



# THE JOURNAL OF EARLY YEARS RESEARCH

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## A Word from the EYRAS President

Stress is inevitable in this dynamic and ever-changing world. Every one of us has to learn to identify the changes, understand how it may affect our lives, adjust ourselves and adapt to what the changes would bring about.

Stress is an intriguing mental state faced by everyone. Some are better at managing them. World Health Organisation (WHO) defines stress as our body response to any type of change that causes physical, emotional and psychological strain. It is interesting to know that medium and high level of stress could enhance our development. However, it is the prolonged extreme stress known as *chronic stress* that is detrimental to our mental health and well-being. Chronic stress could lead to high blood pressure, diabetes, cardiovascular disease, memory impairment, cognitive impairment, addiction, cancer, anxiety disorder and depressive disorder. In short, it leads to physiological, psychological and neurological changes. Perception of stress can be very subjective; the stress threshold for every individual varies widely. So what will be the effects when a person faces chronic stress?

Let us understand how our body reacts when a threat is perceived. When a threat is perceived, the amygdala sends a distress signal to our hypothalamus. Both of them are part of our brain's limbic system. Hypothalamus will in turn activate our *stress response system* and instruct the pituitary gland to send a signal to our adrenal gland to produce both adrenaline, and cortisol of a higher concentration. The adrenaline immediately increases our pulse rate, blood pressure and breathing, preparing our body for a 'fight or flight' response; while cortisol the steroid hormone increases our blood sugar level mainly to supply energy to all parts of our body. This function is one of the many performed by our *Hypothalamus-Pituitary-Adrenal (HPA)* axis. The entire synchronicity happens so naturally fast without our awareness that we react quick to move away from danger before we even think about it.

Indeed, very often, chronic stress is perceived as a constant threat and this causes our stress response system to be constantly activated and constantly triggering the production of adrenaline and cortisol. You should be able to see how harmful it will be to our body when our pulse rate, blood pressure, breathing, blood sugar constantly remain high. It detrimentally leads to high blood pressure, diabetes, cardiovascular disease and other deterioration of our body conditions.

Our hippocampus is not spared from the effect of chronic stress. Hippocampus, part of our temporal lobe and brain's limbic system as well is responsible for memory formation and spatial ability. It is the *only* part of our brain that is capable of generating new neurons (neurogenesis) postnatally. It is important to know that high cortisol level decreases such generation of new neurons in our hippocampus. High cortisol level also kills new cells generated at the same time, reducing the volume of our hippocampus over time when the hippocampal neuron cells that die off naturally are not replaced consequentially. Such phenomena of poor memory and smaller volume of hippocampus are also found in people diagnosed with major depressive disorder and dementia. Research has shown that hippocampus neurogenesis is also responsible for both mood and emotions regulation and cognitive ability.

Cortisol also impairs the development of the dendritic spines of our neurons at our prefrontal cortex (PFC). Without proper developed dendritic spines, neural connectivity is inhibited, leading to impairment in cognitive function. You may know that PFC is responsible for higher order of cognition such as decision making, evaluation, problem solving, creativity, attention and imagination etc. Such phenomena are commonly found in people with anxiety disorder as well.

Having understood the neurological mechanism of chronic stress and its related stress response system, how could we buffer stress for our children? The answer lies in the understanding of

perceived control and self-efficacy. Perceived control is defined as *'the degree an individual believes that he or she has control over things, people, feelings and activities etc surrounding them'*, whereas the self-efficacy is defined as *'the confidence for performing the desired behaviour'*. Both are part of our thoughts and perception. They have powerful effect on our ability to buffer stress and are closely associated with emotional well-being.

Chronic stress is very real for children who may not have developed a strong conscious mind and necessary skills at the young age to regulate their emotions, manage their own thoughts, perceptions and situations, thus often putting them at the mercy of circumstances. Children rely heavily on their caregivers to provide them a positive childhood experience in terms of safety, security, nurturing relationships, knowledge and removing threatening situations awaiting them, preventing unnecessary

activation of their stress response system. The quality in the caregivers' support, care and interaction are not only essential, but has strong influence in children's development of their level of confidence, grit and resilience. It is very important that the caregivers should scaffold the children in their learning journey as suggested in sociocultural theory of Lev Vygotsky (1978), the renowned Soviet Russian psychologist.

Last but not least, I would like to express my sincerest appreciation to the writers who have contributed their insightful articles to this journal. I would also like to express my gratitude to Dr XIE Guo-Hui for his continuous guidance and effort in compiling the articles.

Meng Kiat TAN  
Honorary President  
Early Years Research Association of Singapore  
12 December 2022



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# A Prelude to Understanding Cognitive Disabilities in School-Age Children

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## Abstract

This paper is a prelude to the application of the CHC theory in the assessment and intervention for school-age children with cognitive disabilities (CogDs for short). This is the most common disability type identified by special education officers, school counselors and/or psychologists among school-age children. Cognitive disabilities (also known as intellectual disabilities or IDs for short) is a nebulous term that describes an individual who exhibits more than average difficulty with intellectual tasks. In defining CogDs, there are several overlaps between developmental and cognitive disabilities. These are broad terms used in literature but these labels do not indicate the level of ability or skills. Within the framework of cognition, there are four cognitive subcategories involving what are termed as (i) *lexikos* (ability to use and understand language and literacy skills), (ii) *calculatos* (ability to use and understand mathematics and numeracy skills), (iii) *praxis* (ability to perform voluntary skilled movements), and (iv) *gnosis* (ability to acquire knowledge and its meaning of self and the context in which self engages). In each cognitive category, there are two types of challenging cognitive issues: one is concerned with developmental delay (i.e., dyslexia, dyscalculia, dyspraxia and dysgnosia), and the other is concerned with neurological lesion or injury (i.e., alexia, acalculia, apraxia and agnosia). In this paper, the authors re-examined this framework of cognitive disabilities first proposed by Chia in 2010, and also related each of the four cognitive subcategories to the Cattell-Horn-Carroll (CHC) theory of broad cognitive abilities.

**Key Words:** CHC theory, Cognition, Cognitive ability, Cognitive disability, Intellectual disability

## Introduction

The term *cognition* is one of the three human behavioral potentials, the other two being affect and conation (Poland, 1974), and as cognitive behavior, “as in the words *recognize* and *recognition*, has to do with intellect, i.e., the use of the mind, whether it is logical or illogical” (Poland, 1974, p. 13). In other words, it refers to the mental or intellectual action or process involved in knowledge acquisition and comprehension through thought, experience, and the senses. This at-birth potential involves the implicit process of thinking (of course, not directly observable), “although an individual human may experience within himself what is called thinking” (Poland, 1974, p. 13). Moreover, cognition encompasses all aspects of intellectual functions and processes which include perception, attention, computation, concept/knowledge formation, decision-making, evaluation (involving analysis and synthesis) and judgment, imagination (also known as fantasizing or sub-creating of all possibilities), intelligence,

memory (also working memory), problem-solving, reasoning, reception and expression of language, and thought. All these cognitive processes use existing knowledge and also to discover new knowledge.

Closely related to cognition is the term *cognitive ability*. According to McGue and Bouchard (1998), cognitive ability constitutes one of the most extensively studied topics within the field of behavioral sciences including genetics and psychology. Cognitive ability is essential for human adaptation and survival, and it is sometimes referred to as general intelligence (g) (Newman & Newman, 2020). It includes the capacity in learning quickly and from experience, planning, problem-solving, reasoning, thinking abstractly, and understanding complex ideas/concepts (Plomin, 1999).

When there is any challenging issue related to cognition, three key terms come into mind:

impairment, disability, and handicap, or, in other words, cognitive impairment, cognitive disability, and cognitive handicap. Do they mean the same thing or they are different from one another?

The often-cited definitions of these three terms are provided by the World Health Organization (1980) in *The International Classification of Impairments, Disabilities, and Handicaps* (ICF for short). The term *impairment* refers to any loss or abnormality in terms of psychological, physiological or anatomical structure or function. It affects the functionality of an individual, i.e., the ability to perform a given task or job for which a person is employed to do. Unlike impairment, the term *disability*, on the other hand, refers to any lack, limitation or restriction (that can be the result of an impairment) of one's ability to perform an activity in the manner or within the range considered normal for a typically developed individual. Lastly, the term *handicap* refers to any disadvantage for an individual that causes limitations or prevents the person from fulfilling a role that is typically normal.

When the three terms - impairment, disability and handicap - are used in negative relation to cognitive capability to do a task, cognitive impairment is not the same as cognitive disability and also cognitive handicap should not be taken as synonymous like the other two terms. Cognitive impairment is a more permanent loss or abnormality in an individual's functionality (e.g., memory loss). A good example is when an elderly suffers from a severe form of dementia. Cognitive handicap refers to the mental inability to accomplish something an individual might want to do that most others around him/her are able to accomplish. An example is someone with acquired cognitive handicap (e.g., Broca's or Wernicke's aphasia) due to severe stroke (either ischemic or hemorrhagic) - a medical condition in which poor blood flow to the brain causes necrosis (also known commonly as cell death).

Unlike cognitive impairment or cognitive handicap, the term *cognitive disability* is used when an individual has some specific limitations in his/her mental functions and abilities (e.g., social skills, learning skills, self-help skills, communication skills, etc.). The cognitive disability is also known as *intellectual disability*. These disabilities of cognition can slow down the learning process as well as the developing process of a child than a normal child. Cognitive disabilities can be caused by a brain abnormality, genetic disorder, illness (e.g., meningitis), or an external insult (e.g., automobile accident). These disabilities of cognition can be

assessed through administration of standardized intelligence and adaptive behavior tests.

Two professional associations in the United States, i.e., the American Psychiatric Association (APA) and the American Association on Intellectual and Developmental Disabilities (AAIDD), have each developed their own diagnostic criteria for intellectual disabilities (ID) and in this paper, the term cognitive disability is used interchangeably with ID. Each of their diagnostic criteria protocol has its own merits.

The American Psychiatric Association's (APA) diagnostic criteria for intellectual disability (ID), used to be known as mental retardation (MR), can be found in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; APA, 2013). A summary of the diagnostic criteria in DSM-5 are as follows:

(1) Deficits in intellectual functioning and it includes various mental abilities, i.e., abstract thinking, academic learning (i.e., the ability to learn in class/school via traditional pedagogy), experiential learning (i.e., the ability to learn through experience, trial-and-error, and observation), judgment, planning, problem-solving, reasoning. These mental abilities can be assessed by administering IQ tests. According to the DSM-5 (APA, 2013), approximately two standard deviations below the average IQ score (within the range of standard scores from 90 to 109) represents a significant cognitive deficit or disability. Such an IQ score is typically at 70 or below. Generally, such IQ scores occur about 2.5% of the population. In other words, 97.5% of individuals of the same chronological age and culture would score higher. It is important to note that IQ the tests being administered must be standardized and culturally appropriate.

(2) Deficits/impairments in adaptive functioning and it includes skills required for an independent living and ability to perform appropriately and responsibly in activities of daily living (e.g., dressing, feeding and toileting). With limited abilities in these daily life skills, an individual will experience challenges that make it difficult to achieve age-appropriate standards of adaptive behavior. Without these skills, the person needs additional supports to succeed at home, school, or workplace. Functioning deficits in adaptive behavior can be assessed by administering standardized, culturally appropriate tests such as Vineland Adaptive Behavior Scales-Third Edition (VABS-3; Sparrow, Cicchetti, & Saulnier, 2016) and Diagnostic Adaptive Behavior Scale (DABS; Tassé et al., 2012, 2017). Various adaptive

behavioral skills that are needed for daily living are as follows:

- a) Communication, which refers to the ability to convey information through words and actions from one person to another, and it also requires the ability to understand others as well as to express one's self through words or actions;
- b) Social skills that are critical for success in life, and they refer to the ability to interact effectively with others. Such skills include understanding and compliance with social rules, customs, and standards of public behavior, and they require a person's ability to process figurative/metaphorical expressions as well as to detect unspoken cues (e.g., body language, facial expressions, and hand gestures);
- c) Personal independence at home or outside, and such skills refer to one's self-care ability, e.g., bathing, dressing, and feeding. It also includes the ability to safely complete day-to-day tasks without guidance, e.g., cooking, cleaning, and laundry. Other routine activities performed in the community include grocery shopping and accessing public transportation.
- d) School or workplace functioning, which refers to one's ability to conform to the social standards in class/school or at workplace. This includes one's ability to acquire new content knowledge, skills, and abilities. In addition, this acquired information needs to be applied by the person in a practical, adaptive manner, without excessive supervision, direction or guidance.

(3) All these limitations happen during the developmental period of an individual. In other words, problems with intellectual or adaptive functioning should be evident during childhood or adolescence. If such problems began after this developmental period, the correct diagnosis would be neuro-cognitive disorder (e.g., a traumatic brain injury sustained from a car accident).

According to the AAIDD (see Schalock, Luckasson, & Tassé, 2021, for detail) cognitive disability (CogD) or intellectual disability (ID) is defined as “a condition characterized by significant limitations in both intellectual functioning and adaptive behavior that originates before the age of 22” (AAIDD, 2022, para. 1). The criteria for

diagnostic identification of CogD or ID are as follows (AAIDD, 2022, para. 2-5):

(1) Intellectual Functioning (also known as intelligence) refers to “general mental capacity such as learning, reasoning, problem solving, and so on. To measure intellectual functioning, an IQ test is required, and, generally, the IQ score is “around 70 or as high as 75 to indicate a significant limitation in intellectual functioning” (AAIDD, 2022, para. 3).

(2) Adaptive Behavior, which is refers to as a “collection of conceptual, social, and practical skills that are learned and performed by people in their everyday lives” (AAIDD, 2022, para. 4). There are three subdomains in the adaptive behavior and they are as follows (AAIDD, 2022, para. 4.1-4.3):

- a) Conceptual skills: These include language and literacy skills, concepts such as money, time, and number concepts, and self-direction.
- b) Social skills: They are interpersonal skills which include social responsibility, self-esteem, gullibility, naïveté (i.e., wariness), social problem solving, and the ability to follow rules or obey laws, and to avoid being victimized.
- c) Practical skills: They refer to activities of daily living (i.e., personal care), occupational skills, healthcare, travel or transportation, schedules/routines, safety, use of money, use of the telephone.

Standardized tests such as VABS-3 (Sparrow, Cicchetti, & Saulnier, 2016) and DABS (Tassé et al., 2012, 2017) mentioned earlier can be administered to determine limitations in an individual's adaptive behavior.

(3) Age of Onset: The condition of CogD or ID must originate during the developmental period, and this is defined to take place before the age of 22 years old. “Intellectual disability is one of several conditions known collectively as developmental disabilities” (AAIDD, 2022, para. 5).

The AAIDD (2022) also stresses additional factors, such as community environment typical of the individual's peers, linguistic diversity and cultural differences in the way people communicate, move and behave, to be considered when assessing ID. Finally, assessments of ID must also assume that “limitations often coexist with strengths in an individual, and that the individual's level of life functioning will improve if appropriate, personalized supports are provided over a sustained period” (AAIDD, 2022, para. 9).



**Cognitive Disabilities: Developmental & Neurological**

Cognitive disabilities (CogDs for short) are also known as disabilities of cognition. As mentioned earlier, based on the WHO (1980) definition for the term *disability*, it refers to any lack, limitation or restriction (that can be the result of an impairment) of one’s ability to perform an activity in the manner or within the range considered normal for a typically developed individual. In the context of *cognitive disability* (also known as *intellectual disability* as defined by APA and AAIDD discussed earlier, it is used to refer to the condition of an individual who manifests some specific limitations in his or her mental functions and abilities (e.g., social skills and learning). These CogDs hamper the process of learning, slowing it down as well as interfering with the developing process of an individual. There may be overlapping in defining a developmental and cognitive disability. That is also why the term *intellectual and developmental disabilities* (IDD) is often used to refer to the same challenging condition. The terms are broad labels that do not indicate the level of ability or skills. Hence, in short, CogD is a nebulous term that describes someone who has more than average difficulty performing cognitive tasks. CogDs are also considered as the most common disability type among the school-age children.

