Teacher Literacy Policy Recommendation and Program for Action on the Neurobiology of Learning Differences

Mirela Ramacciotti, Johns Hopkins University, Brazil

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Abstract
This article outlines the program and policy recommendation for teacher literacy into the neurobiology of learning differences. The introductory formation course for teachers describes how, in a 12-hour program for regular schools, teachers can understand how neurological development should look like in typical and atypical trajectories. To attain this objective, the landmarks for neurological linguistic development are discussed as much as the differences in development for boys and girls. Specific language impairments and learning disabilities regarding listening, speaking, reading and writing, math, attentional processing and executive functioning are contemplated. Additionally, instructional strategies for accommodation and intervention are analyzed as well as the main characteristics of Attention Deficit Hyperactive Disorder and Autism Spectrum Disorder. The risks concerning Traumatic Brain Injury and Executive Dysfunction are also discussed. To conclude, an analysis of the necessary elements for an effective and productive communication with the general community (parents, leaders, school-related professional) is conducted.

Keywords: accommodations, learning differences, neurobiology, trajectories, strategies

Introduction

In preparation for the educational agenda for teacher formation, this program addresses the issue of teacher literacy in relation to learning differences. Grounded on several anecdotal cases[1], there is a pressing demand from school leaders and parents for teachers to be literate in neurological development in respect to learning. This demand needs to receive special attention in view of the heightened consideration placed on teachers as enablers of better students' learning outcomes. Having been employed to devise a framework for a 12-hour teachers' development program about teacher illiteracy regarding the neurobiology of learning differences, I will specify what kind of literacy teachers need and the thought, organization and action progression in the acquisition of such literacy skills. The content of the modules for the program are discussed and policy recommendations are given at the end.

The program is the practical part of the policy recommendation. The delivery (in-site interaction) for the teacher program is divided into four modules. Each module comprises material for roughly three hours of work with tasks for teachers to discuss and complete based on their experience and with the input of new content. The whole program should take two days of intensive work (six hours each day). The modules are sequential and build on one another. Therefore, it is essential that all participants take this course as programmed. The program is thus sequenced: the first module is about neurobiological development; the second module analyses infant and language development; the third module gives specific information about the differences and similarities to be found among learning disabilities; the fourth module considers the communication with community members.

To achieve this breadth in scope, there must be some guidelines. The core directives underlying the program rationale are:

1. the provision of equal opportunities to those most in need;
2. the provision of information to teachers through an approach that allows for the generation of ideas which, coupled with practice and execution, can enable the transfer and application of the knowledge created to their settings;
3. the provision of a set of recommendations to be followed for the appropriate implementation of such policy.

General Overview

Educational Policy

To work as a nation and provide education to our entire future work force, we need to devise a common fertile ground to serve as a growth medium of curricula and pedagogical proposals from Pre-K to K12. In the procurement of such ways and methodologies, an educational document, like Common Core Standards, should establish the knowledge, competencies and skills expected from our students along their learning trajectories. The ultimate goal of such directives is to have a more inclusive, democratic and fair society.

[1] There is a huge compilation of anecdotal cases in the minutes of PTA meetings in each of the schools that I consult with. Unfortunately, a quantitative method has not been applied, rendering the collection of more structured data an unfeasible task. This is also a key goal for the proposed plan: objective data collection on the issue of learning differences and unmet learning needs.

In establishing the essential learning elements, this document has to be anchored in the notions of equality, diversity and equity. Equality is consubstantiated in serving our diverse population of learners with fair opportunities in entry points and continuity to safeguard their right to learn. Equity is reflected in acknowledging that diverse students have differing needs and those needs should be addressed adequately. There is no service or address that can happen without the proper recognition by teachers how different struggling learners are and wherein their differences lie so that adequate treatment can be given to their learning needs.

Teacher Literacy in Neurobiology of Learning Differences

In defining the lack of knowledge by teachers of how atypical patterns of development affect learning as illiteracy in learning differences, there is an acknowledgement that literacy is intrinsically the ability to understand and communicate, to interpret and comprehend the world where we live and operate (Drisdale, 2015). In this process, teachers need to learn how to differentiate fact from opinion or anecdotal beliefs; they must also be attentive towards inaccuracies between typical and atypical learning trajectories and they need to start asking for and implementing practices that acknowledge those atypical trajectories (Lewis, 2018a).

