s of total fixation duration, 33.15 fixation counts, and 336.05 ms of average fixation duration of the teacher's visual focus of attention during the eye-tracking recording.

The Mann–Whitney U test for the low individual support classroom showed that teacher's visual focus of attention did not vary statistically significantly between students characterized with high and low teachers' individual support for students in math skills. Students' math skills ($U = 7.00$, $p = .04$) in the low individual support classroom differed significantly between high individual support students ($Mdn = 5$, $n = 3$) and low individual support students ($Mdn = 9$, $n = 19$). Lastly, teachers' individual support for students in math ($U = 57.00$, $p = .001$) in this classroom differed significantly between high individual support students ($Mdn = 4.33$, $n = 3$) and low individual support students ($Mdn = 1.33$, $n = 19$).

Fig. 2 demonstrates the variation in the teacher's visual focus of attention based on low teacher individual support scores and math skills in the low teacher individual support classroom. Overall, 17 out of 24 students had lower teacher individual support scores than the class average. Among students with low teacher individual support scores, 12 students (see Fig. 2, students 1, 6, 5, 15, 18, 11, 13, 12, 2, 19, 4, and 10) received relatively lower teachers' visual focus of attention in terms of fixation counts than others in the classroom, even though some of these students had lower scores in math than in the classroom average (see Fig. 2, students 1, 15, 11, 2, and 10). However, the case of student 13 was similar to our earlier finding, wherein the student had high math skills and low teacher individual support and was fixated on relatively fewer times than the other students. Furthermore, only students 9, 14, and 21 scored lower than the classroom average in math skills and had higher teacher individual support than other students. However, the teacher's fixation counts were somewhat similar for these three students, albeit lower than for some other students in this classroom (e.g., students 8 and 16). Some exceptions were found: students 3 and 17 had higher-than-classroom average math scores and lower teachers' individual support, but were fixated on more frequently by the teacher. In addition, students 7, 8, 16, and 20 had less-than-classroom average math scores and had lower teacher individual support, but the teacher fixated on these students more than those students with high teacher individual support.

4. Discussion

This study investigated how teachers' visual focus of attention is associated with students' basic academic skills and teachers' individual support for students in literacy and math in authentic classroom settings. The results indicated that teachers' fixation counts negatively correlated with students' basic academic skills in literacy and math. In addition, the teachers' fixation counts positively correlated with the teachers' individual support for students in literacy and math. The two case studies showed that there was a significant difference in teachers' visual focus of attention in terms of average fixation duration between the high and low teacher individual support classrooms. In addition, students in low individual support classrooms received less average fixation duration overall than students in high individual support classrooms.

The first finding from our study showed that teachers' visual focus of attention was related to students' basic literacy and math skills and to teachers' individual support for students in these skills. In particular, teachers' fixation counts were found to be positively associated with teachers' individual support for students in literacy and math and negatively associated with student's basic literacy and math skills. This result appears to indicate that students who had low basic academic skills in literacy and math and high teacher-reported individual support received more teachers' visual focus of attention in the form of fixation counts. This result aligns with previous studies which showed that students with low academic skill levels in reading and math received more individualized support from teachers in Grade 1 (Nurmi et al., 2012; Silinskas et al., 2015). This result is also in line with previous eye-tracking studies reporting that teachers focused more on relevant areas in the classroom where students struggled and showed less interest

