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Contingency Theory of Adaptive Practices Through the Lens of Eye Trackers

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Abstract: In this paper, we report on a study of adaptive practices, as revealed by a teacher's eye gazes, in response to the contingencies that arose during a lesson. From the literature, four categories of adaptive practices, namely, *adaptive recognitions*, *adaptive anticipations*, *adaptive deliberations*, and *adaptive insights* were used for initial coding. In this study, eye tracking technologies are positioned as a mediator between the contingencies that arise in the classroom and the adaptive practices undertaken by teachers. The two research questions are: (1) What classroom events and/or objects, as revealed by the eye fixations, invoke the adaptive practice(s) of recognitions, anticipations, deliberations and/or insights during a lesson? (2) What events unfold following the enactment of the adaptive practice as informed by the eye fixations? The findings in this paper were based on a 29-minute lesson video of a biology lesson during which the teacher was wearing eye trackers. The four contingences that arose during the lesson include: (1) students engaging in personal talks, (2) students not taking down notes, (3) students not looking confident when answering, and (4) student raised hand to seek clarification. This study offers new insights into the nature of teachers' adaptive practices in classroom teaching, with two new sub-categories of adaptive practices being identified. The findings suggest that eye-tracking technologies can help to generate new empirical insights on the nature of adaptive practices that teachers adopt in the classroom.

Keywords: eye tracking, contingency theory, adaptive practices

1. Introduction

Teachers engage in adaptive practices as they continually interpret the contextual-specific information related to the subject matter, ecological factors, and students (e.g., expressed emotions, actions, responses) in classroom teaching. As such, it can be challenging for teachers to be aware of the often implicit adaptive practices (Mylopoulos & Scardamalia, 2008) because of the many things that are simultaneously ongoing in class. Post-lesson reflections based upon recall are reconstructed memories that are partial and subjected to personal bias (Dempsey, 2010). Lesson videos offering meso-level insights into the classroom events (Tobin, 2017) may not capture the specific "object" (i.e., person or thing) that invoke the specific adaptive practice. This paper reports on a study of adaptive practices (Männikkö & Husu, 2019; Martin, Nejad, Colmar, & Liem, 2012), as revealed by teachers' eye gazes when enacting a lesson, with the goal to help them gain a deeper understanding of their adaptive teaching practices. According to Männikkö and Husu (2019), there are four categories of adaptive practices, namely, *adaptive recognitions*, *adaptive anticipations*, *adaptive deliberations*, and *adaptive insights*. In this study, eye trackers are used to objectively and accurately collect and analyze visual behavior (Tobii, 2019). Here, eye tracking technologies are positioned as a mediator between the contingencies that arise in the classroom and the adaptive practices undertaken by teachers. The theory of contingency (Donaldson, 2001) is applied here to explain the situatedness of the "organization", that is, the teacher. As key agents in upholding the rules, norms, regulations, and conventions of the school that they teach, teachers represent the embodied forms of the organizations (Freedman & Holmes, 2003). The research questions addressed are:

1. What classroom events and/or objects, as revealed by the eye fixations, invoke the adaptive practice(s) of recognitions, anticipations, deliberations and/or insights during a lesson?
2. What events unfold following the enactment of the adaptive practice as informed by the eye fixations?

The findings illuminate insights on what teachers "see" prior to enacting a specific type of adaptive practice in response to a classroom contingency. Here, we do not make a judgment of the (in)appropriateness of the adaptive practice in response to what they "see". We also do not stop at identifying what they "see" or "should see" as these have been extensively reported in the teacher-noticing literature (see e.g., Sherin, Jacobs, & Philipp, 2011; Smith, 2012). While most previous studies have adopted eye-tracking technologies as a research tool, we use it as a *pedagogical mechanism* to tease out elements that feed into the choice of adaptive practices. By *pedagogical mechanism*, we refer to eye-tracking technologies as a system of parts—comprising multiplistic factors including attention span, personal preference on what one chooses to look at, beliefs about what events or objects deserve attention, the presence of distractors, and so on—that intersects with a lesson pathway comprising the classroom contingency and adaptive practice of a teacher. In integrating the social theory of contingency, adaptive practices and eye-tracking technologies, this paper builds on the existing work and enrich the scholarly discourse of each of the three fields to hone the epistemic quality (Kelly & Licona, 2018) of classroom teaching. Hence, this work makes practical contributions to classroom teaching.