According to Chia (2010), CogDs can be further categorized under four sub-types of challenging issues - *lexikos* (literacy and language), *calculatos* (numeracy and mathematics), *praxis* (motor planning, coordination and execution), and *gnosis* (knowledge of self and the environment needed for adaptation and survival) - that impact on cognitive abilities (i.e., academic skills - traits and strategies that help an individual become a better learner - are essential for school success), which, in turn, interfere with the neuropsychological processes (i.e., psychological processes in the brain that are associated with the biological process, involving psychological, physiological and biological domains) involved in learning activities, and also the ability of relating to oneself (i.e., self-awareness and self-agency) as well as one’s immediate environment. The Figure 1 below shows the relationship among the three key factors: (i) cognitive abilities, (ii) neuropsychological processes, and (iii) academic skills.

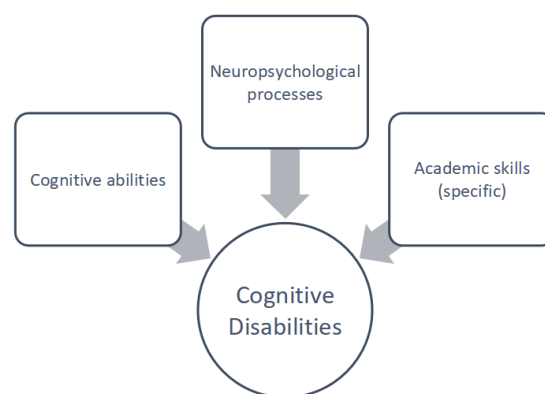


Figure 1. Cognitive Disabilities: Deficits in Cognitive Abilities, Neuropsychological Processes and Academic Skills

The CogDs in each of these subcategories can result in a spectrum of disabilities that fall within either developmental disabilities (DDs) or neurological disabilities (NDs) (see Table 1 below). DDs consists of a diverse group of chronic conditions due to mental or physical impairments whose onset takes place before adulthood. People with DDs experience many difficulties in their lives such as “impairment in physical, learning, language, or behavior areas” (Centers for Disease Control and Prevention/CDC, 2022, para. 1). In the United States alone, “about one in six children in the U.S. have one or more developmental disabilities or other developmental delays” (CDC, 2022, para. 1). Though persist throughout an individual’s lifespan development, DDs can be detected early with appropriate standardized assessment tools such as IQ tests and development screeners. If DD affects two or more areas of a child's development, the condition is often referred to as global developmental delay with the diagnostic code of EI-DD (if it is detected earlier between birth and 3 years of age) or PS-DD (if detected between 4 and 6 years of age) according to the Educator’s Diagnostic Manual (Pierangelo & Giuliani, 2007).

Table 1. Subcategories of Cognitive Disabilities

Category	Developmental Disabilities	Neurological Disabilities
Lexikos ( <i>Literacy &amp; language</i> )	Dyslexia	Alexia
Calculatos ( <i>Numeracy &amp; mathematics</i> )	Dyscalculia	Acalculia
Praxis ( <i>Motor planning, coordination &amp; execution</i> )	Dyspraxia	Apraxia
Gnosis ( <i>Knowledge of self &amp; environment</i> )	Dysgnosia	Agnosia

Figure 2 shows a diagrammatic representation of all the developmental and neurological disabilities of cognition or CogDs.

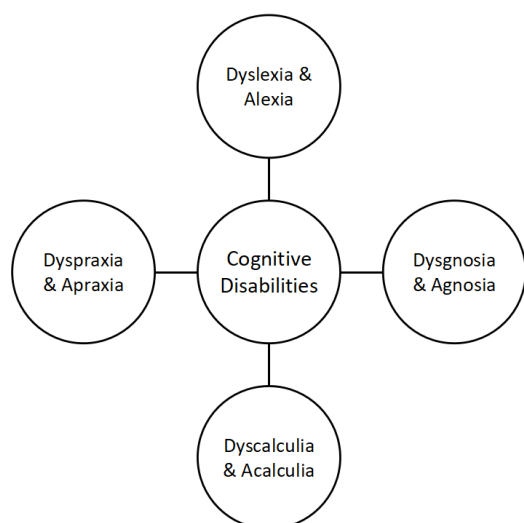


Figure 2: Four Subcategories of Cognitive Disabilities

In this paper, the author has chosen to describe each of these four subcategories of CogDs by relating them to the Cattell-Horn-Carroll (CHC) framework of broad and narrow abilities, whose history of development can be traced back to the early 1940s when Cattell proposed his original conceptualization of intelligence (Flanagan, Ortiz, & Alfonso, 2013) based on the dichotomous understanding of cognitive ability referred to as fluid-crystallized theory or Gf-Gc theory. On one hand, the Gf is fluid intelligence that includes inductive and deductive reasoning abilities, which, in turn, are “influenced by biological and neurological factors as well as incidental learning

through interaction with the environment” (Flanagan, Ortiz, & Alfonso, 2013, p. 7). On the other hand, the Gc refers to crystallized intelligence that generally consists of abilities related to acquired knowledge, which, in turn, is very much influenced by acculturation (Cattell, 1957, 1971).

The CHC framework of human potential (or cognitive abilities) is more than just Gf-Gc theory. In 1965, John Horn, a student of Raymond B. Cattell (b.1905-d.1998) (cited in Flanagan, Ortiz, & Alfonso, 2013) expanded the dichotomous model to include four more abilities: i.e., Gv which is visual perception or processing; Gsm which is short-term acquisition and retrieval; Glr which is long-term storage and retrieval; and Gs which concerns the speed of processing. Later, Horn (1967) added Ga, which is auditory processing ability, to the Gf-Gc model and refined the definitions of Gv, Gs and Glr (Horn & Stankov, 1982).

In 1991, Horn added Gt which represents an individual’s quickness in responding (reaction time) and decision-making (decision speed). Finally, Gq which is the quantitative ability and Grw which represents the broad reading/writing ability were also added by Horn (1991) and Woodcock (1994), respectively. The Gf-Gc theory expanded to a 10-factor model: Gf, Gc, Gv, Gsm, Glr, Gs, Ga, Gt, Gq and Grw in that sequence (see Table 2 for a summary of the 10 broad abilities; also see Flanagan, Ortiz, & Alfonso, 2013, for detail).

Table 2. 10 CHC-based Broad Abilities

Broad Ability	What is it?	What does it concern? (Flanagan, Ortiz, & Alfonso, 2013, p. 17)
Gf	Fluid intelligence	The deliberate but flexible control of attention to solve novel, on-the-spot problems that cannot be performed by relying exclusively on previously learned habits, schema, & scripts
Gc	Crystallized intelligence	The depth & breadth of knowledge & skills valued by one’s culture
Gv	Visual processing	The ability to make use of stimulated mental imagery (often in conjunction with currently perceived images) to solve problems
Gsm	Short-term memory	The ability to encode, maintain, & manipulate information in one’s immediate awareness
Glr	Long-term storage & retrieval	The ability to store, consolidate, & retrieve information over periods of time measured in minutes, hours, days, & years
Gs	Processing speed	The ability to perform simple, repetitive cognitive tasks quickly & fluently
Ga	Auditory processing	The ability to detect & process meaningful nonverbal information in sound
Gt	Reaction & decision speed	The speed of making very simple decisions or judgments when items are presented one at a time

Gq	Quantitative knowledge	The depth & breadth of knowledge related to mathematics
Grw	Reading & writing	The depth & breadth of knowledge & skills related to written language

### **Cognitive Abilities #1: Lexikos - Abilities & Skills in Literacy & Language**

*There are two key specific learning disabilities that are concerned about literacy and language. The first one is the disability of reading known as dyslexia, while the second one is the disability of writing known as dysgraphia. In some ways, both are related to each other in terms of literacy process and product (see Chia, 2007, for detail).*

*Dyslexia is “a specific learning disability that is neurobiological in origin. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction. Secondary consequences may include problems in reading comprehension and reduced reading experience that can impede growth of vocabulary and background knowledge” (Lyon, Shaywitz, & Shaywitz, 2003, p. 2). People with brain lesions have been found to have difficulties in literacy and language processing and this condition is known as alexia ( see Friedman, Ween, & Albert, 1993, for detail).*

*CHC broad abilities for reading include Ga, Gc, Glr, Grw, Gs, Gsm, Gt<sup>1</sup> (see Table 2 for description; also see Flanagan, Ortiz, & Alfonso, 2013, for more detail).*

There is another specific learning disability to do with deficits in writing deficits, and it is known as dysgraphia. Berninger (2020) has defined dysgraphia as “a specific learning disability that affects how easily children acquire written language and how well they use written language to express their thoughts ... [d]ysgraphia is the condition of impaired letter writing by hand, that is, disabled handwriting and sometimes spelling. Impaired handwriting can interfere with learning to spell words in writing ... Dysgraphia may occur alone or with dyslexia (impaired reading disability) or with oral and written language learning disability (OWL LD, also referred to as selective language impairment, SLI)” (p. 1). If writing problems are the result of neurological impairments, the condition is known as lexical or

orthographic agraphia (Beauvois & Derouesne, 1981).

*CHC broad abilities for writing include Ga, Gc, Gf, Glr, Grw, Gs, Gsm, [Gt]<sup>2</sup>, Gv (see Table 2 for description; also see Flanagan, Ortiz, & Alfonso, 2013, for more detail).*

### **Cognitive Abilities#2: Calculatos - Abilities & Skills in Numeracy & Mathematics**

Dyscalculia concerns poor number sense and faulty skill in subitizing (i.e., “instantly seeing how many”) and it refers to difficulty learning or comprehending arithmetic, e.g., problems in understanding and manipulating numbers, difficulties in performing mathematical calculations and trouble in acquiring mathematical facts (Miller, 2021). It is often mistaken for what is known as math dyslexia, but such a term is misleading as dyslexia is a different condition from dyscalculia. Disabilities in learning mathematics can also be the result of some types of brain injury, and it is termed acalculia (Ardila & Rosselli, 2002) rather than called dyscalculia, which is of innate, genetic or developmental origin.

*CHC broad abilities for numeracy and mathematics: Gc, Gf, Glr, Gq, Gs, Gsm, Gv, Gt<sup>3</sup> (see Table 2 for description; also see Flanagan, Ortiz, & Alfonso, 2013, for more detail).*

### **Cognitive Abilities#3: Praxis - Abilities & Skills in Motor Planning, Coordination & Execution**

“Developmental coordination disorder (DCD), also known as ... developmental dyspraxia or simply dyspraxia, is a neurodevelopmental disorder characterized by impaired coordination of physical movements as a result of brain messages not being accurately transmitted to the body” (Wikipedia contributors, 2022, para. 1). Interestingly, praxis has also to do with phenomenal will, also known as self-agency, which is the sense that actions are self-generated (Libet, 1985; Libet et al., 1983). Wegner (2003, 2004) later defined the three criteria of self-agency: (i) priority, (ii) exclusivity, and (iii) consistency. According to Wegner (2003, 2004), priority refers to a planned action before its initiation. Between the initiated

<sup>1</sup> Gt will be required for speed reading (first started by Evelyn Wood in 1959; cited in Frank, 1994).

<sup>2</sup> Gt is needed when participating in poetry slam (first started by Marc Smith in 1986), for example (see Aptowicz, 2009, for detail).

<sup>3</sup> Gt is needed when participating in abacus, speed mathematics and speed calculation (Handley, 2012).

action and the subsequent effect is that time interval known as the intentional binding. Next, exclusivity refers to the effect due to an individual's action instead of other potential causes for the effect. Lastly, consistency refers to one's planned action that must happen as intended. It is not within the scope of this paper to discuss the topic in-depth.

Deficits are noted in fine or gross motor skills movements in an individual with DCD and they interfere with activities of daily living. Often described as the disorder in skill acquisition, learning as well as execution of coordinated motor skills, when assessed, is found to be substantially below that expected of the individual's chronological age. Difficulties in dyspraxia include clumsiness, slowness and inaccuracy of performance of motor skills (e.g., untidy handwriting which is also described as cacographia, clumsy in handling cutlery or using tools). DCD or dyspraxia is also accompanied by challenges in organizing, paying attention, time management, and working memory. Problems in motor-related activities due to brain injuries are often identified as apraxia (see De Renzi & Faglioni, 2020; Heilman, Watson, & Gonzalez-Rothi, 2007 for more detail).

The authors have selectively included the following CHC broad abilities, which they believe are related to movement and coordination: Gp, Gs, Gsm, Gv, Gt (see Table 2 for description; also see Flanagan, Ortiz, & Alfonso, 2013, for more detail).

#### **Cognitive Abilities#4: Gnosis - Abilities & Skills in Knowledge Acquisition**

Dysgnosis is rarely mentioned in literature and it refers to any intellectual impairment. It is a cognitive disorder relating to any mental illness. Though very little is written about it, the term comes from the Greek word *gnosis* which means "knowledge." Best known for its implication within the Gnosticism, i.e., "collection of religious ideas and systems which coalesced in the late 1st century AD among Jewish and early Christian sects" (Margis, 2005, p. 3515), the term *gnosis* signifies "a spiritual knowledge of insight into humanity's real nature as divine, leading to the deliverance of the divine spark within humanity from the constraints of earthly existence" (Rudolph, 2001, p. 2; also see Brakke, 2010; Ehrman, 2003; May, 2008, for more detail). The authors of this paper chose to define dysgnosis as a form of cognitive impairment in two aspects of knowledge: (i) The first aspect concerns the knowledge of self (i.e., self-awareness or being mindful of oneself and one's actions) and that includes self-activated tasks, especially in self-agency (also known as the phenomenal will), which is the sense that actions are self-generated (also

see Wegner, 2003, 2004); and (ii) The second aspect concerns the knowledge of one's surrounding or context, in which one's action, utterance, or expression can only be understood relative to that context (Price, 2008). This may also include epistemic contextualism (EC), whose view concerns what is expressed by a knowledge attribution (i.e., a claim to the effect that *S* "knows" that *p*) that depends partly on something in the context of the attributor, and hence, what is known as the view of attributor contextualism. It is not within the scope of this paper to delve into this topic, but interested readers may want to read more about it elsewhere (e.g., Kompa, 2014; Price, 2008, as provided in the References below).

The American neuroscientist, Benjamin Libet (b.1916-d.2007), who was a pioneer in the field of human consciousness, was the first to study self-agency, discovering that brain activity predicts the action before one even has conscious awareness of his or her intention to act upon that action (Libet, 1985; Libet et al., 1983). This is the knowledge of self as described by the authors of this paper. Interestingly, in the field of psychology and neuroscience, there is another intriguing concept based on the hypothesis of an American psychologist and psychohistorian, Julian Jaynes (b.1920-d.1997), arguing that the human mind used to operate in a way that cognitive functions in the brain were divided between that *which speaks* and that *which listens and obeys*. Jaynes (1976) termed it the *bicameral mind*, from which his hypothesis of bicameral mentality (or the sense of bicamerality of the unconscious mind) came about. He argued that the evolutionary breakdown of this division gave rise to human consciousness. Jaynes (1976) also pointed out that bicameral mentality was the normal and ubiquitous state of the human mind as recently as 3,000 years ago, near the end of the Mediterranean Bronze Age (approximately from 3300BC to 1200BC). If this were indeed the case, there is more to it than meets the eye, concerning the knowledge of self, one's existence, and relationship with one's context. Our understanding of gnosis and also of agnosis (i.e., ignorance) should go beyond what is currently presented here.

