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Artificial Intelligence and Sensor Technologies the Future of Special Education for Students with Intellectual and Developmental Disabilities

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Opinion

Learning environments such as classrooms and online systems for students with developmental or intellectual disabilities are typically dynamic, multisensory, and make use of top-down attention and working memory mechanisms to promote sense making by the student. This is specifically true when the student with intellectual disabilities is mainstreamed into a general education classroom. The complex interactions between the classroom, the student, and the content creates serious difficulty in assessing a student's understanding, particularly for students who are non-verbal or have deficits in communication. However, the last five years have ushered a revolution in computational power, brain mapping, wearable sensors use, large scale data collection, generative artificial intelligence, and physiological signal processing techniques e.g., the 4th industrial revolution [1]. It is now possible to make use of these powerful tools in the context of the special education and general education classroom to understand students in ways which have not been possible before. Drawing on these theoretical and methodological advances, research using these powerful tools in educational contexts and environments has departed more and more from traditional, rigorous, and well-understood paradigms in cognitive science and understandings of cognition. The use of these tools in education to investigate cognitive actions and their underlying neurological mechanisms more holistically and directly in educational and classroom environments is sorely needed [2]. However, current investigations and research in cognitive science typically address the role of one of the attributes using decontextualized tasks in isolated environments such as a laboratory [3]. Of specific interest is how to investigate the interactions of the student within the complex social environment of the classroom in students with extensive support needs in the general education setting [4,5].

Closer inspection of the fields associated with the examination and assessment of cognitive and neurological state for students with intellectual or developmental disabilities reveals that many researchers discussing these topics are housed and credentialed outside of colleges of education, special education departments and not affiliated with educational programs. This separation and isolation of the members of the special education community, excludes exposure and training for a critical group who need to take part in the conversation; the educators (teachers) themselves. Even when included in the conversation, educators that make use of neuroscience often overestimate warrants, engage in the propagation of neuromyths, and are not sufficiently familiar with the application of ideas arising from the fields of neuroscience, machine learning, artificial intelligence, and big data. These disciplinary ideas and associated applications are simply not taught in colleges of education to preservice teachers creating a very large theory to practice gap [6]. In essence, our [educator's] underlying understandings of how best to educate children with intellectual disabilities from a cognitive and neurological perspective do not always align with approaches found in neuroscience and cognitive science where the use of sensors, generative artificial intelligence, and other forms of assessment are routinely integrated [7]. Considering the very different world views held by educators, neuroscientists, and others in related fields, it is necessary to bring these disparate groups together to develop and negotiate a framework that seeks to translate neuroscience and related fields into meaningful contexts within the special education classroom.

Even when teachers are presented with usable work that readily translates from neuroscience and related fields, teachers are not always able to integrate the work into classroom practice. In many cases rather than adopt or adapt tools from these fields, teachers still make use of written or verbal assessments to understand students' learning progress and adapt instruction [8]. For example, teachers working with children with dyslexia; to decrease dysfluency and deficits in phonological processing through remediation still rely on outdated approaches which have been show ineffective by neuroscience studies starting in 2003 [9,10]. This is unfortunately likely an artifact of educational assessment, these forms of data collection used by teachers are necessarily retrospective, do not occur in-the-moment during task completion, and only represent the products of the learning opportunity. This results in the educator in the classroom missing a tremendous amount of real-time cognitive, affective, and behavioral, in the moment, process data from which to make decisions. The lack of immediacy of results and identification of real-time fluctuation during the process of learning creates the conditions for missing teachable moments and increases student stress and frustration.

Owing to the advent of inexpensive and highly accurate sensor technologies, generative artificial intelligence, and neurotechnology's, educators now have a new way to assess every student's learning status, cognitive states, and promote adaption in a multi-modal and multi-dimensional way in real-time [6, 11]. However, there is little in the way of field-based knowledge in special education that would allow special education researchers and educational researchers in general, to make use of these tools. Understanding how a student solves and processes tasks and problems in the classroom environment is an important concern and an area of intense discussion across the field of special education and beyond [12]. The lack of immediacy of feedback (i.e., real-time) in current teaching practices results in losing the best teachable moments, increasing student frustrations, and does not allow an educator to identify lack of engagement with the content. Even when educators are provided with current potentially "usable work" from fields such as cognitive science, it is often not adopted by teachers due to a lack of an educational frameworks, pedagogies, and inexpensive sensor technologies for them to make sense of these approaches. This suggests the need for new frameworks that teachers and educational researchers can use to understand and make use of process data in the classroom. Considering this gap, educators such as Lamb, Choi, and Owens, have begun to call for exploration and research to respond to this need for a more integrated vision of learning and the need to leverage novel sources of process data in real-time to understand student successes and barriers to learning.

To accomplish leveraging novel sources of process data in real-time, it is necessary to identify and develop frameworks and tools such as generative artificial intelligence to illustrate methods and practices for large-scale research and application to create a fully adaptive student-centered classroom. Using neurocognitive, psychophysiological, and other forms of process data along with leveraging existing machine learning and big-data frameworks, special educators and researchers will have an increased understanding of how learning tasks, assessment, and students interact to create cognitive (e.g., reasoning [13], thinking [14], affective (e.g., motivation [15] engagement [16], behaviors (e.g., practices [17] and strategies [18] outcomes in the classroom.

Process data is often contrasted with product data which provides an overall summative retrospective outcome related to cognition, affect, or behavior. Product data is the principal form of data collected in educational assessment and is the primary data used to adapt instruction. The adaption often occurs days, weeks, or months later due to the retrospective nature of product data. In this light, process data can provide additional support, context, and understanding to existing research by providing a window into the millisecond-to-millisecond fluctuations in cognition, affect, and behaviors used by the student as tasks are completed. This will assist in closing the learning gap for students with intellectual disabilities in the quickest way possible.

Process data from sensors and neurotechnology's can be available for use by educators within milliseconds as opposed to minutes, hours, or days, as is the case for product data. This form of data can also allow us a view into the black box which is student cognition. Data from artificially intelligent systems can tracks students' learning progressions using sensor-based data so that content adjustments and differentiation of instruction can meet a student's needs in real-time. Many granting agencies as well as other private and public foundations have invested multimillions of dollars in recent years to develop specific approaches to make use of data from novel assessment tools to facilitate students' "knowledge-in-use learning" and to promote adaptation of instruction and content in the classroom. However, most of these assessments are performance-based constructed response items that often prohibit timely feedback and by their very nature are not continuous and are necessarily retrospective in nature i.e., product data [19]. In addition, even when classroom activities are automated using machine learning, the artificial intelligence is a best performing a rote activity such as grading an essay and not synthesizing meaningful pathways for learning. This is primarily due to the lack of integration of feasible sensor technologies, research frameworks, and broad availability of these powerful technologies in the classroom environment. This alone has hindered special educators from understanding

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moment-to-moment needs of students in real-time thus missing opportunities to garner important information to adjust instruction and provide just-in-time learning opportunities [20]. Another benefit of AI is it provides a means of support for students with intellectual disabilities when supports may not be available for a myriad of factors. To this end, neurocognitive and other data forms are not necessarily accessible using current practices and educational assessment approaches. However, with the rise in the use of machine learning, generative artificial intelligence, and the introduction of neurotechnology's such as non-invasive classroom ready neuroimaging devices, opportunities to understand and make use process data and to create a truly adaptive learning environment with just-in-time supports in special education has arisen.

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