2. Adaptive Practices and Contingency Theory

2.1 Adaptive Practices

Adaptive practices refer to teachers' competencies in responding to the knowledge about students by adjusting their curriculum and teaching practices to achieve improved learning outcomes (Beltramo, 2017; Hammerness, Darling-Hammong, Bransford, Berliner, Cochran-Smith, & McDonald, 2005; Hatano & Oura, 2003; Lin, Schwartz, & Bransford, 2007). When teachers teach, they employ a set of "core practices" within their subject discipline (e.g., conduct science inquiry lessons in laboratory lessons), but also adapt these "core practices" flexibly contingent on the exigencies of their school or classroom contexts (Lampert, Boerst, & Graziani, 2011). Many scholars have argued for the necessity for teachers to engage in adaptive practices due to the complexity and fluidity of the social contexts in which education is embedded (Brown, 2004; Emdin, 2016; Tobin & Roth, 2006). Many studies about adaptive practices have focused on identifying the areas of expertise that teachers should have in order to engage in these practices effectively. The literature, for example, suggests the importance for teachers to develop a strong base of pedagogical content knowledge, a vision of ideal teaching, and a deep understanding and familiarity with their students (Fairbanks, Duffy, Faircloth, He, Levin, & Rohr 2010). However, deeper dialogue about the contingent nature of adaptive practices remain superficial and vague, hence, it is unhelpful to teachers who seek to unpack and understanding more deeply about their own teaching practices. Recently, Männikkö and Husu (2019) have identified adaptive practices of 17 primary school teachers, based upon recall interviews, and inductively coded these practices as fixed or open orientations of teaching. Table 1 summarizes the types of adaptive practices and alignment to the types of teaching orientation reported in their work.

Table 1

Types of adaptive practices and teaching orientations

Fixed orientation (intrapolations)	Open orientation (extrapolations)
Adaptive recognitions refer to teachers' established actions based on knowledge about students or rules that have been set. E.g., • Recalling what students have previously learnt or completed • Identifying rules in problem-solving that students should adhere to	Adaptive deliberations refer to teachers' flexible actions derived from appraising and interpreting the ongoing events. E.g., • Making inferences about students' performance • Making appraisals on students' performance
Adaptive anticipations refer to teachers' customary practices based on beliefs or habits. E.g., • Identifying habits that students should have cultivated • Invoking basic beliefs that shape one's decisions in teaching	Adaptive insights refer to teachers' new understanding about teaching and suggestions about new practices. E.g., • Wondering about imagined practices that one could adopt • Deriving new understandings about students

Based upon our interpretation, the key difference between the two columns in Table 1 lies in the degree of the contingency nature of the adaptive practices. In the case of the fixed orientations of teaching, the adaptive practices are *intrapolations* from existing knowledge or information about students. By intrapolation, we mean looking inward at the "subject" of interest (i.e., student or self) to decision making on the next set of adaptive practices to engage. On the contrary, adaptive practices in the open orientations of teaching seem to be *extrapolations* from the interpreted new and possible, previous, information arising from the existing state of affairs. As such, the open orientation adaptive practices illuminate the contingent nature of teaching and hence, the adaptive nature of practices of teaching.

2.2 Contingent Theory and Adaptive Practices

The theory of contingency is a major theoretical lens used to describe organizations (Donaldson, 2001). The essence of contingency theory is that "organizational effectiveness results from fitting characteristics of the organization, such as structure, to contingencies that reflect the situation of the organization" (Donaldson, 2001, p. 1). In this paper, we position teachers and the teaching profession as the "organization" of embodiments of the institutional values, thinking, norms, and practices. Figure 1 illustrates how we view contingency at play in a classroom.

Education contexts are filled with contingencies that teachers have to respond to. According to Donaldson (2001), there are three underlying contingencies, namely, task uncertainty, task interdependence, and size. The uncertainty in tasks could be due to the nature of the tasks themselves, the technology, technology change, innovation, and environmental instability. In this case, the task can refer to the lesson to be delivered and the uncertainty may arise due to changes in student-related factors such as student behaviours, student performance, and change in classroom ecological conditions. Task uncertainty may be reinforced as a result of engaging in technology and innovation as opposed to direct teaching. Task interdependence may be in the form of prior knowledge required for students to learn a new topic or the set of experiences that a teacher must afford in order for students to participate fully in the subsequent activities. The size refers to the number of students in the class. It tends to be more challenging for teachers to handle larger class sizes due to greater diversities and hence, higher possibilities of unknown events happening.

