SUPPORTING TEACHERS IN FOSTERING COLLABORATIVE LEARNING AMONGST ADOLESCENTS

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Dedication

To my “kids”, both past and present, who have pushed me to grow as much as I have pushed them and have reminded me that we will always be learning. It is them that inspired me to create this resource and remind the world that teenagers aren’t so bad after all.

To my fellow educators, classmates, and professors who have supported me through the many trials, guiding me in the right direction for the production of this project, you have encouraged me to grow as an educator in more ways than one. I would especially like to dedicate this project to Veronica, Alex, and Toni; classmates who have become lifelong friends and provided me with love and guidance throughout it all.

To Dr. Gibb, Dr. Marynowski, and Dr. MacCormack, without whom this project would not have come to life; thank you for challenging me as both an educator and learner, pushing me beyond my comfort zone, and encouraging me to bring this knowledge into the world.

Finally, to my husband Trey, my family, and my closest friends; I truly would not have made it through the trials and tribulations without you by my side, your love and support echoes in all that I do, and has been at the root of this project since the very beginning. Thank you.

Abstract

Although defined through a variety of contexts backed with extensive research, adolescence is still often viewed through a negative lens, placing harsh labels and opinions on teens and their behaviors. Blakemore boldly states “Adolescence isn’t an aberration; it’s a crucial stage of our becoming individual and social human beings” (2018, p. 2). Just as important as childhood, adolescence serves as a second window of reconstruction, with rapid structural and functional modifications leading to immense behavioral alterations. At the forefront of these changes are areas of the social brain network, the prefrontal cortex, and the limibic system, resulting in a drastic shift in an adolescents ability to make effective decisions, manage multiple factors at once, regulate their emotions, and function within social contexts (Blamore, 2018; Cozolino, 2013, Dumontheil, 2016). During the period of adolescence, teens become driven by peer relationships, short-term rewards, and autonomous opportunities. By providing learning opportunities that utilize the social changes that occur with adolescence, educators can better support positive development and thriving amongst their students. Collaborative learning strategies engage adolescents in meaningful discussions and rich thinking tasks and guide them towards the creation of new knowledge (Davidson & Major, 2014). This project encompasses two resources and will provide educators with the foundations of neurological development that occurs during adolescence, as well as a comprehensive guide towards implementing collaborative learning to support such development. Through a four-part professional development session, educators will be informed of the basic neurological structures and functions, basic neural connectivity and learning functions, how the brain alters during adolescence, and how to effectively implement collaborative learning strategies as a tool to optimize the adolescent brain. Within the presentation educators are provided with visuals,

analogies, activities, planning tools and further resources to support their understanding and implementation of neuroscience into education. The second resource hopes to reach educators and students; through a classroom infographic using teen-friendly language, viewers are provided with simple and key information about the adolescent brain. This poster summarizes the first three parts of the professional development session resource, and allows both educators and students to build their understanding of the adolescent brain. By aligning pedagogical practice with research this project serves to build a bridge between education and neuroscience, leading to the empowerment and thriving of adolescent students.

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Introduction

A career in education was never at the forefront of my goals, that is, there was never a time where I felt that being an educator was my path, and it took almost four years of taking other post-secondary courses before I made my way into the education faculty at the University of Lethbridge. Growing up I observed the challenges my mother faced as a Junior High School teacher and often questioned why on earth she put herself through the tough job of working with teens like myself and peers, and even more so, how she enjoyed it. Despite these notions, for many years I found myself working with adolescents through coaching and mentorship programs. By the time I reached the University of Lethbridge, I realized there had already been a slow transition towards the Education program despite never having that "A-ha!" moment or inherent calling. While completing the courses and practicums required for my undergraduate degree, I became more and more drawn to the students of junior high, eventually recognizing the value of providing adolescents with a teacher, mentor, guide, and supporter that many students (including myself) benefited from in junior high school. Thus began my education career, and I have remained in a junior high setting for the entirety of it. Over the course of my career, I have observed the challenges and successes that many adolescents, and their educators, face in a junior high school setting, and thus grew the desire to "do something more", not only for my personal pedagogy, but for the school community as a whole. Returning to the University of Lethbridge to attain a Masters Degree in Education was at the forefront of my learning goals as I knew the faculty of both the Education and Neuroscience departments would provide me with an excellent opportunity to grow immensely as an educator. Throughout the program I found that my research consistently was drawn to the adolescent age group; this led me to create a tangible

resource that supports teachers of these students. With the encouragement of Dr. Richelle Marynowski, Dr. Robbin Gibb, and Dr. Jeffrey MacCormack, this project was brought to life.

Rationale

Teaching in itself is not a job for the faint of heart; combine the challenges of the career with a group of adolescents and many would say it takes a special kind of person to teach junior high. With this societal mindset, I have lost count of the number of times I have received either a puzzled look, or a confused and appalled remark in response to my career choice as a junior high school teacher. This response is amplified even further when I express that not only do I choose to remain teaching students in their teenage years, but that I truly adore the age of these students and find enjoyment in the challenges they bring to the classroom each day. “But why?” I am often asked, with my response often falling along the lines that teaching these students is an opportunity that requires far more than simply curricular learning (existing of outcomes and assessments) and stretches into the development of their whole-being outside of school doors. That is, as a junior high educator I am privileged with the opportunity to foster positive learning environments for my students, guide them as they face many roadblocks, and witness an incredible transformation and discovery of the self both in and out of the classroom.

Within this group of students a great variety of puzzle pieces exist due to a variance in personalities, abilities, and needs. For effective growth and development of adolescents to occur, it is our job as educators to decode each piece and fit them together into a mosaic of learning. Unfortunately, due to a historical lack of understanding of neuroscience related to the adolescent brain not all educators are equipped with the knowledge, skills, and strategies to foster such positive environment. This leads me to believe that teenagers are an extremely misunderstood

and undervalued segment of our society who are not often provided with opportunities that support their development.

Now that I have completed three years of graduate studies and have a far deeper understanding of adolescent growth and development, a tremendous personal pedagogical shift has occurred, adjusting the way I support and speak for this group of students. If teachers are to provide the best opportunities for their students to learn, they must develop the ability to decode adolescents and effectively create a mosaic of learning that goes far beyond observing and controlling behavior in the classroom. They must adjust their pedagogy to incorporate the realm of neuroscience into education as a gateway to provide those opportunities. Why else do educators endure challenges and transformation but to provide opportunity for the younger generation to become their best selves, to succeed as human beings, to change the world? If we are to be the best possible teachers for our students and create the best possible opportunities for growth and development, should we not strive to understand how they learn best and adapt our pedagogy to follow suit? With this holistic approach and principle in mind, I would argue for the value neuroscience holds in enabling educators to provide successful strategies, differentiated learning opportunities, empathy and support, and a deeper connection with students in and out of the classroom. If neuroscience can provide insight into the minds of learners at a deeper level, why not utilize this as a tool to enable teachers to create learning opportunities for junior high students that empower their overall growth? As Noddings (2012) implies in *The Caring Relation in Teaching*, the relation between teacher and student is based largely on the educator's attentiveness and ability to empathize with the cared-for (the student). Even more important in this relationship is the ability of the educator to address the expressed needs of those they are caring for. By providing educators with an understanding of adolescents at a neurobiological

level, the possibility for meeting student's emotional, behavioral, and overall learning needs are amplified.

Having been provided with the knowledge and resources to support adolescents in my own classroom through my graduate studies, I recognize the potential hole that exists amongst my fellow educators who may not have had the opportunity to study at such a level. This has grown to become a great concern for me and led me to develop this project. My goal is to provide fellow educators with professional development (PD) to expand their understanding of adolescent brain development and adapt their pedagogy to create learning opportunities that reflect such knowledge.

Project Outline

This project addresses the gap between neuroscience and education through two components. First, by utilizing the "social brain" (Blakemore, 2018, p. 29) and the drive for social learning that comes with adolescent brain change, I have created a PD session in which I engage educators in learning about their students at a brain-based level, opening them up to new language and forms of communication about their students, creating greater empathy and understanding of the behaviors they may observe. Educators will also be exposed to the strategy of collaborative learning which engages the social brain of adolescents, providing them with a learning context that encourages, promotes, and supports their developmental changes. This is further supported by a second component: an infographic poster that contains basic neurological content such as the structures, learning process, and developmental changes that adolescents undergo. This infographic will be available to the entire school community in hopes of creating school wide language and understanding of the adolescent brain.

During the period of adolescence, all humans undergo a dramatic shift in brain development due to a surge in brain plasticity i.e. an increase in the brain's capacity to form and prune neural connections (Kolb et al., 2019). At this point adolescents become more socially driven, peer interactions and relationships become more apparent, both positive and negative risk-taking behaviors increase, and creativity develops (Blakemore, 2018). Unfortunately these changes combined with a drastic drop in executive function and emotional regulation, as well as a lack of biological understanding, have led to a negative societal label being tattooed on teenagers. This label often negatively influences the learning opportunities that junior high school students encounter, placing them in rows of desks with a set of rigorous boundaries and rules. Neuroscience can prompt pedagogical shifts that further support the positive development of adolescents within a school setting by altering society's view to acknowledge, understand, and utilize the rapid neurological changes that occur during this critical period. That is, by combining cognitive theories with neuroscience research, educators can be provided with an understanding of the adolescent social brain to increase support and empower development, rather than oppress the very nature and social drive of youth.

Literature Review Part One: The Science of Adolescent Brain Development

In recent years there has been a growing push for the integration of neuroscience into the classroom, catching the attention of many researchers and educators alike. Advocating for this integration are researchers like Dr. Bryan Kolb, from the Canadian Centre for Behavioural Neuroscience at the University of Lethbridge and former president of the Canadian Society for Brain, Behavior, and Cognitive Science. As Kolb (2012) states

> Teachers need to know about the principles of brain development in order to understand the impact these processes have on behaviors. Whereas most of the body develops from a

> genetic blueprint, the brain develops in response to experiences. So you are your brain. (University of Lethbridge, 2023, para. 3)

Thus, the concern for teachers to have an understanding of the neuro-functionings of their students is expanding and the literature to support this notion is growing.

