Title: Looking at Philosophy for Children and Its Outcomes Through a Neuroscience Lens

Running Title: Philosophy for Children and Neuroscience

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Plain Language Summary

Among all educational methods all around the world, Philosophy for Children (P4C) has been introduced as one of the effective methods, with various advantages for children. The focus of this study is to review the various outcomes of applying this strategy in different genders, ages, and socioeconomic statuses from a neuroscience standpoint. It seems that gender and socioeconomic status can affect the results of this educational method just in some measured aspects. However, the combination of gender, age, and socioeconomic status appears to influence P4C outcomes.

Abstract

Among all educational methods all around the world, Philosophy for Children (P4C) has been introduced as one of the effective methods, with various educational, cognitive, and emotional advantages for children. This method is built on three types of thinking; critical (logic), caring (ethical), and creative (aesthetic). The focus of this study is to review the various outcomes of applying this strategy in different genders, ages, and socioeconomic statuses from a neuroscience standpoint. It seems that gender and socioeconomic status can affect the results of this educational method just in some measured aspects. However, the combination of gender, age, and socioeconomic status appears to influence P4C outcomes.

Keywords: Philosophy for Children, Neuroscience, Brain regions, Gender, Age, Socioeconomic status

1. Introduction

Children all around the world are taught using a variety of educational methods to improve their skills and knowledge. Each of these methods has advantages and limitations. There is reliable evidence in the literature that highlights the influence of education on individuals' cognitive abilities during development (Ceci, 1991; Lövdén et al., 2020). The primary purpose of conventional schooling approaches is more focused on teaching a wide range of declarative and procedural knowledge, which leads to improved crystallized cognitive abilities (vocabulary, literacy, numeracy, etc.) (Ceci, 1991). To some extent, these approaches may strengthen fluid cognitive abilities (for instance, memory, judgment, and problem-solving) by improving cognitive strategies and test-taking skills (Baker et al., 2015; Wenger & Lövdén, 2016). It appears that various educational cognitive stimulations influence cognitive abilities by inducing neurobiological changes throughout development (Lövdén et al., 2020). This may explain why schooling with various qualities may have effects on the interaction between education and a child's cognition (Cliffordson & Gustafsson, 2008). Childhood is a critical period when neurobiological elements and experiences combine to influence the normal developing brain and permanently affect behavior (Marek et al., 2015; Simmonds et al., 2014). Furthermore, studies have shown that during this time window association, cortices continue to develop structurally and functionally in an experience-dependent manner (Blakemore & Mills, 2014; Larsen & Luna, 2018). To summarize, the temporal co-occurrence of both cognitive growth and increased exposure to environmental experiences implies a critical period of development for shaping children's personalities and behaviors through education (Larsen & Luna, 2018).

Among all educational approaches, Philosophy for Children (P4C) has been introduced as an effective method, featuring different educational, cognitive, and behavioral advantages such as improved executive functions and academic performance (Ab Wahab et al., 2022; Leng, 2020a; Säre et al., 2016; Vansieleghem & Kennedy, 2011). This method, interestingly, has the potential to also positively influence teachers (known as a facilitator) both professionally and emotionally, as well as to promote constructive changes in pupils (Lam, 2021; Roberts, 2006).

Here, we shall discuss a topic called "Neuroeducation", which is a field that aims to optimize knowledge transmission and comprehension by integrating information about brain processes related to the cognitive abilities involved in learning with the efforts of the education community (Hardiman et al., 2011; Rueda, 2020). Cognitive neuroscience research could extend our knowledge of how learning affects the brain and cognition (Ansari et al., 2012). Before neuroeducation research became widely available, educators and the public, in general, had several incorrect assumptions regarding the brain and the learning process. While they had accepted the significance of plasticity, they did not observe its application to instructional approaches (Hardiman et al., 2011). However, many instructors nowadays agree that it is fundamental to comprehend the neural foundation of cognition, behavior, and learning (Serpati & Loughan, 2012). Moreover, non-invasive brain imaging modalities such as magnetoencephalography (MEG), structural and functional magnetic resonance imaging (MRI), electroencephalography (EEG), and near-infrared spectroscopy (NIRS) have recently been widely available. As a result, measurements have been taken to establish which brain areas are involved in school-taught abilities (like math and reading) together with more broad cognitive abilities (like working memory), and how their neural correlates vary as children learn and develop. It has been demonstrated that all these alterations could be seen in both brain functioning and anatomy (Ansari et al., 2012; Hardiman et al., 2011).

In this study, we sought to analyze the impacts of gender, age, and socioeconomic status (SES) on the findings of students' emotions as well as cognition, focusing on potential brain-related regions, without optimism. Moreover, hypotheses on the influence of this training course on neuroplasticity are also discussed.

2. A brief outline of the P4C method

The P4C program focuses on educating youngsters on the skills of questioning, reasoning, creating arguments, and collaborating with others (Trickey & Topping *, 2004). P4C is a learning-to-think approach developed by American philosopher Matthew Lipman in the early 1970s (Vansieleghem & Kennedy, 2011). Lipman claimed that involving youngsters in philosophical debates might help them improve their thinking skills. He argues that by merging children's innate curiosity and willingness to learn about the world with philosophy, they may become more adaptable as well as effective thoughtful persons (Trickey & Topping *, 2004).

Alternative materials have also emerged since Lipman's original materials. For example, Fisher (1996) and Cleghorn (2002) published a series of resources in the United Kingdom and Scotland, respectively (Cleghorn, 2002; Fisher, 1996). Various types of resources are now available in several languages. It should be noted that methods such as "Philosophy with Children" (PwC) are sometimes cited alongside the "Philosophy for Children" method. These methods, however, are not exactly the same as the "Philosophy for Children" (Naji & Hashim, 2017). To be accurate, this study reviewed only research with the designation "Philosophy for Children," not similar methodologies.

Mostly, the P4C approach would be for children aged 4 to 18 years: (a) From the ages 4 to 12, acquire fundamental thinking abilities, and (b) from the age of 12 onwards, apply such skills to ethical, aesthetic, and societal issues (Garcia Moriyon et al., 2005). This program is made up of clearly structured philosophical novels with associated teaching manuals, each aimed at a particular age range. In each story, children and teenagers converse on the philosophical aspects of their lives (Lipman, 1988) and include a wide range of follow-up tasks, games, and discussion plans (Murris, 2016; Trickey & Topping *, 2004).

Generally, P4C engages students in the development and investigation of issues, as well as the potential solutions to address. Throughout this educational approach, the facilitator and the pupils are regarded as co-participants. The facilitator offers a stimulus (for example, a tale, a poem, a painting, or a sketch) to start a P4C session. The students are asked to create some philosophical questions after having time to ponder on this stimulation. Philosophical questions can be "What is fair?" " What qualities distinguish someone as a best friend?" and "What exactly does being good entail?" or other similar ones. To create a favorable environment for the development of thinking skills, facilitators should consider things like establishing general principles beforehand, paying respect to each student's perspective, attempting to apply non-threatening assignments, embracing individual diversity, and enabling children to communicate actively (Gur, 2011). The goals of this educational method are attempted to be achieved in this process, including facilitating knowledge acquisition, empowering students to make decisions on their own, enhancing reasoning ability, improving critical thinking, developing creativity, bracing ethical values, and raising self-awareness (Lipman, 1981; Marashi, 2008).

The program is meant to engage students in exploring the philosophical elements of their own experiences, with a focus on logical, ethical, and aesthetic components. These constitutions of philosophy are linked to thinking types, which include critical (logic), caring (ethical), and creative (aesthetic) thinking (Garcia Moriyon et al., 2005). Critical, creative, and caring thinking, are divided into two categories: cognitive and affective weighted. While critical and creative types of thinking are mostly cognitive, caring thinking is primarily affective (Bacanlı et al., 2011). Although these three types of thinking (critical, caring, and creative) are regarded as the three important "C" in P4C, some refer to collaborative thinking as the fourth "C" (Topping et al., 2019). However, in this study, we will review the three main types. It is also worth noting that P4C emphasizes the integration of all of these three types of thinking; the separation of thinking types and their related brain regions in the following text is only for discussion purposes.

3. Main sets of thinking involved in P4C

3.1. Critical thinking

Numerous studies have shown that P4C promotes critical thinking (Daniel & Auriac, 2011; Falah Mehnehj et al., 2020; Işıklar, 2022; karadağ & Yıldız Demirtaş, 2018; Lomaca & Chiado, 2019; Marashi, 2008; Naseri et al., 2017; Rahdar et al., 2018; Wu, 2021; Yan et al., 2018; Zulkifli & Hashim, 2020). For instance, in 2020, Falah Mehneh et al. reported that applying the P4C method decreased negative metacognitive and irrational beliefs (Falah Mehnehj et al., 2020). But what precisely is critical thinking? Critical thinking, known as reflective thinking by certain authors, is defined as focused, reasoned, and purposeful. Critical thinking is a broad term with several definitions (Lai, 2011), but the most general definition is “analysis of facts to form a judgment”. “Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action. In its exemplary form, it is based on universal intellectual values that transcend subject matter divisions: clarity, accuracy, precision, consistency, relevance, sound evidence, good reasons, depth, breadth, and fairness." as stated by Michael Scriven and Richard Paul at the 8th Annual International Conference on Critical Thinking and Education Reform in Summer 1987 (Michael Scriven, 1987).

Brain areas related to critical thinking:

It might have been claimed that the majority of the neurological basis of critical thinking combines the neural foundations of the prefrontal cortex (PFC) (Sanz de Acedo Lizarraga et al., 2012). The PFC is well recognized for its roles in executive functions such as working memory, attention, sensory organization, reasoning, planning, goal-directed behavior coordination, and language processing (Davidson et al., 2006; Jurado & Rosselli, 2007; Miller, 2001; Miller & Cohen, 2001; Moriguchi & Hiraki, 2013; Uytun, 2018). The dorsolateral prefrontal cortex (dlPFC) follows the hippocampus and retrieves information (declarative memory) along with the memories it contains (episodic memory). Results suggest a critical function for the dlPFC in updating established memories, most likely through interplay with the hippocampus. DlPFC function is to create and regulate higher-level processes like creativity, problem-solving, and decision-making, rather than to transform direct stimuli (Kirsch et al., 2006; Kluen et al., 2019; Lang et al., 2006; Luna et al., 2010; Stuss & Alexander, 2000). The ventromedial PFC, the socioemotional cortex, is associated with the limbic system (LeDoux, 1996) and seems to be concerned with decision-making, reasoning, and resolving conflicts. However, it should be noted that the indicated relationships between these structures and the psychological processes must be interpreted with caution, as it appears that it is a widely accepted truth among neuroscientists that all critical thinking skills include numerous brain areas (Sanz de Acedo Lizarraga et al., 2012).