Teachers will construct understandings of the contingencies that emerge during a lesson and act upon mediators such as their thinking—shaped by their beliefs, personal bias, and assumptions (Day, Pope, & Denicolo, 2013)—and external stimuli that affect what they hear, see, and feel. Informed by the literature on teacher noticing, we argue that teachers' responses to contingencies are, first and foremost,

affected by what they *see*. What they see will impact the choice of practices that they will subsequently adapt.

In order to elicit what teachers see, we harness the affordances of eye-tracking technologies to help us distil the pedagogical data or signals that teachers act upon in their adaptive practices. In the next section, we explain the research design and discuss the findings of the study.

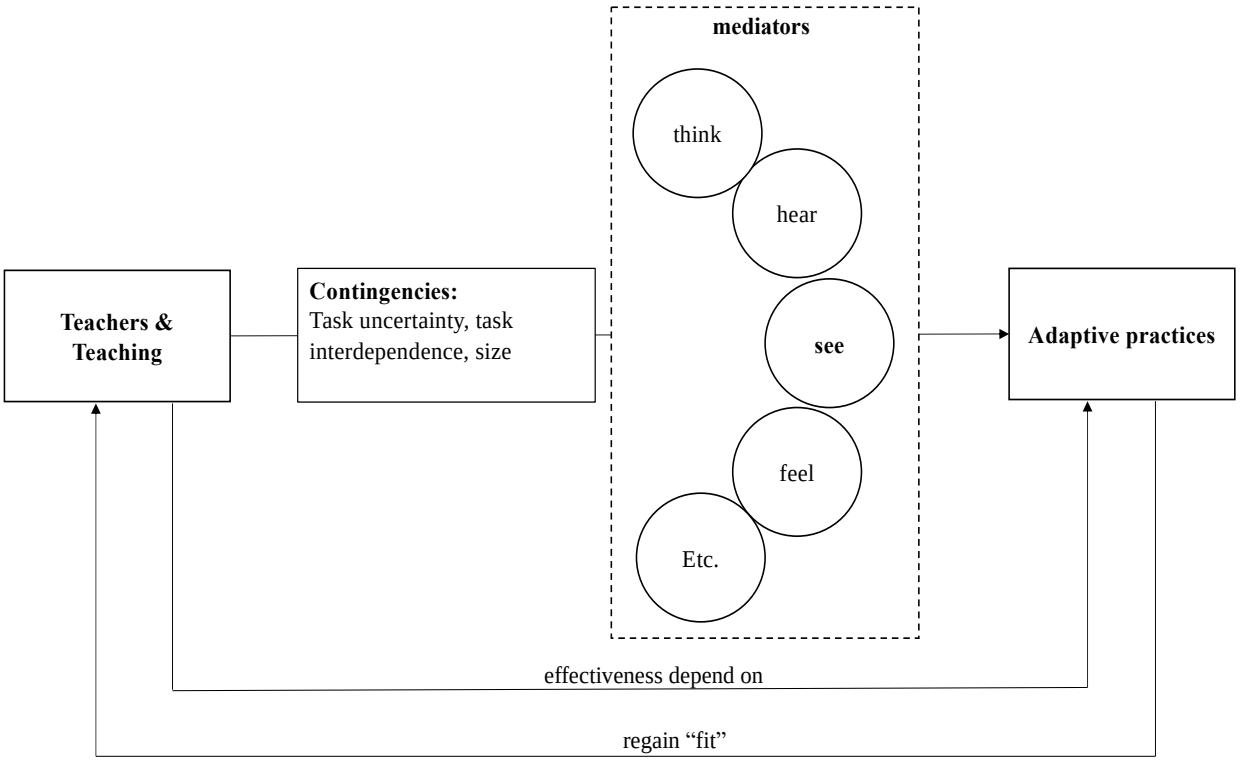

Figure 1. The relationship between teachers and teaching, and adaptive practices using contingency theory

3. Methods

3.1 Participants

The data reported in this paper were drawn from a larger eye-tracking study involving 10 teachers in Singapore secondary schools (for students of Grades 7-10, aged 13-16). This paper reports a biology teacher, Karina (pseudonyms are used in this paper) in her lessons with Grade 9 students in an all-girls secondary school. There were about 40 students in the class. At the time of the study, Karina had 16 years of teaching experience and had taught at the school for 15 years. We have chosen to focus on her as the main research participant for analysis in this paper because she was the most experienced among the teachers. Our assumption was that she would be more adept at adapting her practices in response to the contingencies that emerged during the lesson.