Neuroeducation: The Middle Ground

The brain is a complex structure that is unique to each individual, with varying experiences shaping the neural pathways of each and every one. With that in mind, the concept of creating effective strategies, frameworks, and theories based around one structure becomes challenging. Cuthbert (2015), argues for a difference in the brain and mind, noting that learning does not only occur in the brain but rather occurs as a course of life, very different from learning in education where the focus is largely on content. Similarly, Fischer (2009) argues that consciousness and learning are functions beyond the structure of the brain and are highly affected by experience. Infrastructure to support research while fostering the realistic experiences involved in learning is of incredible importance. Educators observe the individual physical, mental, and emotional differences of our students day in and day out, as well as the varying rates of individual growth throughout the school year. Neuroscience may inform education and provide insight into the minds of students in order to create a differentiated environment that suits the diverse development of each individual.

Born out of pursuit for the synthesis of biological research and pedagogical practice, the discipline of "neuroeducation" (Jolles & Jolles, 2021, p. 1) has found its way into the opinions of both supporters and critics. A number of considerations must be taken into account on both sides of the argument, creating a challenge for connecting research and education. Growing research and technology, converting scientific language to common, classroom implementations, ethical

and moral values, marketing schemes, interventions, and the unique and ever so complex design of the neurological system, have hands in both the strengths and challenges of neuroeducation. As I reflect upon my own axiology and pedagogy, I come to realize how organically theories of neuroscience and cognitive psychology have embedded themselves into my teaching practice, allowing for a seamless translation of research into practice. Yet, despite how naturally concepts of neuroscience and education have blended in my own profession, there may be resistance when implementing neuroeducation into the general classroom. Considering viewpoints of both sides, one must be critical of where and when neuroscience effectively correlates with educational strategies. Although my increasingly dynamic and in depth background of neuroscience has allowed me to further adapt my teaching practice, I do not believe that all educators must undertake graduate level neuroscience courses in order to efficiently make use of the information in their own teaching pedagogy. By developing a general understanding of the basics of neuroscience such as language, structures, synaptic processes, learning, and memory function, I believe teachers can be provided with an excellent foundation for the implementation of neuroscience into practice.

Recognizing the complexity of the brain and neuroscience information, along with the current gap between research and education, it is important for educators to be critical of the information and strategies that claim to be brain-based. The necessity for a middle ground, a translation between researchers and educators is evident in order to logically, ethically, and effectively create a bridge between the two worlds; that is, researchers having knowledge and access to realistic classroom experiences and scenarios, and teachers being provided with information that is easy to understand and implement but is backed by evidence and research. One of the biggest challenges that neuroeducation faces is the ability to communicate effectively

between research and the classroom with the need for a translator in the common ground prominently expressed among supporters and critics alike. While many others are critical of the relationship between researchers and educators, as they are so often left out of one another's realms, advocates like Kurt Fischer of Mind, Brain, and Education acknowledges the vital need for collaboration between researchers, theorists, and practitioners (those in the education system) and argues for the production of educators with skills and training to efficiently communicate and connect between research and practice (Fischer et al., 2007; Fischer, 2009). Educators often remain in the classroom with little knowledge of or hand in research, and researchers remain in the lab with little insight or experience in the real classroom, creating a widespread gap between the two. Because of the separation between research and practice, information is often difficult to translate, and ready-to-use evidence-backed classroom strategies and implementations are not readily available for teachers, causing a sense of skepticism in the ability for neuroscience to smoothly synthesize with practice (Daniel, 2012; Dougherty & Robey, 2018; Fischer et al., 2007; Fischer, 2009; Willingham, 2009).

If the solution to closing the gap and finding a middle ground was simply putting researchers and educators in the same room to collaborate, neuroeducation may improve quickly, but unfortunately the space has been filled by those who are involved in neither party, leading to the formation of "neuromyths" (Fischer, 2009). These neuromyths are created by external parties such as businesses that build their markets around simple appealing strategies, tools, and tricks for educators to utilize in the classroom, but have little research or evidence backing. As educators we see this regularly, a new fad or idea being sprung on us during PD days or teacher conferences; the newest technology or learning program, ideas that utilize captivating and scientific language, are supposedly easy to implement, and are marketed as almost flawless for

the classroom. As many frameworks do, neuroeducation has fallen prey to this scheme in what many market as “brain-based”. What does this mean for effective implementation? Is it possible to connect in a middle ground that has been crowded by others? The regularity of fads, and the promotion of neuromyths creates a vital necessity for educators to utilize their critical awareness and judgment in regard to classroom implementations. Furthermore, the future of neuroeducation will depend heavily on the ability to source a translator between the two sides of the theory; a communicator who can exist within the middle ground of research and classroom, who is able to effectively communicate and advocate for both parties.

Along with many critics of neuroeducation, I would argue for the heavy importance of not only finding a middle ground between research and practice to further ensure the proper translation of information, but to also source a number of professionals that may exist within that space. These professionals shall strive to eliminate the fallacies, dichotomies, and neuromyths that may exist within neuroeducation, and mend the relationship between researchers and educators by advocating for the reality of both worlds. As Fischer (2009) states “what education needs is assessments of real school performances that are shaped by researchers, teachers, and students working together to examine the effectiveness of many aspects of learning and teaching in the context of school” (p. 4); with the construction of a bridge between researchers and practitioners, information and experiences can be shared in order to best critique, inform, and create strategies for the coexistence of neuroscience and education.

As stated by Blakemore and Firth (2005) “Educators are, in a sense, like gardeners… individual gardens involve making the best of what is there, and it is possible to make astonishing new influential designs” (p. 459). In agreement with Blakemore and Firth, I would argue that educators are already predisposed to the integration of neuro-functionings as the basis

of neuroscience exists in every aspect of human nature. That is, neuroscience is already there and the middle ground already exists, but there is a missing player, an advocate to guide educators into the space where one can acknowledge strengths of neuroeducation as a tool for the growth and development of themselves, and their learners. With an advocate for the middle ground in play, a general understanding of neurological content i.e. basic processes, structures, and language, new forms of communication, and a deeper insight into one's students will only increase.

Foundations of Neurobiology: Neural Plasticity and Sensitive Periods

One of the most fundamental characteristics of the human brain is its ability to be sculpted over time, individualizing the brains of every single person on the planet through social relationships and novel experiences. Even identical twins will show structural differences in brain anatomy over time due to the variation in environmental and experiential factors (Lenroot & Giedd, 2008; Valizadeh et al., 2018). This phenomenon is due to the neuroplasticity (also known as neural plasticity) of the brain. Kolb and colleagues (2019) define neuroplasticity as "the nervous system's potential to physically or chemically modify itself in response to environmental change, and to compensate for age-related changes and injury" (p. 34). Serving humans for over thousands of evolutionary years (unlike many other animal brains that replace neurons) existing neurons in the human brain are modified, strengthened, and expanded in order to support an accumulation of information, the development of skills, and the transmission of knowledge onto future generations (Cozolino, 2013).

Adolescent researcher Sarah-Jayne Blakemore breaks the concept of neuroplasticity down further into "experience-dependent plasticity" (p. 91), and "experience-expectant plasticity" (p. 91). She differs between the two by describing experience-dependent plasticity as

the brain's ability to adapt to experiences and intake new information at any given age, and experience-expectant plasticity as the readiness of the brain at a certain point in development to respond to new information and experiences (2018). That is, experience-dependent plasticity is the brain's fundamental ability to adapt, change, and learn throughout a lifetime, whereas experience-expectant plasticity describes optimal time periods where the brain is more sensitive to such changes. Researchers have coined these time periods with the terms "sensitive periods" or "critical periods" (Blakemore, 2018, p. 91, Kolb et al., 2019, p. 276). A sensitive period describes a window in development in which the brain becomes exceptionally susceptible to experiential stimuli as it undergoes a shift in synaptic strengthening and synaptic pruning further influencing the functional properties and structural reorganization of the brain (Blakemore, 2018; Kolb et al., 2019; Kolb & Gibb, 2011; Scalise & Felde, 2017; Sengpiel, 2007).

There is a substantial amount of literature supporting the role of neuroplasticity and that of sensitive periods, yet the importance of such research lies dormant, with many educators having little to no knowledge of either phenomenon. With neuroplasticity as the underlying foundation of the brain's ability to learn throughout a lifetime, it is essential for educators to grasp the basic understandings of the brain's capability of changing in response to new information and experiences. In order to provide educational staff with these underpinnings I have included a section on neuroplasticity (and the function it provides in terms of learning) in *Part Two* of the PD session. In this section, educators are provided with the basic understandings of neuroplasticity in order to further inform *Part Three* of the session which discusses the adolescent sensitive period.

Adolescence Defined

Determining the time period and a firm definition of adolescence has been long debated among researchers, as it is often deciphered in a range of contexts from biological, to psychological, and social. Blakemore (2018) defines adolescence as the time period between puberty onset (biological transformation) and adulthood (where an individual is expected to maintain independence and meet societal standards). The intertwining of biological and cultural or societal boundaries is common within most definitions of adolescence, as it takes into consideration the range of cultural and historical variations throughout the globe and does not restrict the critical period to a range of years of age.

There is a strong agreement among researchers in reference to adolescence as a sensitive or critical period, with advances in neuroscience based technologies showing a considerable increase in neuroplasticity from the onset of puberty well into an individual's twenties (Blakemore, 2018; Cozolino, 2013; Rubia, 2013). Thus, adolescence can be loosely defined by the onset of vast hormonal and physical changes that accompany puberty (age varying), and runs its course until “an individual attains a stable, independent role in society” (Blakemore, 2018, p. 2), which is dependent on the specific cultural and societal standards. Blakemore (2018) shares the importance of adolescence as a sensitive period by pointing out the similarities that have been observed globally across cultures, species, and history, while Dahl and colleagues (2017) advocate for this sensitive period as a “second window of opportunity”, where extensive structural and functional modifications create a window of opportunity for positive experiences to occur and shape healthy patterns of behavior, social and emotional learning, and overall positive development (Dahl et al., 2017). To summarize, it is commonly agreed amongst adolescent researchers that the definition of adolescence must be fluid and dynamic, it simply

cannot come down to number, and must take into consideration the biological differences worldwide, as well as the range of cultural and societal expectations that exist globally (Blakemore, 2008; Dumontheil, 2016; Foulkes & Blakemore, 2018).