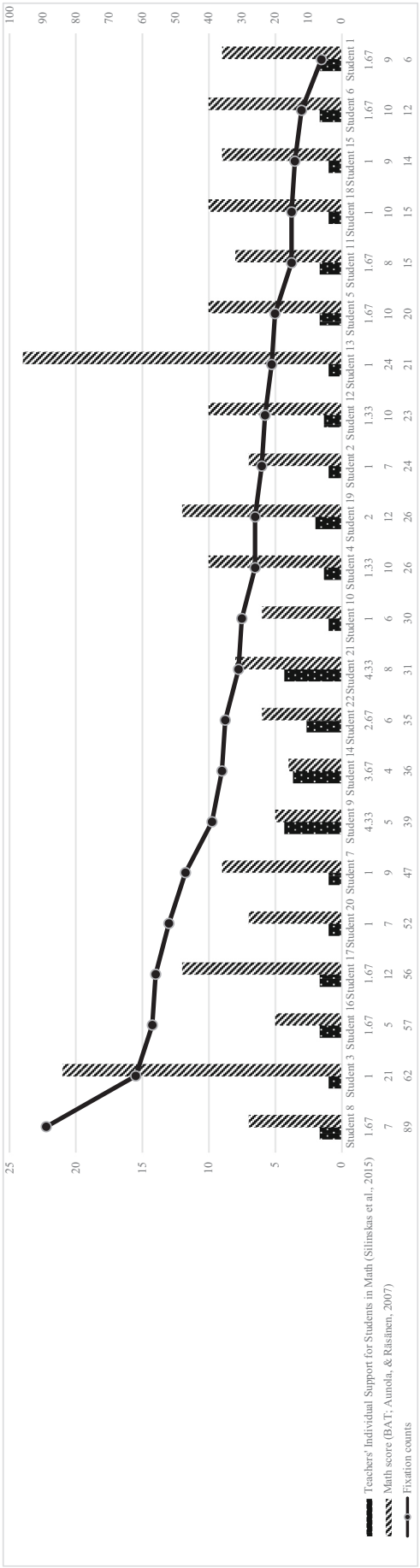

Fig. 2. Teachers' individual support for students, academic performance in math and teacher's fixation counts in low individual support classroom.
Note. Students 9, 14, and 21 have greater individual support requirement in math according to the teacher.

in academic activities (Dessus et al., 2016; Seidel et al., 2020). In line with Classroom Management Script model developed by Wolff et al. (2020), our results may also reflect that teachers can use their prior knowledge of students' academic skills and the amount of individual support they typically provide for students as cues to notice students in the classroom. It may also be that teachers were aware of students' requirements and looked at some students more to provide support and guidance in the classroom. For example, Gegenfurtner et al. (2011) reported that a higher number of fixations indicated improved information processing, increased awareness, and selective focus of attention on targets. In addition, teachers' improved judgment accuracy in relation to students' assessment has been linked to higher fixation counts and shorter average fixation durations on student-related areas (Schnitzler et al., 2020). Therefore, it could be possible that a teacher's visual focus of attention in the form of high fixation counts on students could be linked to improved noticing of students' learning-related issues.

The in-depth investigation of the two classrooms revealed more variation in the teachers' visual focus of attention in terms of students' skills in math and the individual support provided by the teacher. The difference in average fixation duration in the two case-study classrooms could indicate a difference in teachers' monitoring and noticing of students during their lessons. It is important to acknowledge that teachers' visual focus of attention in authentic classrooms follows a complex process. As students, regardless of their academic skills and the teachers' individual support provided, are not challenged equally with every lesson or activity, teachers need to actively modify their visual focus of attention to monitor and support the students accordingly. The results showed that the two selected classrooms seemed to show significant differences in teachers' visual focus of attention in terms of average fixation duration, student's math skills, and teachers' individual support in math. This result is similar to previous research by Dessus et al. (2016) showing that teachers spread their visual focus of attention unevenly due to variations in teachers' individual support for students and the academic skill levels of students in a lesson. The teachers' gaze behavior in the high teacher individual support classroom indicated that students with high teacher-reported individual support were noticed less, as shown by the lower average fixation duration; however, in the low individual support classroom, no statistically significant difference was seen between high and low individual support student groups.

In the high individual support classroom, there were more students with high teacher-reported individual support, which could have made it difficult for the teacher to prioritize their focus of attention on all the students. Surprisingly, students with high teacher-reported individual support received somewhat lower teachers' visual focus of attention, such as lower fixation counts, than those with low teacher-reported individual support during math lessons. It could be possible that there were some unpredictable issues in terms of classroom management and student behavior requiring teachers' immediate attention in the form of selective visual focus of attention (Tatler et al., 2014) that could have influenced the teacher's cognitive load (Prieto et al., 2017). Additionally, there were students in this classroom who were noticed more by the teacher, despite their low teacher-reported individual support in math skills. This appears to be in line with previous research by Goldberg et al. (2021) suggesting that irrespective of students' academic skill levels, teachers' visual focus of attention could be more often directed toward students showing interactive learning-related behaviors that support the progress of classroom instruction rather than those students who showed disruptive behavior and may interrupt the lesson.

In the low teacher individual support classroom, there were no significant variations in the teacher's visual focus of attention between students from the high and low teacher-reported individual support groups. This could be due to the fewer students with high teacher-reported individual support in this classroom. The teacher focused their visual attention on some students more times despite their low teacher individual support in math, similar to the teacher in the high teacher individual support classroom. As Haataja et al. (2019) showed,

teachers tend to look more times at students when they provide encouragement and motivation toward the task in a math lesson. It is possible that the teacher in this classroom needs to engage and interact with other students more than students with high teacher-reported individual support. Therefore, it is important to note that the teacher probably does not only look at students based on their individual support in academics, but also interacts with them during lessons. This could be in line with previous research showing that younger students in elementary school could attract more visual cues from the teacher by showing interactive (Goldberg et al., 2021) or disruptive behavior (Wolff et al., 2016; Yamamoto & Imai-Matsumura, 2013). Previous research has shown that teachers' visual focus of attention is more on those students to whom they provide individual feedback (Cortina et al., 2015). It is also possible that the teacher intentionally tried to focus her visual attention more comparably on the group of high teacher individual support students. However, the low math skill level and low teacher-reported individual support for students in this classroom could suggest that there could be a difference between the actual students' requirements and the teacher's individual support in math skills that is rendered to the students.