If the condition of knowledge acquisition deficits is a result of some form of brain injury, it is known as agnosia, which is the inability to process sensory information, i.e., it includes severe to profound mental retardation (see Farah, 1992, for detail). It is important not to confuse between the two terms: agnosis and agnosia. The former refers to ignorance while the latter is a serious disability. Often there is a loss of ability to recognize objects (Konen et al., 2011), persons (Damasio, Tranel, & Damasio,

1990), sounds (Shell, 2015), shapes (Milner et al., 1991), or smells (Pryse-Phillips, 1975) while the specific sense is not defective nor is there any significant memory loss.

The authors have selectively included the following CHC broad abilities, which they believe are closely related to knowledge acquisition: Ga, Gf, Gkn, Glr, Gq, Grw, Gsm, Gt (*see Table 2 for description; also see Flanagan, Ortiz, & Alfonso, 2013, for more detail*).

### Conclusion

There remains an infinite realm of unknowable unknowns in our pursuit of knowledge in the area of cognitive disabilities and their subcategories within the CHC theory of broad abilities (and also

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# Diagnostic Profiling of Cognitive Strengths and Weaknesses in Autism Spectrum Disorder: What the Cattell-Horn-Carroll Theory tells Us

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## Abstract

Autism spectrum disorder (ASD), or autism for short, has always been identified by its classical triad of impairments (ToI) – difficulty with communication, difficulty with behavior or social interaction, and difficulty with social skills – first established by Lorna Wing and Judith Gould in 1979. This ToI has become generally accepted as the key criteria for identifying children suspected and/or observed to have ASD. While the concept of ToI has set as the central plank of the construct of ASD, it should never be taken as an end in itself with the symptomatic

definition of the condition. It should, however, remain a transitional idea that continues to evolve from the level of behavioral manifestation to that of cognitive processing. As a result, the authors of this short paper have taken a different approach in examining the concept of ASD by applying the Cattell-Horn-Carroll (CHC) theory in terms

cognitive strengths and weaknesses in the diagnostic evaluation of the autistic condition.

**Key Words:** Autism spectrum disorder, CHC theory, Cognitive strengths and weaknesses, PSW model

## Introduction

Autism spectrum disorder (ASD), or autism for short, is a multi-faceted neurodevelopmental disorder that is still not fully understood, and whose operating definition has been changing through past decades with new discoveries. The use of the term *autism* is “a little over than 100 years now” (Ames, 2018, para. 4) and was first mentioned in 1911 by a Swiss psychiatrist, Eugene Bleuler (b.1857-d.1939), who used it as one of the symptoms to describe dementia praecox (i.e., a cluster of schizophrenias) (see Bleuler, 1950, for detail), “which is not associated with ASD today” (Ames, 2018, para. 4).

Years later, in 1926, a Ukrainian child psychiatrist, Grunya Efimovna Sukhareva (b.1891-d.1981), in Kiev, published a paper based on her observation and working with six children with autistic traits in a scientific German psychiatry and neurology journal (cited in Posar & Visconti, 2017). Then in 1938, an American psychologist based in New York, Louise Despert (b.1892-d.1982), detailed 29 cases of childhood schizophrenia, some who displayed symptoms that resembled what we know as autism today. It was not until 1943, when Leo Kanner (b.1894-d.1981), an American psychiatrist, published his paper describing 11 patients who

manifested autistic traits and what he later named the condition infantile autism (Kanner, 1943). About the same time, the Austrian pediatrician, Hans Asperger (b.1906-d.1990) published a paper on his case study of four children aged six to eleven with high-functioning autism, later known as Asperger Syndrome (Asperger, 1944).

In 1952, the first edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM) was published by the American Psychiatric Association listed children with autistic symptoms under childhood schizophrenia (cited in Sasson et al., 2011; also see Cantor, 1988, for more detail). Four years later, an American child psychiatrist, Leon Eisenberg (b.1922-d.2009) published his paper reporting on 63 children with autism being evaluated at a mean age of 15 years after a mean follow-up period of 9 years. Almost a third of the subjects achieved at least a moderate social adjustment, and the prognosis varied significantly with the presence of useful speech at the age of five, which was taken as an index of the severity of autistic isolation (Eisenberg, 1956).

It was during the late 60’s up to mid-70’s that autism – not yet officially known as ASD yet until



the publication of the DSM-5<sup>4</sup> (APA, 2014) in 2014 and its subsequent text revision (DSM-5-TR; APA, 2022) when ASD is taken to be a single disorder without its previous subcategories as listed in the DSM-IV and its subsequent DSM-IV-TR (APA, 2004) - began to get more attention, research, and definition. According to Ames (2018), “[H]owever, some of this research was very off the mark” (para. 15). For instance, the Austrian-born psychologist, Bruno Bettelheim (b.1903-d.1990), published a paper (see Bettelheim, 1959, for detail) about a 9-year-old boy with “autism was caused by unloving, cold mothers, and went on to coin the term *refrigerator mothers* to describe these mothers” (cited in Ames, 2018, para. 16). Later, the American research psychologist, Bernard Rimland (b.1928-d.2006), argued against Bettelheim’s misconception of refrigerator mothers and debunked it. Rimland (1964) published his book *Infantile Autism: The Syndrome and Its Implication for Neural Theory of Behavior*” to help in defining autism and also to direct autism research at that time (cited in Ames, 2018, para. 17).

Both Ames (2018) and Iannelli (2020) had each provided a brief overview or history of autism timeline. Ames (2018) described the autistic condition as a brain disorder whose onset typically becomes apparent around the ages of 2 to 3 years old. However, with new screening tools, diagnosticians are able to assess and identify ASD at 18 months of age or even younger at one year old. By age of 2 years old, an ASD diagnosis by an experienced professional can be quite reliable (Lord et al., 2006). This is indeed great news as the earlier a young child is diagnosed with ASD, the earlier s/he gets treatment, the better is the prognosis.

### **Triad of Impairments: Behavioral Manifestation vs Cognitive Processing**

In the late 1970s, the exceptional pioneering work, notably that of Wing and Gould (1979), gave rise to the concept of the triad of impairments (ToI) as the central plank of the construct of ASD, i.e., impairment in communication, impairment in social skills, and a restricted and repetitive behavior (stereotyped behavior). With the introduction of the ToI concept, it provided a clear articulation of the structures of the little understood phenomenon of autism, allowing a new perspective for both professionals and families with their loved ones identified with ASD to see and understand the condition, as well as to better relate to those with

ASD. Just like with many evolutionary concepts, the ToI model remained and is still very much a transitional idea. The original ToI postulated by Wing and Gould (1979) has provided the behavioral manifestation of ASD.

However, the authors of this paper strongly believe the actual ToI in ASD is best understood and better defined at the level of cognitive processing. Termed as the cognitive ToI, it is static and ubiquitous unlike the variable and fluctuating behavioral ToI. Also, the behavioral ToI in autism is visual as opposed to the cognitive ToI which is concerned about linguistic processing, impaired abstract reasoning, and lack of theory of mind. The authors believe the cognitive ToI offers the diagnostic key that opens our understanding of what constitutes the condition of ASD. It is for this main reason the authors have chosen to take the Cattell-Horn-Carroll (CHC) theory to examine the strengths and weaknesses observed in individuals with ASD based on the assessment data collected from various published papers over the last decades.

### **Autistic Profile of Cognitive Strengths and Weaknesses**

With a gradual introduction as well as a further development of the Cattell-Horn-Carroll (CHC) theory of cognitive abilities since the early 1940s, data gathered from the diagnostic assessment of children with ASD has taken a more targeted approach. “Test data must *now* be interpreted in a manner that is both theoretically and psychometrically defensible” (Flanagan, Ortiz, & Alfonso, 2013, p. 121).

The cognitive ToI now looks to what the CHC theory has to offer in terms of better understanding of ASD through assessment administered and intervention rendered. More importantly, the diagnostic interpretation of the test data “should not begin with the presumption of preexisting deficits ... *but* ... should be guided by the assumption that the examinee is not impaired and that his/her performance on tests will be *within the normal limits* (WNL) of functioning” (Flanagan, Ortiz, & Alfonso, 2013, p. 122-123). This means that confirmatory bias must be avoided even before the start of assessment. Every examinee is treated as having cognitive abilities WNL and this is taken to be a null hypothesis<sup>5</sup> until test data show otherwise. When that happens, the null hypothesis is rejected in favor of an alternative hypothesis that could best

<sup>4</sup> The most recent editions of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5-TR; APA, 2022) and *International Classification of Diseases* (ICD-11, released in 2021; WHO, 2021) both list ASD as a single disorder.

<sup>5</sup> “Only the hypotheses specified a priori or a posteriori are actually tested and evaluated directly in light of the data; opinion and conjecture are not” (Flanagan, Ortiz, & Alfonso, 2013, p. 123).

explain the condition identified. The CHC model can use the test data to establish a smooth transition from assessment to intervention.

Previously, several studies (e.g., Ankenman et al., 2014; Goldstein et al., 2008; Siegel, Minshew, & Goldstein, 1996) were carried out to determine the cognitive profiles of individuals with ASD. It was found that individuals with ASD performed better on nonverbal than verbal tasks. Moreover, these individuals also scored better on tasks relying on visual-spatial abilities as opposed to those tasks depending on verbal skills and understanding on social rules/relations (Mayes & Calhoun, 2008). This is known as Verbal/Nonverbal IQ Score Discrepancy (V/NV-IQsD) Hypothesis. According to Siegel, Minshew, and Goldstein (1996), the Verbal/Nonverbal IQ Score Discrepancy is nearly one standard deviation, i.e., 12 IQ points. However, other studies (Barbaro & Dissanayake, 2012; Grofer-Klinger et al., 2002; Joseph et al., 2002;) found inconclusive results when cognitive abilities were examined across a wide range of intellectual ability and chronological age. For instance, in a study done by Mayes and Calhoun (2003), findings suggested that higher scores in nonverbal IQ were

noted in preschool children, and these scores remained consistently the same throughout the early school-age years in children with IQ scores <80. However, this difference disappeared when children were between 6-7 years old with IQ scores >80. In another study conducted by Ankenman et al. (2014), findings revealed that the pattern of Verbal/Nonverbal IQ Score differences was more common in younger children.

According to Marjanovic (2017), the V/NV-IQsD Hypothesis has already been abandoned in today's cognitive assessment and results interpretation. Most of the current cognitive assessments are designed to include disparate capacities defined by the CHC model of cognitive abilities. The CHC model provides a comprehensive taxonomy of human cognitive abilities empirically validated by the psychometric theory of cognitive abilities. This theoretical model (also known as the three-stratum theory) is derived primarily from Spearman's (1927) model of general intelligence and Horn and Cattell's (1966) theory of fluid (Gf) and crystallized (Gc) intelligence. It is organized hierarchically into three different strata as follows (Carroll, 1997; Schneider & McGrew, 2012) (see Table 1):

Table 1. The Three Strata of Intellectual Abilities

Stratum	Term	Descriptor
Stratum III	General intelligence [denoted by g]	Known as <i>g</i> factor, it accounts for the correlations among the broad abilities at Stratum II.
Stratum II	Broad abilities [denoted by G with a lowercase letter thereafter, e.g., Gf, Gc]	There are eight broad abilities. They are as follows: (1) Gf - fluid intelligence; (2) Gc - crystallized intelligence; (3) Gwm <sup>6</sup> - general memory and learning; (4) Gv - broad visual perception; (5) Ga - broad auditory perception; (6) Grl - broad retrieval ability; (7) Gt - broad cognitive speediness; and (8) Gs - processing speed.
Stratum I	Narrow abilities [denoted after a hyphen which is followed by either alphabetic or numeric symbols or both, e.g., Gs-R9, Gf-I]	These are more specific abilities under each of the broad ability as identified under the Stratum II.

<sup>6</sup> Gwm was previously known by its abbreviation Gsm for Short Memory.

Using the CHC-based Pattern of Strengths and Weaknesses (PSW) model (see Schultz, Simpson, & Lynch, 2006, for detail in terms of specific learning disability) to aid in understanding as well as profiling of individuals with ASD, the cognitive strengths of such individuals could be found to lean on nonverbal Fluid Reasoning (nv-Gf) tasks (Lim & Chia, 2017), e.g., the WISC-IV<sup>7</sup> subtests of Matrix Reasoning (Gf-I) and Picture Concepts (Gf-I) (Mayes & Calhoun, 2008). Based on the CHC taxonomy, both the WISC-IV subtests - Matrix Reasoning and Picture Concepts - fall under the broad ability of Fluid Intelligence, denoted by Gf, which is defined as “the deliberate but flexible control of attention to solve novel, on-the-spot problems that cannot be performed by relying exclusively on previously learned habits, schemas, and scripts” (Flanagan, Ortiz, & Alfonso, 2013, p. 403), and also under the same narrow ability denoted by the letter I, which refers to Induction (or inductive reasoning). Gf-I, in turn, is defined as “the ability to observe a phenomenon and discover the underlying principles or rules that determine its behaviors” (Flanagan, Ortiz, & Alfonso, 2013, p. 403).

According to three separate studies (i.e., Coolican, Bryson, & Zwaigenbaum, 2008; Dawson et al., 2007; Kushner, Benetto, & Yost, 2007), the PSW of nonverbal cognitive functioning in children with ASD showed stronger nonverbal skills on untimed visual-spatial tasks in WISC-IV subtests of Picture Completion (Gv-CF) and Mazes (Gv-SS) as well as quantitative reasoning tasks (Gf-RQ) in SB-4 Quantitative Reasoning domain (verbal and/or nonverbal). Quantitative reasoning, denoted by RQ, is a narrow ability under the broad ability Gf in the CHC taxonomy, and it is defined as “the ability to reason with quantities, mathematical relations, and operators” (Flanagan, Ortiz, & Alfonso, 2013, p. 403). In summary, the PSW of ASD can be determined to a limited extent based on the CHC taxonomy (i.e., the pattern of cognitive strengths found in Gf-I and Gf-RQ) in the diagnostic profiling of such individuals.

On the contrary, a pattern of weaknesses in individuals with ASD are frequently found in “crystallized ability (Gc) tasks that encompass understanding of social rules” (Marjanovic (2017, p. 97). Moreover, Harris, Handleman and Burton (1991) also reported the pattern of weaknesses in individuals with ASD especially in the poor performance on verbal fluid reasoning (v-Gf-I) tasks, e.g., Absurdities test in the SB-4 domain of Fluid Reasoning (Thorndike, Hagen, & Sattler,

1986). Under the CHC taxonomy, the SB-4 Absurdities task also came under the broad ability of Crystallized Intelligence (Gc) and its narrow ability of General Verbal Information (Gc-K0). The broad ability of Gc is defined as “the depth and breadth of knowledge and skills that are valued by one’s culture” (Flanagan, Ortiz, & Alfonso, 2013, p. 400), while Gc-K0 refers to “the breadth and depth of knowledge of one’s culture” (Flanagan, Ortiz, & Alfonso, 2013, p. 400).