Structural and Functional Changes in Adolescence

With advances in research and technology over the last fifty years, researchers have gained much larger access to the structures and functions of the human brain. Magnetic resonance imaging (MRI), and functional magnetic resonance imaging (fMRI) have been utilized to showcase both the growth and development of adolescent brains as well as the changes in activity that occur over the sensitive period (Blakemore, 2018; Cozolino, 2013; Rubia, 2013). This imaging of adolescents as well as supporting literature has allowed for the discovery of many changes within the adolescent brain creating a framework of understanding regarding this critical period. Adaptations to neural connectivity, circuitry and structural changes, functional and behavioral changes, and a social inclination, have all been observed as prominent features of the critical period of adolescence and are important characteristics that should be known to researchers, educators, caregivers, and teens themselves.

Neural Connectivity

Structurally, during adolescence, a large number of modifications have been observed with one of the most significant being dramatic changes in neural connectivity throughout the brain. Decreases in gray matter and synaptic density in the parietal, temporal, and predominantly prefrontal cortex (PFC) regions have been observed with some areas losing up to 17 percent of their gray matter volume (Blakemore, 2018). On the contrary a significant enlargement of white matter has been observed leading researchers to believe there is an increase in the number of axons, the thickening of axons, and the addition of myelin throughout the brain (Blakemore,

2018; Blakemore & Choudhury, 2006; Kolb et al., 2019; Spear, 2013). The decreases in gray matter and increases in white matter throughout the brain have been connected with the concept of synaptic pruning and axon myelination i.e., the brain prunes away excess neural synapses that are not being fired and myelinates (strengthens) the connections that are in order to make for a more refined and efficient brain (Blakemore & Choudhury, 2006; Spear, 2013). This phenomenon is often paired with the phrases "use it or lose it" or "what fires together, wires together" emphasizing an intense reconstruction of the brain that occurs during the adolescent time period.

Neural Circuitry and Cortical Structures

Due to a change in neural circuitry during the reconstructive adolescent period connections between various structures will adapt where needed. Brain imaging has shown alterations in the connections and activation in a number of areas: heightened response of the limbic system and amygdala, while the striatum, hippocampus, ventral tegmental area, the parietal and temporal lobes, and predominantly the PFC show a incredible decrease in gray matter, cortical thickness, and response to stimuli (Blakemore, 2008; Burnett et al., 2011; Kolb et al., 2019**;** Spear, 2013; Romeo, 2013; Rubia, 2013). Structural changes have also been observed in the face perception network, mirroring network, and mentalizing network, all of which are largely in the parietal, temporal, and prefrontal areas (Wang et al., 2017). With major structural changes occurring, connections between neural regions must adapt accordingly. Figure 1 from Kolb and colleagues (2019) shows an example of connections rerouting from childhood to young adulthood by pruning and thickening between core structures.

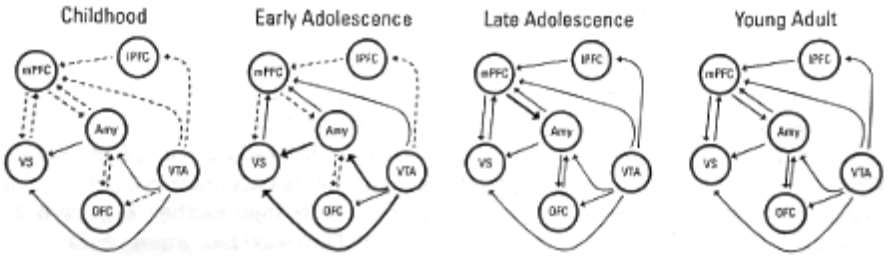

FIGURE 8-28 **Changes in Prefrontal-Subcortical Circuitry** Simplistic illustration of hierarchical age-related changes in connectivity from subcortico-subcortical to cortico-subcortical circuits. Regional changes in connectivity are indicated with dotted and bolded lines. Relative strength of the connections is indicated by the dashed lines (weaker), solid lines (stronger), and bold lines (strongest). Abbreviations: mPFC: medial prefrontal cortex; lPFC: lateral prefrontal cortex; OFC: orbitofrontal cortex; VS: ventral striatum; Amy: amygdala; VTA: ventral tegmental area. Research from Casey et al., 2015.

Figure 1. Example of Adjustments Made to Prefrontal Circuitry Throughout Adolescence (Kolb et al., 2019)

It is important to note that the modifications in neural connectivity and circuitry is a rather dynamic process with different networks altering at different times between individuals. Certain brain regions mature at various times during adolescence, making it difficult for researchers to pinpoint exact ages or order of reconstruction. Additionally, brain maturation can be greatly influenced by factors such genetics, gender, experiences, environment, and timing of puberty, making it that much more difficult to track and pinpoint rates and areas of maturation (Blakemore, 2018; Foulkes & Blakemore, 2018; Spear, 2013).

Despite the range of when and where modifications may occur, there exists substantial evidence highlighting a dramatic structural and functional shift within the many areas of the brain, specifically within the PFC (Blakemore, 2018; Kolb et al., 2019**;** Spear, 2013). It is hypothesized that due to its high-level cognitive and executive functioning, and association and control over many other networks, the PFC remains under construction until most other areas have undergone synaptic pruning, myelination, and reconfiguration (Blakemore, 2018; Dumontheil, 2016; Spear, 2013). Through MRI and fMRI studies, a delayed maturation of the

PFC has been observed, with it being one of the last neurological areas to fully develop, often not maturing until an individual reaches their mid-twenties, or even early thirties (Kolb et al., 2019). This delay in maturation means that neurologically, the period of adolescence could essentially extend over two decades.

Functional and Behavioral Changes

With such drastic structural modifications occurring throughout the brain during the adolescent period, it is easy to assume that functional changes would follow suit. Reorganization of neural connections, structures, and circuitry create both positive and negative functional and behavioral transformations. The neurological areas mentioned previously, in specific the limbic system and PFC, have been shown to be directly correlated with overall executive functioning, emotional processing, and perception of environmental stimuli; all processes that are essential for learning (Kolb et al., 2019). With these neural areas being so involved in decision-making, planning, self-control, social interaction, self-awareness, attention, working memory, and mental flexibility, it is no wonder that adolescence is a tumultuous time for both teens and those around them. A typical day in the classroom is no easy task for an adolescent whose brain is undergoing major reconstruction; the ability to focus on a task, organize their supplies, recall instructions, mediate relationships, and manage stress, all while often sleep and nutrition deprived, is bound to have an impact on a teens ability to learn effectively (Blakemore, 2018; Cozolino, 2013). Through neural studies, it has been shown that individuals with changes to the PFC and limbic system become more impulsive, motivated by short-term rewards, easily affected by stress and trauma, and more influenced by peers and social contexts (Blakemore, 2018; Cozolino, 2013; Dumontheil, 2016; Romeo, 2013; Spear, 2013). Furthermore, due to a change in the prefrontal and limbic regions involved in executive functioning, reactions to social cues, evaluating risks,

and mentalizing, adolescents have a heightened susceptibility to stress, peer influence, and social rejection (Andrews et al., 2020; Blakemore, 2008; Blakemore, 2018; Spear, 2013). Cozolino (2013) reminds us of the difficulties that are faced by teenagers on a day to day basis:

> So while your teenagers may be making you crazy, keep in mind that adolescence is no picnic for them either. Radical upheavals in the brain parallel the sudden mood swings, intense emotions, and the feeling that you are alone in a vast and hostile world. The neural and social revolutions of adolescence are fraught with danger. Driven by rising hormones, dysregulated neural systems, and destabilized frontal lobes, judgment and perspective becomes less than stellar. (p. 34)

Although it may seem as though the difficulties faced by teens are at the forefront of the adolescent period, the neuroplasticity of this sensitive time opens the door for many positive experiences as well. Enhanced creativity and passion, positive risk taking, language capacity, motor coordination, sensory acuity, reaction time, and initiative for autonomy are amongst the many of behavioral and functional changes that have been observed amongst adolescents (Andrews et al., 2020; Blakemore, 2008, 2018; Cozolino, 2013; Lenroot & Giedd, 2008). Although often given a negative stereotype, teens have so much to offer the school and community if provided with opportunities to do so. Adolescents show an increase in motivation when involved in social settings, an increased drive within leadership opportunities, and an increased need for secure attachments and relationships (Gibb et al., 2023). Within a school setting, educators can capitalize on these behaviors to create opportunities that positively support development and positively impact their learning.

The Social Brain

One of the most researched and recognized aspects of adolescent neurodevelopment is that of the *social brain* (alternatively referred to as the *social brain network*). As Cozolino states, the social brain is a network "dedicated to receiving, processing, and communicating messages across the social synapse" (2013, p. 62), thus essential for the effective development and contribution to all human interactions and relationships. This network consists of areas that span the entirety of the brain, with connections and activation in the fusiform face area, superior temporal cortex, amygdala, hippocampus, hypothalamus, temporal-parietal conjunction, PFC, anterior cingulate cortex, inferior frontal gyrus, anterior insula, and anterior temporal cortex (Blakemore, 2008, 2018; Burnett et al., 2011). The social brain predominantly allows individuals to recognize, evaluate, and attribute the mental states, feelings, and intentions of others while also regulating attachment, stress, fear, social engagement, and social motivation (Andrews et al., 2020; Blakemore, 2008, 2018; Cozolino, 2013; Dumontheil, 2016).

The social brain is at the core of all social interactions and relationships, we inherently survive through relationships with others, and our abilities to "detect the needs and intentions of those around us" (Cozolino, 2013, p. 13). From birth onward, but especially in adolescence, the social brain becomes a powerful, essential, and driving force. With such drastic modifications amongst the neural areas of the social brain, teens experience a range of behavioral adjustments that greatly influence how they function within social contexts. Researchers have observed shifts in how socially oriented teens become, especially towards their peers, which only adds to the chaotic nature of adolescence.

Throughout adolescence, a heightened sensitivity to peer influence and evaluation is common yet there is also an increase in communication and collaboration between individuals;

an enhanced initiative for autonomy becomes apparent but sensitivity to peer exclusion increases; risk-taking in the presence of peers increases and the seeking of new experiences or adventures broadens alongside a certain likeness for short-term rewards; the ability to perceive and mentalize others intentions becomes hindered while the desire to discover one's self-identity grows (Andrews et al., 2020; Blakemore, 2008, 2018; Cozolino, 2013; Dumontheil, 2016; Rubia, 2013; Siegel, 2015). Pairing these behavioral changes with the intense pressures of fitting in, reaching academic standards, meeting societal expectations, all while sitting still, quiet, and focused in a row of desks, places immense pressure on teens and creates a turbulent period of development (Cozolino, 2013).

