Teacher educators use various measures to gauge pre-service teachers’ knowledge, skills, and attitudes, including behavioral measures, self-report questionnaires, and interviews. These measures often fail to capture the granularities of the teaching and learning processes. As such, there has been a burgeoning and recent interest in the use of biometrics like eye tracking technology in teacher education. Eye tracking, as an objective measure, provides important insights to prepare pre-service teachers for addressing learner differences and developing engaging online and blended instruction, both of which seem critical during and after the COVID-19 pandemic. Therefore, one of the key goals for teacher education to achieve by 2025 is to expand the integration of eye tracking technology into teacher education. To fulfill this goal, the following steps are envisioned: 1) more eye tracking research in teacher education; 2) more use of eye tracking as a teaching tool; 3) more eye tracking instruction in graduate-level teacher education; 4) more teacher education programs having access to eye tracking technology. For successful implementation, training and research experience are needed to scaffold teacher education students to understand and integrate this technology into their teaching and research practices. Interdisciplinary collaborations are also encouraged among researchers in teacher education and other disciplines to overcome obstacles associated with access to the eye tracking technology.
INTRODUCTION

Teacher educators use a wide variety of measures to gauge pre-service teachers’ knowledge, skills, and attitudes, and the most common ones include behavioral measures, self-report questionnaires, and interviews (Rodrigues & Rosa, 2019). These measures often failed to capture the granularity of the teaching and learning processes (Mayer, 2017a). These limitations call for objective measures such as eye tracking, electroencephalograms (EEG), and functional magnetic resonance imaging (fMRI), all of which have been applied in psychology and educational psychology research, but with minimal use in teacher education (Alemdag & Cagiltay, 2018; Lai et al., 2013; Mayer, 2017b).

Considering this broad gap, there is a need to use these objective process measures to examine the teaching and learning processes in the field of teacher education. It is also worth mentioning that the recent development in eye tracking hardware and software has also allowed more researchers to gain access to eye trackers (Funke et al., 2016; Janthanasub & Meesad, 2015). There has been a burgeoning interest in the use of eye tracking technology in teacher education in recent years (Langner et al., 2022). This paper is going to focus on leveraging the eye tracking technology to improve teacher education.

Eye tracking is a sensor technology that can help identify where individuals pay attention by tracking their eye gaze behavior while learning. Based on the eye-mind hypothesis (Just & Carpenter, 1980), individuals’ eye gaze behavior could reveal where their attention is directed and cognitive processing is engaged. Eye tracking technology may constitute a promising tool by providing an objective and non-invasive measure of attentional and cognitive processing underlying learning (Alemdag & Cagiltay, 2018; Lai et al., 2013). The existing eye tracking research has also suggested an association between eye gaze behavior and learning outcomes (Alemdag & Cagiltay, 2018). Eye tracking has been adopted to study learners’ attentional and cognitive processing in various learning contexts (Alemdag & Cagiltay, 2018). A typical metric of visual attention is eye fixation, which occurs when the eye is stationary on a visual stimulus (Rayner, 2009). Fixation duration and the number of fixations have been commonly used to reflect the underlying cognitive processing of instructional material (Alemdag & Cagiltay, 2018). The eye tracking method will empower teachers in their instruction, by revealing students’ attentional and cognitive processes underlying learning. However, a literature review suggested there is limited integration of this promising tool in the context of teacher education. Here, I
delineate the specific areas where eye tracking can contribute to addressing significant issues in teacher education.

Use Eye Tracking Technology to Prepare Pre-Service Teachers for Addressing Learner Differences

The K-12 classrooms consist of students from diverse backgrounds, which include but are not limited to students with learning disabilities (e.g., dyslexia), students from historically underrepresented or economically disadvantaged groups, first-generation students, English language learners, and others. These learners may need extra support to achieve the desired learning outcomes (Gay, 2018). Additionally, learners also bring in diverse individual differences in the cognitive, motivational, and affective domains (e.g., prior knowledge, self-efficacy, and attitude), which may influence their learning experience and learning success (Cronbach & Snow, 1977; Jonassen & Grabowski, 2012). With diverse learner differences in the classroom, it is critical to prepare pre-service teachers for providing an inclusive learning experience by designing instruction that addresses learner differences.

Previous research suggested eye tracking technology as a useful tool to study individual differences in the learning process, and these individual differences included prior knowledge and expertise (Canham & Hegarty, 2010; Korbach et al., 2016), self-efficacy (Hsu et al., 2019; Wang et al., 2022), working memory capacity (Sanchez & Wiley, 2009), as well as learning disabilities such as dyslexia (Kim, Lombardino, et al., 2014; Zhu et al., 2020). Using the eye tracking technology, teachers would be able to gain a better understanding of individual students’ attentional and cognitive processes during learning. By objectively investigating individual students’ learning processes based on eye gaze data, teachers will be able to develop relevant pedagogical accommodations and address individual student needs and interests, instead of adopting a one-size-fits-all approach to teaching. As teachers strive to design differentiated instruction that addresses the needs of individual learners, the information gathered from objective eye tracking data can help teachers make informed decisions relative to the individual differences in affective, cognitive, and motivational domains and develop differentiated instruction that can maximize individual students’ learning success.
Use Eye Tracking Technology to Prepare Pre-Service Teachers for Developing Engaging Online and Blended Instruction