These examples explain some possibilities of the variation in teachers' visual focus of attention with respect to the amount of high and low teacher individual support for students in the classroom; however, more in-depth investigation is required to learn about the challenges and scope of improving teachers' visual focus of attention in such classrooms.

4.1. Implications of the study

Currently, there is not much known about how teachers notice important student-related cues and events while teaching; thus, the present study makes a significant contribution to this area of research. Eye-tracking studies have provided important insights into potential objectives for teachers' professional development, such as (a) describing a classroom situation that encourages teachers to improve their identification of teaching and learning components, (b) helping teachers to explain and practice reasoning about a situation, and (c) helping teachers to predict classroom events by encouraging them to apply their knowledge in practice (Seidel et al., 2020; Seidel & Stürmer, 2014). The present study could also open discussions and reflections related to teachers' noticed areas in the classroom for improving teachers' individual support for students and basic academic skills during pre- and in-service programs. Both student teachers and experienced teachers can benefit from knowing their visual focus of attention patterns in the classroom and whether they attend to all students who require their attention and support in relation to their learning and behavior. Therefore, eye-tracking could be used in teacher training to generate awareness of their visual focus of attention in the classroom environment in authentic settings among pre- and in-service teachers. In addition, this knowledge could be used to identify the resources needed to engage students (e.g., special needs educators or teaching assistants) and enhance the relevance of in-service training for teachers in terms of teachers' awareness of the support to be rendered to students in the classroom.

4.2. Limitations and future research directions

The present study has some limitations, but it also offers prospects for further research. First, in the present study, mobile eye-tracking technology could have been affected by contextual factors in the classroom. For example, the teachers' characteristics, such as age, teaching experience, stress levels, and work engagement, and the classrooms' characteristics, such as physical space, time in the school day, and lighting, could have influenced the teachers' visual focus of attention. Future studies might want to investigate the role of classroom-related and teacher-related factors in teacher visual focus of attention in more detail. Second, the teachers participated voluntarily irrespective of their age and work experience, and teaching experience was not controlled for in the analyses. Although the teachers' work experience was not related to their visual focus of attention parameters in the current study, future studies could investigate the role of work experience as prior research has shown a link between teachers' professional vision and work experience (Gegenfurtner et al., 2020; Keller et al., 2021; Seidel & Stürmer, 2014; van den Bogert et al., 2014). Third, this study was a cross-sectional investigation of teachers' visual focus of attention, students' basic academic skills, and their teacher-rated individual support for students. A longitudinal approach from fall to spring in one academic year or more could provide an insight into how teachers' visual focus of attention may vary based on changing teachers' individual support for students and their academic development. Fourth, teachers' visual focus of attention needs to be carefully separated from the amount of teacher individual support actually rendered to students. While attention is necessary for specific actions, noticing the student-related individual support alone may not be sufficient for teachers to effectively manage the classroom and achieve the learning objectives. Thus, further research is needed to investigate teachers' visual focus of attention as a mediating factor between perceived student needs and teacher support for individual students and their learning. Fifth, the present study showed that teachers' visual focus of attention is associated with students' academic performance and teachers' individual support for students. However, students and teachers' actual behaviors during the eye-tracking recording were not described in the analyses, which could be considered a limitation. Therefore, in the future, researchers could investigate actual teacher and student behaviors in relation to visual focus of attention, for example, what behaviors the students show at the respective moment of teacher fixation and whether these behaviors differ between students with low or high individual support from the teacher. In addition to student behavior, teachers' visual focus of attention should be studied in combination with other student characteristics in future research, such as temperament, motivation, self-regulation skills, and social skills since they might relate to students' academic performance in early school years. Sixth, in this study, the relationship between teachers' visual focus of attention, students' basic academic skills and teachers' individual support for students were not analyzed separately for math and literacy. In future research, differentiating between the teachers' visual focus of attention across different subjects would be interesting to show potential subject-specific variations in terms of teachers' visual focus of attention and individual support for students. Seventh, since only literacy and math skills without the involvement of students' behavior and self-regulation were considered, the type of support provided by the teacher may therefore not have been clear since literacy and math skills are not the only issue involved in determining teachers' individual support for students. Eighth, in the present study, teachers' visual focus of attention was measured for only 20–25 min during a lesson and teachers' individual support was measured only for the general support the teacher provided to the students. Therefore, it may not be suitable to make robust inferences using the case studies based on only two classrooms. Finally, the case-studies provided detailed demonstration on how teachers' visual focus of attention can vary during math lessons among students with different skills and teachers' individual support for students. However, in future research, the verbal communication during the eye-tracking recordings should also be considered in order to explain the teachers' visual focus of attention in more detail. In the future, verbal communication needs to be examined in combination with eye movements for a comprehensive understanding of the teacher's pedagogical actions. Further examination of individual support from the perspective of special needs could add to the understanding of teachers' changing visual focus of attention in the classroom as well. For example, the case of comorbidity among students with special needs could also influence the nature of individual support provided to the student in specific situations. Further studies could also examine teachers' quality of instructional support and the challenges and opportunities in high teacher individual support classrooms in