Changes observed in adolescents often reflect the average and do not necessarily take into account the drastic impact of stress, trauma, and negative experiences have on development. As Cozolino (2013) states, "While social stress inhibits neural plasticity, social support, compassion, and kindness support positive neural growth" (p. 62). Thus on the contrary, positive relationships and experiences that utilize neural changes and amplify the gifts of the social brain can promote positive development amongst adolescents. Adolescence is an essential sensitive period where teens are empowered with malleable, passionate, and creative minds that are geared for learning in social contexts. By recognizing the changes that occur in adolescence, educational staff can create and provide their students with opportunities that utilize the characteristics of the social brain.

Thriving

Thriving can be defined as a combination of development and success that stems from the relationship between the individual and their context; often associated with levels of well-being, thriving therefore is greatly influenced by both personal or individual enablers as well as

developmental or contextual factors (Brown et al., 2017; Benson & Scales, 2009; Ryan & Deci, 2017). Personal (individual) enablers or assets can be defined as the internal attitudes, emotions, perspectives, and behaviors that an individual holds in regard to themselves and their surrounding context, whereas contextual (developmental) enablers or assets refer to external factors that influence an individual, more specifically the characteristics of an individual's environment that either support or hinder development (Brown et al., 2017; Oberle, 2018). Both personal and contextual enablers play a crucial role in the growth of non-cognitive factors (i.e., the skills, behaviors, attitudes) that aid in the development of an individual as a member of society and as a learner (Farrington et al., 2012), but during the critical period of adolescence a great shift in the brain occurs which drives the primary focus towards social development where contextual factors gain leverage in their influence on development (Blakemore, 2018).

Studies have shown that both direct and indirect pathways between contextual and individual assets contribute to an adolescent's positive development; positive self-concept has a direct influence on well-being which is largely impacted indirectly by the quality of social relationships and supportive contextual environments (Oberle, 2018; Walker & Graham, 2021). The evidence of these pathways supports the notion that although personal assets such as positive self-concept and resilience are still developing as crucial components of adolescence, contextual enablers like relationships of attachment and trust, challenging environments, and emotional support from adults and peers, formulate a driving force behind the overall personal development and well-being of the adolescent (Benson & Scales, 2009; Brown et al., 2017).

With the shift in developmental focuses during adolescence, youth have historically been viewed as problems or issues that require managing, fixing or straightening out and are often quick to be labeled as "at-risk"; a buzz word amongst many educators, counselors, psychologists,

and the general public, the term “at-risk” has little to no concrete or universal definition amongst professionals or contexts (Blakemore, 2018; Damon, 2004; Lerner et al., 2013; Tidwell & Garrett, 1994). One perspective of at-risk youth refers to individuals who have been exposed to contextual risk factors such as trauma (i.e., poverty, abuse, neglect etc.), which may place them at further risk for a negative lag or shift in their development and well-being (Sanders et al., 2015). Knowing that adolescents are greatly impacted by social relationships and environments, a framework known as the Positive Youth Development (PYD) (Lerner et al., 2013) model has emerged to battle the negative lens that adolescence has been viewed through, especially those who have been labeled at-risk. The PYD approach focuses on the development and well-being of the adolescent through a positive lens by viewing youth as resources with endless capacities and potential to thrive, encouraging personal agency and autonomy, supporting youth in their contexts and those involved (ie. families, schools, etc.), and recognizing the critical influence of positive social relationships and encouraging the development of such relationships (Damon, 2004; Lerner et al., 2013; Sanders et al., 2015). Within the PYD approach, Competence, Confidence, Connection, Character, and Caring form the foundational “5 C’s”in which interventions can be drawn upon; additionally, a sixth C: Contribution is achieved through the developmental path of the original five (Lerner et al., 2013).

The PYD approach has the potential to be impactful in a range of contexts for a variety of adolescents; specifically those who have been labeled at-risk may greatly benefit from PYD approaches as these youth have often experienced an early push towards autonomy without proper support and guidance, are often viewed solely by their deficits or challenges, and often do not receive contextual support (Sanders et al., 2015). In comparison to receiving multiple services that did not implement a PYD approach, high-risk youth from New Zealand reported

greater resilience and overall well-being when provided with services that were empowering, respectful, and focused on positive development, even if they received less services (Sanders et al., 2015). Furthermore, it has been found that interventions that prioritize the development of positive quality connections with adults and peers, as well as a supportive contextual environment led to a greater development of personal assets (i.e., resilience, motivation, positive self-concept) and overall well-being (Oberle, 2018; Walker & Graham, 2021).

Recognizing that the well-being and thriving of youth can be impacted by a change in theoretical framework towards one that is strength-based and positive at its foundational core, provides professionals with an approach that further reaches and supports adolescents in their development, especially those labeled at-risk. By focusing on the development and support of contextual assets through positive social interactions, challenging environments, and opportunities for agency and autonomy, personal enablers such as resilience, motivation and positive self-concept are indirectly developed. Furthermore, recognizing that thriving stretches far beyond academic achievements and by shifting interventions from a deficit viewpoint towards adopting a PYD approach that focuses on the development of both contextual and personal enablers, adolescents are provided with a greater opportunity to experience success, raise their levels of well-being, and thrive (Damon, 2004; Lerner et al., 2013; Sanders et al., 2015).

Implications for Education

With little light shed on the brain development of teens, especially their inherent social nature, educators often find themselves trapped, struggling to understand the reasoning behind behaviors and to develop effective strategies to support positive development. With the reorganization of neural networks, in particular that of the PFC, neural functions such as working

memory and the ability to mentalize the intentions of others are often left fighting for neural space and energy, thus creating tension between the two. Because the adolescent brain is geared towards social engagement and discovery of the self within social contexts, the social brain takes precedence over other neural functions i.e. functions such as working memory will not be as effective during this period as energy will be spent on networks and functions that prioritize social learning (Blakemore, 2010; Cozolino, 2013; Lieberman, 2012). With this example in mind, a valuable lesson for educators is to recognize that pedagogical practices must shift in order to accommodate the social brain of teens and promote positive learning and development. Cozolino (2013) discusses a concept called the "tribal classroom" (p. 9), in which "teachers and students are bound together in affection, kinship, and mutual survival" (p. 9), utilizing the inherent social nature of learning. Cozolino posits that the tribal classroom is beneficial for all students as it optimizes the strengths of the social brain by coming together through collaboration, but is especially beneficial for those students without secure attachments and strong relationships outside of the classroom. Additionally, Lieberman (2012) pulls from previous studies to provide evidence for social learning opportunities within the classroom; strategies such as providing rich social cognitive narratives, alternate perspectives, collaborative learning groups, peer-tutoring, and social emotional education may support adolescents in positive development and engage them in their learning environments. Unfortunately school can be quite stressful for adolescents, but by modifying the pedagogy and culture of the school community to create a positive and interpersonal environment that explores the social environment and capitalizes on the characteristics of the social brain, adolescents' ability to multitask, plan, mentalize, become self-aware and self-controlled, and have a positive self-identity and relationship with learning will only increase (Blakemore, 2010; Cozolino, 2013). To

summarize the importance of implementing social learning structures into education (that is, develop tribal classrooms and utilize the social brain), Cozolino states

> A fundamental truth is that children need a family as a safe foundation from which to meet the challenges of life. Without this, their minds and brains can be closed to learning and the energy and resources poured into teaching fall on closed ears and shuttered hearts. By watching a teacher work to create a cohesive tribe in the classroom, students get to witness what real heroism looks like. (2013, p. 265)

As educators, it is our duty to provide opportunities for students that foster the positive growth and development of the whole self. In order to do so, an understanding of the neurological underpinnings of the adolescent period can inform education leading to the creation of frameworks that utilize the adolescent brain. Through the creation of tribal classrooms and the use of social learning strategies, educators can harness the positive changes that occur during the adolescent period to enable thriving youth.

Literature Review Part Two: The Pedagogy of Collaborative Learning

Humans are an inherently social species that have evolved both structurally and functionally to learn in relationship with others. A vast amount of literature exists in which the role of social interactions in learning has been studied; theories from social constructivists, cognitive psychologists, and neuroscientists all provide evidence for the role of social learning. While social constructivists such as Vygotsky, Erikson, and Bandura, advocate for the necessity of a relationship between the learner and his or her environment (physical and social) in receiving stimuli and constructing knowledge, cognitive psychologists argue that language development is one of the most influential indicators of the evolutionary ability to communicate and coordinate as a part of the natural information processing systems, and neuroscientists have

utilized brain imaging to identify structural and functional relationships that exists between the brain and social interactions (Drew, 2020; Kirschner et al., 2018; Paas & Sweller, 2012; Schcolnik et al. 2006). Additionally, research in the areas of feedback, motivation, resilience, and mental health, show a strong influence of experiential stimuli and social groups such as peers, adults, and caregivers on the development of self-identity, self-efficacy, and mentalizing (Blakemore, 2019; Ryan & Deci, 2000; Scalise & Felde, 2017; Yeager & Dweck, 2012). Thus, learning in itself is deeply rooted in the inherent ability to functionally interact with environmental, social, and experiential stimuli and therefore opportunities that foster such interactions are vital in enabling successful learning throughout education.

Collaborative Learning Defined

There are a wide range of approaches for implementing social learning, some vastly different and some closely related; from collaborative learning to cooperative learning, to problem-based learning, there are many opportunities for educators to engage their students in social contexts (Davidson & Major, 2014). Collaborative learning can be tricky to distinguish from other group-based approaches with many educators incorrectly using strategies by taking pieces or elements from various theories. As Davidson and Major mention, a key component to collaborative learning is the importance of "working with each other (but not necessarily interdependently) toward the same goal… in this case toward the discovering, understanding, or production of knowledge" (2014, p. 21). The production of new knowledge is fundamental in collaboration; utilizing the previous knowledge and lived experiences of each group member, and combining different perspectives, talents, and ideas to create unique knowledge that could not have been done individually. Through a metaphor of a potluck dinner, Kozar (2010) exemplifies the difference between cooperation and collaboration:

> Finally, let me finish with a metaphor of a potluck dinner, where people cook and bring different dishes to the table. The dinner is more exciting than what each individual would have eaten individually - but the guests return back to their homes being able to cook only the same dish they brought to the potluck. Even though they may have gotten recipes, they still need to learn to make the new dishes themselves. On the other hand, had they cooked together in the first place they would have observed and learned a lot more from one another; they would have taken away some practical, hands-on skills even if cooking together had meant a messier and more chaotic process. (p. 22)

Kozar distinguishes between collaboration and communication by establishing a key difference between the two; negotiation, discussion, and accommodation of one another's perspective through direct integration of individual knowledge and experiences creates effective collaboration. Whereas given enough time and resources, the work done in cooperative contexts could essentially be completed by a single person.