In the process of neuroplasticity, the PFC is one of the cortical structures that takes the longest to mature (Arain et al., 2013). This process continues in the PFC region into the third decade of life, but not in all parts of the frontal cortex (Arain et al., 2013). Many functional MRI (fMRI) studies have found that in school-aged children and adolescents, the relevant areas in the PFC exhibit age-related increases in activity as they mature (Kwon et al., 2002; Rubia et al., 2006; Tamm et al., 2002). The connections in this area become stronger each time a route is triggered by studying or applying the knowledge (Kennedy, 2013; Owens & Tanner, 2017). The development of executive functions is influenced by the improvement of these networks throughout the age of preschool (Best & Miller, 2010).

3.2. Creative thinking

Creative thinking is one type of thinking that can be defined as “observing the same and thinking various”, “the capacity to resolve aesthetic difficulties”, “collecting the problems which were not put together in the past”, “being sensitive to difficulties, concerns, lack of information, parts of the missing, non-compliance and recognize challenges, explore solutions and to make estimations” and “bringing unique answers to the daily difficulties” (Bacanlı et al., 2011). So, people who study the arts aren't the only ones who have creative minds, all prospective professions and circumstances need innovative thinking (Koontz, 2019).

Guilford, the researcher who coined the modern meaning of "creativity," differentiates two types of creative thinking: convergent and divergent thinking (Cropley, 2006). Convergent thinking is based on awareness of what is already known. Divergent thinking, on the other hand, is generating several or alternative responses from given evidence. It necessitates the creation of unexpected combinations, the identification of relationships among distant associates, and the transformation of data into unexpected forms (Cropley, 2006).

Brain areas related to creative thinking:

Creativity is one of the most important and complex human processes, and it causes sophisticated areas of the brain to operate together; including the hippocampus (Beaty, 2020), the frontal cortex (Fink et al., 2009), the parietal lobe (Fink et al., 2009), and the basal ganglia (Cavdarbasha & Kurczek, 2017). The hippocampus is critical for piecing together elements of experiences—people, locations, things, and actions—to both flawlessly recreate former experiences and to create prospective future occurrences. The hippocampus is also fundamental in not only remembering but also imagining the future (Beaty, 2020).

Also, Fink et al. (Fink et al., 2009) reported increased activity in the frontal cortex (the left hemisphere) and parietal lobes while coming up with innovative thoughts. In general, creative thinking refers to the ability to deviate from well-established conventional concepts in novel and unpredictable contexts and develop alternate notions. In this perspective, creativity seems to be a type of adaptation or problem-solving (Runco, 2004; Sternberg, 2006). According to this theoretical perspective, creativity is based on critical cognitive functions including attention (Posner, 1994; Sarter et al., 2001), cognitive flexibility (Lhermitte, 1983; Lhermitte et al., 1986), abstract thinking (Rylander, 1948), planning (Norman & Shallice, 1986; Shallice & Burgess, 1991), and working memory (Baddeley, 1996; Fuster, 2000; Goldman-Rakic, 1992) which are largely dependent on the integrity of the PFC (Dietrich, 2004). In creative activities such as brainstorming and daydreaming, imagination is critical (Koontz, 2019). The posterior medial cortex (primarily the posterior cingulate cortex (PCC) and parts of the precuneus), the medial prefrontal cortex (mPFC), the bilateral inferior parietal lobule (IPL), which expands to the posterior temporal region located near the temporoparietal junction (TPJ), the lateral temporal cortex (LTC) extending toward the temporal pole (TP), and the hippocampus and its adjacent areas in the medial temporal lobe (MTL) are typically recognized as significant regions could be involved in imagination (Andrews-Hanna et al., 2010; Buckner et al., 2008; Shulman et al., 1997). The last region is the basal ganglia involved in creativity as they interact between affective, cognitive, and motivational functions (Greenberg, 2002). Also, many studies have been conducted to thoroughly study the brain regions associated with convergent thinking and divergent thinking (Razoumnikova, 2000; Takeuchi et al., 2020).

3.3. Caring thinking

Caring can be considered a cognitive process that causes individuals to appreciate things (Shaari & Aswati, 2018). Caring thinking involves passionate, forceful reasoning, attention to oneself and others, as well as letting go of the claims' conclusiveness regarding various issues. This entails collaborating with others and delegating duties rather than making choices for others (Ghaedi, 2016). We can highlight two principles in caring thinking: understanding what we think and understanding how we think. If we want to categorize caring thought, there are five types: appreciative, emotional, active, normative, and empathic (Ghaedi, 2016). According to Lipman's perspective on caring thinking (2003), encouraging individuals to develop their sense of humanism is effective teaching and learning guidance (Lipman, 2003; Shaari & Aswati, 2018). "To care is to focus on that which we respect, to appreciate its worth, to value its value ". To improve the appropriate and wise manner of teaching, we must prioritize caring as much as creativity and critical thinking. Lipman emphasized the importance of considering the transactivity and interdependence of multidimensional thinking (critical, creative, and caring) in teaching since their integration leads to an equilibrium among emotional and cognitive capacities, mental and physical aspects, perceptual and conceptual processes, and commandments and non-commandment processes (Lipman, 2003).

Empathy as one of the most discussed subtitles of caring thinking is described as a fundamental capacity to recognize and react to the emotional feelings of another, as well as the desire to care for their well-being (Decety & Lamm, 2006; Singer & Lamm, 2009). The concept of empathy is classified into three categories: Emotional empathy/affective empathy, empathic concern (having the drive to care for the well-being of others), and cognitive empathy. Emotional empathy is the capacity to experience another person's feelings, and cognitive empathy is the capacity to comprehend others' points of view (Salavera et al., 2021).

Brain areas related to caring thinking:

Direct research in the field of brain regions associated with caring thinking is limited. Among all characteristics, empathy is the most researched feature. Empathy is controlled by a network of brain regions including the brainstem, hypothalamus, amygdala, insula, striatum, orbitofrontal cortex, and anterior cingulate cortex (ACC), in addition to the autonomic nervous system and neuroendocrine/hormones (Decety, 2015). Reviewing a great deal of research using different methods such as neuroimaging (fMRI and PET), electrophysiological (ERP), and lesion studies, Light et al. specified the role of the dorsolateral and frontopolar regions of the PFC in empathy (Light et al., 2009). According to Ruby and Decety (Ruby & Decety, 2004), and Singer et al. (Singer et al., 2004), increased activity is observed in the frontopolar cortex and lateral PFC in an empathic process. Interestingly, empathic concern responding is identified in newborns as young as 6-8 months old and continues as they grow older (Decety, 2015). Therefore, considering evidence of affective empathy at early ages, it appears that the regions associated with empathy may be modified from very young ages, and various contexts and training in these ages may represent significant changes in the related type of thinking at older ages.

4. P4C and Gender

According to Topping's study, the P4C approach resulted in significant improvements in verbal cognition as well as gains in nonverbal and quantitative reasoning abilities that were consistent across schools and mainly independent of the child's gender or ability (Topping & Trickey, 2007).

P4C has been shown to increase moral, social, emotional, and intellectual aspects of thinking (Fisher, 2013; Zulkifli & Hashim, 2020), educational achievement (Gorard et al., 2017a; Leng, 2020a), cognitive ability (Topping & Trickey, 2008; Topping & Trickey, 2007), and reduce anxiety (Malboeuf-Hurtubise et al., 2021) and neglection in both boys and girls, with no significant noted differences. However, a study reported that P4C can improve girls' social and emotional dimensions more than boys' (Mehta & Whitebread, 2004).

On the other hand, many studies have been conducted on critical, creative, and caring thinking. For instance, some studies demonstrated that girls outperformed boys in some of the critical thinking-related skills (Walsh & Hardy, 1999). In contrast, other findings indicate that boys perform better (Bataineh & Zghoul, 2006). Some researchers claim that gender has no statistically significant impact on creative thinking (Agarwal & Kumari, 1982; Bromley, 1956). However, other research confirmed gender differences. On the whole, gender differences in creativity are suggested to be a function of social, cultural, and environmental factors (Ai, 1999; Romo, 2018). These differences can result from gender stereotypes in some abilities such as mechanical ability and sports strategy or be consequences of different amounts of social support given to each gender (Baer & Kaufman, 2008; Kaufman, 2006). It is also proposed that these gender differences can be associated with various barriers perceived by each gender (Morais & Almeida, 2019), as well as genetic factors (Nakano et al., 2021; Vernon, 1989). Well-known gender stereotypes have a major impact on self-perceptions of creativity (Baer & Kaufman, 2008). On the other hand, there has not been much research on the interaction between caring thinking and gender. However, gender differences in subfields of caring thinking range from little evidence of gender changes in empathy in individuals experiencing personal distress to the dominance of girls' reactivity over boys' in sympathetic responses according to the type of indirect emotion evaluated (Eisenberg & Strayer, 1990).

Gender: A neuroscience perspective

Gender variations in different brain regions may explain certain disparities in behavior, cognition, disease risk, and even disease outcomes between girls and boys (Ruigrok et al., 2014). Sex differences cause variations in the development processes of some brain areas, notably the PFC, amygdala, and striatum, which are involved in controlling and performing motivated behavior (Hammerslag & Gulley, 2016). According to the gender variations in the development of the amygdala, boys have shown a greater peak volume than girls, although boys peak later in puberty (Goddings et al., 2013). However, throughout adolescence, boys and girls may not vary in total amygdala volume (Blanton et al., 2010). As previously stated, a longitudinal large-scale study showed a linear association between the volume of white matter and age. According to these changes, girls showed a lower rate of volume increase than boys. Changes in cortical gray matter volume, on the other hand, demonstrated a gender and regionally-specific pattern. Gray matter in the frontal and parietal lobes attained a maximum size at the ages of 12.1 and 11.8 years old, respectively, 13 and 18 months later in men, followed by a decrease during post-adolescence. The maximum volume in the temporal-lobe gray matter changes curve for boys is estimated to be approximately 16.5 years and 16.7 years for girls, with a modest decrease after that. Unlike other regions, changes in grey matter in the occipital lobe showed a linear trend throughout the age period, with no signs of substantial decline (Giedd et al., 1999).

Although the absolute volume of cortical gray matter was roughly 10% greater in boys, it peaked marginally sooner in girls, matching with an earlier age of puberty initiation, which implies a probable role of gonadal hormones. Interestingly, the curve patterns of the volume-age chart did not vary significantly between boys and girls (Giedd et al., 1999). Some other studies have also reported these gender variations in cortical remodeling in adolescence (Hammerslag & Gulley, 2016). They reported that the overall pattern of cortical development shows that boys matured latterly and generally have larger volume, thickness, and surface area, although this is not entirely correct in all areas (Raznahan et al., 2014).

Some studies have more locally addressed gender differences in different brain regions. According to Raznahan et al., girls had faster thinning in the right orbitofrontal cortex, which is associated with decision-making. Meanwhile, boys have a focal delay in the maturation of frontal basal and dorsolateral subregions that are critical for inhibitory control and impulsivity, in comparison to girls (Raznahan et al., 2010).

In a cross-sectional study with 118 boy and girl healthy children and adolescents, boys displayed faster development rates according to the size of the corpus callosum (De Bellis et al., 2001). Altogether, since no statistically significant age-by-gender interactions were found, it was assumed that the age-related decline in boys and girls is similar (Koikkalainen et al., 2007).