relation to teachers' visual focus of attention.

4.3. Conclusions

The findings of this study indicate that teachers' visual focus of attention is associated with the students' basic academic skills and the individual support provided by the teachers. However, there seems to be a variation in relation to teachers' visual focus of attention depending on how much individual teacher support the students receive. We found that teachers' visual focus of attention, in terms of fixation counts, was associated positively with teachers' individual support for students and negatively with students' basic academic skills. In addition, attention should be paid to the classroom population to ensure that they include a manageable ratio of students with different needs so that the teacher will be able to provide them with the required attention. Further investigation of these findings is needed to gain a better understanding of various student characteristics that could influence teachers' visual focus of attention in the classroom.

Declaration of competing interest

We wish to confirm that there are no known conflicts of interest associated with this publication that could have appeared to influence the work reported in this paper.

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Appendix 1

Descriptive scores of students' math skill, teacher's individual support for students in math skills and teacher's visual focus of attention in higher teacher individual support classroom.

	Math skills (BAT; Aunola & Räsänen, 2007)	Teachers' Individual Support in Math (Silinskas et al., 2015)	Total fixation duration (ms)	Average fixation duration (ms)	Fixation counts
Student 1	11	1.66	9934	473	21
Student 4	18	1.66	26,925	528	51
Student 6	16	1	16,790	525	32
Student 13	19	1	11,653	486	24
Student 14	14	1.33	46,693	599	78
Student 7	14	2	20,728	768	27
Student 2	*12*	*5*	*34,560*	*596*	*58*
Student 3	*9*	*4*	*11,333*	*567*	*20*
Student 5	*11*	*4*	*1259*	*252*	*5*
Student 8	*7*	*4.5*	*19,009*	*404*	*47*
Student 9	*10*	*4.33*	*3078*	*308*	*10*
Student 10	*16*	*4*	*7096*	*417*	*17*
Student 11	*2*	*4.33*	*18,629*	*454*	*41*
Student 12	*10*	*3.66*	*12,433*	*414*	*30*

Note. *Student.* Those students who had higher than overall average scores for teachers' individual support in math.

Appendix 2

Descriptive scores of students' math skill levels, teacher's individual support of students in math skills and teacher's visual focus of attention in low teacher individual support classroom.

	Math score (BAT; Aunola & Räsänen, 2007)	Teachers' Individual Support in Math (Silinskas et al., 2015)	Total fixation duration (ms)	Average fixation duration (ms)	Fixation counts
Student 1	9	1.67	760	127	6
Student 2	7	1	9774	407	24
Student 3	21	1	20,448	330	62
Student 4	10	1.33	12,932	497	26
Student 5	10	1.67	5977	299	20
Student 6	10	1.67	3838	320	12
Student 7	9	1	20,608	438	47
Student 8	7	1.67	24,066	270	89
Student 10	6	1	11,153	372	30
Student 11	8	1.67	5437	362	15
Student 12	10	1.33	7795	339	23
Student 13	24	1	5757	274	21
Student 15	9	1	5697	407	14
Student 16	5	1.67	19,009	333	57
Student 17	12	1.67	23,186	414	56
Student 18	10	1	3858	257	15
Student 19	12	2	8575	330	26
Student 20	7	1	14,432	278	52

(*continued on next page*)

(*continued*)

	Math score (BAT; Aunola & Räsänen, 2007)	Teachers' Individual Support in Math (Silinskas et al., 2015)	Total fixation duration (ms)	Average fixation duration (ms)	Fixation counts
Student 22	6	2.67	11,593	331	35
Student 9	*5*	*4.33*	*12,313*	*316*	*39*
Student 14	*4*	*3.67*	*26,604*	*739*	*36*
Student 21	*8*	*4.33*	*8295*	*268*	*31*

Note. *Student.* Those students who had higher than overall average scores for teachers' individual support in math.

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