STEAM Education for Students with Specific Learning Disorders

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In recent years researchers and educators have paid more attention to the importance of integrated fields of science, technology, engineering, arts, and mathematics (STEAM) as powerful approach in teaching all students, including those with learning disorders (Ge, Ifenthaler & Spector, 2015; Hwang & Taylor, 2016). Elements of STEAM have been applied to nearly every group of age, including to kindergarten (Aronin & Floyd, 2013), elementary stage (Han, Park, Jo, Park & Kim, 2011), high school (Jho, Hong & Song, 2016), and at the higher education level (Ge, Ifenthaler & Spector, 2015). Further, STEAM has been utilized with students with disabilities (Hwang & Taylor, 2016). In this chapter, an emphasis will be placed on the importance of applying STEAM education for students with learning disorders (LD). These students have been recently included in the general classrooms with their peers who come from the community. Students with disabilities have the right for a full access to the general education system. Yet, the question to be asked, is the educational system ready to welcome them and provide them with the best education that most match their needs?

Background on STEM Education

The term STEM was proposed back in the early 1990s by the National Science Foundation (NSF) and has been used as a generic term spanning across various fields including education, business, policy, programs, or practices that involve one or several of the STEM disciplines (Kuenzi, 2008; Morrison & Raymond, 2009; Johnson, 2012). Bybee (2010) argues that the education community has embraced a slogan without really clarifying what the term might really mean when applied beyond a general label. Generally, they refer to STEM education as teaching science or math. Despite numerous attempts to define STEM in educational perspectives, yet the term has not been globally defined. Some researchers, according to Hwang and Taylor (2016), have referred to STEM education as a broad education category involving math, science, engineering, or technology education; thus, teaching any one of the four disciplines can simply be referred to as STEM education (Hwang & Taylor, 2016). Sanders (2009) expands the definition and proposed that “STEM education includes approaches that explore teaching and learning among any two or more of the STEM subject areas, and/or between a STEM subject and one or more other school subjects” (p. 21).

The USA Department of Education (2007) provides a more inclusive definition of STEM education, “Science, Technology, Engineering, and Mathematics education programs are defined as those primarily intended to provide support for, or to strengthen, science, technology, engineering, or mathematics (STEM) education at the elementary and secondary through postgraduate levels, including adult education" (p. 11). Brown (2012), however, proposed that STEM education is not about blending STEM disciplines one with another as a set of construct, but rather to collaboratively move towards using STEM as continued learning. Teaching and learning STEM disciplines viewed as valuable in improving the quality of daily life for all students, especially for students with disabilities. STEM education provides more and faster work-related opportunities in the upcoming years (Basham & Marino, 2010).

The Emerging of STEAM Education and its Benefits

From a sociocultural perspective, Moss (2003) asserts that:

> "Learning is perceived through changing relationships among the learner, the other human participants, and the tools (material and symbolic) available in a given context. Thus learning involves not only acquiring new knowledge and skill, but taking on a new identity and social position within a particular discourse or community of practice. As Wenger puts it, learning "changes who we are by changing our ability to participate, to belong, and to experience our life and the world as meaningful."(p.14).

From this understanding STEAM education, driven by learner-centered instruction, provides a powerful learning opportunities for students with learning disabilities. The principles guiding this approach depend on active learning, hands-on engagement to solve real world problems and opportunities for purposeful movement abound (Park, Byun & Sim, 2016; Kim & Park, 2012; Radziwill, Benton & Moellers, 2015). Further, STEAM allows for shorter class times in a unique way. Actually, STEM class time is not shorter; however, there are built-in stopping and starting points as students move through the engineering design process. This provides breaks and time for students to process what they are learning. In smaller classes, teams of four to six students are the norm for well-designed STEAM classes. While the class may contain a normal number of students, students work primarily in small group settings.

In STEAM learning setting, students learn in respectful, understanding environments. STEAM classes generally are safe spaces. If a team fails to create a workable solution for a problem, it is not a problem. It's just a normal step in improving the design and succeeding. Ideally, team members show respect and accept one another, and teachers monitor teams as they work to see that this is happening. Finally, STEAM allows for flexible teaching styles as the ultimate exercise in teaching is flexibility (Park, Byun & Sim, 2016). Land (2013) argues that progress in industrial economy does not come from technology alone, but rather from the melding of technology and creative thinking through art and design. The "A" in the STEM feed creativity and innovation. As long as an individual challenges his or her boundaries by developing conceptual innovation, a person may be able to achieve their best innovative potential in any field.