Based on the majority of the previously mentioned studies, it appears that gender has no characterized effect on the outcomes of this education system. Nonetheless, some studies have indicated that girls outgrow boys in terms of socioemotional functioning and caring thinking.

Changes in the amygdala or prefrontal cortex, two brain regions associated with empathy and socioemotional characteristics, may be the basis of these outcomes. All in all, given the delicate correlation between age and gender, as well as biological variations between the sexes, applying this approach considering gender differences at different ages can contribute to making this method as effective as possible.

5. P4C and Age

While reviewing papers on P4C, we noticed that most of the articles, which were also mentioned in different previous sections, focused on children in elementary school, with far less research focusing on upper secondary school students. According to Fair et al. (Fair et al., 2015), the results of their replicated study on the impacts of the P4C program revealed a substantial difference in the beneficial effects of cognitive abilities obtained between 7th and 8th-grade primary pupils. Contrary to the 7th-grade experimental group students, who showed substantial progress when compared to students in the 7th-grade control group, the 8th-grade experimental group students did not demonstrate comparable improvements when compared to students in the eighth-grade control group. However, they justified this apparent difference in the number of P4C program sessions attended by each group. Altogether, it seems that both the age and duration of the program attendance should be evaluated independently.

Giménez-Dasí et al. (Giménez-Dasí et al., 2013) enrolled 60 children aged 4 to 5 in a 9-month P4C program to enhance social skills and emotional comprehension throughout early childhood. Unlike 5-year-old children, who improved in both emotion comprehension and social skills, 4-year-olds improved solely in social skills related to implicit knowledge.

Friend and Zubek (Friend & Zubek, 1958), empirically demonstrated a dynamic rise in critical thinking capacity from late childhood to the mid-20s, followed by a steady drop into the seventies.

Diverse studies have revealed various results of creative thinking changes at different ages as dealing with different aspects of this type of thinking. A life-span developmental study demonstrated age-related reductions in thought flexibility and response quantity (fluency), but no change in response quality (originality) in divergent thinking tasks (Jaquish & Ripple, 1985). Roskos-Evoldsen et al. (Roskos-Ewoldsen et al., 2008) used the Creative Invention Task (CIT) and the Torrance Tests of Creative Thinking (TTCT) to study age-related differences in creative thinking and reported age-related differences, particularly in the CIT. However, the differences were mostly caused by variations in the working memory performance. After accounting for working memory, they confirm the equivalency in originality among younger and older participants, on both distinct TTCT and the CIT tests (Roskos-Ewoldsen et al., 2008).

Age: A neuroscience perspective

Age-related brain changes may be effective in developing diverse outcomes through the P4C program, and vice versa. In terms of volume, at birth, the human brain has generally grown to 25% of its mature size (Huelke, 1998; Stuart & Stevenson, 1959). In the first five years following birth, the brain expands rapidly, reaching about 80 percent of adult size by the age of two, and approximately 90 percent by the age of five (Huelke, 1998; Kennedy et al., 2002). Also, analyzing the brain MRI of 116 healthy individuals suggested that the size of the brain peaks in early adolescence and subsequently diminishes (Courchesne et al., 2000). Following that, the total brain size does not expand considerably, but the connections or synapses between neurons continue to develop, generating a complex network of neural pathways (Graham). Interestingly, pruning also takes place as synapse development progresses (Kolb & Gibb, 2011). The human brain undergoes substantial synaptic pruning in childhood, continuing to lose nearly 50 percent of its synapses by puberty (Chechik et al., 1999). Of course, the synaptic pruning timetable varies based on the regions. As in the visual and auditory perception-related areas of the brain, pruning is completed between the ages of four and six years old. In comparison, through adolescence, pruning occurs in regions connected to higher cognitive functions (like inhibitory control and emotion regulation) (Tierney & Nelson, 2009). So, appropriately modifying synapses (removing the weaker synapses) is necessary to preserve function when synapses are being removed (Chechik et al., 1999).

Exclusively cross-sectional pediatric neuroimaging studies had demonstrated linear declines in the cortical gray matter while white matter increased between the ages of 4 and 20 (Caviness Jr et al., 1996; Giedd et al., 1996; Jernigan et al., 1991; Pfefferbaum et al., 1994; Reiss et al., 1996). However, a longitudinal MRI study reported nonlinear alterations in regionally localized cortical gray matter that increased before preadolescence and decreased after preadolescence. They stated that the curves of cortical gray matter alterations for the peak of the frontal and parietal lobe around age 12 and the temporal lobe peak around age 16 (Giedd et al., 1999). In 2004, evidence from Sowell et al.'s study verified age-related thickness rises of gray matter in not only the frontal language regions (i.e., Broca's area on the left) but also the temporoparietal cortex (Wernicke's area on the left). Additionally, they reported gray matter thinning in the right frontal. They also noted gray matter thinning in the bilateral parietal, and occipital correlation cortices (Sowell et al., 2004).

A cohort research on age-related alterations of the human brain (4–18 years) reported a linear rise of the relative volume of the left hippocampus and hippocampal region CA1 with age, but no differences in the right hippocampus relative volume were found (Sussman et al., 2016). According to Dennison et al., adolescent girls (12–18 years old) have a greater decline in the caudate, putamen, and thalamus volume than boys (Dennison et al., 2013).

As well, in 2000, Thompson et al. reported a rostrocaudal wave of peak growth rates in the corpus callosum. They found that neural structure involved in language function and associative thinking expanded faster than nearby areas both before and throughout puberty (6-13 years), while expansion thereafter slowed (11-15 years), coinciding with the final point of a well-established substantial time for language learning (Thompson et al., 2000). Entirely, the relative volumes of many subcortical subregions show inverted U-shaped patterns that reached their peak around the age of 12 years (Sussman et al., 2016).

In light of the age-related changes in the cortical and subcortical areas, it's been suggested that many of the regions that have been previously matured in childhood take part in fundamental sensorimotor processing, which is essential for the later development of cognitive processes (Luna et al., 2004; Simmonds et al., 2014). Most of the other regions that mature in adolescence are involved in motor response and executive functions such as language, spatial attention, and working memory. It is in line with other findings indicating that cognitive and executive functions continue to grow into adolescence (Bedard et al., 2002; Luna et al., 2004; Simmonds et al., 2014; Williams et al., 1999). According to the delayed maturation of some regions of intracortical white matter, as mentioned before, the development of basal ganglia regional termination zones proceeded throughout adulthood, forming loops with the cortex and serving as a major relay in the cognitive and affective process (Middleton & Strick, 2000). The prolonged development of these regions may verify the required wide cortical-subcortical connections for the integration of cognition and emotion (Simmonds et al., 2014).

Neurobiology of P4C implications in the neuroplasticity process

Considering that the P4C-related courses are age-appropriate, it is hypothesized that age-related changes in brain structures may play a significant role in developing varied outcomes by employing this teaching technique at different ages. Education and experience can modify neural structure and function, which is a definition of neuroplasticity, and vice versa (Johnston et al., 2001; Mundkur, 2005). As a result, in the field of neuroeducation, one of the most critical aspects of an educational approach is the amount and way in which it interacts with neuroplasticity.

Throughout one's personal life, the developing brain is exposed to a variety of factors and is capable of remarkable plasticity changes that have behavioral consequences. Among these influences are early experiences in motor, sensory, and language as well as caregiver interactions and peer relationships (Kolb et al., 2017). Indeed, neuroplasticity is at its highest level in the first few years of life, and it declines as one gets older (Mundkur, 2005).

A systematic review concluded that experience-dependent interventions related to various environmental experiences (sensory-motor training (i.e. music or motor-based training) or cognitive-based (i.e. academic and behavioral intervention, or social skills training)) result in functional and structural neuroplastic changes in the human brain in children and adolescents. (Weyandt et al., 2020). Human training studies have revealed MRI alterations that could be induced by alterations in axonal growth and myelination, as well as changes in synapses and astrocytes (Tymofiyeva & Gaschler, 2020). Indeed, cognitive changes in children and adolescents have been reported to be closely associated with neuroplastic alterations, including changes in neural connectivity, changes in neuronal activity in various regions, and enhanced cortical thickness in functionally relevant cognitive skill areas (Everts et al., 2017; Iuculano et al., 2015; Maximo et al., 2017; Meyler et al., 2008; Romeo et al., 2018). P4C, an educational approach that develops cognitive capacities, seems to be effective in improving brain neuroplasticity in children and adolescents. Furthermore, it may ameliorate the cognitive consequences of early-life adversities. Early-life social adversities are some unfavorable experiences that appear to be relevant in reducing the volume of the hippocampus and PFC in adolescence and resulting in the precocial creation of redundant, immature synapses by delaying the initiation of synaptic pruning (Miskolczi et al., 2019). Considering that brain circuits governing cognition and social behavior are highly plastic during early life, evidence suggests that adversity in childhood may influence the expression of this mediator (Miskolczi et al., 2019).

Remarkably, there are specific times when learning and experiences have the greatest impact on the brain. If the exposure to these experiences does not occur during this time frame, a similar experience will have a reduced or sometimes no effect on making significant alterations in neural connections. For example, the period of the first 6 years of life is crucial for natural language learning; beyond that, the intrinsic capacity to learn language decreases progressively, and after 12 years, it slows considerably (Mundkur, 2005). As P4C is an educational program aimed at children and adolescents that impacts brain neuroplasticity, it may work in tandem with puberty processes to improve neuroplasticity in brain areas involved in higher-order cognitive functions such as episodic memory and executive functions.

Ultimately, according to the supplied details concerning the neurological changes at different ages, more precise usage of the P4C approach based on age-related educational demands may lead to improved outcomes in future endeavors.

6. P4C and Socioeconomic status

According to research, parental investments in children are among the most substantial parameters in improving children's skills in their early stages of development (Attanasio et al., 2020; List et al., 2018), but it has also been demonstrated that these investments vary depending on SES (Hoff, 2003; Huttenlocher et al., 2010; Kalil, 2015). Generally, some studies indicated that the cognitive performance (including memory and executive functioning (Noble et al., 2007)) of children from high-income households tends to be better than their classmates from lower-income (disadvantaged) families (Farah, 2017). When compared to their higher SES peers, they appear to have worse behavioral performance in the fields of language and social-emotional preparation, with some indicators that point to correlating neural variations (Alexandra Ursache & Kimberly G. Noble, 2016).

Socioeconomic status: A neuroscience perspective

Multiple differences in brain structure have been reported between children from different socioeconomic backgrounds. Left hemisphere regions (such as the left inferior frontal gyrus, left superior temporal gyrus, and left fusiform (language-associated regions)) (Jednoróg et al., 2012; Noble et al., 2015; Noble et al., 2012), the hippocampus (memory-associated region) (Raffington et al., 2019), the PFC (executive function related cortex) (Noble et al., 2015), and the amygdala (socioemotional processing related region) (Luby et al., 2013) are among these different brain structures. Furthermore, Ursache et al. (A. Ursache & K. G. Noble, 2016) have reported that worse cognitive flexibility in children from low-income backgrounds is associated with their lower white matter volume or fractional anisotropy. However, Jednoro'g et al. found no meaningful correlation between SES and white matter design (Jednoróg et al., 2012). Additionally, several studies have found that children and teenagers from higher socioeconomic backgrounds possess cortexes that are thicker than those from less affluent backgrounds. (Alnæs et al., 2020; Lawson et al., 2013; Leonard et al., 2019; Mackey et al., 2015).