The Benefits of Collaborative Learning Amongst Adolescence

Living as naturally social beings, learning occurs largely in socially grounded contexts. The period of adolescence is a time of great social learning as the social brain becomes more malleable, and the reorganization and strengthening of the connections within the social brain drives the behavior of many youth. Lieberman (2012) argues that by implementing strategies that promote social interaction such as a collaborative learning framework, educators can utilize the social cognition and the social drive of adolescents to further develop their knowledge and skills beyond the classroom. That is, by implementing collaborative learning strategies, educators can create tribal classrooms (Cozolino, 2013) that harness the increased need for autonomy, motivation to work alongside peers, willingness to take risks, and new found creativity and

passion that comes with the adolescent period. By implementing social perspectives into collaborative learning, educators tap into the social motivation of youth and develop lifelong social skills such as effective communication, collaboration with others, and problem solving (Lieberman, 2012). As discussion, explanation, and reasoning amongst group members are at the core of collaborative learning, encouraging students to bring in past knowledge and experiences, ask and answer questions, and deliberate concepts, collaborative groups can be an effective strategy to further develop critical-analytic thinking amongst teens; thus, involving children in conversations with questioning, opposing beliefs, and extended concepts is a powerful instructional tool that can further enhance learning in any social context (Davidson & Major, 2014; Murphy et al., 2014). With collaborative learning having roots in Vygotsky's concept of learning as a constructivist process in which the learner is actively involved in the content, taking ownership for their own learning, and working to create positive relationships between contributors, the development of positive interpersonal relationships as a motivating factor of the adolescent time period is supported (MS'Sakshi & Dhull, 2018). Involving adolescents in collaborative processes further celebrates diversity amongst group members, acknowledges and utilize individual differences, actively pushes students to advocate for their own learning and growth as well as that of their peers, develop intrinsic motivation, and creates an understanding of civic responsibility between and within groups (Davidson & Major, 2014; MS'Sakshi & Dhull, 2018; Smith & MacGregor, 1992). Thus, collaborative learning supports the overall adolescent development by allowing students to interact and build knowledge about the world around them, take risks, develop interpersonal skills, and work with their peers in a safe and positive environment with educators simply acting as supporting agents in this process.

A Framework for the Implementation of Collaborative Learning

In collaborative learning, it is essential for each member to understand the value in their experiences and knowledge and feel encouraged to contribute. To tap into the social drive and development of adolescents, teachers should intentionally implement collaborative strategies that incorporate social learning into their teaching practice. In Chapter One of *Building Thinking Classrooms in Mathematics*, Liljedahl prefaces his book with "If we want our students to think, we need to give them something to think about - something that will not only require thinking but will also encourage thinking" (2021, p. 19), setting the stage for the importance of intentionally planning thinking tasks and engaging students. Often educators fall into the belief trap in which group work or working in pairs is considered collaborative learning and optimizes social learning but unfortunately this is not the case if not guided properly. By implementing a framework of collaborative learning, educators can ensure that communication, deliberation, and the construction of knowledge occurs amongst groups i.e. actual thinking occurs.

Further research in collaborative learning has brought many key aspects of effective collaborative learning implementation to the surface. Reid and colleagues (1990) describe five phases of the collaborative learning process: *engagement and input, exploration, transformation, presentation,* and *reflection*. These phases guide the process of effective collaboration but are not necessarily linear and may be implemented as more of a dynamic or cyclical process (Davidson & Major, 2014). In order to foster effective and true collaboration amongst students, there are a number of considerations to keep in mind in the planning process such as: the nature of the task, learning goals, type of problem and context, prior knowledge and experience, group creation, classroom setup, communication between parties, presentation of findings, consolidation of knowledge, and finally the role of the teacher (Davidson & Major, 2014; Kaendler et al., 2015;

Liljedahl, 2021; Smith & MacCregor, 1992). Figure 2 shows a planning tool that I created for educators to make use of when looking to implement collaborative learning strategies; the planning tool utilizes the main consideration points found in the literature alongside reflection questions and points to guide educators towards effective collaboration in their classroom.

When planning for CL, consider the following:	**Reflection Questions/Points:**
The nature of the task and your learning goals	• What are the goals of your task, are they curriculum based, social-emotional based, etc. • What is the nature of the task: low-floor, high-ceiling, open-middle task? • Research shows that the energy and willingness to engage in a collaborative task drops after 5 minutes, it is important to get them energized and thinking right away!
The type of problem and context	• What type of problem are you trying to solve? • Is it a rich-thinking task or a mimicking task (not effective in the long-term)? • Is the context of the problem relevant to students and their lives?
Your students prior knowledge and experience with the problem and with CL	• What prior knowledge about the problem do your students have? Have they encountered collaborative learning before (if no, start with a non-curricular task to build collaborative fluency).
What your groups look like	• How big will your groups be? 3 is the "golden number" for grades 3 and up, for k-2 the number is 2. • How will you make your groups? Reflect back to your learning goals. • Research shows that visibly randomized groupings are the most effective within adolescents for curriculum based tasks, but as teachers we know that this may not always be the best option if your learning goals are non-curricular.
Where your students will work	• What spaces will you have for the students to collaborate? • To engage in a "thinking classroom", research has shown that vertical non-permanent surfaces have one of the largest influences on eagerness to take risks, time spent on the task, and engagement in the task. These surfaces also increase knowledge mobility between groups and allows the teacher to easily observe what is happening in the room.
How you want the students to communicate	• How do you want students to communicate to each other, to you, and to other groups? • Knowledge mobility and transfer between groups is very beneficial. Try to avoid the word "cheating" between groups. • If students are communicating but off-task, consider allowing them to self redirect before intervening
How students will share their findings	• Gallery walks are more beneficial than each individual group presenting. Trying to decode someone else's work changes consolidation from telling to thinking. • As a teacher you may present each individual solution, or select a few, but keep them standing, walking, and thinking throughout. • Question the groups to explain certain parts rather than just going through the sequence.
How you will consolidate the knowledge	• Extensive note taking should not be a part of collaborative learning until the very end, and it should be open-ended, where the groups formulate their main takeaways. • Students should write down points that are meaningful to them in a way that they will remember. • Consider graphic organizers for students to consolidate their learning in a way that suits them best.
Your role as the teacher	• As the teacher, your role in collaborative learning is to guide and encourage the students to think deeply about a task, to engage in conversation with one another and create new knowledge. • Give prompts and extensions when needed but be careful of students who are looking for answers and quick-fixes. • Try answering questions in the form of another question. Model positive interactions and encourage risk-taking and mistakes!

Figure 2. Educator Planning Tool for Effective Implementation of Collaborative Learning

As mentioned previously, neuromyths (Fischer, 2009) are common in education and often trick educators into believing that their teaching strategies are evidence or research-based. This is often the case with group work or working in pairs, where despite working in relationship with others, the work being done is more cooperative and/or split than collectively and collaboratively constructed. Liljedahl (2021) describes a thinking classroom as "a classroom where students think individually and collectively. The collective goes well beyond the limits of the group boundaries and encompasses the whole class" (p. 139). With this in mind, as well as

the guiding considerations of other research, it is essential for educators to recognize what effective collaboration looks like amongst students. Research has shown that effective collaborative learning looks like a combination of the following: small groups (two or three), self-managed dialogue led by the students, deliberation and negotiation amongst group members, contributions and accommodations by all group members, inclusion of past experiences and knowledge, the construction of relevant knowledge, working on vertical non-permanent surfaces, transferable and mobile knowledge between groups throughout the classroom, educators acting as supporting agents, and most importantly educators are encouraging deeper thinking through prompts and extensions (Davidson & Major, 2014; Kaendler et al., 2015; Liljedahl, 2021; Smith & MacCregor, 1992). Within the planning tool created for educators, I have also included reflection questions for educators to question the validity of their collaborative learning strategies in hopes of dismantling some neuromyths and guide educators to effective implementation. These questions are shown in Figure 3 as part of the PD session for educators.

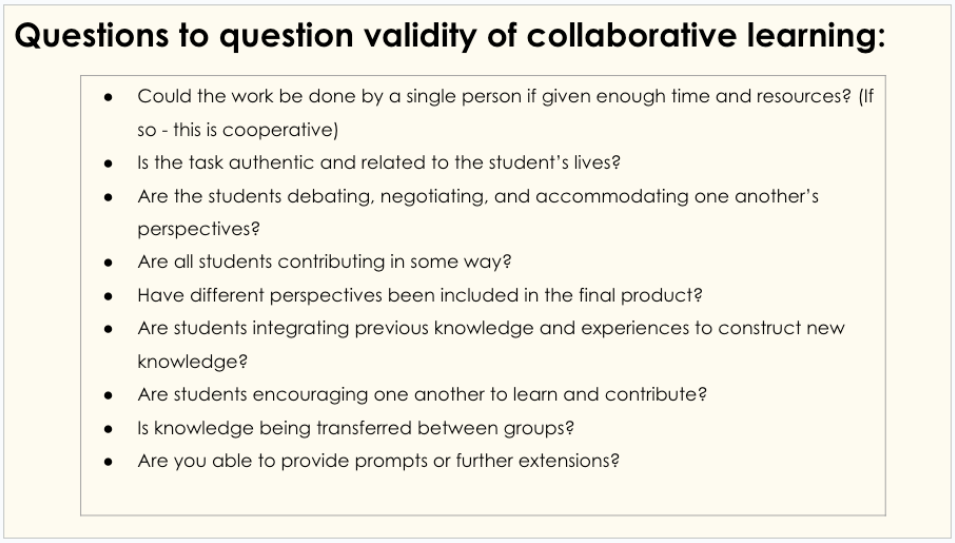

Figure 3. Reflection Questions for Educators

In order for educators to effectively implement collaborative learning within their classrooms, it is valuable for them to understand the true meaning of collaboration, directly plan

for rich thinking tasks, and to utilize critical thinking analysis to gauge whether or not a task is truly collaborative. By following the questions and phases of the collaborative learning framework, educators can be guided in the right direction towards adapting their pedagogical beliefs and strategies to better suit the needs and development of their students.