The more capacity teachers acquire to rapidly process the decoding of atypical behaviors, the more time they will have for deeper analysis and selection of activities to effectively address struggling learners' needs (Wolf, 2007). To attain that goal, teachers need navigational skills that will allow them to: know when they need information, identify what information is needed, find it, assess it to apply that same information so that a solution can be implemented and evaluated (Gok, 2015).

The information teachers need to generate new thoughts about neurodevelopment for learning is grounded in typical and atypical features. Teachers need information on cognitive, affective, psychomotor, and behavior systems. They also need to know what effects certain medications produce in learning as well as disorders that do not abide by what is commonly found in typical learning trajectories (Lewis, 2018b). It is not simply a question about what to learn, how to learn, and why to learn; it has a lot do with perceived differences in expected levels of production, in discrepancies in processing and comprehending content and in how interventions and accommodations may interfere with learning. This is the critical kind of literacy that our teachers need, and this is a matter for educational policy and concern (Elmborg, 2012).

Course Content

In this section, the content that is developed in each module of the 12-hour program is specified. Important to mention that the brevity which is given to some deeply complex topics, such as brain development, happens in relation to time and purpose. Teachers taking part in this formation course do not become experts in neurobiology. That is not an expectation nor a demand. But knowing the very basics of such topic is central to an overall understanding of how biology underlies learning differences. This will make them better apt at dealing with diagnosis and atypicity in the classroom. In each module below, the main content is made explicit and references are provided. During the program, a variety of tasks, ranging from computer-based quizzes, total-physical response tasks and game-like activities, like bingo and jeopardy, are employed.

Module about Neurological Development

To better understand how learning differences or disabilities emerge, teachers need an introduction to neurological development. Therefore, the first topic examined within this module is brain development. Within this broad topic, the program delves deeper into the reason for humans' long term in uterus and how neurons follow a pre-programmed route that is chemically based. A lot that happens during pregnancy is activity dependent and the concept of critical period must be well understood within this time frame. Teachers are guided to reflect on the precise patterns of activations that our complex structural and functional architecture entails. In this process, there needs to be an overall understanding that environment is constantly shaping the brain (Aamodt & Yang, 2011).

Following brain development, the topic of myelination is tackled. In this part, STEAM activities developed with participants lend much strength to understanding. By working with cables and insulation properties, teachers quickly grasp the idea that myelin is an outgrowth of a glial cell that insulates the axons of neurons. That insulation is needed for connections to work in much the same way that electric cables can only conduct electricity once they are properly insulated. If that does not happen, accidents are bound to occur, and much the same happens in the brain. Participants get to know how myelination happens, before birth, in the motor and sensory systems, and the importance that it has for motor learning afterwards. It is also within this topic that teachers get to understand that differences in the timing of neural responses may be related to impairments in cognitive abilities (Dehaene-Lambertz & Spelke, 2015).

After myelination, the program moves onto the notion of mirror neurons and how that relates to social learning. Knowing that infants process sensory experience within one hour of birth confers deeper appreciation for the concept of reciprocity (Bulf, Johnson, & Valenza, 2011). The notion that newborns match orofacial movements shown to them lays the foundations of shared representations of self and others and of language acquisition (Werker & Tees, 1999). To better understand students within autism spectrum disorder (ASD), teachers need to grasp that it is from the imitation of surroundings stimuli (faces/sounds), that language emerges to communicate needs and thoughts. If there is a failure in neuronal pruning and/or less myelination in neural connections, these students may not develop language in the same way as children in typical development trajectories do (Bartzokis et al., 2010; Courchesne & Pierce, 2005).

Moving on to early years (1st to 3rd years of life), there is much value in knowing about apoptosis. Neuronal death, which is a natural ontogenetic process, plays an important role in uncluttering the infant brain. During the first year, the brain is programmed to select ineffective neurons that go unused or do not transmit the electrical signal properly. It is during this period that neuronal networks undergo a great change; the skills that do not get developed, dissipate. Also present is the well-acquainted notion that the second year of life is a 'blooming buzzing confusion'. Understanding that human brains are, at that age, typically dealing with an overflow of neural connections is central to a more biologically-driven perspective. At 24 months old executive functions are still maturing so toddlers can not be helped, nor expected, to interpret and manage their emotions. Participants also get to know why a lot of procedural learning is typical of this period as much as what to look for, in

typical and atypical development, in relation to language; sense of time and sequence; and small motor and hand-eye coordination.