Overall, the past two years have witnessed a significant increase in the adoption of online instruction following the shutdown of face-to-face education during the pandemic. As teachers navigate the shift to online instruction during the pandemic, it has also been found that major challenges faced by teachers during the COVID-19 pandemic included a lack of student participation and engagement in the online learning environments (An et al., 2021). Despite the growing need for flexible learning environments, the inherent transactional distance caused by the asynchronous nature of online learning poses persistent challenges. The low level of participation and engagement compared to face-to-face instruction has been a problem for online learning since its emergence (Chen et al., 2017; Kim, Guo, et al., 2014; Krause et al., 2015; Vitiello et al., 2018), but the COVID-19 pandemic has highlighted the need to alleviate this issue. Recent studies have surveyed K-12 teachers on their perspectives of the “new normal” after the COVID-19 pandemic, and it was found that more online and blended learning was expected after the pandemic (An et al., 2021). The COVID-19 pandemic will eventually subside, but online learning and virtual conferencing will possibly stay (An et al., 2021; Cicha et al., 2021; George et al., 2022). As the pandemic has reshaped the landscape of future K-12 education, it is essential to prepare pre-service teachers for developing engaging online and blended instruction in response to the evolving needs of K-12 education (see also Hodges et al., this volume).

The ability to hold learners’ attention is a critical component of engaging online and blended instruction. However, unlike face-to-face environments, online education poses challenges for identifying where learners pay attention (George et al., 2022). In the online learning environment, teachers and students often do not have the opportunity to interact with each other immediately. Therefore, it is not possible to tell if the learner is engaged or disengaged to the same degree as in a face-to-face learning environment. The information from eye tracking data will provide additional insights into the students’ learning processes in online learning environments. By objectively evaluating learners’ attention and pinpointing the issues with online and blended instruction, pre-service teachers will be better equipped with the knowledge to develop engaging online and blended instruction that attains learners’ attention and promote engagement during the online learning experience.
Leveraging Eye Tracking Technology to Improve Teacher Education

VISION

One of the key goals for teacher education to achieve by 2025 is to expand the integration of eye tracking technology in teacher education. I envision teacher education programs taking the following steps toward achieving the goal.

More Eye Tracking Research in Teacher Education

Extending its application in psychology research that mostly occurs in a lab-based setting, the eye tracking technology has the potential to aid teachers and researchers in teacher education in the study of various instructional contexts, on different subject areas and with diverse learner populations. More research is also needed to examine the relationship between objective measures of learning processes (e.g., eye tracking) and students’ learning outcomes in both face-to-face and online settings. For example, the eye tracking data will shed light on diverse learners’ gaze patterns regarding instructor, material, and peers in the face-to-face classroom. The eye tracking data can also reveal information about various learners’ attentional processing of instructional material in the online setting, for example, virtual meetings, video lectures, and slides. Further, eye tracking data will be useful in identifying factors that sustain student attention and ultimately enhance learning outcomes. Findings from future eye tracking research in teacher education will provide insights for effective teaching strategies and instructional designs that aim to engage diverse learners and contribute to their learning success.

In addition to serving as an objective measure of learning processes, eye tracking has proved to be a valuable tool for providing explicit evidence of teachers’ noticing behavior (Ferdig & Kosko, 2020; Keller et al., 2022; McIntyre et al., 2019; van Driel et al., 2021). Teacher noticing is a critical element of teaching competence and can be developed in teacher education (Seidel & Stürmer, 2014). Teacher noticing described teachers’ ability to selectively attend classroom events during teaching (Van Es & Sherin, 2002). This noticing ability varies with classroom expertise and is based on teacher’s pedagogical content knowledge (Blomberg et al., 2011; Blömeke et al., 2015; Meschede et al., 2017; Shulman, 1986). The findings from this line of eye tracking research will contribute to empirical evidence and practical insights for enhancing teachers’ noticing competence in teacher education and professional development.
More Use of Eye Tracking as a Teaching Tool for Pre-Service Teachers

The eye tracking technology has the potential to serve as a teaching tool and aid teachers in exploring the design of the instructional material in authentic learning contexts. However, a literature review suggested only one study has been conducted with the population of pre-service teachers (Langner et al., 2022). Their findings suggested pre-service teachers of chemistry education perceived the eye tracking technology as an interesting and useful evaluation tool that helped improve instructional material design (Langner et al., 2022). The dearth of literature calls for more integration of eye tracking as a teaching tool into teacher education curricula focusing on different subjects.

More Eye Tracking Instruction in Graduate-Level Teacher Education

In addition to undergraduate education, more eye tracking instruction is expected at the graduate level in teacher education. It is anticipated more research methodology courses in teacher education will enrich the curricula by incorporating the eye tracking method. In these graduate-level courses, graduate students will be introduced to the fundamentals of eye tracking and provided opportunities to explore eye tracking research in teacher education.