In addition, age-related changes in the association between SES and cortical thickness have been stated in studies. According to some studies, SES in young individuals aged 3-20 years modulates the negative interaction between age and cortical thickness in developmental stages. These findings reveal that compared to young individuals from higher SES, youth from lower SES undergo a more dramatic curvilinear decline in cortical thickness earlier in life (Khundrakpam et al., 2019; Piccolo et al., 2016). In contrast, two recent studies examined youth aged 5-25 years (McDermott et al., 2019) and 14-19 years (Judd et al., 2020) and found no SES-directed associations in the connection between age and cortical thickness.

Particularly, poorer memory performance and smaller hippocampus volume have been reported in associated with lower family wealth in middle childhood, and these correlations have been demonstrated to be steady over time (Raffington et al., 2019). Also, individuals with low SES have been reported to be less likely to retain executive network activity from early to late age compared to those with high SES; yet, there is a greater possibility of improved activity in their reward-related areas. Gray matter volume also showed similar activity. Moreover, the meta-analysis findings back up the theory of fronto-parietal/cinguloopercular executive network hypoactivity and right caudate nucleus hyperactivity throughout as well as the function of age among children from disadvantaged families (Yaple & Yu, 2019).

Backing to P4C, a few papers acknowledged the role of SES in P4C program efficacy. Concerning cognitive abilities, Gorard (2017) reported that while disadvantaged students got fewer gains from P4C in general, they improved more in math, reading, and writing than advantaged pupils. More than three thousand pupils participated in this study at the outset, which is considerable (Gorard et al., 2017a). In another more than 2700 pupils participated study, Siddiqui showed that disadvantaged P4C students outperform their peers in terms of self-confidence, empathy, sociability and communication, collaboration and resiliency, and social responsibility (Siddiqui et al., 2019). They also presented a modest advantage in terms of happiness, self-reported resiliency, and not being afraid to try new things. In this study, the first survey was done for the P4C group and was conducted 6 months later for the control. So, the P4C group was, on average, 6 months younger than the control pupils at the time of the first survey. Although for the second survey, both groups were the same age, this six-month age difference may be critical for the outcomes. Therefore, there is room for discussion considering children's brain development, especially at around this age. In a study examining the effectiveness of the P4C on critical thinking skills of preschool children (5 and 6 years old), it has been shown that after the P4C intervention, the private school students scored better in terms of "Question Formation", "Language and Cognitive Skills" and "General Total" than the state school students. It might be due to the differences in the SES between these two groups (karadağ & Yıldız Demirtaş, 2018).

A meta-analysis study has shown that there is no significant diversity in the effectiveness of P4C on pupils' cognitive outcomes between the two groups of high/low SES pupils (Yan et al., 2018). This article has examined research published from 2002 to 2016 and the data is apparently not sufficient to reach this conclusion. Altogether, according to two other recently discussed studies with large sample sizes, it seems that there is an association between P4C and SES.

It appears that advantaged pupils have improved more than disadvantaged pupils in a short period since the beginning of the classes but in a long period, disadvantaged pupils on average have improved more than advantaged pupils and this hypothesis should be investigated.

Financial costs for the P4C program are one of the problems that prevent more research from being done on this factor.

7. Conclusion, Limitations, and Future Directions

P4C is one of the contemporary educational strategies that, according to data, has a considerable influence on children's cognition, emotion, and abilities. This educational program, just like every other, has some advantages and also limitations (Colom et al., 2014). What is evident is that more research is required to investigate the more detailed effects of this program. However, reviewing the findings of previous studies suggests that the majority of the effects of this program are at least in part due to some effects on the nervous system. The adoption of different educational programs for different ages, which can affect neuroplasticity, or the presence of different types of thinking, each of which engages distinct parts of the brain, also validates this idea (Torrijos-Muelas et al., 2021).

Here, we attempted to evaluate the influence of the P4C educational approach in various situations and groups. According to most of the studies mentioned above, it seems that gender does not have a significant impact on the results of this educational method. However, some studies have shown that caring thinking and socioemotional dimensions progress more in girls than boys. This result can be due to changes in brain areas related to empathy and socioemotional features such as the amygdala or prefrontal cortex.

Additionally, due to a scarcity of research explicitly focusing on the effects of children's age on P4C, we seem to be unable to verify any noteworthy effects of children's age on P4C outcomes. It should be noted that the outcomes cannot be regarded as age-independent since age is taken into account in the instructional content of this program. Furthermore, due to the prominence of neuroplasticity in the aforementioned ages, an attempt was made to assess the degree of concordance of this educational program with critical ages in neuroplasticity as much as achievable. Given the significant changes in the function and structure of many areas of the brain at school age, it appears that training programs adapted to these changes can significantly boost educational outcomes.

From a socioeconomic point of view, P4C seems to have diverse effects on children depending on their SES. In each of these categories of SES, certain factors seem to improve more significantly than others, although a strict conclusion cannot be drawn yet because of the limited studies.

Here, it should be mentioned that along with all the promising findings about P4C educational method, there are also challenges and limitations for both pupils and educators that should be resolved and improved. In implementing P4C, pupils might face challenges like a lack of interpersonal skills (Leng, 2020b) and insufficient knowledge (Cassidy & Heron, 2020). Also, educators may encounter obstacles including classroom management (Gorard et al., 2017b; Rahdar et al., 2018; Siddiqui et al., 2019), optional methods (Gorard et al., 2017b; Siddiqui et al., 2019), and a shortage of ideas (Gorard et al., 2017b). P4C-related challenges have been discussed in length in some papers, and more exploration could be the focus of future research (Ab Wahab et al., 2022; Farahani, 2014).

Finally, the impacts of gender, age, and economic condition all appear to combine to affect the outcomes of P4C. Although there is evidence that this educational method influences several mental and behavioral features of children, more extensive studies, concentrating on socioeconomic status, age, and gender, can evaluate the accurate efficacy of P4C. The intention must be to develop a common language between neuroscientists, educational researchers, and educators; so that research directions might well be developed and turned into practical instructional applications (Ansari et al., 2012). It is stated that by describing different types of translation and applying a levels-of-organization framework, research and practice may be contextualized and steered more effectively (Horvath & Donoghue, 2016). It is important to note that establishing hypotheses about learning in everyday situations necessitates merging neuroscience knowledge with insights from other fields (Jolles & Jolles, 2021).

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References:

Ab Wahab, M. K., Zulkifli, H., & Abdul Razak, K. (2022). Impact of Philosophy for Children and Its Challenges: A Systematic Review. *Children (Basel)*, *9*(11). https://doi.org/10.3390/children9111671

Agarwal, S., & Kumari, S. (1982). A correlational study of risk-taking and creativity with special reference to sex differences. *Indian Educational Review*, *17*(3), 104-110.

Ai, X. (1999). Creativity and Academic Achievement: An Investigation of Gender Differences. *Creativity Research Journal*, *12*(4), 329-337. https://doi.org/10.1207/s15326934crj1204_11

Alnæs, D., Kaufmann, T., Marquand, A. F., Smith, S. M., & Westlye, L. T. (2020). Patterns of sociocognitive stratification and perinatal risk in the child brain. *Proceedings of the National Academy of Sciences*, *117*(22), 12419-12427. https://doi.org/doi:10.1073/pnas.2001517117

Andrews-Hanna, J. R., Reidler, J. S., Sepulcre, J., Poulin, R., & Buckner, R. L. (2010). Functional-anatomic fractionation of the brain's default network. *Neuron*, *65*(4), 550-562. https://doi.org/10.1016/j.neuron.2010.02.005

Ansari, D., De Smedt, B., & Grabner, R. H. (2012). Neuroeducation – A Critical Overview of An Emerging Field. *Neuroethics*, *5*(2), 105-117. https://doi.org/10.1007/s12152-011-9119-3

Arain, M., Haque, M., Johal, L., Mathur, P., Nel, W., Rais, A., Sandhu, R., & Sharma, S. (2013). Maturation of the adolescent brain. *Neuropsychiatric disease and treatment*, *9*, 449-461. https://doi.org/10.2147/NDT.S39776

Attanasio, O., Cattan, S., Fitzsimons, E., Meghir, C., & Rubio-Codina, M. (2020). Estimating the Production Function for Human Capital: Results from a Randomized Controlled Trial in Colombia. *American Economic Review*, *110*(1), 48-85. https://doi.org/10.1257/aer.20150183

Bacanlı, H., Dombaycı, M. A., Demir, M., & Tarhan, S. (2011). Quadruple Thinking: Creative Thinking. *Procedia - Social and Behavioral Sciences*, *12*, 536-544. https://doi.org/10.1016/j.sbspro.2011.02.065

Baddeley, A. (1996). Exploring the Central Executive. *The Quarterly Journal of Experimental Psychology Section A*, *49*(1), 5-28. https://doi.org/10.1080/713755608

Baer, J., & Kaufman, J. C. (2008). Gender Differences in Creativity. *The Journal of Creative Behavior*, *42*(2), 75-105. https://doi.org/10.1002/j.2162-6057.2008.tb01289.x

Baker, D. P., Eslinger, P. J., Benavides, M., Peters, E., Dieckmann, N. F., & Leon, J. (2015). The cognitive impact of the education revolution: A possible cause of the Flynn Effect on population IQ. *Intelligence*, *49*, 144-158. https://doi.org/10.1016/j.intell.2015.01.003

Bataineh, R. F., & Zghoul, L. H. (2006). Jordanian TEFL Graduate Students' Use of Critical Thinking Skills (as Measured by the Cornell Critical Thinking Test, Level Z). *International Journal of Bilingual Education and Bilingualism*, *9*(1), 33-50. https://doi.org/10.1080/13670050608668629

Beaty, R. E. (2020). The Creative Brain. *Cerebrum : the Dana forum on brain science*, *2020*, cer-02-20.