3.2 Data collection

The data collection involved videoing, eye-tracking and interviews with the teachers. Two (1 Front 1 back) video cameras were set up at the back and front of the classroom for the teacher and student views. During the lesson, the teacher wore the eye-tracker and data were wirelessly recorded via the transmitter to the laptop using the D-Lab software. As the eye-tracker was light-weight and portable, the level of discomfort for the teacher was minimized. Prior to the lesson, the teacher had explained to the students the purpose of the device and study hence, they were preempted on the changes around the classroom. The eye tracker recorded the movement of the eye pupils and simultaneously video recorded the view in

front of the eye tracker. Each lesson duration was about 30 minutes. We also interviewed Karina after Each lesson observations and recording. The interview lasted about 60 minutes and was video recorded. Videos of the eye gazes on objects, the teacher's view lesson video, and student's view lesson videos were synchronized and combined for analysis. The interview was transcribed for analysis. For the purpose of this paper, only one of Karina's lesson videos was reported for detailed analysis.

3.3 Data analysis

The combined video data from one lesson were analyzed stepwise. In Phase 1, we identified the significant episodes during which adaptive practices were adopted. This is a form of event-oriented inquiry (Tobin, 2014) which helped us to focus on what is relevant and significant in illuminating the contingencies and subsequent adaptive practices in the classroom. A total of four episodes were identified. In Phase 2, we first adopted prescriptive coding using Männikkö and Husu's (2019) four categories and eight sub-categories (see Table 1) of adaptive practices to those episodes. Three out of the four categories (i.e., *adaptive recognitions, adaptive anticipations, and adaptive deliberations*) were identified and used to code the four episodes. Adaptive insight was not observed in the lesson analyzed. As such, adaptive practices identified in Karina's video data were not all the same as the ones identified in Männikkö and Husu's study. This could be because: (a) adaptive practices identified through recall interviews may not be the same as that enacted in practice; and/or (b) the adaptive practices in the lesson analyzed were different from the ones in Männikkö and Husu's study. However, only two of the eight sub-categories (i.e., *rules* and *habits*) of the adaptive practices were identified in two episodes. For the remaining two episodes, we have identified two new sub-categories (i.e., *alternative pedagogical tools* and *re-constructed explanations*) of adaptive practices. In Phase 3, we returned to the parts of the video coded for specific adaptive practice and code the "object" (e.g., student, table, book, ceiling, door, window) at which Karina was looking at when the adaptive practice was engaged. In Phase 4, we return to the part of the video coded in Phase 1 and 2 to identify the contingency that arises to draw the teacher's eye gaze. The constant comparative approach (Glaser, 1965) was employed to ensure that the data were analyzed in a rigorous manner and validity was achieved. Additionally, the data were independently coded and checked by two researchers. Discrepancies were negotiated and the data were recoded until 100-percent consistency was achieved.

4. Findings and Discussion

In Table 2, we summarized: (a) the episodes during which adaptive practices were enacted, (b) the specific type of adaptive practices adopted, (c) the "object" on which the eye gaze fell upon, and (d) the contingencies that arose that triggered the respective adaptive practices.

Table 2
Summary of episodes, adaptive practices, "object" of eye gaze, and contingencies

	Episode	Adaptive Practice	"Object" of eye gaze	Contingencies
1	Karina disciplining two students engaging in personal talks	Adaptive recognition (rules): Pausing a lesson to discipline students	Two students	Students engaging in personal talks rather than paying attention to the lesson
2	Students taking down notes from the whiteboard	Adaptive anticipations (habits): Teachers complimented students who took notes from the whiteboard without being told	Whiteboard and students	Noticing that some students were not taking down notes
3	Having students guess whether the upper side of the leaf is the phloem or xylem	Adaptive deliberations (repetitions): demonstrating the movement of the hand again	Teacher's lower arm and students	Students generally did not look confident when answering
4	Providing alternative answer to students	Adaptive deliberations (reconstructed explanations): Explaining using another set of words	Student who posed query	Student raised hand to ask for clarification

In what follows, we describe the four episodes during which adaptive practices were enacted and then provide our discussion of the episode.