According to Marjanovic (2017), individuals with ASD performed badly or scored poorly on the following cognitive tasks:

(i) Understanding of social situations and rules (Dawson, et al., 2007; Siegel et al., 1996), e.g., poor score on the WISC-IV Comprehension subtest, under the broad-and-narrow ability of Gc-K0 (i.e., Crystallized Intelligence-General Verbal Information), which refers to “the breadth and depth of knowledge of one’s culture” (Flanagan, Ortiz, & Alfonso, 2013, p. 400);

(ii) Speed of information processing (Oliveras-Rentas et al., 2012; Wallace, Anderson, & Happé, 2009), e.g., poor score on the WISC-IV Coding subtest, under the broad-and-narrow ability of Gs-R9 (i.e., Processing Speed-Rate of Test Taking), which refers to “the speed and fluency with which simple cognitive tests are completed” (Flanagan, Ortiz, & Alfonso, 2013, p. 408);

(iii) Retention and recall of information (Kercood, et al., 2014), e.g., poor score on the WISC-IV Digit Span subtest, under the broad-and-narrow ability of Gwm-MS (i.e., Working Memory-Memory Span), which refers to “the ability to encode information, maintain it in primary memory and immediately reproduce the information in the same sequence in which it was represented” (Flanagan, Ortiz, & Alfonso, 2013, p. 408); and

(iv) Capacity of working memory (Kercood, et al., 2014; Nakahachi et al., 2006), e.g., poor scores on the WISC-IV Arithmetic and Letter-Number Sequencing subtests, under the broad-and-narrow ability of Gwm-MW, (i.e., Working Memory-Working Memory Capacity), which refers to “the ability to direct the focus of attention to perform relatively simple manipulations, combinations, and transformations of information within primary memory while avoiding distracting stimuli and engaging in strategic /controlled searches for information in secondary memory” (Flanagan, Ortiz, & Alfonso, 2013, p. 407).

Table 2 (on the next page) provides a summary of the pattern of strengths and weaknesses - based on the administration of various subtests of IQ tests,

<sup>7</sup> WISC-IV stands for Wechsler Intelligence Scale for Children-Fourth Edition (Wechsler, 2003).

such as WISC-IV and SB-4, as reported in various published studies (e.g., Harris, Handleman, & Burton, 1991; Lim & Chia, 2017; Marjanovic,

2017) found in the identification of ASD based on the CHC taxonomy.

Table 2. Pattern of Strengths and Weaknesses in ASD Profiling

Examples of Strength	Examples of Weakness
1. WISC-IV Matrix Reasoning (Gf-I)	1. SB-4 Absurdities (v-Gf-I; Gc-K0)
2. WISC-IV Picture Concepts (Gf-I)	2. WISC-IV Comprehension (Gc-K0)
3. WISC-IV Picture Completion (Gv-CF)	3. WISC-IV Coding (Gs-R9)
4. WISC-IV Mazes (Gv-SS)	4. WISC-IV Digit Span (Gwm-MS)
5. SB-4 Quantitative Reasoning (Gf-RQ)	5. WISC-IV Arithmetic (Gwm-MW)
	6. WISC-IV Letter-Number Sequencing (Gwm-MW)

However, there are also other studies that refuted what was believed to cognitive impairments due to ASD. One good example is the working memory. As mentioned in the the fourth point of the paragraph above, working memory was believed to be severely impaired in individuals with autism, but Ozonoff and Strayer (2001) reported that “working memory is not one of the executive functions that is seriously impaired in autism” (p. 263). Bennetto, Pennington and Rogers (1996) reported that both intact and impaired working memory could be found in individuals with ASD. In addition, low or poor performance on nonverbal measures (Gf) is noted when the task is presented verbally (v-Gf task) but high or better performance when the presentation is nonverbal (nv-Gf task). However, not all measures on verbal tasks are low for individuals with ASD. Marjanovic (2017) rightly pointed out that performance of individuals with ASD on these verbal tasks is very much dependent on their language proficiency.

### Conclusion

The CHC theory/model/taxonomy has been “considered the state-of-the-art of the psychometric tradition about intelligence” (Gomes et al., 2014, p. 22). It has also garnered a panoply of research support in the application of classifying the intelligence attributes in terms of broad and narrow cognitive abilities. Assuming the CHC approach is valid and reliable, it would be a useful method for identifying a pattern of strengths and weaknesses in order to establish a profile of an individual with ASD. Its diagnostic or clinical utility, which refers to the value of information to the individual being tested, is useful only if the results can provide information that is of the value to that individual so that the information can be used to seek an appropriate and effective treatment or preventive strategy for the condition of ASD.

However, even until today, the validity of the CHC model using the dual discrepancy/consistency (DD/C) model (see Kranzler et al., 2019, for detail) to identify whether an individual has specific

learning disability (SLD) shows “a very low probability of accurately identifying true SLD ... assessment data with the DD/C method does not result in a high level of identification accuracy ... its use is grounded largely on the illusion of validity” (Maki, Kranzler, & Moody, 2022, p. 46), and what Lilienfeld et al. (2007) called it the *alchemist’s fantasy*. What about the application of CHC model in accurately identifying an individual with ASD? The answer to the question remains unascertainable and evasive (Gomes et al., 2014; also see Beaujean et al., 2018, for more detail). The authors of this paper strongly advocate for more studies on the diagnostic utility of the CHC model in identification of ASD are needed.

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# The Symbolic Significance of the Christmas Tree Drawing

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## Abstract

Christmas Day falls on the 25<sup>th</sup> day in the month of December each year and is associated with a religious celebration of the birth of Jesus by the Christians – both the Roman Catholics and the Protestants as well as other Christians from different denominations – worldwide. In fact, there are several hypotheses regarding the exact date of Jesus' birth. However, in the early 4<sup>th</sup> Century AD, the Western churches fixed the date as 25 December, while the Eastern churches put it on 7 January of the following year. Christmas has also become a cultural and commercial event associated with iconic figures such as Santa Claus, reindeer, snowy winter, snowman, and, of course, not forgetting the Christmas tree. Today, what is known about the special occasion has almost been lost or drowned in commercialism. In this short paper, the authors explored the historical and religious symbolism of the Christmastide through the projective drawing of a Christmas tree (suitable for both children and adults), and what this fun activity can offer to help drawers of all ages to understand the true meaning behind the celebration of Christmas.

**Key Words:** Christmas Day, Christmastide, Christmas tree, Draw-a-Tree, Jesus Christ

## Introduction

As each year comes to a gradual close, Christmas comes into the picture. According to Lizorkin-Eyzenberg (2022), “[N]owhere in the Holy Scriptures are we told about a celebration commemorating the birth of Christ Jesus” (para. 1). In fact, “[T]he first church figure to discuss the date of Jesus’ birth was Clement (c.200), an Egyptian preacher from Alexandria” (Lizorkin-Eyzenberg, 2022, para. 3). By the middle of the 4<sup>th</sup> Century AD, the Western churches were already celebrating the birth of Christ on 25 December (Roll, 1995), while the Eastern churches did so on 7 January in the following year. It is important to note that “it was not until the 4<sup>th</sup> to 6<sup>th</sup> centuries of the Common Era that Christians began to ‘Christianize’ the local pagan celebrations of the peoples they sought to evangelize” (Lizorkin-Eyzenberg, 2022, para. 7).

Christmas Day, which is primarily observed by several branches of Eastern Christianity on 25 December<sup>8</sup> each year based on the Julian calendar, is an annual festival commemorating the birth of Jesus Christ among billions of people throughout the world. It is a feast central to the Christian liturgical year, preceded by the season

of Advent (also known as the Nativity Fast), and the special occasion initiates the season of Christmastide. Historically, Christmastide in the West lasts 12 days and culminates on Twelfth Night<sup>9</sup> (see Forbes, 2008, for detail) – remember the popular song *The Twelve Days of Christmas* written by the English composer Frederic Austin (b.1872-d.1952), whose version of the song and the melody only became popular in 1909. Unlike the majority of the churches, the Armenian churches observed the nativity on January 6 even before the Gregorian calendar originated. There are also some Armenian churches using the Julian calendar to celebrate Christmas Day on January 19 on the Gregorian calendar, with January 18 being Christmas Eve.

Today, Christmas has been declared a public holiday in many countries except for Muslim countries and a few other countries (e.g., China and North Korea). It is now celebrated religiously by a

<sup>8</sup> Christmas Day based on the Gregorian calendar is celebrated on January 7 each year. Most Armenian Christians use the Gregorian calendar, still celebrating Christmas Day on January 6.

<sup>9</sup> According to Forbes (2008), “In 567AD, the Council of Tours proclaimed that the entire period between Christmas and Epiphany should be considered part of the celebration, creating what became known as the 12 days of Christmas, or what the English called Christmastide. On the last of the 12 days, called Twelfth Night, various cultures developed a wide range of additional special festivities. The variation extends even to the issue of how to count the days. If Christmas Day is the first of the 12 days, then Twelfth Night would be on January 5, the eve of Epiphany” (p. 27).

majority of Christians (Ehorn, Hewlett, & Hewlett, 1995) as well as culturally by many non-Christians (Hytrek, 2009), and has become a special occasion of gift giving and sharing of the festive joy, goodwill and glad tidings among all people, young and old.

In this paper, the authors have chosen to focus on the symbolism of the Christmas tree, its significance and what its archetypal meaning.

### The Cross, the Tree

Among the Christian symbols, the Cross is most widely used and known throughout the world. It has become the universal symbol of Christianity representing God's redemption for sinful mankind through Christ Jesus who was crucified on the Cross or hung on the Tree. In other words, the Cross and the Tree mean the same thing here. According to Brasseaux (2015), when the Holy Bible mentions that Jesus was hung on a *tree*, he explained that the word *tree* is being used in the general sense to refer to 'a structure made of wood' (para. 12) – more of an archaic word which carries the poetic/literary definition of *tree*. 'It was *not* a tree in the sense of Jesus being nailed to something growing in the ground with branches and leaves' (Brasseaux, 2015, para. 12). It was referring denotatively to some type of wooden structure, a tree that had already been cut down, stripped of leaves and branches, and trimmed into beams that could be carried by men (for more detail, see Matthew 27:32; Mark 15:21; Luke 23:26; John 19:17 in the New Testament of the Holy Bible).



Figure 1. A Tree-shaped Cross

The Cross (see Figure 1) itself has multiple meanings and hence, it can mean different things to different people. 'Some have it displayed on their mantel, others wear it around their neck' (Coleman, 2022, para. 2). According to Coleman (2022), the Cross means (i) love and (ii) a portrayal of willful humility; it is also (iii) personal, (iv) prophetic, and (v) final when Christ uttered His last words, while still being hung on the cruel tree, "It is finished" found in the gospel according to Saint John (Chapter 19, Verse 30). The Greek word translated "it is finished" is *tetelestai* - an accounting term

that means 'paid in full' (Jenkins, 2020, para. 1). It also means that Christ has provided the only solution to the sin of mankind: the only way to God is through Himself (see John 14:6; Acts 4:12). It is only through the death of Christ that Christians can put to death their sin and put on Christ (Colossians 3:5-14).

The Cross is the agent of redemption. This is the doctrine of *redemptionism* whose advent began with Rev Michael Williams, a traditional Evangelical Christian, in the early 1990s. It is '[T]he doctrine that all of humanity was redeemed (i.e., saved, sanctified) through the death and resurrection of Jesus Christ and asserting that the redemption of all was completed and concluded in His resurrection. There was no further need for scriptural fulfillment thereafter' (Mike Williams Gospel, 2016, para. 2).

### The Tree as a Symbol of being redeemed from every Curse

*Christ has redeemed us from the curse of the law, having become a curse for us (for it is written, "Cursed is everyone who hangs on a tree"), that the blessing of Abraham might come upon the Gentiles in Christ Jesus, that we might receive the promise of the Spirit through faith. (Galatians 3:13-14; New King James Version<sup>10</sup>)*

In the above passage from the Bible, in Galatians 3:13-14, the curse of Jesus Christ for all believers is clear. This is how all the blessings that God wants to give fallen mankind can be realized. Jesus died for sinners, in their place. The death he suffered was not his because the sin was not his, the sin was not his, and the punishment he endured was not his.

The method by which Jesus died on the tree also makes sense for several reasons. Crucifixion, hanging the convicts on a wooden cross, was reserved for the vilest criminals. Criminals are often left to die by slow suffocation (when their lungs collapse after bearing the full weight of their body) in a very public space. This means that the location of the cross with the criminals being crucified will likely be along busy streets. This should serve as a warning to everyone that the consequences of this intrusion are huge. Roman citizens were rarely executed this way. When Jesus was executed by crucifixion, he became the most shameful sinner before a holy God, who placed upon him the sin of all those for whom he died. Since being hanged from a tree meant that Jesus would be in sight of everyone in a crowd on a busy street, it means that this very public form of

<sup>10</sup> Testament, N., & Psalms, P. (1987). The New King James Version. Tennessee: National Publishing Company.



execution was witnessed by a lot of people during this period.

Being crucified on a tree means that Jesus carries within him the covenant curse that Adam's rebellion has inflicted on all mankind. Ignoring God's clear command to not do so, Adam ate from the tree of the knowledge of good and evil, and the curse of eternal death fell upon him and all who came after him.

Deuteronomy 21:22-23 states that if a man has committed a sin deserving of death, and he is put to death and hung on a tree, he who is hanged is accursed of God. Jesus, who is also known as the last Adam, was hung from a tree to redeem mankind from all the curses caused by Adam's rebellion. Even the curse mentioned in Galatians 3:13 (which was quoted from Deuteronomy 21:22-23) must be fully included in the act of redemption.

Thus, the innocent and blessed Son of God was hung from a tree as if He were a vile criminal, and He suffered the wrath of God on our behalf, bringing all the curses upon Himself, so we can experience all the blessings of the new covenant.

#### **Christian Symbols related to the Christmas Celebration**

There are also many other Christian symbols besides the prominent symbol of the Cross. These symbols include angel, blood, bread, door, dove, heart, light, love, and water. Among the symbols, it is during the Christmas festive season that one can find most Christian symbols displayed widely everywhere, such as the Star of Bethlehem, the Magi (i.e., the three Kings of the East who came to worship Christ when He was born), an angel blowing a trumpet hearkening to the birth of Christ, and many more.

In this short paper, the authors' focus is targeted on the Christian symbols relevant to the Christmas celebration. However, to begin, we need to know and understand what Christmas is and how it came about.

The celebration of Christmas, which was originally known as Christ's Mass, started in Rome about AD 336. However, for the first 300 years of Christianity, it was not a celebration of Christ's birth. According to Graves (2020), found 'in an old list of Roman bishops, compiled in AD 354, the following words appeared for AD 336: "25 Dec.: natus Christus in Betleem Judeae" (para. 1). It means 'December 25th, Christ born in Bethlehem, Judea.' This is the day, December 25, 336, that has been recorded as the first celebration of Christmas. However, it did not become a major Christian festival until the 9th century. The early Christian

community distinguished between the identification of the date of Jesus' birth and the liturgical celebration of that event. The actual observance of the day of Jesus' birth was long in coming.

Among the Christian symbols that we often see during the Christmas season is the prominent Christmas tree. Nobody is certain exactly when the Christmas tree came into the picture. In Christianity, it is a symbol of the birth and resurrection of Jesus Christ. The branches of a Christmas tree and the shrubs are often viewed as an emblem of immortality. They symbolize the crown of thorns to be worn by Christ when He was falsely accused and sentenced to death by being crucified on the Cross (or figuratively speaking, hung on the Tree of Death).

According to Graves (2020), there was an interesting myth that originated in Germany - quite popular in the 15th century - tells a story of an 8th century English missionary, Saint Boniface, Apostle to Germany, who thwarted a pagan human sacrifice under an oak tree by cutting down that tree. In its place, a fir tree grew with its branches representing a symbol of the everlasting Christ and His eternal truth. By the end of the 16th century, Christmas trees were common in Germany. Some say it was the reformist, Saint Martin Luther, who cut the first Christmas tree, took it home and decked it with candles to represent the stars. When the German court came to England, the Christmas tree came with them.

#### **Symbolic Meaning of Christmas Tree**

The Christmas tree (see Figure 2) symbolizes the birth of Jesus Christ. It is also a representation of the Tree of Life in the Garden of Eden and it is also a reminder that we are all children of God who should love one another. There are also many other symbolic meanings for the Christmas tree. A cut or chopped-down Christmas tree symbolizes our fallen world, sinful human nature. An uncut and undecorated Christmas tree symbolizes the plain message of salvation for mankind through Christ Jesus - the pinnacle of God's redemption for us.