Research reveals that jobs in the STEM fields are increasing three times faster than positions in the rest of the economy (McDougall, 2012). This huge gap between the sub-areas of the industrialized jobs in the USA economy has drawn the attention to the importance of investing resources in teaching STEM domains areas (Land, 2013). With a quick-tempered youth focused on self-indulgence and leisure, Land (2013) argues that the society must make STEM education more appealing. Adding the arts into the STEM equation can revive the platform, providing not only an interesting approach, but also opportunities for the self-expression and personal connection new generations aspiration. Proponents of the movement of integrated of the arts into STEM education claim that an integrated STEM and arts is vital to foster innovation and creativity in the STEM disciplines. In essence, integration of arts has the potential of engage the mind in multimodality, thus leading to the integration of motor, perceptual, and cognitive skills.

Anderson-Inman (2009) makes the case for the importance of STEAM education drawing on the 21st century skills. Citizens of the 21st century are required to know how to work collaboratively within a collected intelligence, participate in social networks, negotiate across cultural differences, and navigate contradictory data available to them. According to Sutherlin (in Land, 2013) 21st century skills extend beyond literacies and may include play, performance, simulation, appropriation, multitasking, distributed cognition, collective intelligence, judgment, transmedia navigation, networking, negotiation, and visualization.

In South Korea, for an example, whose students have achieved one of the top five scores among the 64 countries participated in the survey in 2012, in the Program for International Student Assessment (PISA) and the Trends in International Mathematics and Science Survey (TIMSS), the reports indicate that the Korean students, despite their excellence achievement in the mathematics, science and technology, indicate in 2006 that they have low levels of interest in and enjoyment of learning science and mathematics. Based on this, the Korean Ministry of Education in 2011, proposed a policy on the reconstruction of Science, Technology, Engineering, and Math (STEM) education via enhancing interdisciplinary learning and adding “Arts” to STEM, which led to what is known as Science, Technology, Engineering, Arts, and Math (STEAM) (Park, Byun & Sim, 2016). This Korean experience, shows the emergence and importance of the “Arts” integration in STEM for the purpose of making the learning for elementary and secondary students learning experience as meaningful and engaging as possible.

Students with Learning Disorders Included in the General Education System

Not so long ago, students with disabilities, including learning disorders, were taught in self-contained special education classrooms within their own school or even in segregated schools for disabilities (Mader, 2017). But since the early 1990s students with learning disorders have been gradually included in the general education system. Research shows as many as 85 percent of students with disabilities can master general-education content if they receive educational supports. Supports can include access to a special-education teacher, having test questions read aloud, or being allowed to sit in a certain part of the classroom. When students with disabilities are included in classrooms with their peers, researchers assert that the high expectations and instructional strategies "lend themselves to those students being more successful than they would be had they been in a separate, self-contained environment (Mader, 2017).

Researchers (i.e., Lindsay, 2007; Skrtic, Sailor & Gee, 1996) argue that general education classes allow students with disabilities to be educated in the mainstream, which is a more inclusive setting. Generally, inclusion was created to advance the learning opportunities for students with disabilities. The students received their education from general education teachers that received their training in the particular subject. Students in the mainstream also have the opportunity to interact with students that do not have disabilities. Inclusion allows students with disabilities to become members of their school community and begin to feel valued as a student (Causton-Theoharis & Theoharis, 2008).

Causton-Theoharis and Theoharis (2008) argue that inclusion is built on the premise that all students should be valued for their unique abilities and included as essential members of a school community. Inclusion is not a place; it is a way of thinking. Therefore, moving students with disabilities from special education setting to the general education is just the first step towards full inclusion. The next step according to Causton-Theoharis and Theoharis (2008) is to make them feel they belong.

Characteristics and Needs of Students with Learning Disorders: Students with specific learning disorders (SLD), also referred to as specific learning disabilities under IDEIA, a Specific Learning Disability (SLD) is defined as: A disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, which may manifest itself in the imperfect ability to listen, think, speak, read, write, spell, or do mathematical calculations, including conditions such as perceptual disabilities, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia. Specific learning disability does not include learning problems that are primarily the result of visual, hearing, or motor disabilities, or mental retardation, of emotional disturbance, or of environmental, cultural, or economic disadvantage. (US Department of Education, 2006, pg. 46757).

Since the reissuing of the Diagnostic Manual of Mental Disorders (DSM-5) in 2013, a new definition of SLD has emerged. DSM-5 identified the following diagnostic criteria

A. Difficulties learning and using academic skills, as indicated by the presence of at least one of the following symptoms that have persisted for at least 6 months, despite the provision of interventions that target those difficulties: 1. Inaccurate or slow and effortful word reading (e.g., reads single words aloud incorrectly or slowly and hesitantly, frequently guesses words, has difficulty sounding out words). 2. Difficulty understanding the meaning of what is read (e.g., may read text accurately but not understand the sequence, relationships, inferences, or deeper meanings of what is read). 3. Difficulties with spelling (e.g., may add, omit, or substitute vowels or consonants). 4. Difficulties with written expression (e.g., makes multiple grammatical or punctuation errors within sentences; employs poor paragraph organization; written expression of ideas lacks clarity). 5. Difficulties mastering number sense, number facts, or calculation (e.g., has poor understanding of numbers, their magnitude, and relationships; counts on fingers to add single-digit numbers instead of recalling the math fact as peers do; gets lost in the midst of arithmetic computation and may switch procedures). 6. Difficulties with mathematical reasoning (e.g., has severe difficulty applying mathematical concepts, facts, or procedures to solve quantitative problems). (Eissa, 2018).