Episode 1:

Time stamp	Descriptions of Karina's eye gazes
00:25	Karina saw Nurhasni chewing.
00:35	Karina told Nurhasni to swallow her food (as they had just returned from recess) or to throw it out in the trash bin. She thanked her in advance for complying.
1:17	Karina started teaching. She asked, "What is the meaning…?" (paused) and stared at Nurhasni and Melissa (sitting next to each other at the second row in the column furthest away from Karina).
1:50	Nurhasni stood up to throw something into the trash bin. Karina's eye gaze followed Nurhasni to the front of the class where the trash bin was located as she continued teaching.
2:08	Karina looked at Kelly (sitting in front of Nurhasni) as she turned around to talk to Nurhasni. Karina then looked at Nurhasni.
2:18	Karina looked at Divya (middle column, middle row) and told her to stop playing with her stapler.
2:31	Karina looked at Nurhasni as she was talking to Melissa. Now Nurhasni has turned her body 90-degrees to face Melissa.
3:31, 3:36, 3:48, 3:49-3.50, 3:58-4:00, 4:01	Karina's eye gazes were on Nurshani on these instances.

Time stamp	Descriptions of Karina's eye gazes
4:23	Karina looked at Melissa and asked if the textbook belonged to her or Nurhasni. Melissa said the textbook was hers. Nurhasni said she left her textbook at home. Karina told Nurhasni, "You need to bring your textbook yah?"
4:48, 4:50, 4:53-4:54	Karina's eye gazes were on Nurshani on these instances.
4:58	Karina requested to the researcher to pause the data collection and removed her eye tracker. The whole class looked in Karina's direction. As Karina walked towards Melissa, her jaws dropped and looked in fear. Karina stood in front of Nurhasni and spoke with her (the content of the conversation was unrecorded).
5:27	Karina walked back to her teacher's desk.
5:29	Melissa seemed embarrassed as she shielded her face with her left hand. Subsequently, Melissa and Nurhasni did not engage in private talks. The whole class had eyes on Karina. Karina's eye gazes left Nurhasni and Melissa and were distributed to the rest of the class until the end of the lesson. She did more content teaching thereafter.

In Episode 1, Karina was seen adopting the practice of *adaptive recognitions* of rules. She kept a close eye on Melissa and Nurhasni as she noticed the two of them engaging in frequent private talks. As such, her eye gazes frequently landed on the two girls. She did not openly reprimand them until much later (timestamp at 4:58) when she took a drastic decision to remove her eye trackers, probably to respective the privacy of the students while scolding them or to not have the eye tracker hinder her direct face-to-face interaction with the students). In this case, the flow of her lesson was disrupted and she stopped her lesson to address a recurrent discipline issue. Her adaptive practices were enacted as a result of her expectations of proper behavior (habits) when she was teaching. She was very attentive to the misbehaviours and hence, her eye gazes frequently landed on students who were engaging in non-lesson related activities. The contingencies that arose, in this case, were the lack of alignment of student behaviours to the classroom norms which Karina had set. Following her adaptive practice, the two students paid attention for the rest of the lesson and stopped engaging in personal talks.

Episode 2:

Timestamp	Descriptions of Karina's eye gazes
10:04	Karina was teaching and she said, "This is a very important idea. Good, I see some of you writing." The students sitting in the front row could be seen picking up their pen to write. She stopped talking and the students were taking notes.

Karina adopted the practice of *adaptive anticipations* of *habits*. Instead of telling students that they should be taking down notes without being told to do so, she praised the students who had taken the initiative to do it. In doing this, she was instilling in students the good habits of independent learning without constant and direct reminders. She praised those who did it as a means to also imply that those who did not do so, did not know how to take ownership of their own learning. The contingencies of this practice were her observations of the different student actions—those who were writing and those who were not writing anything and simply staring at the teacher. Subsequently, the whole class of students was taking notes. Karina paused the lesson for them to complete their writing.

Episode 3:

Timestamp	Descriptions of Karina's eye gazes
15:44	Karina drew schematic diagrams of the cross-sections of roots on the whiteboard.
16:17	Karina demonstrated the drawing of schematic diagrams of the cross-section of the stem.
16:20	Karina recapped on the concept of xylem and phloem which students had prior knowledge.
16:58	Karina labeled the words "xylem" (on her inner lower arm) and "phloem" (on her outer lower arm). She said that the whole hand is a "vascular bundle".
18:19	She modeled the extension of a leaf as it grew and asked if the xylem or phloem was facing the top of the leaf. Not all students answered and they generally did not sound confident.
18:29	Karina demonstrated one more time.
18:43	Karina asked again if the xylem would be at the top or bottom of the leaf. This time, more students answered that it would be on top. The collective voice was louder and more students sounded confident of their answer.
18:46	Karina reiterated, "The xylem ends up being on top."
19:13	Karina said, "That is how you remember."