To close this module, potentials and limitations in relation to development are examined. Human learning demands the development of multiple, hierarchically organized levels of structures and of connections (Dehaene-Lambertz & Spelke, 2015). In early infancy, the development of knowledge should follow a regular pattern which converges into a system. Early brain lesions, developmental disorders and abnormal environments disrupt that delicate – and individually-gauged balance - and that is when atypical cognitive development may occur. There are three domains that should be in every teacher's radar: brain areas and structure; connectivity; and temporal constraint.

Module about Infant & Language Development

Teachers must understand that susceptibility for learning differences results from the interaction between individual neurobiology and environmental influences. That is rooted in gene x environment interaction (Belsky & Pluess, 2009; Boyce, 2007). A child that is overstimulated at infancy may present some failure in pruning 'noisy' connections as much as that who is understimulated may fail to adequately develop some necessary networks. This is known as the Goldilocks Principle and safeguarding this 'zone' for optimal development has to be within teachers' capability. Teachers need to know that a demand for something that is not at the appropriate level of development, in terms of connectivity, may end up in disruption or malfunction.

Another topic within this module is that of gender differences. As much as 20 weeks in womb is enough for girls to become more mature than boys. That discrepancy will only grow in the years ahead. In kindergarten, a typical developing girl is, on average, one-year ahead of a typically developing boy (De Bellis et al., 2001). That is mother nature's doing and that knowledge can confer great latitude for teachers who suffer in differentiating instruction. At puberty onset, girls will typically be two years ahead of boys. But, by age 13, i.e., during puberty, girls' brains reach a plateau, and boys even them out. It is only after puberty that differences between sexes are fewer to be found than those between individuals.

The following topic deals with memory and the ages and different stages that signpost developments. At 3 months old, babies have but a functional working memory (WM), that memory accessed for what is needed at the moment, but that development is crucial for language development (Friederici, 2011). From that cornerstone on, we should observe developmental gains in phonological short-term WM, which translates into more efficiency in storing, ordering, rehearsing, retrieving and reconstructing information, i.e., acquiring new words. Complex WM, which translates into gains in processing efficiency and attentional capacity, takes more time to develop and greatly increases during childhood. It underscores learning (Gathercole, 1999).

To better appreciate how chronological age brackets are paired with typical stages of development, teachers get immersed in a series of tasks involving certain parameters. An example is that from 4-6 years, typically developing children have more hippocampal connectivity, central to memory formation, due to better myelination. That confers them gains in declarative/episodic memory. It is also when children start consolidating memories about their lives. From 6 years on, long cerebral pathways

myelinate. These pathways are employed, for instance, in learning how to write. That skill develops within a large range in age, and anything from 3 to 7 years is normal in terms of development of writing. When adolescence comes, there is an abundance of hormones leading to greater synaptic pruning. The amygdala, a central brain structure for emotional regulation, gets enlarged. There is great myelination in the corpus callosum, the fibers that connect our brain hemispheres, signaling that maturation in hemispheric interconnectivity is underway. So, the attention and correction mechanisms - located throughout the brain - that permeates impulse and control functions are not at their prime, yet. Therefore, external support, and understanding, is much needed (Blakemore, Burnett, & Dahl, 2010).

The next topic to be examined is that of language milestones. Knowing what is expected for a typically developing child since gestation till the age of 5, both in comprehension as in production, sets some cornerstones of development that teachers should be aware of (Saxton, 2010). Far from expecting the same developmental trajectory in relation to time, as some individual variability must be always considered, parameters in language acquisition aid teachers that should be on the lookout for atypical trajectories. Such trajectories can be better understood once the three domains of children's receptive skills are clearly comprehended: sensibility to sounds and vocalic combinations, i.e., phonology; inference of the abstract structure of speech, i.e., syntax; parity of words to objects, i.e., semantics. Disturbances in any of these domains when clearly signaled by an informed adult can be crucial for early detection of a learning disability.