Project: Embedding Neuroscience into Education

In combination with the experiential knowledge of my career, the knowledge I have gained in the Teaching, Learning, and Neuroscience program has allowed me to recognize the need for a transformative shift in junior high pedagogy to embed neuroscience into educational practices. By adapting my own pedagogical practices to incorporate what many coin as "neuroeducation" (Jolles & Jolles, 2021, p. 1), I have observed a positive shift in student growth in areas such as: social development, executive function, and academics. Having noticed that not all educators reach the same success with their students, I have come to recognize several roadblocks teachers face when attempting to implement learning strategies for junior high students.

First, the lack of knowledge regarding adolescent brain development and their social needs that exists amongst educators is concerning. Neuroscience provides insight into the development of learners beyond the external behaviors observed in the classroom, yet many educators have little to no knowledge of how the brain learns and changes through the lifespan, specifically during critical periods such as adolescence. A gap between neuroscience research and application into education seems to exist, with the general population of educators having little access to evidence-based theories, knowledge, and strategies, being left exposed to the deception of neuromyths (MacDonald et al., 2017). It was important for me to create a project that serves to bridge this gap and combines neuroscience and education into a practical strategy.

This project serves as an important tool for educators to gain and apply neuroeducation and piece together the puzzle of adolescents in a way that benefits their overall development; research and the development of this projects has deepened my own understanding of adolescent brain development and collaborative learning, and I will continue to share these understandings and practices with my fellow educators in hopes of improving overall pedagogical practices in junior high school. This project resulted in the creation of two main components: a PD session and a printable infographic for the classroom.

Professional Development Session

The foundation of this PD session is rooted in a student-based presentation that I created with Dr. Leah Fowler in the fall of 2020. For Dr. Fowler's course I created a google slides presentation that was presented to students within junior high; the slides contained basic information regarding the structural components of the brain and how the brain learns, as well as correlating activities for the students to deepen their understanding of their own brain and behaviors during sensitive periods. This was a critical starting point for embedding neuroscience into education, transforming my overall pedagogy and creating a strong foundation and outline for the components of this project.

The intentions of the presentation are to inform educational staff of the basics of neuroanatomy and function, the underpinnings of how the brain learns, how the brain is impacted by the critical period of adolescence, and how collaborative learning environments are exceptionally beneficial for teens. Creating a school wide foundation of knowledge, language, and effective ways to implement neuroeducation are the ultimate goals of the session. The presentation is split into four parts: *1. The Structural Brain, 2. The Learning Brain, 3. The Adolescent Brain,* and *4. Collaborative Learning with Teens*, and can be presented separately or

all together if time and attention allows. Although all four sections can be presented to all staff, the first three sections are intended for the entire school community and educational staff i.e. teachers, educational assistants, counselors, principals, and administration staff, and even parents, while the last section may be informative for those directly in the classroom. Building from the ground up, educators will develop a basic understanding of how the brain functions at a neural level which will further inform how students learn, what affects their learning i.e. adolescence, and how to support such learning with tools such as collaborative learning contexts. The goal of the PD session is to inform, but not overwhelm, with each section of the presentation including notes for the presenter, correlating activities, and further resources. Engaging in discussions and participating in activities is essential to consolidating the knowledge that is presented throughout the four parts.

Part One: The Structural Brain

Part One of the PD presentation is an essential building block that provides educational staff with a strong foundation of neuroanatomy and structural knowledge, empowering them to not only understand the root of student behavior and action, but of their own as well. Grasping the very basic neural structures will inform the remainder of the presentation, staff will gain a deeper understanding of how their students learn and how certain tools and strategies may (or may not) be effective at various times, creating a school wide environment where common language and understanding is utilized. Along with brief informative points, *Part One* includes presenter notes, visual diagrams, hand models, and kinesthetic activities to promote an understanding of basic structures and functions within the brain. This section is intended to be informative but brief, providing viewers with enough information to gain an overall basic level of understanding, but not overwhelm with in depth information. If interested, there are resources

linked in the presenter notes for those who would like to dive deeper into individual brain components and their functions.

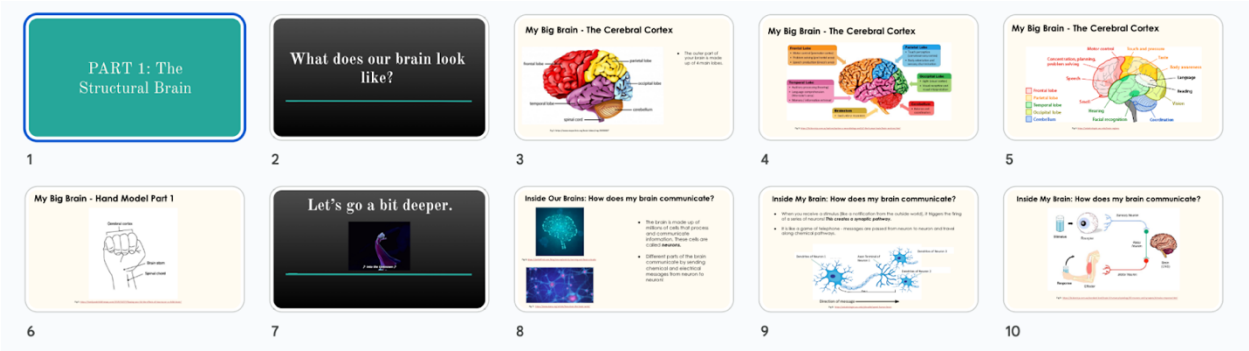

Figure 4. Screenshot of "Part 1: The Structural Brain" Slides.

Part Two: The Learning Brain

In *Part Two* of the presentation knowledge of the structural brain is utilized to gain a deeper understanding of what learning is, key areas involved in learning, and the essential role of neuroplasticity ie. the creation and destruction of neural pathways. Again viewers are met with visual diagrams, a hand model, correlating activities, as well as analogies and videos to further support the information presented in this section.

Part One and *Part Two* form the foundation for the remainder of the PD presentation and are essential building blocks for understanding students at all levels, but especially in sensitive periods such as adolescence. By empowering educational staff with the foundations of neuroanatomy and the learning process, a basis of common language can be created, and resources and supports can be effectively implemented with neuroscience backing. In order to further understand the adolescent brain and the changes it undergoes, and implement tools and strategies that further support adolescent brain development, it is imperative that educational staff have this foundation of knowledge.

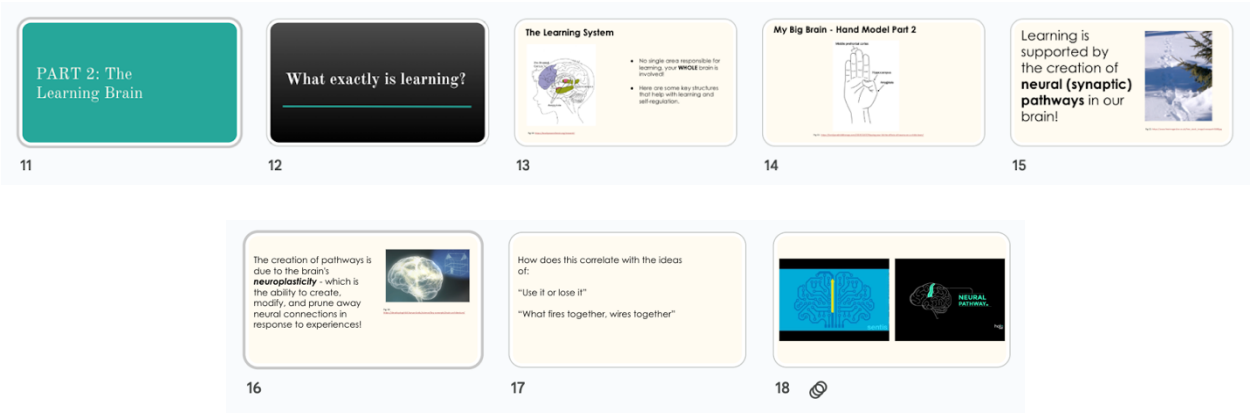

Figure 5. Screenshot of "Part 2: The Learning Brain" Slides.

Part Three: The Adolescent Brain

Part Three of the PD session dives into the underpinnings of the adolescent brain as it undergoes drastic structural and functional changes following the onset of puberty. To begin, the definition of adolescence is discussed which is then followed by the discussion of factors that may impact adolescent learning (utilizing knowledge that was developed in *Part One* and *Part Two*). This section then expands into the structural changes that are found to occur with adolescence, the development of the social brain, and the behavioral shifts that tend to come with the structural reconstruction. *Part Three* is the most information dense of all presentation sections, and is paired with diagrams, charts, videos, and discussion breaks to support knowledge consolidation and correlation with the previous sections of the PD session. Additionally, there are specific resources such as the website *So You Teach Junior High?* (Craig, 2023), that provides educational staff with more in depth information in regard to adolescent development. In this part of the presentation educational staff are also given access to the classroom poster (see below *Classroom Infographic: The Adolescent Brain*), which I have created to summarize and make this information accessible to the entire school community.

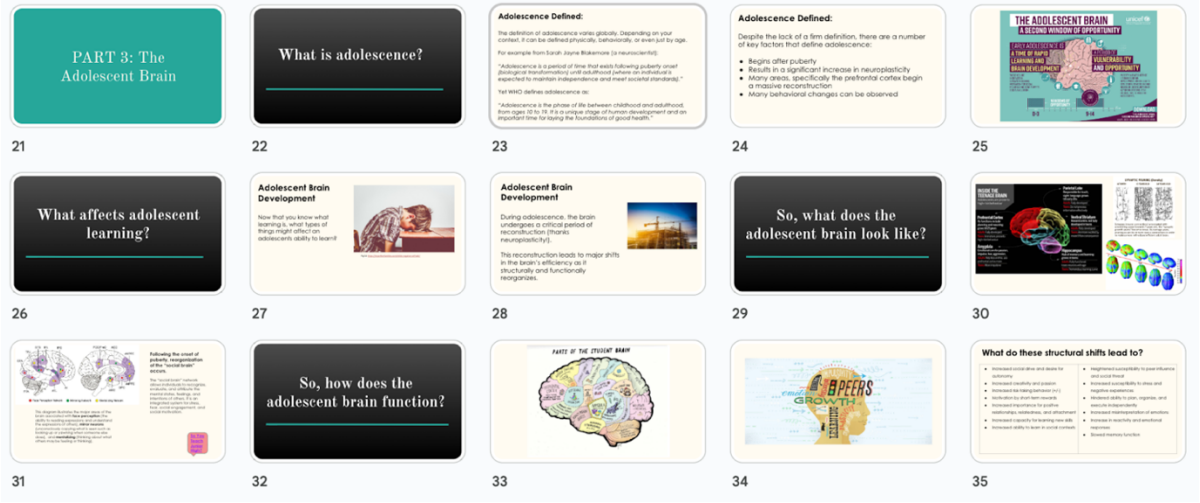

Figure 6. Screenshot of "Part 3: The Adolescent Brain" Slides.