Bedard, A. C., Nichols, S., Barbosa, J. A., Schachar, R., Logan, G. D., & Tannock, R. (2002). The development of selective inhibitory control across the life span. *Dev Neuropsychol*, *21*(1), 93-111. https://doi.org/10.1207/s15326942dn2101_5

Best, J. R., & Miller, P. H. (2010). A developmental perspective on executive function. *Child development*, *81*(6), 1641-1660. https://doi.org/10.1111/j.1467-8624.2010.01499.x

Blakemore, S. J., & Mills, K. L. (2014). Is adolescence a sensitive period for sociocultural processing? *Annu Rev Psychol*, *65*, 187-207. https://doi.org/10.1146/annurev-psych-010213-115202

Blanton, R., Chaplin, T., & Sinha, R. (2010). Sex differences in the correlation of emotional control and amygdala volumes in adolescents. *Neuroreport*, *21*, 953-957. https://doi.org/10.1097/WNR.0b013e32833e7866

Bromley, D. B. (1956). Some Experimental Tests of the Effect of Age on Creative Intellectual Output*. *Journal of Gerontology*, *11*(1), 74-82. https://doi.org/10.1093/geronj/11.1.74

Buckner, R., Andrews-Hanna, J., & Schacter, D. (2008). The Brain's Default Network. *Annals of the New York Academy of Sciences*, *1124*, 1-38. https://doi.org/10.1196/annals.1440.011

Cassidy, C., & Heron, G. (2020). Breaking into secure: Introducing philosophical discussions to young people in secure accommodation. *Journal of Social Work*, *20*(3), 287-306.

Cavdarbasha, D., & Kurczek, J. (2017). Connecting the Dots: Your Brain and Creativity. *Frontiers for Young Minds*, *5*. https://doi.org/10.3389/frym.2017.00019

Caviness Jr, V., Kennedy, D., Richelme, C., Rademacher, J., & Filipek, P. (1996). The human brain age 7–11 years: a volumetric analysis based on magnetic resonance images. *Cerebral Cortex*, *6*(5), 726-736. https://doi.org/10.1093/cercor/6.5.726

Ceci, S. J. (1991). How much does schooling influence general intelligence and its cognitive components? A reassessment of the evidence. *Developmental psychology*, *27*(5), 703. https://doi.org/10.1037/0012-1649.27.5.703

Chechik, G., Meilijson, I., & Ruppin, E. (1999). Neuronal Regulation: A Mechanism for Synaptic Pruning During Brain Maturation. *Neural Computation*, *11*(8), 2061-2080. https://doi.org/10.1162/089976699300016089

Cleghorn, P. (2002). *Thinking through philosophy*. Educational Printing Services.

Cliffordson, C., & Gustafsson, J.-E. (2008). Effects of age and schooling on intellectual performance: Estimates obtained from analysis of continuous variation in age and length of schooling. *Intelligence*, *36*(2), 143-152. https://doi.org/10.1016/j.intell.2007.03.006

Colom, R., Moriyón, F., Magro, C., & Morilla, E. S. (2014). The Long-term Impact of Philosophy for Children: A Longitudinal Study (Preliminary Results).

Courchesne, E., Chisum, H. J., Townsend, J., Cowles, A., Covington, J., Egaas, B., Harwood, M., Hinds, S., & Press, G. A. (2000). Normal Brain Development and Aging: Quantitative Analysis at in Vivo MR Imaging in Healthy Volunteers. *Radiology*, *216*(3), 672-682. https://doi.org/10.1148/radiology.216.3.r00au37672

Cropley, A. (2006). In Praise of Convergent Thinking. *Creativity Research Journal*, *18*(3), 391-404. https://doi.org/10.1207/s15326934crj1803_13

Daniel, M. F., & Auriac, E. (2011). Philosophy, Critical Thinking and Philosophy for Children. *Educational Philosophy and Theory*, *43*(5), 415-435. https://doi.org/10.1111/j.1469-5812.2008.00483.x

Davidson, M. C., Amso, D., Anderson, L. C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia*, *44*(11), 2037-2078. https://doi.org/10.1016/j.neuropsychologia.2006.02.006

De Bellis, M. D., Keshavan, M. S., Beers, S. R., Hall, J., Frustaci, K., Masalehdan, A., Noll, J., & Boring, A. M. (2001). Sex Differences in Brain Maturation during Childhood and Adolescence. *Cerebral Cortex*, *11*(6), 552-557. https://doi.org/10.1093/cercor/11.6.552

Decety, J. (2015). The neural pathways, development and functions of empathy. *Current Opinion in Behavioral Sciences*, *3*, 1-6. https://doi.org/10.1016/j.cobeha.2014.12.001

Decety, J., & Lamm, C. (2006). Human Empathy Through the Lens of Social Neuroscience. *TheScientificWorldJOURNAL*, *6*, 280363. https://doi.org/10.1100/tsw.2006.221

Dennison, M., Whittle, S., Yücel, M., Vijayakumar, N., Kline, A., Simmons, J., & Allen, N. B. (2013). Mapping subcortical brain maturation during adolescence: evidence of hemisphere- and sex-specific longitudinal changes. *Dev Sci*, *16*(5), 772-791. https://doi.org/10.1111/desc.12057

Dietrich, A. (2004). The cognitive neuroscience of creativity. *Psychonomic Bulletin & Review*, *11*(6), 1011-1026. https://doi.org/10.3758/BF03196731

Eisenberg, N., & Strayer, J. (1990). *Empathy and its development*. CUP Archive.

Everts, R., Mürner-Lavanchy, I., Schroth, G., & Steinlin, M. (2017). Neural change following different memory training approaches in very preterm born children–A pilot study. *Developmental neurorehabilitation*, *20*(1), 14-24. https://doi.org/10.3109/17518423.2015.1027010

Fair, F., Haas, L., Gardosik, C., Johnson, D., Price, D., & Leipnik, O. (2015). Socrates in the schools from Scotland to Texas: Replicating a study on the effects of a Philosophy for Children program. *Journal of Philosophy in Schools*, *2*, pp. 18-37. https://doi.org/10.21913/JPS.v2i1.1100

Falah Mehnehj, T., Yamini, M., & Mahdian, H. (2020). The Effect of Teaching Philosophy on Metacognitive and Irrational Beliefs of Male Students of Elementary School [Case report]. *Journal of Research and Health*, *10*(3), 183-192. https://doi.org/10.32598/jrh.10.3.1642.1

Farah, M. J. (2017). The Neuroscience of Socioeconomic Status: Correlates, Causes, and Consequences. *Neuron*, *96*(1), 56-71. https://doi.org/10.1016/j.neuron.2017.08.034

Farahani, M. F. (2014). The study on challenges of teaching philosophy for children. *Procedia-Social and Behavioral Sciences*, *116*, 2141-2145.

Fink, A., Grabner, R., Benedek, M., Reishofer, G., Hauswirth, V., Fally, M., Neuper, C., Ebner, F., & Neubauer, A. (2009). The Creative Brain: Investigation of Brain Activity During Creative Problem Solving by Means of EEG and fMRI. *Human brain mapping*, *30*, 734-748. https://doi.org/10.1002/hbm.20538

Fisher, R. (1996). *Stories for Thinking*. Nash Pollock.

Fisher, R. (2013). Thinking for life. In *Teaching Thinking : Philosophical Enquiry in the Classroom: 4th Edition* (4 ed., pp. 187-232). Bloomsbury Academic.

Friend, C. M., & Zubek, J. P. (1958). The Effects Of Age On Critical Thinking Ability. *Journal of Gerontology*, *13*(4), 407-413. https://doi.org/10.1093/geronj/13.4.407

Fuster, J. M. (2000). Executive frontal functions. *Experimental Brain Research*, *133*(1), 66-70. https://doi.org/10.1007/s002210000401

Garcia Moriyon, F., Rebollo, I., & Colom, R. (2005). Evaluating Philosophy for Children. *Thinking: The Journal of Philosophy for Children*, *17*, 14-22. https://doi.org/10.5840/thinking20051743

Ghaedi, Y. (2016). *Theoretical Foundations of Philosophy for Children*. Meraat.

Giedd, J. N., Blumenthal, J., Jeffries, N. O., Castellanos, F. X., Liu, H., Zijdenbos, A., Paus, T., Evans, A. C., & Rapoport, J. L. (1999). Brain development during childhood and adolescence: a longitudinal MRI study. *Nature Neuroscience*, *2*(10), 861-863. https://doi.org/10.1038/13158

Giedd, J. N., Snell, J. W., Lange, N., Rajapakse, J. C., Casey, B. J., Kozuch, P. L., Vaituzis, A. C., Vauss, Y. C., Hamburger, S. D., Kaysen, D., & Rapoport, J. L. (1996). Quantitative Magnetic Resonance Imaging of Human Brain Development: Ages 4–18. *Cerebral Cortex*, *6*(4), 551-559. https://doi.org/10.1093/cercor/6.4.551

Giménez-Dasí, M., Quintanilla, L., & Daniel, M.-F. (2013). Improving emotion comprehension and social skills in early childhood through philosophy for children. *childhood & philosophy*, *9*(17), 63-89.

Goddings, A.-L., Mills, K., Clasen, L., Giedd, J., Viner, R., & Blakemore, S.-J. (2013). The influence of puberty on subcortical brain development. *NeuroImage*, *88*. https://doi.org/10.1016/j.neuroimage.2013.09.073

Goldman-Rakic, P. S. (1992). Working memory and the mind. *Scientific American*, *267*(3), 110-117.

Gorard, S., Siddiqui, N., & See, B. H. (2017a). Can 'Philosophy for Children' Improve Primary School Attainment? *Journal of Philosophy of Education*, *51*(1), 5-22. https://doi.org/10.1111/1467-9752.12227

Gorard, S., Siddiqui, N., & See, B. H. (2017b). Can 'Philosophy for Children'improve primary school attainment? *Journal of Philosophy of Education*, *51*(1), 5-22.

Graham, J. *Children and Brain Development: What We Know About How Children Learn*. University of Maine Cooperative Extension publications. Retrieved April 5, 2023, from https://extension.umaine.edu/publications/4356e/

Greenberg, N. (2002). Adaptive functions of the corpus striatum: the past and future of the R-complex. In *The evolutionary neuroethology of Paul MacLean: Convergences and frontiers* (pp. 45-81). Prager.

Gur, C. (2011). International Conference on Education and Educational Psychology (ICEEPSY 2010) Philosophy in the early years. *Procedia - Social and Behavioral Sciences*, *12*, 501-511. https://doi.org/10.1016/j.sbspro.2011.02.062

Hammerslag, L. R., & Gulley, J. M. (2016). Sex differences in behavior and neural development and their role in adolescent vulnerability to substance use. *Behavioural Brain Research*, *298*, 15-26. https://doi.org/10.1016/j.bbr.2015.04.008

Hardiman, M., Rinne, L., Gregory, E., & Yarmolinskaya, J. (2011). Neuroethics, Neuroeducation, and Classroom Teaching: Where the Brain Sciences Meet Pedagogy. *Neuroethics*, *5*, 1-9. https://doi.org/10.1007/s12152-011-9116-6

Hoff, E. (2003). The Specificity of Environmental Influence: Socioeconomic Status Affects Early Vocabulary Development Via Maternal Speech. *Child development*, *74*(5), 1368-1378. https://doi.org/10.1111/1467-8624.00612

Horvath, J. C., & Donoghue, G. M. (2016). A Bridge Too Far – Revisited: Reframing Bruer's Neuroeducation Argument for Modern Science of Learning Practitioners [Review]. *Frontiers in Psychology*, *7*. https://doi.org/10.3389/fpsyg.2016.00377

Huelke, D. F. (1998). *An overview of anatomical considerations of infants and children in the adult world of automobile safety design* Annual Proceedings/Association for the Advancement of Automotive Medicine,

Huttenlocher, J., Waterfall, H., Vasilyeva, M., Vevea, J., & Hedges, L. V. (2010). Sources of variability in children's language growth. *Cogn Psychol*, *61*(4), 343-365. https://doi.org/10.1016/j.cogpsych.2010.08.002

Işıklar, S. A. Ö., Y. (2022). The Effect of Philosophy for Children (P4C) Curriculum on Critical Thinking through Philosophical Inquiry and Problem Solving Skills. *International Journal of Contemporary Educational Research*, *9*(1), 130-142.