Next in line comes reading and writing. As human brains are not biologically preprogrammed to read and write, as opposed to listen and speak, such abilities need investments of time and skill. Teachers are central to the process that every student in school undergoes and their correct appraisal of this restructuring of the brain is necessary. Knowing, for instance that for reading readiness children have to mature nothing less than 16 different neuronal networks does lend breadth to an accomplishment that may remain unparalleled throughout schooling (Pugh et al, 2013; Schlaggar & McCandliss, 2007; Tokuhama-Espinosa, 2011). In the case of writing, the concept of myelination dealt with in module one is explored in greater depth. The long fibers connecting the motor cortex to our fingertips take time – which is a variable factor - to myelinate. And motor learning, based on procedural memory, is extremely resistant to change. Once a student that is forced to write prematurely learns how to do it in the wrong way, i.e., not with fingertips, but with hand or elbow movements, unlearning is exponentially harder. This will, in time, lead to disinterest and a real hardship in writing development. Good intentions, when misdirected can lead to disastrous consequences. Teachers have to appreciate, understand, respect and support individual variability.

To close this module, comes the notion about numerical cognition. Knowing that the concept of natural numbers is strictly human (Dehaene, Izard, Spelke, & Pica, 2008).) can stimulate teachers who may inadvertently bring their personal math anxiety to classes. By working with the five properties of numerical cognition observable at any age (Dehaene-Lambertz & Spelke, 2015), teachers can skillfully scaffold students in investing on their spatial skills to better prepare for STEAM careers, regardless of learning differences (Newcombe, 2013).

Module about Learning Differences/Disabilities

The moment that teachers come to this module, they have fully grasped the reason why we should be talking more about differences and less about disabilities. Besides our potentials and limitations, we are all endowed to survive and thrive. Making use of mechanisms, within the boundaries of the contextual influences we are subjected to, is what should steer our efforts, and decisions, about how we learn. Along these lines, it is important to know that what is generically named *learning disabilities* should be indeed understood as a holdall term for heterogeneous disorders which present **significant** difficulties in listening, speaking, reading, writing, reasoning, and math abilities. They can cooccur without causal link. Determining them is a function of capacity in relation to performance.

When talking about these hardships, important to note that they relate to neurodevelopmental areas that can be better understood if presented within the domains of motoric capacity, language development, and organizational skills (Levine, 2003). Besides, there needs to be an understanding of where a disability lies as in, for instance, does a student present problems in oral comprehension or expression? Is the significant difficult to be found in math reasoning or calculation? Does the problem appear in reading comprehension or in written expression? As academic skill deficits may be found in neurobiology, in cognition, in behavior and in the environment, the testing route may not be the most adequate, lest reliable, to determine a condition. Investigations into a student's response to an intervention - the way through a deficit - may provide more effective answers.

After examining neurodevelopmental areas, next in line are the characteristics of individuals with learning disabilities. Among the ten general features, teachers start to pair some of what is being worked in the program with the faces and reactions of many a student. It is adamant, at this point, to retrace steps taken to remind participants about the relevance of significant differences for some of the characteristics that can cooccur in students with severe learning issues. It is not a single characteristic that defines a learning disability. There needs to be discretion and humility on the part of teachers who are not to diagnose learning disorders. This is a job for another class of professionals. Nonetheless, teachers are in charge of effectively managing the implications of diagnosis for learning purposes.

Moving on to oral expression and to the impairments that may be present, teachers get to know that a specific language impairment (SLI) is not due to a cognitive deficit, poor hearing, neuropsychiatric condition, or social problems. What happens in this area may be more related to a weak procedural learning that is highly heritable (Newbury, Bishop, & Monaco, 2005). In relation to SLI, teachers need to discreetly understand the components of oral expression. Besides phonology, syntax and semantics, there is morphology and pragmatics. Knowing these different areas aids teachers in identifying the difficulties inherent to the different subtypes of SLI that students may present.