According to Learning disabilities Association (2019), some of the most common features of SLD include difficulty following directions, inability to discriminate between/among letters, numerals, or sounds, poor reading and/or writing ability, eye-hand coordination problems; poorly coordinated, difficulties with sequencing, and/or disorganization and other sensory difficulties. Additional characteristics in a day to day life may include: responding inappropriately in many instances, distractible, restless, difficult to discipline, difficulty adjusting to new changes, difficulty listening and remembering, difficulty telling time and knowing right from left, difficulty sounding out words… etc. Such difficulties cannot be attributed to lack of intelligence, or environmental issues or sensory related deficits (Learning disabilities Association, 2019).

Generally, individuals identified with SLD in schools also may have a Reading Disorder, Mathematics Disorder, Disorder of Written Expression, or Learning Disorder Not Otherwise Specified. Students with SLD are at high risk for school dropout compared to their general education peers (Morrison & Cosden, 1997). Additionally, research contends students with SLD who have graduated from secondary school have lower rates of attending postsecondary education.

In terms of behavioral issues, students with SLD are at higher rates of conducting behavioral problems compared to their peers without disabilities (Zach, Yazdi-Ugav & Zeev, 2016). Zack, et al. (2016) indicate that about 75% of learning-disorders children manifest deficits in the social skill area that differentiate them from their non-learning disorders peers. Further, they add that limited social ability may often affect social interactions, and therefore cause a feeling of rejection, isolation, and loneliness among students with SLD. Some common behaviors include, attentions deficits disorders, impulsivity, hyperactivity, conduct problems, and withdrawn behavior. Socially, most individuals with SLD exhibit greater level of social incompetence. Common social deficits include, less interaction with peers, peer rejection, and lower social status (Kavale & Mostert, 2004). Common learning and cognitive characteristics of students with SLD include, short attention span, poor memory skills, temporal processing deficits, processing speed (Démonet, Taylor & Chaix, 2004; Moll, Göbel, Gooch, Landerl & Snowling, 2016).

Generally, students with SLD need to be taught in the general inclusive system, and they need a more blended instructional approaches that take into consideration their educational, emotional, and social needs without compromising on the quality of education they receive. Further, students with SLD need a more specific support including:

- differentiated instruction that increases their engagement,
- academic support that help them access the full curriculum,
- behavioral support to help them maintain a positive learning environment with their peers with no disabilities,
- and continuous use of school resources including technology, hands-on experiments and all other available resources.

Teaching Students with Learning Disorders Using STEAM

Although there is a scarce research on STEAM education for students with disabilities, researchers have started to pay greater attention on how to meet students' special needs into the design of instructional plans. The journal of "Teaching Exceptional Children" for example, has recently launched a special issue on the integration of STEM education for the purpose of supporting students with disabilities in K-12 grades (Hwang & Taylor, 2016). Bashsm and Marino (2013) suggested that the origin of the STEM education lies in the understanding of the role of engineering, and they proposed that the universal design for learning framework would be a valuable asset STEM education. Researchers argue that STEM education should be expanded to embrace and integrate with the disciplines of the arts in order to facilitate and promote accessibility of STEM learning. The arts areas may include (i.e. dance, music, and theatre, visual arts and media arts. (National Coalition for Core Arts Standards, 2014).

Hwang and Taylor (2016) contend that STEM + 'A' (STEAM) should benefit students with disabilities in different ways: the nature of arts, as oppose to other disciples where a student is required to achieve a certain level at a certain time, arts is liberal and focuses on creativity rather than a standard achievement. Therefore, introducing the arts in the STEM education lowering the threshold and make way for various ways to approach learning. For an example, Hwang and Taylor (2016), suggested that the teacher can connect science instruction to the concept maps and graphic organizers as a visual support can be considered as visual arts. In this case, the researchers indicated that "students allowed to create their own visual representations of science concepts allows students to be visually creative and provides teachers an opportunity to determine what students may or may not have learned." (Hwang & Taylor, 2016, p. 43). (see Figure 1 for examples of graphic organizers: **concept map**: the civil war in America, and **cycle**: the life of a sea turtle).