Iuculano, T., Rosenberg-Lee, M., Richardson, J., Tenison, C., Fuchs, L., Supekar, K., & Menon, V. (2015). Cognitive tutoring induces widespread neuroplasticity and remediates brain function in children with mathematical learning disabilities. *Nature communications*, *6*(1), 1-10. https://doi.org/10.1038/ncomms9453

Jaquish, G. A., & Ripple, R. E. (1985). A Life-Span Developmental Cross-Cultural Study of Divergent Thinking Abilities. *The International Journal of Aging and Human Development*, *20*(1), 1-11. https://doi.org/10.2190/rnjj-nbd0-4a3k-0xpa

Jednoróg, K., Altarelli, I., Monzalvo, K., Fluss, J., Dubois, J., Billard, C., Dehaene-Lambertz, G., & Ramus, F. (2012). The influence of socioeconomic status on children's brain structure. *PLoS One*, *7*(8), e42486. https://doi.org/10.1371/journal.pone.0042486

Jernigan, T. L., Trauner, D. A., Hesselink, J. R., & Tallal, P. A. (1991). MATURATION OF HUMAN CEREBRUM OBSERVED IN VIVO DURING ADOLESCENCE. *Brain*, *114*(5), 2037-2049. https://doi.org/10.1093/brain/114.5.2037

Johnston, M. V., Nishimura, A., Harum, K., Pekar, J., & Blue, M. E. (2001). Sculpting the developing brain. *Adv Pediatr*, *48*, 1-38.

Jolles, J., & Jolles, D. D. (2021). On Neuroeducation: Why and How to Improve Neuroscientific Literacy in Educational Professionals [Review]. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.752151

Judd, N., Sauce, B., Wiedenhoeft, J., Tromp, J., Chaarani, B., Schliep, A., van Noort, B., Penttilä, J., Grimmer, Y., Insensee, C., Becker, A., Banaschewski, T., Bokde, A. L. W., Quinlan, E. B., Desrivières, S., Flor, H., Grigis, A., Gowland, P., Heinz, A., . . . Klingberg, T. (2020). Cognitive and brain development is independently influenced by socioeconomic status and polygenic scores for educational attainment. *Proc Natl Acad Sci U S A*, *117*(22), 12411-12418. https://doi.org/10.1073/pnas.2001228117

Jurado, M. B., & Rosselli, M. (2007). The elusive nature of executive functions: a review of our current understanding. *Neuropsychol Rev*, *17*(3), 213-233. https://doi.org/10.1007/s11065-007-9040-z

Kalil, A. (2015). Inequality Begins at Home: The Role of Parenting in the Diverging Destinies of Rich and Poor Children. In *Families in an era of increasing inequality: Diverging destinies* (pp. 63-82). Springer. https://doi.org/10.1007/978-3-319-08308-7_5

karadağ, F., & Yıldız Demirtaş, V. (2018). The Effectiveness of The Philosophy with Children Curriculum on Critical Thinking Skills of Pre-School Children. *TED EĞİTİM VE BİLİM*, *43*. https://doi.org/10.15390/EB.2018.7268

Kaufman, J. C. (2006). Self-reported differences in creativity by ethnicity and gender. *Applied Cognitive Psychology*, *20*(8), 1065-1082. https://doi.org/10.1002/acp.1255

Kennedy, D. N., Makris, N., Herbert, M. R., Takahashi, T., & Caviness Jr., V. S. (2002). Basic principles of MRI and morphometry studies of human brain development. *Developmental Science*, *5*(3), 268-278. https://doi.org/10.1111/1467-7687.00366

Kennedy, M. B. (2013). Synaptic Signaling in Learning and Memory. *Cold Spring Harb Perspect Biol*, *8*(2). https://doi.org/10.1101/cshperspect.a016824

Khundrakpam, B., Choudhury, S., Vainik, U., Al-Sharif, N., Bhutani, N., & Evans, A. (2019). Non-linear effects of socioeconomic status on brain development: associations between parental occupation, cortical thickness and language skills in childhood and adolescence. *bioRxiv*, 575993. https://doi.org/10.1101/575993

Kirsch, P., Lis, S., Esslinger, C., Gruppe, H., Danos, P., Broll, J., Wiltink, J., & Gallhofer, B. (2006). Brain activation during mental maze solving. *Neuropsychobiology*, *54*(1), 51-58. https://doi.org/10.1159/000095742

Kluen, L. M., Dandolo, L. C., Jocham, G., & Schwabe, L. (2019). Dorsolateral Prefrontal Cortex Enables Updating of Established Memories. *Cereb Cortex*, *29*(10), 4154-4168. https://doi.org/10.1093/cercor/bhy298

Koikkalainen, J., Hirvonen, J., Nyman, M., Lötjönen, J., Hietala, J., & Ruotsalainen, U. (2007). Shape variability of the human striatum—Effects of age and gender. *NeuroImage*, *34*(1), 85-93. https://doi.org/10.1016/j.neuroimage.2006.08.039

Kolb, B., & Gibb, R. (2011). Brain plasticity and behaviour in the developing brain. *J Can Acad Child Adolesc Psychiatry*, *20*(4), 265-276.

Kolb, B., Harker, A., & Gibb, R. (2017). Principles of plasticity in the developing brain. *Dev Med Child Neurol*, *59*(12), 1218-1223. https://doi.org/10.1111/dmcn.13546

Koontz, A. (2019). *The Circuitry of Creativity: How Our Brains Innovate Thinking*. Retrieved April 5, 2023, from https://caltechletters.org/science/what-is-creativity

Kwon, H., Reiss, A. L., & Menon, V. (2002). Neural basis of protracted developmental changes in visuo-spatial working memory. *Proceedings of the National Academy of Sciences of the United States of America*, *99*(20), 13336-13341. https://doi.org/10.1073/pnas.162486399

Lai, E. (2011). Critical thinking: A literature review. *Pearson's Res Rep*, *6*, 40-41.

Lam, C.-M. (2021). The impact of Philosophy for Children on teachers' professional development. *Teachers and Teaching*, *27*(7), 642-655. https://doi.org/10.1080/13540602.2021.1986693

Lang, S., Kanngieser, N., Jaśkowski, P., Haider, H., Rose, M., & Verleger, R. (2006). Precursors of Insight in Event-related Brain Potentials. *Journal of Cognitive Neuroscience*, *18*(12), 2152-2166. https://doi.org/10.1162/jocn.2006.18.12.2152

Larsen, B., & Luna, B. (2018). Adolescence as a neurobiological critical period for the development of higher-order cognition. *Neuroscience & Biobehavioral Reviews*, *94*, 179-195. https://doi.org/10.1016/j.neubiorev.2018.09.005

Lawson, G. M., Duda, J. T., Avants, B. B., Wu, J., & Farah, M. J. (2013). Associations between children's socioeconomic status and prefrontal cortical thickness. *Dev Sci*, *16*(5), 641-652. https://doi.org/10.1111/desc.12096

LeDoux, J. (1996). *The emotional brain. new York: Touchstone*. Simon & Schuster.

Leng, L. (2020a). The Role of Philosophical Inquiry in Helping Students Engage in Learning [Original Research]. *Frontiers in Psychology*, *11*(449). https://doi.org/10.3389/fpsyg.2020.00449

Leng, L. (2020b). The role of philosophical inquiry in helping students engage in learning. *Frontiers in psychology*, *11*, 449.

Leonard, J. A., Romeo, R. R., Park, A. T., Takada, M. E., Robinson, S. T., Grotzinger, H., Last, B. S., Finn, A. S., Gabrieli, J. D. E., & Mackey, A. P. (2019). Associations between cortical thickness and reasoning differ by socioeconomic status in development. *Developmental cognitive neuroscience*, *36*, 100641. https://doi.org/10.1016/j.dcn.2019.100641

Lhermitte, F. (1983). 'Utilization behaviour'and its relation to lesions of the frontal lobes. *Brain*, *106*(2), 237-255. https://doi.org/10.1093/brain/106.2.237

Lhermitte, F., Pillon, B., & Serdaru, M. (1986). Human autonomy and the frontal lobes. Part I: Imitation and utilization behavior: A neuropsychological study of 75 patients. *Annals of Neurology: Official Journal of the American Neurological Association and the Child Neurology Society*, *19*(4), 326-334. https://doi.org/10.1002/ana.410190404

Light, S. N., Coan, J. A., Zahn-Waxler, C., Frye, C., Goldsmith, H. H., & Davidson, R. J. (2009). Empathy is associated with dynamic change in prefrontal brain electrical activity during positive emotion in children. *Child development*, *80*(4), 1210-1231. https://doi.org/10.1111/j.1467-8624.2009.01326.x

Lipman, M. (1981). *Philosophy for children*.

Lipman, M. (1988). *Philosophy goes to school*. Temple University Press.

Lipman, M. (2003). *Thinking in Education*. Cambridge University Press.

List, J. A., Samek, A., & Suskind, D. L. (2018). Combining behavioral economics and field experiments to reimagine early childhood education. *Behavioural Public Policy*, *2*(1), 1-21. https://doi.org/10.1017/bpp.2017.6

Lomaca, C., & Chiado, J. A. (2019). Learning Values and Critical Thinking: A P4C Approach for Young Children. *Revista de Filosofie Aplicată*, *2*(2).

Lövdén, M., Fratiglioni, L., Glymour, M. M., Lindenberger, U., & Tucker-Drob, E. M. (2020). Education and Cognitive Functioning Across the Life Span. *Psychol Sci Public Interest*, *21*(1), 6-41. https://doi.org/10.1177/1529100620920576

Luby, J., Belden, A., Botteron, K., Marrus, N., Harms, M. P., Babb, C., Nishino, T., & Barch, D. (2013). The Effects of Poverty on Childhood Brain Development: The Mediating Effect of Caregiving and Stressful Life Events. *JAMA Pediatrics*, *167*(12), 1135-1142. https://doi.org/10.1001/jamapediatrics.2013.3139

Luna, B., Garver, K. E., Urban, T. A., Lazar, N. A., & Sweeney, J. A. (2004). Maturation of Cognitive Processes From Late Childhood to Adulthood. *Child development*, *75*(5), 1357-1372. https://doi.org/10.1111/j.1467-8624.2004.00745.x

Luna, B., Padmanabhan, A., & O'Hearn, K. (2010). What has fMRI told us about the development of cognitive control through adolescence? *Brain Cogn*, *72*(1), 101-113. https://doi.org/10.1016/j.bandc.2009.08.005

Mackey, A. P., Finn, A. S., Leonard, J. A., Jacoby-Senghor, D. S., West, M. R., Gabrieli, C. F., & Gabrieli, J. D. (2015). Neuroanatomical correlates of the income-achievement gap. *Psychol Sci*, *26*(6), 925-933. https://doi.org/10.1177/0956797615572233

Malboeuf-Hurtubise, C., Léger-Goodes, T., Mageau, G. A., Joussemet, M., Herba, C., Chadi, N., Lefrançois, D., Camden, C., Bussières, È.-L., Taylor, G., Éthier, M.-A., & Gagnon, M. (2021). Philosophy for children and mindfulness during COVID-19: Results from a randomized cluster trial and impact on mental health in elementary school students. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, *107*, 110260. https://doi.org/10.1016/j.pnpbp.2021.110260

Marashi, S. (2008). Teaching Philosophy to Children: A New Experience in Iran. *Analytic Teaching*, *27*(1), 12-15.