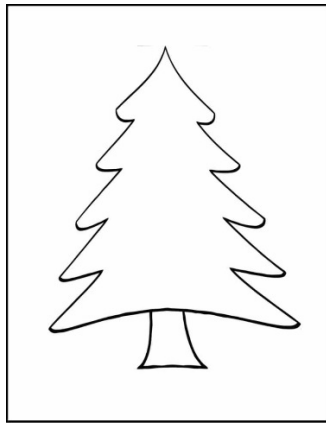


Figure 2. A Christmas Tree

### Christmas Tree Drawing (CTD)

Like the Tree Drawing Test (TDT; Koch, 1949), also known as Koch's Baum Test, drawing a Christmas tree (or Christmas Tree Drawing) has become itself a form of projective drawing activity, but *not* a projective drawing test *per se*, that can tell us something about what a drawer, be s/he a child, adolescent or adult, is aware of Christmas and the symbolic meaning that underlies the special occasion of celebration. The instruction is simple: "Draw a Christmas tree."

The purpose of the Christmas Tree Drawing (CTD) is very much related to the Christian faith. Most Christians attach the Christmas symbols to their faith. Hence, the CTD tells us about a drawer's degree of his/her spiritual attachment to what s/he believes. The catholic purpose of red and green colors resonates with the blood shed by Jesus and the everlasting life one gets when one surrenders one's life to Christ Jesus, respectively.

### Colors of Christmas in CTD

The colors of Christmas used in CTD refer to those colors that traditionally symbolize Christmas. The two key colors are a medium red and green, which originated with the leaves and berries of holly. According to Spacey (2020), "[T]he evergreen varieties of holly plants constitute the traditional symbol of Christianity and have been used since the Medieval Age to make Christmas wreaths" (para. 1). Spacey (2020) has identified 14 colors associated with Christmas such as blue, gold, grey, pink, purple, red, silver, white and shades of green, and these signature colors help with marketing and branding products related to Christmas (Andersen, 2022).

According to Andersen (2022), the five significant Christmas colors are listed alphabetically as follows with their respective symbolic meanings provided (para. 10-14):

1. **Gold:** This bright shiny color represents the sun as well as the Son (meaning the Son of God, i.e., Jesus Christ). It is used at Christmastime to symbolize light has broken into the darkness. It is also taken to represent one of the gifts that the Magi (or commonly known as the Wise Men from the East) brought before the infant Jesus to adore and worship Him with reverence. The metallic color gold conveys wealth, prosperity and glamour.
2. **Green:** This is one key Christmas color because evergreen plants (e.g., holly and mistletoe) are used at Christmastime. It symbolizes Christ's life and eternal nature. During the olden pagan era, these evergreen plants served as a reminder that nature keeps growing even during the cold times. The color green often symbolizes money, good luck and health.
3. **Purple:** This rich shade or purple or violet symbolizes holiness. It is also the main color of Advent, the period before Christmas, when Christians throughout the world fast and repent in anticipation of Christ's birth. The color purple symbolizes royalty, luxury and a sense of magic or whimsy.
4. **Red:** This deep hue symbolizes the blood of Jesus Christ. It was He that Christmas celebrates but Jesus was never born on the Christmas Day. Moreover, in secular sense, the color red also associates with Santa Claus and his distinctive red outfit. Generally, red represents love, courage and romance.
5. **White:** This color is associated with the blanket of fresh white snow that is often seen the Christmas picturesque, especially in the northern hemisphere. The color white hearkens back to the times of pagan winter solstice festivals. It represents purity and the triumph of good over evil; these are the two main themes at Christmastime.

The colors green and red listed in the Christmas colors should not be confused and misinterpreted as colors of personality (Hammer, 1968; Jolles, 1957; Precker, 1950; also see Rabin, 1968, for detail). Red, may be related to violence or excessive emotion, but it is also associated with cheerfulness, especially when young children use the color in their drawings. The emphasis of red in this aspect suggests "happier, well-adjusted, and more emotional in their personal reactions" (Klepsch & Logie, 1982, p. 35). Green, like blue, is similar in its symbolic meaning, represents "controlled behavior" (Klepsch & Logie, 1982, p. 35).

### CTD Symbolic Interpretation

A drawer may add many colorful decorations to his/her Christmas Tree Drawing. Each of these

decorations has its own symbolic meaning. Here the authors have provided a list of 12 key Christmas objects that are often used in decorating the Christmas tree and provided their respective symbolic meanings.

1. **Candles:** When added to the CTD, they represent the 'Star of Bethlehem'. Different colored candles mean different things, e.g., white means purity, and pink means joy. Instead of drawing Candles, Christmas Lights are more widely seen in drawing especially when a drawer adds ornamental balls of different colors. These lights represent the new light or hope that Christ is. It also means spending meaningful time together as a family with a refreshed hope for a better future. Like candles, different colored lights mean different things: e.g., white means purity and pink means joy. The lights and candles represent the Star that guided the three Wise Men (the Magi). It can also mean making one's candle shine and light one's path in one's life: positive Christian living. The lit candle also represents Jesus, the light of the world, and candlelight Christmas Eve church services are popular Christmas celebrations in many countries
2. **Candy Cane:** The Christian legend of the candy cane claimed that the shape of the candy is actually a "J" for Jesus and that the red and white stripes represent the blood Jesus spilled and His purity, respectively.
3. **Christmas Angel:** Traditionally, a Christmas angel is the tree topper, placed at the apex of a Christmas tree, to represent the role of angels at the birth of Jesus, e.g., informing the Virgin Mary that she would be the mother of Jesus, visiting Joseph in a dream to tell him that his role as Jesus's father on Earth, and, most importantly, appearing in the sky over Bethlehem to announce and celebrate Jesus's birth.
4. **Christmas Garland (also Evergreen Tree):** This refers to the evergreen boughs which are a part of winter celebrations for countless centuries, and the Winter Solstice has long had an evergreen holiday garland among its many traditions. The evergreen originally provided inspirational persistence to help people get through the cold, dark days of winter. When Christianity came along, the Christmas celebration simply adapted this custom. However, as the years have passed, most Christmas garland has morphed into something completely different today.
5. **Christmas Presents:** The tradition of Christmas presents takes its roots in the celebration of the Epiphany. It symbolizes the remembrance of the gifts the Magi gave to Jesus when He was born. By extrapolation, it means to show our love and appreciation for others. That is why Christmas is the time when everyone exchange presents with each other.
6. **Christmas Star (also known as the 'Star of Bethlehem'):** According to the Biblical story, the Christmas Star shining sparkly and bright, guided the three wise men from the East (also known as the Magi), to the baby Jesus. The Christmas Star symbolizes Christ's birth on that first Christmas night. The wise men followed the new Star to the babe born in Bethlehem. In a projective tree, if the Star is added, it symbolizes the drawer's desire for the Light in his/her life and to be wise just like the Magi. The Star also stands for hope for humanity.
7. **Christmas Wreath:** Included in the CTD, the wreath represents eternal life (Painter, 2022). Traditional wreaths are in the form of a circle. This circle represents the eternal presence of God, with no beginning and no end, the hope of eternal life through Christ, the Savior, and the unending love of God. Many Christians also see the colors as being inspired by the life of Jesus, with evergreen leaves representing the everlasting life of Christ and the red berries decorations representing the bloodshed during His crucifixion.
8. **Dove:** In CTD, the inclusion of a dove symbolizes peace on Earth that comes through Jesus Christ.
9. **Poinsettia:** It was first introduced to the United States by Joel Poinsett (b.1779-d.1851), an American linguist, scientist, horticulturist, and also a missionary to Mexico. The plant was named after him sometime in the 19<sup>th</sup> century in honor of his missionary work. As far as the symbolism of poinsettia goes, there is a lot. To the ancient Aztecs, they called the plant Cuitlaxochitl (or 'star flower'), whose color red symbolizes purity. The poinsettia is also a symbol of motherhood. An ancient remedy in Mexico prescribed a decoction of the red floral leaves of poinsettia to nursing mothers to increase their milk production. Moreover, poinsettia also symbolizes joy, love, hope, and holiness, too.
10. **Snowflake:** Snowflakes have many positive meanings and they symbolize joy, delicacy, clarity, and transformation. They also constitute a sign of the joy and magic of winter. However, its most important symbolic meaning is that of uniqueness because every snowflake is different.
11. **Stocking:** A longing for something that the drawer desires so much.

### Conclusion

The Christmas Tree Drawing (CTD) should not in any way be taken as a formal or informal projective drawing test, but as an activity of fun to help drawers to understand the symbolic meaning behind the celebration of Christmas. The authors of this paper want to emphasize their stance to caution readers never to use this projective drawing tool as some kind of an assessment or measurement of one's spiritual growth or maturity or the level of Christian faith. However, it can be used as an ice-breaking activity during Christmas gatherings or parties among Christians and non-Christians to learn about true event behind the historical and religious symbolism of Christmas celebration.

May the spark and joy of Christmas fill the heart of everyone during this season of celebration!

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# Young Children's Androgynous Human Figure Drawings (Cephalopods): The Four Perspectives on Androgyny - Sociological, Psychological, Iconographic and Theological

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## Abstract

One of the earliest schemata drawn by young children is the human figure. This human figure drawing remains most popular among the schemata used by counselors, therapists and psychologists in projective drawing tests, especially the Draw-a-Person (DAP) test. When a human figure first drawn by a young child, it appears very bizarre with no torso and/or limbs. If limbs are drawn, they are often attached to the head of the human figure. It has no clear features to distinguish its gender: male or female. The entire human figure drawing appears like a tadpole of some sort and it is often called a cephalopod or nicknamed 'tadpole man'. The young drawer might describe the cephalopod as 'daddy' at one moment and when asked again, might say it is 'mommy'. Hence, there is no consistency in the gender identification or discrimination in young children's human figure drawings. The authors of this short paper have decided to use term 'androgynous', i.e., indeterminate gender that can be partly male and partly female in appearance, to describe such drawings. In this short paper, the authors attempted to explore the androgynous cephalopod drawings done by young children and hypothesized that such drawings could be traced to the archetypal symbolism of Adam and Eve based on the biblical story of God's creation of man and woman.

**Key Words:** Adam, Androgyny, Cephalopod, Eve, Female, Human figure drawing, Male

## Introduction

According to Cox (1993), among all the schemata drawn by children and adolescents as well as adults, the human figure drawing is most popular. As a result, most, if not all, of the projective drawing tests have often involved single human figure drawings (SHFDs), also commonly known as Draw-a-Person (DAP) test (alternatively also known as Draw-a-Man or Draw-a-Woman test), first popularized by Goodenough (1926). Maley (2009) claimed that young children draw "what they know rather than what they see" (Goodenough & Tyler, 1959, p. 316) long before they "can read and write – and understand the functions of reading and writing – they draw" (Maley, 2009, p. 3). This belief has been supported by several earlier studies such as Luquet (1913), and Piaget and Inhelder (1956, 1971) and later studies such as Crook (1985), Davis (1985), and Freeman and Cox (1985), mainly published toward the end of the last century. In addition, young children also draw animals, flowers, houses, trees and shapes of all kinds.

Most children, if not all, as they approach three years of age, they exhibit "an increasing tendency to make circular strokes" (DiLeo, 1973, p. 4) in their kinesthetic drawings (e.g., circle, spiral, triangle). These kinesthetic drawings are gradually replaced with creating representational form of things (e.g., circle for face or body, triangle for dress) these young children know or remember than what they see (Eng, 1954; Spearing, 1912) - but Arnheim (1965, 1969) continued to insist that they draw what they see - as a way to the greater satisfaction. Most of these emerging representational drawings often constitute circles - the simplest pattern of all - what DiLeo (1973) described as "the universally selected pattern, and the most common form in nature" (p. 4) and added that "[T]he child will continue to use it as he represents a variety of perceptions - head, eyes, mouth, trunk, ears, and even hair" (p. 4).

## What do Young Children draw?

DiLeo (1973) has provided his answers to the question frequently asked by both parents and early childhood educators what young children draw: "(1) what is important to them: predominantly

people, then animals, houses, trees; (2) some, but not all, of what is known about the object; (3) what is remembered at the time; (4) the idea colored by feelings; (5) what is seen, as in the sense used by Arnheim (1965, 1969); and (6) an inner, not an optical reality” (p. 10).

Based on his observation of innumerable drawings done by young children over the years, DiLeo (1973) came to his own conclusion that “children are expressionists for whom the object serves merely as a cue or catalyst. Whether drawing from a model or from memory, the result is the same” (p. 10).

In this short paper, the authors have chosen to focus on single human figure drawings (SHFDs) done by young children aged 3 to 5 years old.

### Emergence of Cephalopod or Tadpole Man

Generally, children represent a single human figure drawing (SHFD) by what they deem is most essential. In fact, nothing is as interesting as a face to an infant or young child, and being fascinated by that circular configuration (i.e., the face) “wherein resides what eats, talks, sees, hears, smiles, and frowns” (DiLeo, 1973, p. 14) resembling an emoji<sup>11</sup> that the child would select that part of the anatomy as representing a human figure or person. Much later, young children add the appendages (i.e., limbs - arms and/or legs) to their circular human figures which look like the green Mike in the *Monsters, Inc.* Movie. This primitive circle representation of a human figure drawn by young children before the age of four has been termed cephalopod (see Figures 1a, 1b, 1c and 1d below) or tadpole man (including other terms *Kopffüssler* and *bonhomme têtard*), “all head and legs, so unreal and yet so unmistakably human - an uncanny reduction to essentials” (DiLeo, 1973, p. 14). Arnheim (1965) took issue with what he called the misnamed tadpoles being erroneously applied and misleading. He espoused his view stating firmly that it was “the most striking case of misinterpretation due to realistic bias” (p. 188). He argued that the trunk of the so-called cephalopod is not left out but was included within the circle, and that consequently the arms and legs were correctly attached. It was only after the age of five that “children begin to draw a second circle to represent the body, the primacy of the head is proclaimed by its exaggerated size” (DiLeo, 1973, p. 14).



Figure 1a. A  
Cephalopod Drawing



Figure 1b. A  
Cephalopod Drawing



Figure 1c. A  
Cephalopod Drawing



Figure 1d. A  
Cephalopod Drawing

### Which Gender in the Human Figure Drawings would be drawn first?

Another interesting question that is also often asked is whether young children draw a male or female human figure first. To answer this question, the authors have posed the same question to their friends and clients if they were to ask their young children to draw a single human figure. The response is not surprising to them at all: the boys will choose to draw a male human figure while the girls will choose to draw a female human figure. This is a genderized single human figure drawing or gSHFD for short: i.e., the boys draw a male figure; the girls, a female figure. However, the authors of this paper have also made an interesting observation that for younger children below four years of age, their SHFDs are often genderless or agSHRD. For instance, if a child is asked who the SHFD is, the young drawer might describe the human figure as ‘daddy’ at one moment and when asked again, might say it is ‘mommy’. Hence, there is no consistency in the gender identification or discrimination in young children’s SHFDs.

### Sex-Gender Differences in Cephalopod Drawings

First of all, there is a need to differentiate between the two terms *sex* and *gender*. Although both terms appear to be very closely related, they are not totally the same. Moreover, it is also difficult to distinguish the exact meaning of the two terms. In other words, it is by no means the two terms *sex* and *gender* are the same although most people, if not all, use these two words interchangeably, assuming that they are synonymous. The term *sex* is generally determined by the anatomy of a person, either of two divisions, male and female. The other term *gender* refers a set of traits (masculine or

<sup>11</sup> Emojis are first invented by Shigetaka Kurita (b.1972), a Japanese interface designer, in the late nineties as a project for Docomo, the predominant mobile phone operator in Japan.

feminine) that are seen and use to distinguish between male and female. To delve further into the concept of sex and gender, one may discover, for example, that a female by the anatomy of the physical body could have masculine traits such as preferring rough sports and body strength. While sex is biological, gender is a social construct defined by the society.