More Teacher Education Programs Having Access to Eye Tracking Technology

At this moment, very few teacher education programs have incorporated eye tracking into their curricula (Langner et al., 2022). With the recent advances in eye tracking technology, eye tracking hardware and software have become more accessible, and it is easier to conduct eye tracking research. With more teacher education programs integrating eye tracking into their curricula and research, students and faculty in teacher education programs will increasingly appreciate the values of eye tracking technology in the field of teacher education. A massive increase is anticipated in the number of teacher education programs that will have access to eye tracking software, hardware, and research facilities.
IMPLEMENTATION

The increasing accessibility of eye tracking devices and more value attached to the technology will motivate more applications of eye tracking in teacher education by 2025. Efforts are needed for the successful implementation of eye tracking in teacher education to maximize its potential to improve teacher education.

Obtaining Eye Tracking Hardware and Software

One obstacle to the widespread implementation of eye tracking in teacher education is related to the cost of the eye trackers (e.g., hardware and software). Depending on the research purpose, researchers will need to decide the level and type of eye trackers to employ. The hardware and software of high-resolution standalone video eye tracker (e.g., EyeLink 1000 Plus) or wearable eye tracker (e.g., Tobie Pro Glasses) usually cost $20,000 ~$30,000. The high-level eye trackers are ideal for conducting studies that look for eye gaze data at a high sampling rate (e.g., collecting data every millisecond by EyeLink Plus 1000).

If a high sampling rate is not required for research purposes, consideration should be given to some less expensive eye trackers for more widespread integration into teacher education (Dalmaijer, 2014; Funke et al., 2016; Janthanasub & Meesad, 2015). Among these eye trackers, it is worth noting the invention of a free online webcam-based eye tracker (WebGazer, Papoutsaki et al., 2016), which could turn a webcam into an eye tracker. This eye tracker has allowed the researchers to study individuals’ attentional processes during web searches remotely (Papoutsaki et al., 2017). The findings from the evaluation of the eye tracker suggested that it could gauge users’ attentional dynamics with acceptable accuracy and precision (Papoutsaki et al., 2017). An advantage of this remote eye tracker is that it does not require standalone eye tracking hardware, and it just needs to access the webcam on the learners’ end with their permission. As such, data collection does not need to be restricted to the lab, and this eye tracker can be easily integrated into everyday use and authentic learning environments. This eye tracker offers a reasonably good solution for collecting learners’ eye gaze data and gauging where they are paying attention when learning online. The advantage of convenience and cost would also enable a scalable application and democratize eye tracking technology into teacher education.
Provide Training in Undergraduate- and Graduate-Level Teacher Education Courses

Caution has to be exercised, however, because it may involve a learning curve when introducing the novel eye tracking technology for the first time (Lilienthal & Schindler, 2019). For example, it was noted in an eye tracking study with pre-service teachers that a large amount of eye tracking data and the complexity of the data might cause challenges and learning obstacles (Langner et al., 2022). Therefore, teacher education courses should consider incorporating the eye tracking method into the curricula or at least providing accessible training opportunities. First and foremost, it requires the instructor of these courses or training sessions to have proficient knowledge of the eye tracking technology and provide support to the students as needed.

To facilitate the integration of eye tracking technology in teacher education, training sessions should include the following elements: 1) provide basic information about the eye tracking technology, the applications and the value of eye tracking in teacher education; 2) provide a step-by-step protocol on collecting eye tracking data collection and analysis; and 3) facilitate discussion and exchange of information among students, which could help mitigate the challenges associated with analyzing and interpreting the eye tracking data (Langner et al., 2022). Certain resources would also be useful, for example, the systematic review by Alemdag & Cagiltay (2018) as an overview of the eye tracking method and its applications. Another good resource is Holmqvist and colleagues’s (2011) book, which focuses on the eye tracking methods and measures. Students will also be encouraged to brainstorm ideas for integrating the eye tracking method to address specific questions related to their research and teaching interests. After the education and training, students should be confident and competent to incorporate this tool into their research and teaching practices. Students should also be encouraged and supported to design and conduct eye tracking research to further explore this method beyond the relevant course or training session.

Promote Collaborations among Researchers in Teacher Education and Other Disciplines

Researchers in teacher education are also encouraged to partner with researchers in other disciplines (e.g., psychology, learning sciences, educational technology) to collaboratively design and conduct eye tracking studies and address research questions of common interest. This interdisciplin-
ary collaboration can also help researchers in teacher education overcome the obstacles caused by access to hardware, software, and sometimes research facilities (e.g., eye tracking lab), as eye tracking is a more established research tool in the abovementioned disciplines. Opportunities should also be provided for undergraduate and graduate researchers in teacher education programs to engage in authentic eye tracking research projects under the guidance of faculty researchers. The research experience will help the student researchers in teacher education further develop their knowledge of the eye tracking method and hone their skills related to eye tracking data collection and analysis.

References


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