Marek, S., Hwang, K., Foran, W., Hallquist, M. N., & Luna, B. (2015). The Contribution of Network Organization and Integration to the Development of Cognitive Control. *PLoS Biol*, *13*(12), e1002328. https://doi.org/10.1371/journal.pbio.1002328

Maximo, J. O., Murdaugh, D. L., O'Kelley, S., & Kana, R. K. (2017). Changes in intrinsic local connectivity after reading intervention in children with autism. *Brain and Language*, *175*, 11-17. https://doi.org/10.1016/j.bandl.2017.08.008

McDermott, C. L., Seidlitz, J., Nadig, A., Liu, S., Clasen, L. S., Blumenthal, J. D., Reardon, P. K., Lalonde, F., Greenstein, D., Patel, R., Chakravarty, M. M., Lerch, J. P., & Raznahan, A. (2019). Longitudinally Mapping Childhood Socioeconomic Status Associations with Cortical and Subcortical Morphology. *The Journal of Neuroscience*, *39*(8), 1365. https://doi.org/10.1523/JNEUROSCI.1808-18.2018

Mehta, S., & Whitebread, D. (2004). Philosophy for Children and moral development in the Indian context. First Global Conference on Philosophy with Children,

Meyler, A., Keller, T. A., Cherkassky, V. L., Gabrieli, J. D., & Just, M. A. (2008). Modifying the brain activation of poor readers during sentence comprehension with extended remedial instruction: A longitudinal study of neuroplasticity. *Neuropsychologia*, *46*(10), 2580-2592. https://doi.org/10.1016/j.neuropsychologia.2008.03.012

Michael Scriven, R. P. (1987). Critical Thinking. 8th Annual International Conference on Critical Thinking and Education Reform.

Middleton, F. A., & Strick, P. L. (2000). Basal Ganglia Output and Cognition: Evidence from Anatomical, Behavioral, and Clinical Studies. *Brain and Cognition*, *42*(2), 183-200. https://doi.org/10.1006/brcg.1999.1099

Miller, E. (2001). Prefrontal cortex and the neural basis of executive functions. Brain and Cognition, San Diego, USA.

Miller, E. K., & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. *Annu Rev Neurosci*, *24*, 167-202. https://doi.org/10.1146/annurev.neuro.24.1.167

Miskolczi, C., Halász, J., & Mikics, É. (2019). Changes in neuroplasticity following early-life social adversities: the possible role of brain-derived neurotrophic factor. *Pediatric Research*, *85*(2), 225-233. https://doi.org/10.1038/s41390-018-0205-7

Morais, M. d., & Almeida, L. (2019). “I would be more creative if...”: Are there perceived barriers to college students’ creative expression according to gender? *Estudos de Psicologia (Campinas)*, *36*. https://doi.org/10.1590/1982-0275201936e180011

Moriguchi, Y., & Hiraki, K. (2013). Prefrontal cortex and executive function in young children: a review of NIRS studies [Review]. *Frontiers in Human Neuroscience*, *7*. https://doi.org/10.3389/fnhum.2013.00867

Mundkur, N. (2005). Neuroplasticity in children. *The Indian Journal of Pediatrics*, *72*(10), 855-857. https://doi.org/10.1007/BF02731115

Murris, K. (2016). The Philosophy for Children curriculum: Resisting 'teacher proof'texts and the formation of the ideal philosopher child. *Studies in Philosophy and Education*, *35*(1), 63-78. https://doi.org/10.1007/s11217-015-9466-3

Naji, S., & Hashim, R. (2017). *History, Theory and Practice of Philosophy for Children: International Perspectives*. Taylor & Francis. https://books.google.com/books?id=eCUlDwAAQBAJ

Nakano, T. d. C., Oliveira, K. d. S., & Zaia, P. (2021). Gender differences in creativity: A systematic literature review. *Psicologia: Teoria e Pesquisa*, *37*. https://doi.org/10.1590/0102.3772e372116

Naseri, S., Gorjian, Z., Ebrahimi, M., & Niakan, M. (2017). Critical Thinking in P4C (Philosophy for Children) Educators: An Intervention Study. 108. https://doi.org/10.17354/ijss/2017/506

Noble, K. G., Houston, S. M., Brito, N. H., Bartsch, H., Kan, E., Kuperman, J. M., Akshoomoff, N., Amaral, D. G., Bloss, C. S., Libiger, O., Schork, N. J., Murray, S. S., Casey, B. J., Chang, L., Ernst, T. M., Frazier, J. A., Gruen, J. R., Kennedy, D. N., Van Zijl, P., . . . Sowell, E. R. (2015). Family income, parental education and brain structure in children and adolescents. *Nature Neuroscience*, *18*(5), 773-778. https://doi.org/10.1038/nn.3983

Noble, K. G., Houston, S. M., Kan, E., & Sowell, E. R. (2012). Neural correlates of socioeconomic status in the developing human brain. *Developmental Science*, *15*(4), 516-527. https://doi.org/10.1111/j.1467-7687.2012.01147.x

Noble, K. G., McCandliss, B. D., & Farah, M. J. (2007). Socioeconomic gradients predict individual differences in neurocognitive abilities. *Developmental Science*, *10*(4), 464-480. https://doi.org/10.1111/j.1467-7687.2007.00600.x

Norman, D. A., & Shallice, T. (1986). *Attention to action: Willed and automatic control of behavior*. Springer.

Owens, M. T., & Tanner, K. D. (2017). Teaching as Brain Changing: Exploring Connections between Neuroscience and Innovative Teaching. *CBE life sciences education*, *16*(2), fe2. https://doi.org/10.1187/cbe.17-01-0005

Pfefferbaum, A., Mathalon, D. H., Sullivan, E. V., Rawles, J. M., Zipursky, R. B., & Lim, K. O. (1994). A quantitative magnetic resonance imaging study of changes in brain morphology from infancy to late adulthood. *Arch Neurol*, *51*(9), 874-887. https://doi.org/10.1001/archneur.1994.00540210046012

Piccolo, L. R., Merz, E. C., He, X., Sowell, E. R., Noble, K. G., & Pediatric Imaging, N. G. S. (2016). Age-Related Differences in Cortical Thickness Vary by Socioeconomic Status. *PLoS One*, *11*(9), e0162511. https://doi.org/10.1371/journal.pone.0162511

Posner, M. I. (1994). Attention: the mechanisms of consciousness. *Proceedings of the National Academy of Sciences*, *91*(16), 7398-7403. https://doi.org/10.1073/pnas.91.16.7398

Raffington, L., Czamara, D., Mohn, J. J., Falck, J., Schmoll, V., Heim, C., Binder, E. B., & Shing, Y. L. (2019). Stable longitudinal associations of family income with children's hippocampal volume and memory persist after controlling for polygenic scores of educational attainment. *Developmental cognitive neuroscience*, *40*, 100720. https://doi.org/10.1016/j.dcn.2019.100720

Rahdar, A., Pourghaz, A., & Marziyeh, A. (2018). The Impact of Teaching Philosophy for Children on Critical Openness and Reflective Skepticism in Developing Critical Thinking and Self-Efficacy. *International Journal of Instruction*, *11*(3), 539-556.

Raznahan, A., Lee, Y., Stidd, R., Long, R., Greenstein, D., Clasen, L., Addington, A., Gogtay, N., Rapoport, J. L., & Giedd, J. N. (2010). Longitudinally mapping the influence of sex and androgen signaling on the dynamics of human cortical maturation in adolescence. *Proceedings of the National Academy of Sciences*, *107*(39), 16988-16993. https://doi.org/10.1073/pnas.1006025107

Raznahan, A., Shaw, P. W., Lerch, J. P., Clasen, L. S., Greenstein, D., Berman, R., Pipitone, J., Chakravarty, M. M., & Giedd, J. N. (2014). Longitudinal four-dimensional mapping of subcortical anatomy in human development. *Proceedings of the National Academy of Sciences*, 201316911. https://doi.org/10.1073/pnas.1316911111

Razoumnikova, O. M. (2000). Functional organization of different brain areas during convergent and divergent thinking: an EEG investigation. *Cognitive Brain Research*, *10*(1), 11-18. https://doi.org/10.1016/S0926-6410(00)00017-3

Reiss, A. L., Abrams, M. T., Singer, H. S., Ross, J. L., & Denckla, M. B. (1996). Brain development, gender and IQ in children: A volumetric imaging study. *Brain*, *119*(5), 1763-1774. https://doi.org/10.1093/brain/119.5.1763

Roberts, A. F. (2006). *The effects of a teacher development programme based on Philosophy for Children* University of the Western Cape].

Romeo, R. R., Christodoulou, J. A., Halverson, K. K., Murtagh, J., Cyr, A. B., Schimmel, C., Chang, P., Hook, P. E., & Gabrieli, J. D. (2018). Socioeconomic status and reading disability: Neuroanatomy and plasticity in response to intervention. *Cerebral Cortex*, *28*(7), 2297-2312. https://doi.org/10.1093/cercor/bhx131

Romo, M. (2018). Tiene género la creatividad? Obstáculos a la excelencia en mujeres. *Estudos de Psicologia (Campinas)*, *35*, 247-258. https://doi.org/10.1590/1982-02752018000300003

Roskos-Ewoldsen, B., Black, S. R., & Mccown, S. M. (2008). Age-related Changes in Creative Thinking. *The Journal of Creative Behavior*, *42*(1), 33-59. https://doi.org/10.1002/j.2162-6057.2008.tb01079.x

Rubia, K., Smith, A. B., Woolley, J., Nosarti, C., Heyman, I., Taylor, E., & Brammer, M. (2006). Progressive increase of frontostriatal brain activation from childhood to adulthood during event-related tasks of cognitive control. *Hum Brain Mapp*, *27*(12), 973-993. https://doi.org/10.1002/hbm.20237

Ruby, P., & Decety, J. (2004). How would you feel versus how do you think she would feel? A neuroimaging study of perspective-taking with social emotions. *J Cogn Neurosci*, *16*(6), 988-999. https://doi.org/10.1162/0898929041502661

Rueda, C. (2020). Neuroeducation: Teaching with the brain. *Journal of Neuroeducation*, *1*, 108-113. https://doi.org/10.1344/joned.v1i1.31657

Ruigrok, A. N. V., Salimi-Khorshidi, G., Lai, M.-C., Baron-Cohen, S., Lombardo, M. V., Tait, R. J., & Suckling, J. (2014). A meta-analysis of sex differences in human brain structure. *Neuroscience & Biobehavioral Reviews*, *39*, 34-50. https://doi.org/10.1016/j.neubiorev.2013.12.004

Runco, M. A. (2004). Creativity. *Annual Review of Psychology*, *55*(1), 657-687. https://doi.org/10.1146/annurev.psych.55.090902.141502

Rylander, G. (1948). Personality analysis before and after frontal lobotomy. *Research publications-Association for Research in Nervous and Mental Disease*, *27*, 691-705.