As mentioned earlier, cephalopod drawings are often agender or genderless (i.e., agSHRDs), and the gender of the cephalopod depends on what the young drawer has to say. Such cephalopod drawings can also be androgynous<sup>12</sup>, sociologically or psychologically speaking. The common dictionary (e.g., Merriam-Webster) definition of androgyny or androgynous refers to the quality or state of being neither specifically feminine or masculine, but a combination of both feminine and masculine features.

However, from the sociological perspective, androgyny is seen as “sociologically problematic because it does not fit neatly into the binary of male and female, and what ‘male’ and ‘female’ characteristics are varies by culture and society” (see Bell, n.p., for further detail). In this regard, androgyny may pose some problems for data accumulation and analysis in population census by gender.

From the psychological perspective, Kark (2017) describes it<sup>13</sup> as an “attributional term used to describe an individual who possesses similar (high) levels of stereotypical ‘feminine’ and ‘masculine’ psychological attributes or characteristics” (p. 1).

Interest in androgyny has led to several earlier studies mainly with adult subjects (e.g., Constantinople, 1973, Heilbrun & Pitman, 1979; Heilbrun & Schwartz, 1982) and hardly at all with child subjects (Zuker & Torkos, 1989) in the 1970s and 1980s advocating the usefulness of the psycho-social construct with its “implications of a dual sex-role development ... for males and females” and also the removal of “the constraints imposed by stereotypic sex-role conformity” (Heilbrun & Schwartz, 1982, p. 201).

### Sexual Awareness in Young Children

Sexual awareness in young children constitutes a part of their sexual development and sexual play,

and this is a natural and healthy process that begins during the toddler-hood through early, middle and late childhood into adolescence. According to the National Sexual Violence Resource center (2013), during the infancy phase (ages 0-2 years), toddlers are curious about their body including genitals, touch their private parts in public or private without feeling embarrassed and show no inhibitions around nudity. During the following developmental phase of early childhood (ages 2-5 years), young children may occasionally masturbate, engage in consensual and playful exploration of their body with peers of the same age, may ask questions about sexuality or reproduction, may show curiosity in regard to adult bodies (e.g., touching the mother’s breast when bathing together) but continue to show a lack of inhibition around nudity (e.g., taking off their diaper or clothes and walk about naked). This unabashed nudity exists within the realm of collective unconscious for these young children. It constitutes the archetype of Adam and Eve’s nakedness and innocence on two different sides of the same coin without an explicit suggestion of androgyny.

The word ‘naked’ (or ‘nakedness’) can be explained further by the innocence of Adam and Eve, their being unashamed. Adam and Eve were unclothed and they were not embarrassed. However, the moment they lost their innocence, shame set in, and the couple became ashamed, guilty, as revealed in the use of the word ‘naked’ as mentioned in the biblical book of Genesis. The first use of the word ‘naked’ means just that, i.e., ‘unclothed’ (Genesis 2:25). However, in the second term of ‘naked’ or ‘nakedness’ in Genesis 3:7, the Hebrew word *erom* is used differently in form and meaning as distinguished by its use in another biblical book of Deuteronomy 28:48. Its meaning is now more than just the denotative meaning of ‘unclothed.’ The second word of ‘nakedness’ carries the connotative idea of being *guilty*, now *exposed* and *vulnerable* to God’s judgment, in the aftermath of their disobedience to God. It is not within the scope of this paper to discuss further on this topic, but interested readers can refer to the sermon available on the website of Redeemer Bible Church (2020) as listed in the References.

As how young children perceive the issue of androgyny, the authors postulate that they develop their own schema to categorize or group things they see around them based on what they perceive as being same or similar. For example, a toddler might call all four-legged animals cats or dogs, or s/he might call all men daddies and women mommies (regardless of whether these adults are married and/or have children). This is primordial stereotyping which the authors believe is some

<sup>12</sup> Andro- is a latin prefix referring to maleness or men, while -gyn is a root that can be used as either a suffix or prefix meaning woman.

<sup>13</sup> Psychological androgyny is first coined by the American psychologist, Sandra Ruth Lipsitz Bem (b.1944-d.2014), and it refers to the idea that an individual could have both masculine and feminine qualities.

form of collective unconscious. As children grow older and/or mature, they learn that their schemata need to be refined to sustain some form of constancy. They try to do this through pondering or by questioning themselves. Many four-year-old children often assume that so long as a person has long hair, s/he is female, until they see a boy/man with long hair (or tied a pony tail) for example. Through pondering or by questioning themselves of what they see around them, they are incessantly trying to refine their mental definition of a particular schema, in this case, what differentiates men from women, boys from girls. This is the emergence of conscious stereotyping of sex or gender with socio-cultural influence and expectations.

### The Cephalopod as an Archetype of Adam and Eve

In the similar way that nudity or nakedness is an unabashed experience embedded within the collective unconscious of young children as explained above through the archetype of Adam and Eve's nakedness and innocence, the androgynous cephalopod drawings done by these children also constitutes another phenomenon within their collective unconscious. This is iconographic androgyny (based on the genderless cephalopod drawings) which is certainly different from sociological androgyny and psychological androgyny described earlier above.

According to Callender (n.p.), "Adam was androgynous" (para. 4), and this argument provides a fourth perspective, that of theological androgyny. The name *Adam* comes from the Hebrew word *adama*, which means 'earth' or 'soil.' There is also a variety of spellings for Adam: Adao, Adan and Adem. In fact, this idea of androgynous Adam is not totally new and can be found in Plato's *Symposium 189c-193e* (see Carnes, 1998, for detail) and had also been discussed in rabbinic circles (Genesis Rabba<sup>14</sup> 8:1). Adam is conventionally thought of simply as the male half of the first human couple with the other female half being known as Eve (see Figure 3 below for the engraving of Adam and Eve done by the German painter, Albrecht Dürer (b.1471-d.1528), in 1504).



Figure 3. Engraving of Adam and Eve  
(Albrecht Dürer, 1504)

However, when the definite article *the* precedes the name *Adam* (see Genesis 1:26), the Septuagint<sup>15</sup> refers to *ho Adam*, i.e., *the Adam*, in addition to *anthropos* or *human*. That is to say, within the literary framework of Genesis 1-5, Callender (n.p.) explained that "the two members of the couple (Adam and Eve) as representing aspects of the single archetypal *adam* - composed of earth (Hebrew, *adamah*; Genesis 2:7) in terms of (i) constituting both male and female potentialities (Genesis 2:21-23; also compare Genesis 1:26-27 and 5:1-2); (ii) being endowed like God with certain capacities (Genesis 2:19-20, 4:1 & 4:25; compare Genesis 1:26-27); and (iii) fatefully acquired wisdom (Genesis 3:6) and becoming like God, knowing good and evil (Genesis 3:22). Hence, the archetypal Adam as well as Eve, being the first human - not 'the man' but rather 'the human' (Meyers, n.p.) - has become a gender-inclusive term. As a result, Callender (n.p.; see also Kessler, 2020, for further detail) argued that the archetypal human (Adam-Eve being androgynous) is "a complex expression of the relational potentialities of class, plurality, and individuality" (para. 1).

Interestingly, Walton (2015) also argued that Adam and Eve are archetypes. This means Adam as well as Eve was "a representative of a group in whom all others in the group are embodied" (Walton, 2015, p. 240). Wu (2015) explained that "[A] person is an archetype if what is true of the one is also true for all those who are represented by in him. Adam and Eve are *historical*, not fictitious. In some sense, Christ, Abraham, and Melchizedek are also archetypes" (para. 8). Hence, according to Wu (2015), Adam and Eve are ancient archetypes and when the two are brought together, they become a theogonic pair - the male-female complementarity

<sup>14</sup> *Genesis Rabba* (Hebrew: בְּרֵאשִׁית *B'reshith Rabba*) is a religious text from Judaism's classical period (dated between 300 and 500 CE) with some later additions. "It is a *midrash* comprising a collection of ancient *rabbinical homiletical* interpretations of the *Book of Genesis* (*B'reshith* in Hebrew)" (Wikipedia Contributors, 2022, para. 1).

<sup>15</sup> The Septuagint (also known as the Greek Old Testament) is the earliest extant Greek translation of books from the Hebrew Bible.



that can also be found in the myths and legends of the ancient Middle East, such as Enki and Ninmah or Ninhursaga (Sumerian version), and Tiamat and Apsu (in the Babylonian epic known as *Enuma Elish*), and others in the Far East, such as Izanagi and Izanami (see Davis, 1992, for detail) whose creation is similar to that of Adam and Eve in the Japanese mythology. However, in the Chinese mythology, Nuwa and Fuxi (see Yuan, 2020, for detail), who commonly appear in classic Chinese painting or carving, are not equivalent to Adam and Eve. According to Yuan (2020), the Chinese people were created by goddess Nuwa with yellow clay, while Fuxi was the creator of Chinese culture, which includes scripts, agriculture and the original Eight Trigrams (Yuan, 2020).

Depending on how one chooses to interpret the first androgynous couple of humankind, it is without doubt that the cephalopod drawings produced by young children bear the collective unconscious of the archetype of our primordial parentage. The second author of this paper has also noticed that SHFDs done by demented elderly also resemble the androgynous cephalopods done by young children, as in one of his recent cases (see Figure 4 below).

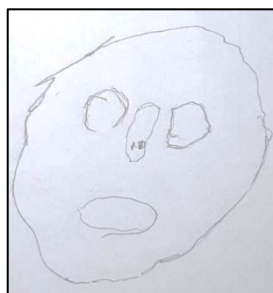


Figure 4. A Cephalopod Drawing by a demented Elderly

### Conclusion

To understand the androgynous state of cephalopod drawings done by young children, it is important to take note that young drawers produce their SHFDs based on what they know or remember than what they see. In other words, these cephalopods or tadpole-like human figures are often agender or genderless, and young drawers are often not

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conscious of the differences between male and female human figures, making their cephalopods very much hermaphroditic.

Interestingly, this paper has taken into consideration of the four perspectives - sociological, psychological, iconographic and theological (archetypal) - in an attempt to make a brief examination of androgyny observed in cephalopod drawings produced by young children. The authors believe that the SHFDs of young children constitute the primordial stereotyping of genderless human figures (or androgynous archetype) found floating (figuratively) in the deep ocean of their collective unconscious. This could also be the same mental state when demented elderly are asked to draw single human figures as they regress to their primeval cephalopod scribbling.

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- Singh, M. (2014, August 20). What kids' drawings say about their future thinking skills. Retrieved online [November 9, 2022] from: <https://www.npr.org/sections/health-shots/2014/08/20/341604160/what-kids-drawings-say-about-their-future-thinking-skills/>.

Figures 1c and 1d are taken from the following source:

- McAteer, O. (2014, August 19). Parents: The quality of your child's drawings is linked to their intelligence ten years later. Retrieved online [November 9, 2022] from: <https://metro.co.uk/2014/08/19/parents-the-quality-of-your-childs-drawings-is-linked-to-their-intelligence-ten-years-later-4837555/>.

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# Post-Pandemic Evolution of Pedagogical Methods for Young Learners in Mathematics (7 to 10 Years Old)

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## Abstract

The first author is a former mainstream school mathematics teacher and the second author is his wife, also a former mainstream school teacher. The two authors have taught in their schools during and after the pandemic period and have explored various ways to engage their students through various forms of pedagogy. They acknowledge that the pandemic brought a set of challenges to teaching, but together with it, long-lasting opportunities that may transform the education scene permanently. As such, the authors have employed a repertoire of teaching strategies to cater to their student's learning needs, learning from fellow educators and seeking feedback from different stakeholders. One of the key challenges the authors have encountered is to inculcate a sense of self-directedness in their students when it comes to blended learning. In this paper, they have chosen to share, from the perspective of experienced educators who have taught students during the pandemic period, how to leverage and capitalize on the new pedagogical approaches that arose out of the pandemic and integrate them into existing pedagogical strategies, particularly in the area of Mathematics.

**Keywords:** Mathematics Learning, Self-Directed Learning, Blended Learning

## Introduction

The sudden onset of the global Covid-19 pandemic has affected countries all over the world, causing major disruption to teaching and learning for educators and students alike. The transition towards online learning as a main mode of instruction have become a panacea for this unprecedented pandemic. This expository seeks to highlight the underlying challenges of transiting from face-to-face lessons in school towards online synchronous and asynchronous learning, in the context of teaching and learning of Mathematics. For those who have courageously taken this leap to transit, they have also been able to embrace the many new opportunities posed by the pandemic. Lastly, the study also seeks to expand its discussion beyond the pandemic period, to expound on possible post-pandemic pedagogies that have evolved in recent times and how these new pedagogical approaches have been seamlessly integrated into the teaching and learning of Mathematics in the post-pandemic period.

## Challenges Posed By The Pandemic

Transitioning from traditional face-to-face learning to online learning is a whole new experience for both educators and student. The speed at which both parties are compelled by circumstances to adapt and embrace this transition, gives rise to much anxiety and stress. Out of the many

challenges faced, the key challenges are namely; short attention span of students, inconducive home environment for learning, limited access to the appropriate online tools and the internet, systemic issues as well as the lack of a personal touch.

The short attention span of students is often a challenge especially when delivering content-heavy materials and lectures. Studies show that attention cannot remain at the same level of intensity for prolonged periods of time for the same piece of work. The duration of the focus and the focus itself are also correlated to the age of the individual as well as the task given and timing given within a course (Bunce, Flens, & Neiles, 2010; Cummings Hlas, Neyers, & Molitor, 2017)<sup>16</sup>. Attention problems are common challenges faced at every educational level (Bunce et al., 2010; Cummings Hlas et al., 2017; Wang, 2015; Weimer, 2014)<sup>17</sup>. Therefore, intentional efforts of educators to sustain student's attention and maintain high energy in delivering the lesson, while challenging,

<sup>16</sup> Bunce, D. M., Flens, E. A., & Neiles, K. Y. (2010). How Long Can Students Pay Attention in Class? A Study of Student Attention Decline Using Clickers. *Journal of Chemical Education*, 87(12), 1438–1443. <https://doi.org/10.1021/ed100409p>

<sup>17</sup> Ibid.

is albeit imperative for the effective retention of skills and knowledge taught.<sup>18</sup>

Moreover, many students confined to their home quarters have undergone great psychological and emotional distress, affecting their learning productivity. Some students expressed that they had to attend to their family members who have taken ill, preoccupying their learning time. Others have younger siblings at home that may contribute to the noise in the house, making online lessons difficult to attend. For others, low internet bandwidth also poses problems. Online face-to-face classes are encouraged by most; however, some students (who are economically disadvantaged) have expressed that the face-to-face online class consumes more data packages, which strains the family's finances<sup>19</sup>. For others, the lack of access to the required software for the learning of Mathematics can also impede online learning. These new-found anxiety and stress often extend to the parents and guardians of students. According to an interview conducted by The Straits Times (2020), parents who are not as well-versed in technology and online learning may struggle to assist their children in the administrative processes and trouble-shooting through any technical issues that might arise. This is even more so for parents with children belonging to the younger age group, who may be more dependent on parental guidance and supervision to complete their online lessons and assignments. For others, the interview brought to light the common challenge of time management; parents often find themselves stretched on both ends handling work-from-home while also needing to supervise their children's home-based learning.<sup>20</sup>

Furthermore, effective learning may be further hampered by the limitations of online platforms. Although a variety of online learning platforms such as Zoom, Padlet, SLS (Student Learning

Space) etc. are available, it proves limited in the teaching and learning of Mathematics. One key reason is the lack of an avenue to check for student understanding, especially for large groups of students for online lessons. Such platforms also make it hard to check the working of every single student and provide immediate and personalized feedback. Although Padlet does give the affordance of allowing the upload of photos showing solutions and screen sharing, such affordances are limited by the lack of Mathematical notations and functions embedded in the software. There is also little avenue for educators to check on the authenticity of the work submitted (as some students may end up plagiarizing their classmate's work or from online materials). This proves a challenge for subsequent assessment of the quality of actual learning taking place<sup>21</sup>. As such, all these contribute to an overall limitation in fully engaging students in their learning of Mathematics. In addition, the sheer high volume of student login and usage may often cause systemic issues and server overload. Common learning platforms such as the Student Learning Space (SLS) portal was reportedly facing periodic hiccups and glitches during the home-based learning period<sup>22</sup>. All these can thus impede learning from taking place and give rise to much frustration and inconvenience. While technical and systemic issues may be unavoidable, it underscores the importance and need for a robust online learning platform and regular systemic upgrades.