Part Four: Collaborative Learning with Teens

In *Part Four* of the presentation, information from the previous three sections is combined and utilized to explore the learning strategy of collaborative learning contexts, specifically for adolescents. Louis Cozolino (2013) states "establishing a tribal classroom can be so beneficial to learning, especially for children without secure attachments and strong affiliations outside of the classroom" (p. 11), thus although this section may deem more valuable and directed to those planning the instruction for adolescents, I propose that it would greatly benefit all members of the school community in terms of providing opportunities for positive adolescent development in and out of the classroom.

This section of the PD begins with an engaging activity and reflection where educational staff actively participate in a collaborative learning activity that is directed by the presenter, and later discuss the key components of the collaborative learning context. A key understanding of collaboration is that new knowledge is created by utilizing the information and experiences of all group members; this is emphasized throughout this section through analogies, videos, diagrams, and planning tools. *Part Four* further ties in previous information by discussing the benefits of

collaborative learning for adolescents in specific; by engaging the social brain, educational staff are informed of how collaborative tools and practices can promote positive development of adolescent students. Lastly, a framework for effectively implementing collaborative learning is discussed. This is the final building block to the presentation, and discusses the phases of collaborative learning, planning considerations, and factors to consider when questioning the validity of collaborative learning contexts. Additionally, educational staff are provided with a printable planning tool that summarizes the considerations, reflection questions, and validity questions, into an easy-to-use chart for reference when planning collaborative learning opportunities in and out of the classroom.

The powerpoint slides are intended to showcase the value that neuroscience in the classroom can hold, and empower educational staff with a common language and understanding of neuroanatomy and neurodevelopment to effectively support students.

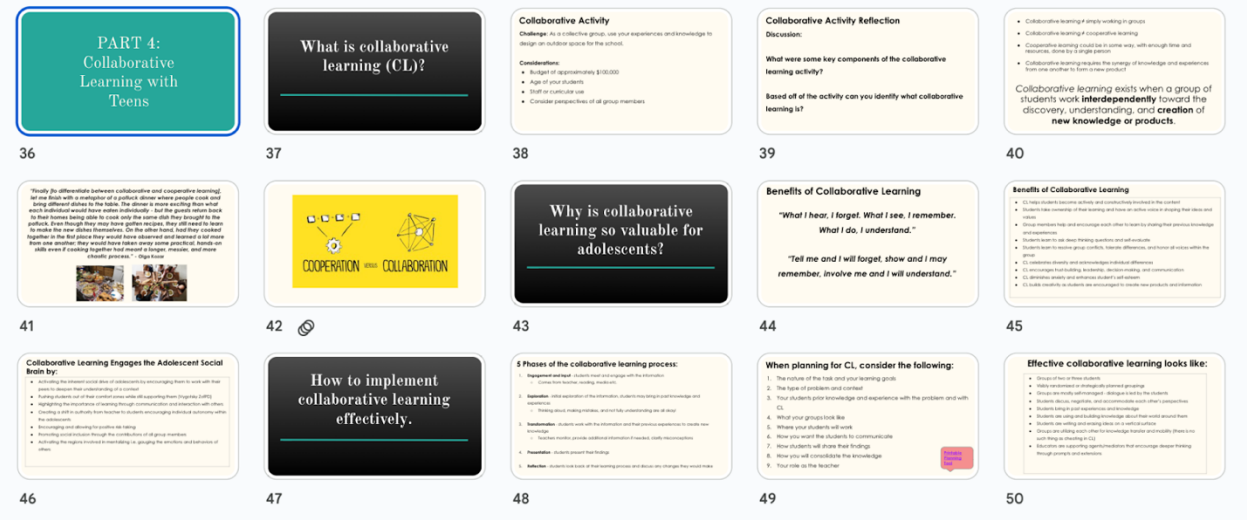

Figure 7. Screenshot of "Part 4: Collaborative Learning with Teens" Slides

Classroom Infographic - The Adolescent Brain

This portion of the project was derived out of the PD session, as I felt called to create a product that summarized key points from the session, was easily accessible, readily-available,

and informative to both educational staff and students themselves. As mentioned earlier in this paper, within the first two months of beginning my Master's program, I began implementing neuroscience into my teaching strategies, and spent time directly informing my students of their brain and behaviors. From this, I immediately observed a change in my students' awareness of their own learning; they became advocates for the support they needed, they were more attune to their behaviors and actions, their self-regulation increased, and their motivation for their own learning increased. Thus, I recognized the importance of providing the information presented in the PD session to both the educational staff, and the students. The infographic is intended to be posted in the junior high school classrooms and visible to the entire school community. It is a colorful poster with bold images and attention grabbing headlines with the language of the infographic being in second-person and geared towards adolescents; for example: "Your brain is plastic, meaning it will change over time!". The poster includes brief information about the changes that occur during adolescence, neuroplasticity, executive function, the social brain, social learning, risk taking, creativity and passion, memory, and the influence of stress. I have also included a QR code on the bottom of the poster that will take anyone who scans it to the PD session slide, where they can access more in depth information. By creating an eye-grabbing poster that is in student friendly language, it is my hope that both the adolescents and educational staff will refer to it for common language, strategies, and understandings.

Figure 8. Classroom Infographic - The Adolescent Brain.

Conclusion

As an educator of junior high school students I have commonly observed two obstacles within education when it comes to adolescents. First, there is a common negative lens that adolescence is often viewed through; adolescents are often labeled as misbehaving, irrational, emotional, and unable to make decisions for themselves. Yet, despite this assumption, society puts immense pressure on adolescents to become independent, develop proper social skills, do well in school, and explore and excel in extra-curricular activities. Junior high school students are often feared, with many educators giving up on this group of students, labelling them as "too much". Through this observation, I have come to recognize a lack of understanding of adolescent behaviors and choices exists, that is, there is minimal understanding of the underpinnings of adolescent development leading many educators to feel hopeless in supporting them.

The second struggle exists with a lack of tangible resources for teachers; in order to implement effective teaching strategies for adolescents, educators need to be provided with resources that are supported by research and are ready to use. Too often teachers are overloaded with ideas and strategies, but lack effective resources to directly implement such information and strategies into their pedagogical practice. This can create a resistance to growth further impacting both the educator and student. These two factors, a lack of knowledge around adolescent development and a lack of tangible resources available to support such development, were key in motivating the creation of this project.

The overall purpose of this project is to provide educators with an understanding of the adolescent brain in hopes of shifting the negative narrative that often surrounds teenagers, further creating a shift in middle school pedagogy to provide positive learning opportunities for these students. Educators will have an opportunity to learn and utilize practical research-based

knowledge to adapt their pedagogical practices, and support the learning and development of adolescents in a way that best empowers the positive growth of their students. Through a PD session that builds foundational knowledge of the brain and how it develops throughout adolescence, as well as an understanding of the use collaborative learning amongst teens, I hope to align research with classroom practice and provide educators with an opportunity to embedd neuroscience into their own pedagogy to further support their students. Additionally, with the display of the classroom infographic, my hope is that both educators and students themselves will have daily access to valuable information and gain a deeper understanding of the adolescent brain as it undergoes such drastic changes.

Before beginning this project, one of the main motivations was to create a tangible resource for myself and other educators that could be put into play quickly and efficiently. To begin rolling out the resources I have been fortunate to have my infographic presented by Dr. Robbin Gibb in her *Building Brains Together* program as a resource for the adolescent category. With the initial presentation of the infographic, I received positive feedback in regards to the information, layout of the infographic, and practicallity and applicability. The poster has already made its way into a number of classrooms, schools, counselling offices, and online resource banks. As for the PD sessions, I will begin providing the presentation to my own staff in August, and will have the poster printed in each classroom before students attend their first day. My goal is that by providing educational staff with the foundational knowledge prior to the new school year beginning, they will have the confidence to go into the year with new strategies, new information, new understandings, and a new way to communicate with their students.

This project is a clear display of my engrained desire to continue learning, to support adolescent students, and to support educators in providing the best opportunities for our students.

As junior high educators, we are in a position where it is our duty to create environments in which teens feel encouraged, safe, and understood. We must continue to develop our own understanding and recognize that learning through social interaction will continue to be at the root of human nature and evolution, especially during adolescence. Thus, in order to keep youth engaged in their learning, develop a positive sense of self, and overall thrive in their environment, it is essential that educators support the social nature of teens, implement opportunities for the inherent social processes to occur, and empower students to utilize their social brain within educational environments.

References

Ackerman, S. (1992). *Discovering the brain*. National Academies Press.

Andrews, J. L., Ahmed, S., & Blakemore, S. J. (2020). Navigating the social environment in adolescence: The role of social brain development. *Biological Psychiatry*, *89*, 109-118.

Blakemore, S. J. (2008). The social brain in adolescence. *Nature Reviews Neuroscience*, *9*(4), 267-277.

Blakemore, S. J. (2018). *Inventing ourselves: The secret life of the teenage brain*. PublicAffairs.

Blakemore, S. J. (2019). Adolescence and mental health. *The Lancet*, *393*, 2030-2031.

Blakemore, S. J., & Frith, U. (2005). The learning brain: Lessons for education: a précis. *Developmental Science*, *8*(6), 459-471.

Blakemore, S. J., Burnett, S., & Dahl, R. E. (2010). The role of puberty in the developing adolescent brain. *Human Brain Mapping*, *31*(6), 926-933.

Boettcher, J., Mattson, D., Wilson, C., & Wutzke, J. (2021). Chapter 3: Cognition and instructional design. In K. Scallise & K. Felde (Eds), *Why neuroscience matters in the classroom* (pp. 62-90). Pearson.