Salavera, C., Usán, P., Teruel, P., Urbón, E., & Murillo, V. (2021). School bullying: Empathy among perpetrators and victims. *Sustainability*, *13*(3), 1548. https://doi.org/10.3390/su13031548

Sanz de Acedo Lizarraga, M. L., Sanz de Acedo Baquedano, M. T., & Villanueva, O. A. (2012). Critical thinking, executive functions and their potential relationship. *Thinking Skills and Creativity*, *7*(3), 271-279. https://doi.org/10.1016/j.tsc.2012.04.008

Säre, E., Luik, P., & Tulviste, T. (2016). Improving pre-schoolers' reasoning skills using the philosophy for children programme. *Trames. Journal of the Humanities and Social Sciences*, *20*, 273. https://doi.org/10.3176/tr.2016.3.03

Sarter, M., Givens, B., & Bruno, J. P. (2001). The cognitive neuroscience of sustained attention: where top-down meets bottom-up. *Brain research reviews*, *35*(2), 146-160. https://doi.org/10.1016/S0165-0173(01)00044-3

Serpati, L., & Loughan, A. R. (2012). Teacher Perceptions of NeuroEducation: A Mixed Methods Survey of Teachers in the United States. *Mind, Brain, and Education*, *6*(3), 174-176. https://doi.org/10.1111/j.1751-228X.2012.01153.x

Shaari, A., & Aswati, H. (2018). A Comparative Review of Caring Thinking and Its Implications on Teaching and Learning. *Malaysian Journal of Learning and Instruction*, *15*, 83-104. https://doi.org/10.32890/mjli2018.15.1.4

Shallice, T., & Burgess, P. W. (1991). Deficits in strategy application following frontal lobe damage in man. *Brain*, *114*(2), 727-741. https://doi.org/10.1093/brain/114.2.727

Shulman, G., Fiez, J., Corbetta, M., Buckner, R., Miezin, F., Raichle, M., & Petersen, S. (1997). Common Blood Flow Changes across Visual Tasks: II. Decreases in Cerebral Cortex. *Journal of Cognitive Neuroscience*, *9*, 648-663. https://doi.org/10.1162/jocn.1997.9.5.648

Siddiqui, N., Gorard, S., & See, B. H. (2019). Can programmes like Philosophy for Children help schools to look beyond academic attainment? *Educational review.*, *71*(2), 146-165. https://doi.org/10.1080/00131911.2017.1400948

Simmonds, D. J., Hallquist, M. N., Asato, M., & Luna, B. (2014). Developmental stages and sex differences of white matter and behavioral development through adolescence: A longitudinal diffusion tensor imaging (DTI) study. *NeuroImage*, *92*, 356-368. https://doi.org/10.1016/j.neuroimage.2013.12.044

Singer, T., & Lamm, C. (2009). The social neuroscience of empathy. *Ann N Y Acad Sci*, *1156*, 81-96. https://doi.org/10.1111/j.1749-6632.2009.04418.x

Singer, T., Seymour, B., O'Doherty, J., Kaube, H., Dolan, R. J., & Frith, C. D. (2004). Empathy for pain involves the affective but not sensory components of pain. *Science*, *303*(5661), 1157-1162. https://doi.org/10.1126/science.1093535

Sowell, E. R., Thompson, P. M., Leonard, C. M., Welcome, S. E., Kan, E., & Toga, A. W. (2004). Longitudinal mapping of cortical thickness and brain growth in normal children. *J Neurosci*, *24*(38), 8223-8231. https://doi.org/10.1523/jneurosci.1798-04.2004

Sternberg, R. (2006). The Nature of Creativity. *Creativity Research Journal*, *18*, 87-98. https://doi.org/10.1207/s15326934crj1801_10

Stuart, H., & Stevenson, S. (1959). General factors in the care and evaluation of children. Physical growth and development. *Textbook of pediatrics, seventh edition. Philadelphia: Saunders*, *30*.

Stuss, D. T., & Alexander, M. P. (2000). Executive functions and the frontal lobes: a conceptual view. *Psychological Research*, *63*(3), 289-298. https://doi.org/10.1007/s004269900007

Sussman, D., Leung, R. C., Mallar Chakravarty, M., Lerch, J. P., & Taylor, M. J. (2016). The developing human brain: age-related changes in cortical, subcortical, and cerebellar anatomy. *Brain and Behavior*, *6*(6), e00515. https://doi.org/10.1002/brb3.515

Takeuchi, H., Taki, Y., Matsudaira, I., Ikeda, S., dos S. Kawata, K. H., Nouchi, R., Sakaki, K., Nakagawa, S., Nozawa, T., Yokota, S., Araki, T., Hanawa, S., Ishibashi, R., Yamazaki, S., & Kawashima, R. (2020). Convergent creative thinking performance is associated with white matter structures: Evidence from a large sample study. *NeuroImage*, *210*, 116577. https://doi.org/10.1016/j.neuroimage.2020.116577

Tamm, L., Menon, V., & Reiss, A. L. (2002). Maturation of brain function associated with response inhibition. *J Am Acad Child Adolesc Psychiatry*, *41*(10), 1231-1238. https://doi.org/10.1097/00004583-200210000-00013

Thompson, P. M., Giedd, J. N., Woods, R. P., MacDonald, D., Evans, A. C., & Toga, A. W. (2000). Growth patterns in the developing brain detected by using continuum mechanical tensor maps. *Nature*, *404*(6774), 190-193. https://doi.org/10.1038/35004593

Tierney, A. L., & Nelson, C. A., 3rd. (2009). Brain Development and the Role of Experience in the Early Years. *Zero Three*, *30*(2), 9-13.

Topping, K., & Trickey, S. (2008). Collaborative philosophical inquiry for schoolchildren: Cognitive gains at 2-year follow-up. *The British journal of educational psychology*, *77*, 787-796. https://doi.org/10.1348/000709907X193032

Topping, K. J., & Trickey, S. (2007). Collaborative philosophical enquiry for school children: Cognitive effects at 10–12 years. *British Journal of Educational Psychology*, *77*(2), 271-288. https://doi.org/10.1348/000709906X105328

Topping, K. J., Trickey, S., & Cleghorn, P. (2019). *A teacher's guide to philosophy for children*. Routledge.

Torrijos-Muelas, M., González-Víllora, S., & Bodoque-Osma, A. R. (2021). The Persistence of Neuromyths in the Educational Settings: A Systematic Review [Systematic Review]. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.591923

Trickey, S., & Topping *, K. J. (2004). 'Philosophy for children': a systematic review. *Research Papers in Education*, *19*(3), 365-380. https://doi.org/10.1080/0267152042000248016

Tymofiyeva, O., & Gaschler, R. (2020). Training-Induced Neural Plasticity in Youth: A Systematic Review of Structural and Functional MRI Studies. *Front Hum Neurosci*, *14*, 497245. https://doi.org/10.3389/fnhum.2020.497245

Ursache, A., & Noble, K. G. (2016). Neurocognitive development in socioeconomic context: Multiple mechanisms and implications for measuring socioeconomic status. *Psychophysiology*, *53*(1), 71-82. https://doi.org/10.1111/psyp.12547

Ursache, A., & Noble, K. G. (2016). Socioeconomic status, white matter, and executive function in children. *Brain Behav*, *6*(10), e00531. https://doi.org/10.1002/brb3.531

Uytun, M. C. (2018). Development period of prefrontal cortex. In *Prefrontal Cortex*. IntechOpen.

Vansieleghem, N., & Kennedy, D. (2011). What Is Philosophy for Children, What Is Philosophy with Children—After Matthew Lipman? *Journal of Philosophy of Education*, *45*. https://doi.org/10.1111/j.1467-9752.2011.00801.x

Vernon, P. E. (1989). The nature-nurture problem in creativity. In R. R. R. J. A. Glover, & C. R. Reynolds (Eds.) (Ed.), *Handbook of creativity* (pp. 93-110). Plenum Press.

Walsh, C. M., & Hardy, R. C. (1999). Dispositional differences in critical thinking related to gender and academic major. *J Nurs Educ*, *38*(4), 149-155. https://doi.org/10.3928/0148-4834-19990401-04

Wenger, E., & Lövdén, M. (2016). The Learning Hippocampus: Education and Experience-Dependent Plasticity. *Mind, Brain, and Education*, *10*(3), 171-183. https://doi.org/10.1111/mbe.12112

Weyandt, L. L., Clarkin, C. M., Holding, E. Z., May, S. E., Marraccini, M. E., Gudmundsdottir, B. G., Shepard, E., & Thompson, L. (2020). Neuroplasticity in children and adolescents in response to treatment intervention: A systematic review of the literature. *Clinical and Translational Neuroscience*, *4*(2), 2514183X20974231. https://doi.org/10.1177/2514183x20974231

Williams, B. R., Ponesse, J. S., Schachar, R. J., Logan, G. D., & Tannock, R. (1999). Development of inhibitory control across the life span. *Developmental psychology*, *35*(1), 205. https://doi.org/10.1037/0012-1649.35.1.205

Wu, C. (2021). Training Teachers in China to Use the Philosophy for Children Approach and Its Impact on Critical Thinking Skills: A Pilot Study. *Education Sciences*, *11*(5). https://doi.org/10.3390/educsci11050206

Yan, S., Walters, L. M., Wang, Z., & Wang, C.-C. (2018). Meta-Analysis of the Effectiveness of Philosophy for Children Programs on Students' Cognitive Outcomes. *Analytic Teaching and Philosophical Praxis*, *39*(1), 13-33. https://journal.viterbo.edu/index.php/atpp/article/view/1160

Yaple, Z. A., & Yu, R. (2019). Functional and Structural Brain Correlates of Socioeconomic Status. *Cerebral Cortex*, *30*(1), 181-196. https://doi.org/10.1093/cercor/bhz080

Zulkifli, H., & Hashim, R. (2020). Philosophy for Children (P4C) in Improving Critical Thinking in a Secondary Moral Education Class. *International Journal of Learning, Teaching and Educational Research*, *19*, 29-45. https://doi.org/10.26803/ijlter.19.2.3