Lastly, the lack of personal touch can impede effective learning. According to researchers Drago and Wagner (2004), certain student learner profiles especially kinesthetic learners, often require a more hands-on approach to learning, which may prove challenging in an online learning context.<sup>23</sup> Kinesthetic learners often prefer experiential learning, while the nature of an online learning environment may be deemed more suitable for other learner profiles (visual and read-write learners). Moreover, the lack of an in-person, face-to-face collaborative learning experience may also

<sup>18</sup> Cicekci, M. A., & Sadik, F. (2019). Teachers' and Students' Opinions About Students' Attention Problems During the Lesson. *Journal of Education and Learning*, 8(6), 15. <https://doi.org/10.5539/jel.v8n6p15>

<sup>19</sup> Pokhrel, S., & Chhetri, R. (2021). A Literature Review on Impact of COVID-19 Pandemic on Teaching and Learning. *Higher Education for the Future*, 8(1), 133–141. <https://doi.org/10.1177/2347631120983481>

<sup>20</sup> Ang, J. (2020, April 8). *Parents struggle to juggle working from home and supervising kids' home-based learning amid Covid-19 crisis*. The Straits Times. <https://www.straitstimes.com/singapore/juggling-working-from-home-and-supervising-kids-home-based-learning-is-a-struggle-for-some>

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<sup>22</sup> Ong, J. (2021, May 19). *Covid-19: Some parents, students face login issues, delayed uploads on first day of home-based learning*. TODAY. <https://www.todayonline.com/singapore/covid-19-some-parents-students-face-login-issues-delayed-uploads-first-day-home-based>

<sup>23</sup> Drago, W. A., & Wagner, R. J. (2004). Vark preferred learning styles and online education. *Management Research News*, 27(7), 1–13. <https://doi.org/10.1108/01409170410784211>

give rise to feelings of isolation, especially in the learning of Mathematics. A phenomenon known as “Math anxiety” is defined as a feeling - or set of feelings - with negative connotations resulting in a specific behaviour toward Mathematics tasks. Such feelings are generally centred on fear and nervousness, resulting in blockage when dealing with Mathematics tasks.<sup>24</sup> Such feelings have arisen over the course of the pandemic, where online learning becomes a norm. Feelings of isolation when attempting Mathematical problems and the lack of a physical educator readily available to provide immediate support and guidance, may be leading causes. Mathematics anxiety also occurs to a greater extent for students who are afraid of failure and punishment, for high performing students in mathematics, and those who have behavioural anxiety towards low performance in mathematics (García-Fernández et al., 2013)<sup>25</sup>. With online learning taking place, the lack of immediate feedback to close any learning gaps or an affirmative nod/ pat on the shoulder from educators, may thus escalate such anxiety.

### Overcoming The Challenges

All is not doom and gloom. With the concerted efforts of the various stakeholders; school leaders, educators, parents/guardians and students themselves, the above-mentioned challenges can in fact be mitigated.

Firstly, the Ministry of Education (MOE) has, in recent years, made the necessary provisions to better support students who lack a conducive learning environment at home. Such is done by allocating several school personnel and classrooms to accommodate students who may prefer using the school facilities to conduct their Home-Based Learning classes<sup>26</sup>. Many schools have even generously loaned out laptops to students under the Financial Assistance Scheme (FAS) as they may not have the means to own a personal laptop for learning<sup>27</sup>. Class mentors and technicians have also been deployed on stand-by to assist parents and

students in trouble-shooting technical glitches. All these were done to help mitigate the stress and anxiety of transiting to online platforms for learning.

Secondly, to safeguard and promote the mental and emotional well-being of students during the pandemic, class mentors have conducted more frequent check-ins with individual students in their class. Under the Ministry’s guidelines, Character and Citizenship Education (CCE) lessons were also modified to focus on mental wellness<sup>28</sup>. Specific to Mathematics, educators are intentionally integrating more collaborative tasks to students while also activating the chat function of online lectures to allow for personal queries and clarifications. Class buddies were also tactfully assigned to pair up a higher progress learner with a lower progress learner to provide more peer support. As an additional measure, educators have even taken the initiative to record instructional videos to further support lower-progress learners. On a national level, the Ministry of Education removed the common last topics (CLTs) from End-of-Year examinations in recent years to further reduce the stress faced by students and parents<sup>29</sup>.

Thirdly, to balance out the removal of CLTs, curriculum recovery lessons were also conducted after examinations to bridge learning gaps. This is especially paramount for Mathematics, a multi-layered subject. In order to engage students for higher-level topics, basic fundamentals must first be established. For instance, without a robust and concrete understanding of linear algebraic equations, students may face difficulties grasping the subsequent topic on quadratic equations. As such, many schools have taken to conducting bridging classes in the post-examination period to cover the CLT.

It is through the concerted efforts of various stakeholders that the challenges posed by the

<sup>24</sup> Arnal-Palacián, M., Arnal-Bailera, A., & Blanco, C. (2022). Math Anxiety in Primary Education during Covid-19 Confinement: Influence on Age and Gender. *Acta Scientiae*, 24(1), 145–170. <https://doi.org/10.17648/acta.scientiae.6745>

<sup>25</sup> García-Fernández, J. M., Inglés, C. J., Martínez-Monteagudo, M. C., Marzo, J. C., & Estévez, E. (2011). Inventario de Ansiedad Escolar: validación en una muestra de estudiantes de Educación Secundaria. *Psicothema*, 23(2), 301-307.

<sup>26</sup> Mahzam, R. (2020, May 4). *Support for students returning to their schools during full HBL*. Ministry of Education, Singapore. <https://www.moe.gov.sg/news/parliamentary-replies/20200504-support-for-students-returning-to-their-schools-during-full-hbl>

<sup>27</sup> *ibid.*

<sup>28</sup> 2020 Student Development Curriculum Division. (2020). *Character & Citizenship Education (CCE), Syllabus Secondary*. Ministry of Education, Singapore. <https://www.moe.gov.sg/-/media/files/secondary/syllabuses/cce/2021-character-and-citizenship-education-syllabus-secondary.pdf?la=en&hash=D41C87D627D3AA6CF52C14538121EA5E1B9E0B44>

<sup>29</sup> Ng, W. K. (2021, July 27). *Lighter load for national and year-end school exams to help ease stress: Chan Chun Sing*. The Straits Times. [https://www.straitstimes.com/singapore/politics/lighter-load-for-national-and-year-end-school-exams-to-help-ease-stress-chan-chun?utm\\_campaign=stfb](https://www.straitstimes.com/singapore/politics/lighter-load-for-national-and-year-end-school-exams-to-help-ease-stress-chan-chun?utm_campaign=stfb)

pandemic can be better mitigated, to ensure the continued effective learning of Mathematics.

### Emerging Opportunities

On a related note, through the process of mitigating challenges posed by the pandemic, many valuable new opportunities for the teaching and learning of Mathematics have emerged.

Firstly, educators have introduced a more dynamic and interactive approach to online learning. Such initiatives include the use of dialectic approaches that involve conversational journaling between learners and educators. Educators have encouraged the active use of live chat room features between students working together in groups, allowing for real-time communication and the exchange of ideas and strategies to solving Mathematical tasks. One such communication platform is found in zoom, where educators can utilize the screensharing function to share two selected students' work, demonstrating how two different approaches can be used on the same question. Educators can then facilitate active student discussion on which of the following methods / approaches is better. Moreover, through the creative use of social media platforms like Twitter, Instagram, facebook and telegram, students are better able to sound out any further queries to address individual learning gaps, while allowing their peers to contribute valuable inputs online. For government schools in Singapore, educators have also undergone professional development in the area of ICT to further boost their facilitation skills and mastery of online platforms for better online discussions and collaboration<sup>30</sup>. These have indeed helped encourage greater student participation and effectiveness in collaborative learning, to arouse greater curiosity and interest for the learning of Mathematics.

Secondly, Singapore schools have also sought the benefits of a more Blended learning approach towards education. This approach is essentially hybrid learning, which combines the use of online learning with that of the conventional face-to-face learning in a classroom (Lee et al., 2017; Thai et al., 2017). This integration has been proven to be able to enhance student engagement and learning (Garrison & Kanuka, 2004)<sup>31</sup> beyond the confines

of a physical classroom. For effective Blended learning, educators need to first develop a deeper understanding and appreciation of the different learner's profile amongst their students. Many educators have consequentially adopted differentiated instructions (DI) and a plateau of various appropriate online platforms to cater to these differing learning needs. Such commonly used platforms during the pandemic include Microsoft Teams, Google Classroom, Google Meets, Canvas and Blackboard. These platforms serve as a one-stop unified communication tool to allow educators to communicate effectively with both fellow colleagues and students, easing the creation and sharing of useful resources online and offline for enhancing student engagement. (Petrie, 2020).<sup>32</sup>

Specific to the teaching and learning of Mathematics, new software like Ace-learning's Math Virtual Reality also addresses the aforementioned limitations of existing platforms like Padlet which lacks Mathematical expressions. Ace-learning's Math Virtual Reality application allows students to look at 3D shapes and objects from different angles, which enables better visualization of complex geometrical shapes (see Figures 1a and 1b )<sup>33</sup>. This is especially useful in solving and visualizing three-dimensional problems related to bearings, angles of elevation and angles of depression, a topic students tend to face difficulties in. Consequentially, students can thus more accurately calculate the respective volume, surface area and dimensions of these objects to solve the Mathematical problems.



*Higher Education*, 7(2), 95–105.

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<sup>32</sup> Petrie, C., Aladin, K., Ranjan, R., Javangwe, R., Gilliland, D., Tuominen, S., & Lasse, L. (2020). spotlight on quality education for all during Covid-19 crisis. In

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<sup>33</sup> ACE-Learning System. (2018, April 18). *Math VR* [Video]. YouTube. <https://www.youtube.com/watch?v=E-ZlqaTMIsU>

<sup>30</sup> *Learn for Life – Ready for the Future: Refreshing Our Curriculum and Skillsfuture for Educators*. (2020, March 4). Ministry of Education, Singapore. <https://www.moe.gov.sg/news/press-releases/20200304-learn-for-life-ready-for-the-future-refreshing-our-curriculum-and-skillsfuture-for-educators>

<sup>31</sup> Garrison, D., & Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education. *The Internet and*

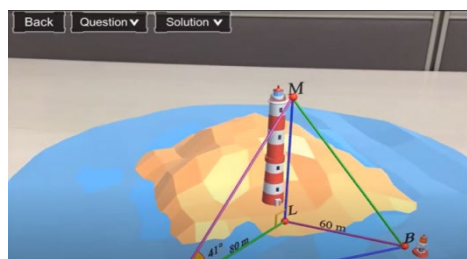


Figure 1. Visualization of Complex Geometrical Shape

Additionally, another useful Mathematical software that has recently been popularized in schools for Blended learning is GeoGebra.<sup>34</sup> GeoGebra is an interactive Mathematics application that allows for a more hands-on virtual learning experience. This application allows for an accurate drawing of straight lines, coordinates and two-dimensional shapes. The user-friendly application has clear instructions given and is popular amongst primary schools especially in teaching and learning the topic on angles. Inserted below is a sample of a hands-on activity done on Geogebra (see Figure 2)<sup>35</sup> which allows primary school students to practice measuring an angle using a movable digital protractor. The angles can be randomized for repeated practice to further instill confidence.

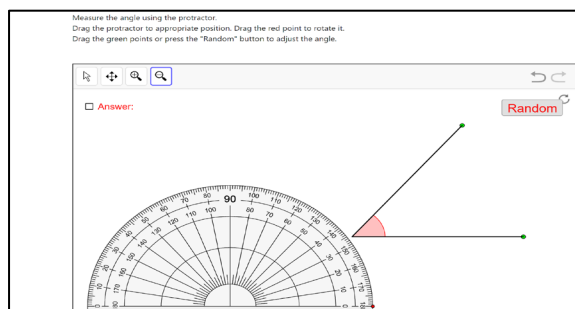


Figure 2. A Sample of a Hands-on Activity done on Geogebra

Such 'hands on' activities thus create an online learning environment that allows students to experience high interaction and experimentation with key Mathematical materials, a great tool for kinesthetic learners. Geogebra also ties in topics with real-life scenarios and applications, to encourage students to formulate, connect, and apply new ideas to existing knowledge to facilitate higher-order thinking (see Figure 3).<sup>36</sup> Through its

interactive geometry, algebra, statistics and calculus application, the learning and teaching of Mathematics becomes more engaging. Furthermore, the application can be used on multiple platforms (desktops, website, phones etc.). For students from less privileged backgrounds, this ease of access allows them to continue their learning on their personal mobile devices, no longer being constraint by the limited access to a shared family desktop/laptop.<sup>37</sup> Learning can now take place anytime, anywhere.

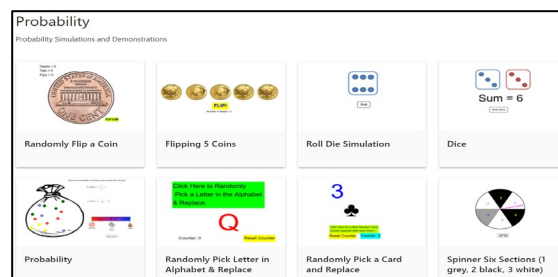


Figure 3. New Ideas to existing Knowledge to facilitate Higher-Order Thinking

A subset of Blended learning that emerged from the pandemic, is the flipped classroom pedagogical approach, which allows educators to further engage learners. This pedagogical approach allows educators to provide pre-learning resources such as articles, pre-recorded videos and YouTube links before the class. Students are thus able to engage with the content online prior to the lesson, thus allowing educators to use actual lesson time (online and offline) to facilitate discussions to deepen understanding, while also addressing any common misconceptions and learning gaps (Doucet et al., 2020).<sup>38</sup> This approach reduces lesson time used for content coverage or repetition of concepts previously covered. Educators can better focus on more interactive engagements with students during lesson, thus managing the challenge of student's short attention span. Flipped classroom can also be utilized to assess student's actual learning taking place, through the uploading of pop-quizzes and mini assignments online. Some platforms like SLS, Nearpod and Ace-learning etc. also offer a self-checking function where students can receive immediate feedback on their performance and be given brief explanations on why certain methods/answers are incorrect. Intrinsically motivated and higher progress learners can further explore related topics and content uploaded online,

<sup>34</sup> *Probability and Statistics (Middle School)*. (n.d.-b). GeoGebra. <https://www.geogebra.org/m/tn7wppdp>

<sup>35</sup> *Measuring Angles Using Protractor*. (n.d.). GeoGebra. <https://www.geogebra.org/m/fMnsdbzv>

<sup>36</sup> Wood, N., & Sereni-Massinger, C. (2016). Engaging Online Kinesthetic Learners In Active Learning. *IMCIC*. <https://www.iiis.org/CDs2016/CD2016Spring/papers/HB788PF.pdf>

<sup>37</sup> *Classroom resources*. (n.d.). GeoGebra. <https://www.geogebra.org/materials>

<sup>38</sup> Doucet, A., Netolicky, Dr. D., Timmers, K., & Jim Tuscano, F. (2020). Thinking about pedagogy in an unfolding pandemic (An Independent Report on Approaches to Distance Learning during COVID-19 School Closure). *Education International*.



while also attempting higher-order thinking questions. Such asynchronous learning is an effective way to promote greater self-directedness.