Burnett, S., Sebastian, C., Kadosh, K. C., & Blakemore, S. J. (2011). The social brain in adolescence: Evidence from functional magnetic resonance imaging and behavioural studies. *Neuroscience & Biobehavioral Reviews*, *35*(8), 1654-1664.

Child Mind Institute Inc. (2020) *Guides*. https://childmind.org/topics-a-z/guides/

Collins, J. W. (2007). The neuroscience of learning. *Journal of Neuroscience Nursing*, *39*(5), 305-310.

Cozolino, L. (2013). *The Social neuroscience of education: Optimizing attachment & learning in the classroom*. W.W. Norton and Company.

Dahl, R., Suleiman, A., Luna, B., Choudhury, S., Noble, K., Lupien, S. J., ... & Uncapher, M. R. (2017). *The adolescent brain: A second window to opportunity: A compendium*. https://www.unicef-irc.org/publications/933-the-adolescent-brain-a-second-window-of-opportunity-a-compendium.html

Daniel, D. B. (2012). Promising principles: Translating the science of learning to educational practice. *Journal of Applied Research in Memory and Cognition, 1*(2012), 251-253.

Davidson, N., & Major, C. H. (2014). Boundary crossings: Cooperative learning, collaborative learning, and problem-based learning. *Journal on Excellence in College Teaching*, *25*.

Dougherty, M. R., & Robey, A. (2018). Neuroscience and education: A bridge astray? *Current Directions in Psychological Science*, *27*(6), 401-406.

Drew, C. (2021). *31 major learning theories in education, explained!* Retrieved August 1, 2022, from https://helpfulprofessor.com/learning-theories/

Dweck, C. (2015). Carol Dweck revisits the growth mindset. *Education Week*, *35*(5), 20-24.

Fischer, K. W. (2009). Mind, brain, and education: Building a scientific groundwork for learning and teaching1. *Mind, Brain, and Education*, *3*(1), 3-16.

Fischer, K. W., Daniel, D. B., Immordino-Yang, M. H., Stern, E., Battro, A., & Koizumi, H. (2007). Why mind, brain, and education? Why now? *Mind, Brain, and Education*, *1*(1), 1-2.

Gibb, R., Gonzalez, C., Hazelwood, V., Halliwell, C., & Oldfield, J. (2023, June 6). *Building brains together 2.0: Supporting executive function in teens through play* [Community Presentation]. Building Brains Together. Lethbridge Public Library, AB, Canada.

Goswami, U. (2006). Neuroscience and education: from research to practice? *Nature Reviews Neuroscience*, 2-7.

Goswami, U. (2008). Principles of learning, implications for teaching: A cognitive neuroscience perspective. *Journal of Philosophy of Education*, *42*(3-4), 381-399.

Guy, R., & Byrne, B. (2013). Article Commentary: Neuroscience and learning: Implications for teaching practice. *Journal of Experimental Neuroscience*, *7*, 39-42.

Harvard University. (2020). *Brain architecture.* Center on the Developing Child. https://developingchild.harvard.edu/science/key-concepts/brain-architecture/

Hinton, C., Fischer, K. W., & Glennon, C. (2012). *Mind, brain, and education: The students at the center series*. Jobs for the Future Publication.

Jolles, J., & Jolles, D. D. (2021). On neuroeducation: Why and how to improve neuroscientific literacy in educational professionals. *Frontiers in Psychology*, *12*(752151), 1-18.

Kaendler, C., Wiedmann, M., Rummel, N., & Spada, H. (2015). Teacher competencies for the implementation of collaborative learning in the classroom: A framework and research review. *Educational Psychology Review*, *27*, 505-536.

Kirschner, P. A., Sweller, J., Kirschner, F., & Zambrano, J. (2018). From cognitive load theory to collaborative cognitive load theory. *International Journal of Computer-Supported Collaborative Learning*, *13*(2), 213-233.

Kolb, B., & Gibb, R. (2011). Brain plasticity and behaviour in the developing brain. *Journal of the Canadian Academy of Child and Adolescent Psychiatry*, *20*(4), 265.

Kolb, B., Whishaw, I. Q., & Teskey, G. C. (2019). *An introduction to brain and behavior* (6th ed). Worth Publishers.

Kozar, O. (2010). Towards better group work: seeing the difference between cooperation and collaboration. *English Teaching Forum*, *48*(2), 16-23.

Laal, M., Khattami-Kermanshahi, Z., & Laal, M. (2014). Teaching and education; collaborative style. *Procedia-Social and Behavioral Sciences*, *116*, 4057-4061.

Lenroot, R. K., & Giedd, J. N. (2008). The changing impact of genes and environment on brain development during childhood and adolescence: Initial findings from a neuroimaging study of pediatric twins. *Development and Psychopathology*, *20*(4), 1161-1175.

Lieberman, M. D. (2012). Education and the social brain. *Trends in Neuroscience and Education*, *1*(1), 3-9.

Liljedahl, P. (2021). *Building thinking classrooms in mathematics, grades K-12: 14 teaching practices for enhancing learning*. Corwin Press Inc.

Macdonald, K., Germine, L., Anderson, A., Christodoulou, J., & McGrath, L. M. (2017). Dispelling the Myth: Training in Education or Neuroscience Decreases but Does Not Eliminate Beliefs in Neuromyths. *Frontiers in Psychology*, *8*, 1314.

MS'Sakshi, P., & Dhull, I. (2018). Collaborative and cooperative learning: An overview. *Journal of Education*, *34*, 21-30.

Murphy, P. K., Rowe, M. L., Ramani, G., & Silverman, R. (2014). Promoting critical-analytic thinking in children and adolescents at home and in school. *Educational Psychology Review*, *26*(4), 561-578.

Ngeow, K. Y. H. (1998). *Enhancing student thinking through collaborative learning*. ERIC Clearinghouse on Reading, English, and Communication, Indiana University.

Noddings, N. (2012). The caring relation in teaching. *Oxford Review of Education*, *38*(6), 771-781.

Paas, F., & Sweller, J. (2012). An evolutionary upgrade of cognitive load theory: Using the human motor system and collaboration to support the learning of complex cognitive tasks. *Educational Psychology Review*, *24*(1), 27-45.

Reid, J. A., Forrestal, P., & Cook, J. (1990). *Small group learning in the classroom*. Portsmouth, NH: Heinemann; Toronto: Irwin Publishing.

Romeo, R. D. (2013). The teenage brain: The stress response and the adolescent brain. *Current Directions in Psychological Science*, *22*(2), 140-145.

Rubia, K. (2013). Functional brain imaging across development. *European Child & Adolescent Psychiatry*, *22*, 719-731.

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*(1), 68-78.

Scalise, K., & Felde, M. (2017). *Why neuroscience matters in the classroom: Principles of brain-based instructional design for teachers*. Pearson.

Schcolnik, M., Kol, S., & Abarbanel, J. (2006). Constructivism in theory and practice. *English Teaching Forum, 4*, 12-20.

Sehgal Cuthbert, A. (2015). Neuroscience and education: An incompatible relationship. *Sociology Compass*, *9*(1), 49-61.

Sengpiel, F. (2007). The critical period. *Current Biology, 17*(17), R742-R743.

Siegel, D. J. (1999). *The developing mind: Toward a neurobiology of interpersonal experience*. Guilford Press.

Siegel, D. J. (2015). *Brainstorm: The power and purpose of the teenage brain*. Penguin.

Siegel, D. J. (2020). *The developing mind: How relationships and the brain interact to shape who we are*. Guilford Press.

Siegel, D. J., & Bryson, T. P. (2012). *The whole-brain child: 12 revolutionary strategies to nurture your child's developing mind*. Bantam.

Smith, B. L., & MacGregor, J. (1992). *Collaborative learning: A sourcebook for higher education.* National Center on Postsecondary Teaching, Learning, and Assessment.

Spear, L. P. (2013). Adolescent neurodevelopment. *Journal of Adolescent Health*, *52*(2), S7-S13.

TED-Ed. (2013, June, 1). The *mysterious workings of the adolescent brain - Sarah-Jayne Blakemore.* [Video]. YouTube. https://youtu.be/6oKsikHollM

UNESCO. (2003). Literacy, a UNESCO perspective. *UNESDOC digital library*. Retrieved August 26, 2022, from https://unesdoc.unesco.org/home

University of Lethbridge (2012). *Moving from brain research to the classroom - Dr. Bryan Kolb*. [Video]. Youtube. https://youtu.be/sxzdz4pobPk

University of Lethbridge. (2023). *Neuroscience research in the classroom.* Faculty of Education. https://www.ulethbridge.ca/education/story/4105

Wang, Y., Metoki, A., Alm, K. H., & Olson, I. R. (2018). White matter pathways and social cognition. *Neuroscience & Biobehavioral Reviews*, *90*, 350-370.

Willingham, D. T. (2009). Three problems in the marriage of neuroscience and education. *Cortex*, *45*(4), 544.

Wood, D., & Deprez, L. S. (2012). Teaching for human well-being: Curricular implications for the capability approach. *Journal of Human Development and Capabilities*, *13*(3), 471-493.

Yeager, D. S., & Dweck, C. S. (2012). Mindsets that promote resilience: When students believe that personal characteristics can be developed. *Educational Psychologist*, *47*(4), 302-314.

Zeanah, C. H., Gunnar, M. R., McCall, R. B., Kreppner, J. M., & Fox, N. A. (2011). Sensitive periods. *Monographs of the Society for Research in Child Development*, *76*(4), 147-162.

Appendix:

Further Resources

Link to Professional Development Session
https://docs.google.com/presentation/d/10SsZOOWRjb9Tz9z1Kk0tVMMtdarm37OujrZ4ZESAVRE/edit?usp=sharing

Link to Classroom Infographic
https://www.canva.com/design/DAFhPDOvd98/fLs9svkHBeztXkR7fdQGrA/edit

Website - So You Teach Jr. High?
https://sites.google.com/view/soyouteachjrhigh/home?authuser=0&fbclid=IwAR2YHXLPeZNDoKIwsrFXPTW-Ss7Xrj8pHsj319vm2P2swfI85mmAMATVVX0

Building Brains Free Resources
https://www.buildingbrains.ca/adolescents

Building Brains Education Courses & Certifications
https://www.buildingbrains.ca/courses