Karina was seen making the *adaptive deliberations of repetitions* and using her hand as a pedagogical tool to help students identify a convenient and vivid way of remembering the content. Her decision to repeat her demonstration was contingent on her observation and interpretations of the lack of confidence in the students' responses, probably from the loudness and number of students answering. Karina had used this method to help students remember the content many times before and she thought it would be useful for this group of students as well. Hence, she had applied this method again to help students derive at the answer confidently and concretize their learning in a visual manner.

Episode 4:

Timestamp	Descriptions of Karina's eye gazes
21:54	Karina looked up at the clock (indicated 11.30am) and decided that she would not carry on teaching. She highlighted the importance of knowing how to draw the cross-sections of the root, stem, and leaf. Karina asked the students if they had any questions.
22:30	A student asked a question, "What is trans-locate?" It was a word that Karina had used earlier.
22:32	Karina explained, "'Trans-locate' means to transfer from one location to another. In this context, it refers to where it is made to where it is needed."

Karina adopted the *adaptive deliberation of reconstructing explanations* to help a student understand a jargon more easily. The student expressed difficulty understanding the meaning of the word "trans-locate". Instead of providing a formal definition, Karina first explained what it meant in layman terms, and then contextualized it to the topic that she was teaching to help the student understand the term more easily. In this case, she had deliberated on the method of making the word clear, the choice of words to use and process to scaffold it from decontextualized to contetxualised meaning making. Her responses were contingent on the type of question that the student asked, that is, the clarification of word meaning.

5. Implications and Conclusion

In this paper, we reported on the use of eye-tracking technologies as a mediator of the pathway from the emergence of classroom contingencies to the adaption of practices in a lesson. In our analysis of a 29-minute lesson video, we identified the contingencies that arose in the lessons and were captured by the eye-trackers as: (1) students who engaged in personal talks, (2) students not taking down notes, (3) students not looking confident when answering, and (4) student raised hand to seek clarification. For (1) the eye gazes were fixed on students and adaptive recognitions of rules were practiced. For (2), the eye gazes were fixed on the whiteboard and students, and adaptive anticipations of habits were practiced. For (3) the eye gazes were fixed on the teacher's own lower arm and students, and adaptive deliberations of repetitions were practiced. For (4) the eye gazes were fixed on the student asking a question, and adaptive deliberations of reconstructed explanations were practiced. The adaptive practices led to improved discipline and enhanced understanding.

This study illuminated the process in which the eyes performed as a mediator in the emergence of classroom contingencies and the types of adaptive practices that result in improved and positive outcomes. Insights on the nature of teachers' adaptive practices in classroom teaching can be drawn. Two new sub-categories of adaptive practices, namely, adaptive deliberations of repetitions and adaptive deliberations of reconstructed explanations, that have not been reported in Männikkö and Husu's (2019) study have been identified here. This implies that eye-tracking technologies can afford new empirical insights on the nature of adaptive practices that teachers adopt in the classroom. This knowledge can be used to inform teacher preparation courses to get them ready for the types of contingencies and hence, potential useful practices that they can adapt in the classrooms. As such, we argue that eye-tracking technologies can potentially contribute to the literature on teaching and teacher education. Teacher educators can consider using eye-tracking technologies to help preservice teachers identify and refine their adaptive practices when teaching (e.g., microteaching scenarios).

6. Limitations

This paper is based upon the case study of one teacher to analyze the occurrences that took place immediately before the next action or spoken word. While we do not aim to generalize the findings, the adaptive practices identified can add to the database of known adaptive practices that teachers adopt and form the base for coding other datasets. Additionally, we acknowledge that while the data collected were meant to be objective and accurate, in comparison to other types of data that were collected retrospectively (e.g., stimulated recall interviews), the object of interest in the eye gaze was contingent on the nature of the adaptive practice identified by the researchers. Hence, inter-rater reliability in the form of independent coding by two or more researchers was necessary to ensure validity.

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