### Post-Pandemic Learning

Hybrid learning holds great promise for the future of education as it exploits advancements made in the recent pandemic years to meet the needs of learners today and in the near future, to attain desired learning outcomes in education. Since its incorporation into the education sector, technology has proven itself to be invaluable and indispensable in safeguarding our learning continuity.

Under the government's directives towards being a Smart Nation, the Ministry of Education has since revitalized its ICT in Education Masterplan (originated in 1997) to its newly minted Education Technology (EdTech) Plan.<sup>39</sup> The crux of the EdTech Plan consists of four aspects. Firstly, it seeks to encourage greater self-directedness through developing pedagogy, tools and structures to help students develop intrinsic motivation for greater ownership of their learning. Secondly, it seeks to personalize and customize learning experiences for students to better suit differing learning pace and pathways of each child. Thirdly, it seeks to promote more positive collaborative learning experiences by connecting students' learning to the community and the larger world (real-world context). Lastly, it seeks to promote a more human-centred learning experience (with each child at the centre) by leveraging on data to better understand students' interests, attitudes and motivations so as to optimize their learning<sup>40</sup>. This new directive thus seeks to position Singapore as a leader in the use of ICT in education, effectively integrating ICT into everyday learning and teaching<sup>41</sup>. Furthermore, the steady roll-out of Personal Learning Devices (PLDs) to students in all secondary schools across Singapore by 2021<sup>42</sup>, serves as a means to enhance digital literacy and promote blended and self-directed learning. Many schools have even taken the liberty to install useful softwares like Geogebra, MathType etc. to assist students in their learning of Mathematics.

In schools across Singapore, Home-Based Learning (HBL) has also become common place. For instance, at Queensway Secondary School, the HBL Day is conducted once a fortnight<sup>43</sup>. The school has also introduced an hour of Student-Initiated Learning into its HBL curriculum, where students are given the freedom to explore projects and skills of their interest, moving beyond syllabus content and assessment. Topics for exploration can range from cooking to sports to art to even coding. Students are then encouraged to journal down and document their learning progress under the supervision of their parents and guidance of class mentors, before sharing their reflections with peers in school. Such an initiative has not only helped deepen students' passions and interests for learning, it has also encouraged critical and inventive thinking of the society and world around them through experimental learning and reflective thinking, underpinning the holistic education approach and 21st century competencies directed by the ministry<sup>44</sup>.

Attached below are some artefacts of Student-Initiated Learning that took place in Queensway Secondary School (see Figure 4 on the following page)<sup>45</sup>.

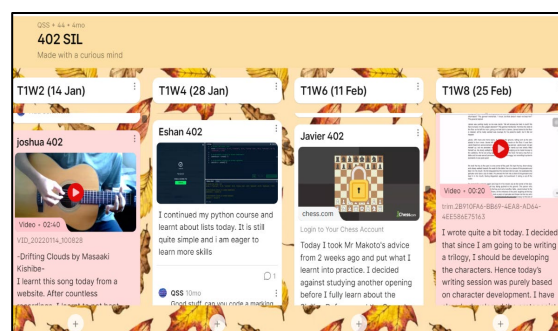


Figure 4. Some Artefacts of Student-Initiated Learning

Another school that successfully took on the student-initiated learning programme was Junyuan Secondary School. The school has crafted a comprehensive scaffold to better guide students on

<sup>39</sup> *EdTech Plan*. (2021, June). Ministry of Education, Singapore. <https://www.moe.gov.sg/education-in-sg/educational-technology-journey/edtech-plan>

<sup>40</sup> *ibid.*

<sup>41</sup> *EdTech* (n.d.). Ministry of Education, Singapore. <https://www.sgdi.gov.sg/ministries/moe/departments/etd>

<sup>42</sup> *Personal learning device*. (2020, November). Ministry of Education, Singapore. <https://www.moe.gov.sg/news/parliamentary-replies/20201102-personal-learning-device>

<sup>43</sup> *Blended Learning at Queensway*. (2022). Queensway Secondary School. <https://www.queenswaysec.moe.edu.sg/the-Queensway-experience/blendedlearning/>

<sup>44</sup> *21st Century Competencies*. (2021, October). Ministry of Education. <https://www.moe.gov.sg/education-in-sg/21st-century-competencies>

<sup>45</sup> *Blended Learning at Queensway*. (2022). Queensway Secondary School. <https://www.queenswaysec.moe.edu.sg/the-Queensway-experience/blendedlearning/>

their self-directed learning journey, ensuring greater ease (see Figures 5a, 5b and 6).<sup>46</sup>

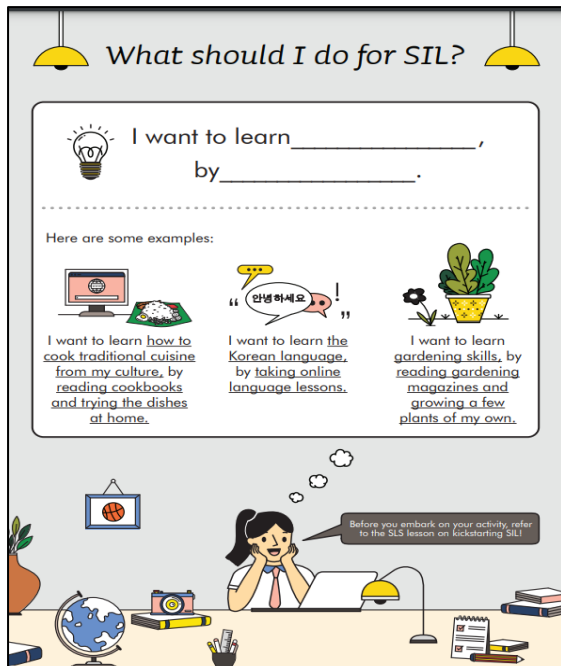


Figure 5a. A Comprehensive Scaffold on Self-Directed Learning

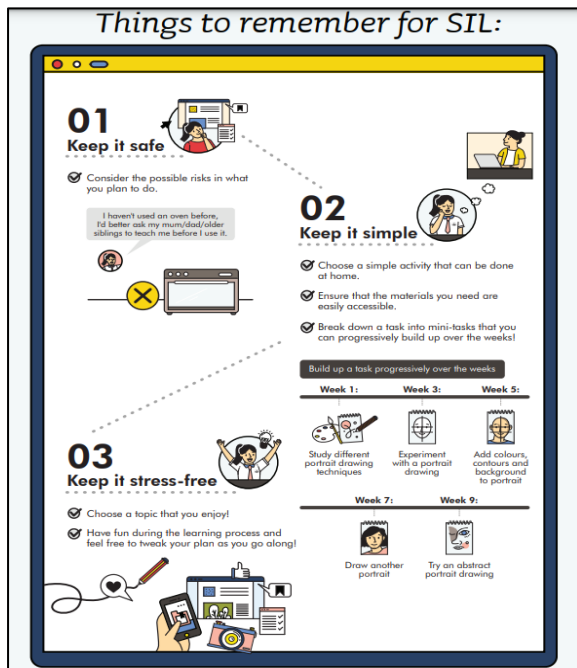


Figure 5b. A Comprehensive Scaffold on Self-Directed Learning

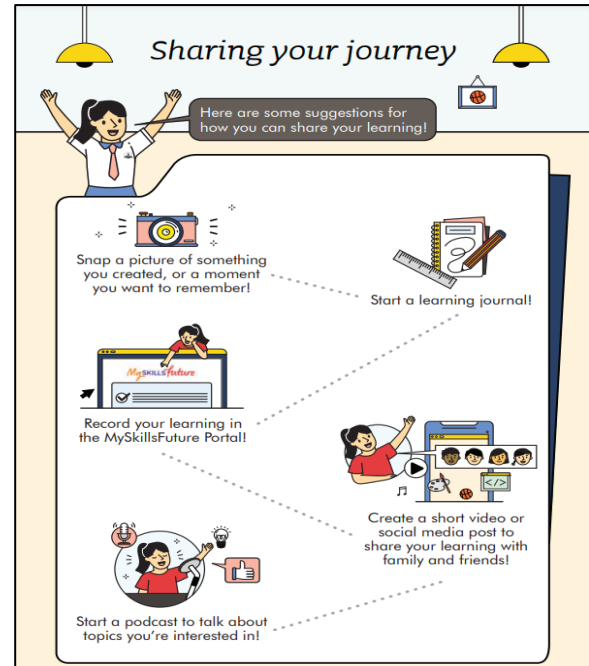


Figure 6. A Comprehensive Scaffold on Self-Directed Learning

Such initiatives are part of a larger ministry wide effort to inculcate a greater sense of ownership in learning and fostering self-directedness in learning. It reinforces the Ministry's direction to ease away from an overt emphasis on extrinsic motivation like grades, awards and examinations to more intrinsic motivations fuelled by a deeper passion for learning and the joy of learning<sup>47</sup>. Accompanying this gradual shift is a noticeable change in the role of teachers. Teaching in classrooms is moving away from frontal teaching that emphasizes on singular methodical approaches, to embrace multiple approaches to problem solving. Educators also undergo professional development to enhance their pedagogical effectiveness for blended learning. Intentional efforts are made to integrate more discussions in classrooms. One such initiative is Talk Moves (Michaels, O'Connor, 2013)<sup>48</sup> which uses effective questioning techniques to provide opportunities to probe and assess student's understanding of key Mathematical concepts and skills. Through the learners' articulation, a teacher

<sup>47</sup> (2019, July 30). Primary and secondary schools to cut down on exams and tests, as MOE announces sweeping changes to reduce emphasis on grades. *TODAY*.

<https://www.todayonline.com/singapore/primary-and-secondary-schools-cut-down-exams-and-tests-moe-announces-sweeping-changes>

<sup>48</sup> Michaels, S., & O'Connor, C. (2015). Conceptualizing Talk Moves as Tools: Professional Development Approaches for Academically Productive Discussions. *Socializing Intelligence Through Academic Talk and Dialogue*, 347-361.

[https://doi.org/10.3102/978-0-935302-43-1\\_27](https://doi.org/10.3102/978-0-935302-43-1_27)

<sup>46</sup> Home Based Learning. (2022). Junyuan Secondary School. <https://junyuansec.moe.edu.sg/our-programmes/home-based-learning>

can better assess their depth of understanding, while also correcting any misconception. Learner’s overtime develop greater confidence in talking about Mathematics and using it. This initiative has been adopted into primary schools in the teaching and learning of Mathematics.<sup>49</sup>

To boost and promote greater self-directed learning, lesson materials also require more customization to cater to differing progress learners, while including more open-ended questions to stimulate critical thinking. See Table 1 below for a comparative analysis of the difference between a conventional Mathematics worksheet for primary school, with one that encourages greater self-directedness.

The comparison is based on three question sets on the topic of angles and perimeters. The third question is a higher-order thinking (HOT) question that is included to stretch higher progress learners.

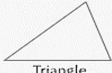
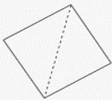
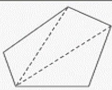
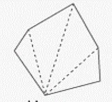
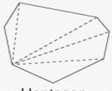
Table 1. A Comparative Analysis of the Difference between Conventional Math Worksheet for Primary School

Typical Worksheet Questions (Conventional)	Questions designed to induce Self-Directed Learning
1a. List down two properties of a square. 1b. List down two properties of a rectangle.	1. Are all rectangles, squares? Are all squares, rectangles? ❖ Discuss this with your partner.
2. What is the sum of angles in a triangle?	2. Can you draw a triangle with two right-angles? Why? ❖ Login to your Personalised Learning Device (PLD) and try drawing such a triangle using the Geogebra App.
3. What is the sum of angles in a 7-sided shape?  Hint: You can divide the shape into triangles.	3. How can we find the sum of angles in any shape, regardless of the number of sides? a. Use Geogebra to draw the following shapes. b. Divide the shapes

<sup>49</sup> Curriculum Planning and Development Division. (2020). *Mathematics syllabus (Primary one to six)*. Ministry of Education, Singapore.

	into triangles. c. Find the sum of angles in each shape (see Table 1a below).
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Table 1a. Angles in Various Shapes

Polygon	Number of sides	Number of Triangle(s) formed	Sum of Interior Angles
 Triangle	3	1	$1 \times 180^\circ = (3 - 2) \times 180^\circ$
 Quadrilateral	4	2	$2 \times 180^\circ = (4 - 2) \times 180^\circ$
 Pentagon			
 Hexagon			
 Heptagon			

As shown in Table 1, Mathematical questions can be more intentionally designed to promote self-directed learning in students, using the following guiding principles:

1. Arousing Curiosity
2. Facilitating Discourse
3. Progressive Thinking

*Arousing Curiosity*

To arouse curiosity, the question usually starts with a trigger. Educators trigger students to tap on prior knowledge by asking the following question, “Are all squares, rectangles?” or “Are all even numbers multiples of 2?” These statements spark curiosity in students as they are induced to ponder over the given question, tapping on their understanding of the mathematical concept/notion.

*Facilitating Discourse*

As a follow-up, educators can facilitate discourse amongst students on the trigger question to elicit a multitude of responses. It promotes self-directed learning as students are trained to justify their perspectives and hypotheses to their peers, using mathematical concepts and logical reasoning. This is an advancement from the more conventional approach to learning; through formulae application and recall. For younger learners, perhaps more teacher facilitation and simplification of the discourse can be given. Younger learners could

simply be instructed to choose between a few options and share with their seat partner. Teacher can then gather a few pairs to share their conclusion while getting the class to raise their hands if they agree or disagree. Exposing to discourse at a young age is imperative in nurturing a culture of positive questioning and discussion.

### *Progressive Thinking*

Questions given can also be better scaffolded in sequential order to promote progressive thinking. Through Socratic questioning techniques, students are progressively directed towards discovering and understanding a mathematical concept on their own. Educators facilitate the process by guiding and probing students towards the right direction, while avoiding hand-holding so as not to short-circuit the discovery process. This is imperative as research has shown that memory retention for self-acquired knowledge in an integrated and progressive manner is generally higher compared to information that has been dictated or passed down in isolation.<sup>50</sup>

### **Conclusion**

Blended learning and online learning can indeed be powerful tools to supplement the teaching and learning of Mathematics. This can be so if the following criterion are met: Sufficient student support from various stakeholders (from schools, teachers and parents), students' ability to practice more self-directed learning skills and foster good online learning habits, educator's continued professional development to keep them up-to-date with the latest technological affordances and platforms to make well-informed choices and applications of suitable online learning tools. A progressive shift in parental mindset to embrace the prospects and benefits of online learning as well as sustained school support for learning from home are also imperative for the continued success of blended learning.

Finally, the combination of different techniques and software is also necessary as no one solo software is holistic in catering to the myriad of learning styles and learner profiles.<sup>51</sup> Scholars have often worked on the assumption that students are

reflective learners who are able to be self-directed in their learning. However, this may not be so for younger age groups who may need more scaffolding and facilitation in order to effectively use ICT for the learning of Mathematics.

It is only with the concerted effort and dedication of the various stakeholders in meeting the above criterion, can the learning of Mathematics evolve to encourage greater debate, reasoning, questioning, and self-discovery to ignite the joy of learning.

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