Taking the large bandwagon of phonological processing, a common deficiency for SLI, the program moves forward to a possible comorbidity by analyzing Dyslexia, which is also connected to a faulty phonological processing (Catts et al, 2005). Dyslexia is a specific reading disability, according to the DSM-5, that has a neurobiological nature. It is a persistent functional deficit and not a delay in

development. The telltale signs are, although not limited to, slow, difficult and inaccurate reading, frequent spelling mistakes, and sub-par writing skill. The treatment has to be scientific and evidence-based, with techniques and strategies that approach learner needs' wholly. That demands that teachers, and education leaders, acquire enough knowledge to change educational practices and policies that are not in tandem with what we presently know about dyslexia. Additionally, there needs to be more information on the kind of dyslexia a student may present; processing issues are different than comprehension problems. However, both types translate into a low decoding ability that leads to poor reading. In time, if left unattended, these students will have less vocabulary and knowledge gains.

Comorbidity in relation to processing speed may happen for dyslexia and ADHD (Mahone, 2015). Considering that an ADHD diagnosis is highly influenced by beliefs and profiles, i.e., boys regarded as more ADHD-prone than girls (Bruchmuller, Margraf, & Schneider, 2012), there are biomarkers, such as connections that mediate attention, memory and EFs which are not strong in ADHD learners (Shaw et al., 2007). ADHD is not a neuromyth lest an invention of pharmaceutical companies. However, any medicine for this condition has to be used in conjunction with other behavioral interventions. Apart from being a condition hard to diagnose as it has to be done, presently, by exclusion; there are three subtypes that have to be considered for interventions and accommodations that take place in the classroom. Teachers have to know that a demand from students in class for excessive speed, dual tasks (reading and writing), and multiple rules is too much for a student with ADHD. Therefore, teachers once again are led to appreciate the value in distinguishing planning, like time management and sequencing, from organization, as in class settings and materials. Such confusion can cause much damage in instruction (Lewis, 2018c).

In getting more knowledge about ADHD, another issue has to be introduced as cooccurring characteristics may be found. Many ADHD learners present an inability to infer language, self-monitor, organize materials and apply strategies, commonly found in Executive Dysfunction (EDF) (Reader, Harris, Schuerholz, & Denckla, 1994). Although, teachers may attribute this processing problem, i.e. EDF, to many students, the persistence of symptoms defines the problem. In the case of EDF, there is an array of teaching strategies, that can accommodate, i.e., work around the deficit, till students are better able to inhibit their attention, sustain it in order to to deliver on tasks.

Attention is the common thread for another possible comorbidity: between ADHD and ASD. Whereas learners with ADHD have difficulty in selecting the stimulus for attentional focus, ASD subjects have problems in shifting their attentional focus. And the intervention that is highly effective for both scenarios is called ABC (Antecedent; Behavior; Consequence). In this intervention, circumstances that precede the action are proactively examined, the behavior is treated as it is, a manifestation of an underlying condition (and not an inconsequent attitude, as in misbehavior), and consequences are ascertained, i.e., results from said behavior are subjected to a needs analysis. But ASD deserves time in the program as it presents greater challenges for the educational community.

To begin with, teachers get to know how ASD, a highly heterogenous neurological disorder, has no 'cure', as it is not a disease. But the fact that there are no medical

tests, nor a definitive cause to this disorder, does cause great anxiety. That is not conducive to an effective approach for ASD students in schools. Although each case is a case in ASD, there are some core deficits that allow for an identification. These are: repetitive patterns of behavior, persistent difficulties in social interactions and in verbal and non-verbal communication. These features translate into qualitative impairments, analyzed in greater detail during the program, that bring a constellation of challenges. Far from discouraging participants, this program makes sure that each group of challenges presented are coupled with possible accommodation strategies. But there can be no sugar-coating to the difficulties that ASD students face. They have to supported, aided and understood so that their atypical learning trajectories also find room for success in schools.

The last topic in this module is about Traumatic Brain Injury (TBI). This condition, which is not always so obvious, results from an acquired injury to the brain due to external forces. As with ASD, each case of TBI is unique and presents challenges that have to be individually assessed. The diagnosis is based on the level of consciousness and focal signs. There are two subtypes: primary injuries, those resulting from sustaining a blow to the head through an acceleration/decelleration movement with cooccurring rotational trauma; and secondary injuries, those resulting from decreased cerebral flow, increased cerebral blood volume and intracranial pressure. The impairments after a TBI can be of a mild, moderate or severe nature to one's cognition, behavior and/or motor capacity. But, pre-lesion factors, such as age and development, play a major role in recovery and treatment. After the TBI, some cognitive and behavioral deficits can only be detected once the individual returns to a challenging environment, like a classroom. There is a range of abilities that may be altered after a TBI, such as attention, memory, language, motor and executive functioning. However, greater impairments will affect those with preexisting learning disabilities. To note, recovery in the first 2 years after a TBI can be crucial. Unfortunately, the fact that among those affected, half do not get reported or treated, makes the case for TBI awareness much more pressing (Blankenship & Canto, 2016).

Module about Connections with the Community

In this module, we deal with a thorny issue for education professionals: communication. Teachers live surrounded by students and other teachers. Therefore, the vocabulary that is used and the conversations that take place, while may give them the notion of pervasiveness, correspond, to a fraction of the conversations and of the vocabulary that students use. These students take part of other circles, such as family, community centers, and social groups. And in these circles, the vocabulary used changes.

Therefore, when teachers get to talk to parents or students about learning differences, misunderstandings may occur. And a common reason for them is lack of shared vocabulary. Teachers have to take steps to make sure that, when communicating about learning disabilities or disorders, and the difficulties that students face, parents and students themselves get to understand where the problems reside and how expectations should be expertly adjusted.

Parents are the greatest allies that teachers of students with severe learning difficulties may have. They are the ones that can furnish precious information about early development so that teachers can better understand the individual in class. On the

other hand, parents who have been thoroughly informed about curriculum choices, expectations, content and assessments may aid the work that is taken home by the leaner. Treating that ally with confidence is the first step towards trust. Teachers have to invest in building a solid, patient and professional avenue of communication with parents. In this work, the learner is the one that is most benefited (Lewis, 2018a).

In scaffolding this communication, it is adamant that teachers share information with parents on how cognitive impairment impacts pace and learning. Likewise, students with deficits should know about development stages and how to invest in their strengths to compensate for their weaknesses (Levine, 2003). Being able to pinpoint their successes is, therefore, a must. Another important step is to make clear how cognitive development relies on language and social development. The stages of development may serve as a good foundation for what modifications/accommodations can be done in schools. Parents should also be aware and coached on how to support them at home.

Recommendations

In this section, recommendations will be furnished for education leaders and policymakers in relation to teacher literacy on the neurobiology of learning differences. Each paragraph highlights one recommendation in view of what has been exposed in this article and program for action.

Accelerate the inclusion of struggling students to match Common Core Directives
Education leaders and parents have already expressed their dissatisfaction with current teachers' knowledge of learning impairments. In view of Common Core Standards, that call matches the foundational basis for learning outcomes in relation to content and development of competencies and skills that are essential to learning.

Our recommendation is that state and local education policymakers work together to promote mechanisms to address teachers' lack of knowledge in relation to learning differences. Blaming teachers for struggling learners' difficulties does little in advancing practices for the effective inclusion of such students in alignment with Common Core demands. The procurement of a coherent, balanced and effective system of teacher continued formation should answer that pressing need more thoroughly.

Adopt a teacher literacy program to develop their knowledge in neurobiology of learning differences
Teacher initial formation does not presently cater for the knowledge that they should have to address those with learning disabilities. That realization does not prevent our society from developing mechanisms to fill that void. Such is the adoption of a literacy in learning impairments that will provide teachers with the fundamental knowledge they need to design learning experiences that will accommodate the learning needs of all students, especially those with specific needs.

In view of the fact that teacher literacy in learning differences is strategic and central to the effective enactment of Common Core Standards, teachers who do not have information on what is atypical in learners' neurological development will not be able to enact practices that guarantee learning through adequate curricula and learning

programs. A program that develops teacher literacy in this area should be a priority in teacher development programs to be adopted.

Develop a STEAM approach to teacher literacy in learning differences
An approach that promotes integration across levels and subjects as STEAM does is in line with the attainment of successful continued learning. Teachers can make effective use of the problems that are central to this new literacy by using discovery learning through STEAM. To develop an effective inclusive education, experience is the adamant recommendation. By developing teachers' literacy in learning impairments, it becomes possible to accommodate all learning profiles through a feasible and commendable approach. That can be done through the integration of subjects and the complimentary possibility of discovery and creation in learning designs. STEAM courses for teachers provide that possibility with a greater probability of successful outcomes.

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Contact email: neuroeducamente@gmail.com