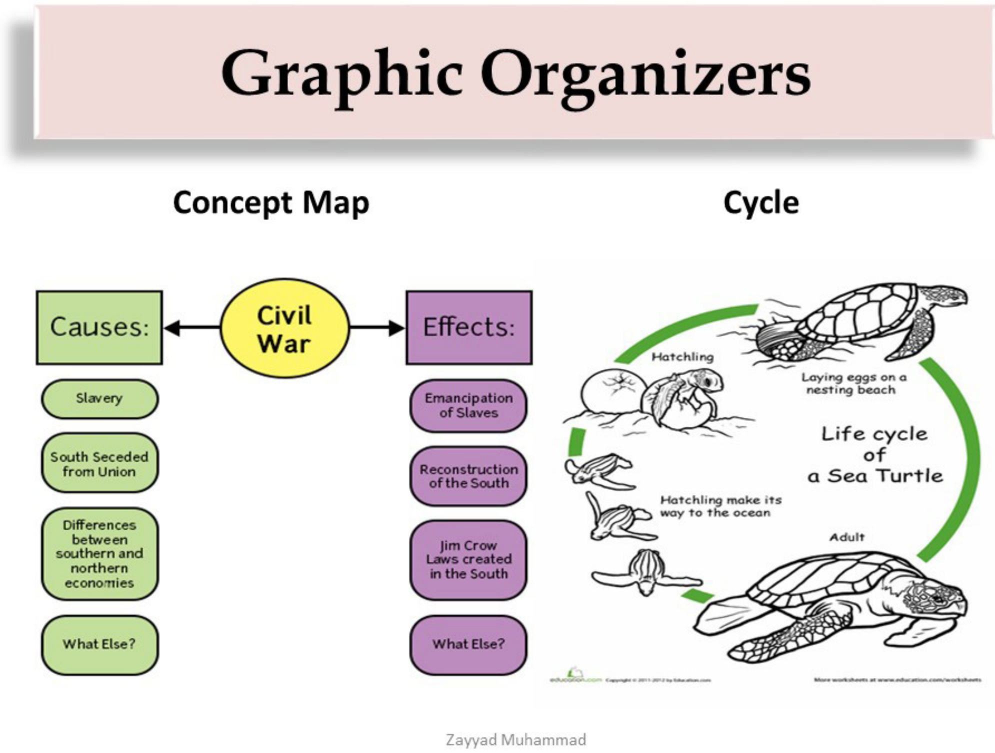

Figure 1. Four Examples of Graphic Organizers as Visual Supports.

Universal Design for Learning (UDL) and STEAM Education

The Universal Design for Learning (UDL) has been proposed by a group of researchers in the mid of the 80s of the twentieth century at the Center for Applied Special Technology with the goal of using technology to enhance learning for students with disabilities at various school ages (CAST, 2011). UDL model soon become a vital instrument for educators at the academy as it integrates multiple disciplines. UDL provides a learning framework to actual change the learning environment for students with disabilities (Fovet, Mole, Jarrett & Syncox, 2014). UDL relies on the three learning principles: a) using multiple means of representation, b) expression and action, and c) and engagement. Representation is the actual delivery of materials performed by the educators. Some students, may need a visual representation to better perceive the information, while others may rely heavily of audio display. Multiple ways of expression refer to the students' ability to respond to the learning conditions. Some students with disabilities, may need to use computers or touch screens to respond to the learning, while others may need to orally record their responses. Engagement provides opportunities for students to stay motivated and involved in the learning tasks (Basham & Marino, 2013).

The premise of the UDL model relies on the assumption that the brain of human being has three incredible networks that guide their learning. The first network is the "recognition" network. It answers the question "what" of learning. Data and information transferred through the senses to the back of the brain, including the occipital and temporal lobes "recognition network", processed for meaning in the center of the brain "the affective network", and ultimately organized in the frontal lobe for meaningful action "the strategic network". This broad understanding of the role of the brain in organizing the learning experience of humans, maybe helpful for educators to better arrange and predict the learning experience of all children.

UDL recognize the variability of learning in the following three domains as illustrated by CAST (2018):

- Engagement: this network concerns with the "Why" question, where students show their interests, task investment and effort, self-regulation and persistence in task completion. The engagement network optimizing the interest of the learners. It optimize individual choices, relevance, values, and authenticity. Further, it minimize threat and distractions.

- Representation: this relates to the "What" question, which aligns with the recognition network which include perception, memory, language and comprehension. This network provides multiple ways of customizing the display of information, offers alternative ways for auditory and visual information.

- Action and Expression: this is the "How" question which aligns with the strategic network. It represents physical action, expression and communication, and all executive functions of the brain. It provides options for physical action, and vary the methods for response and navigation, and optimize access to tools and assistive technology.

The figure below explains the UDL guidelines as elaborated by CAST.

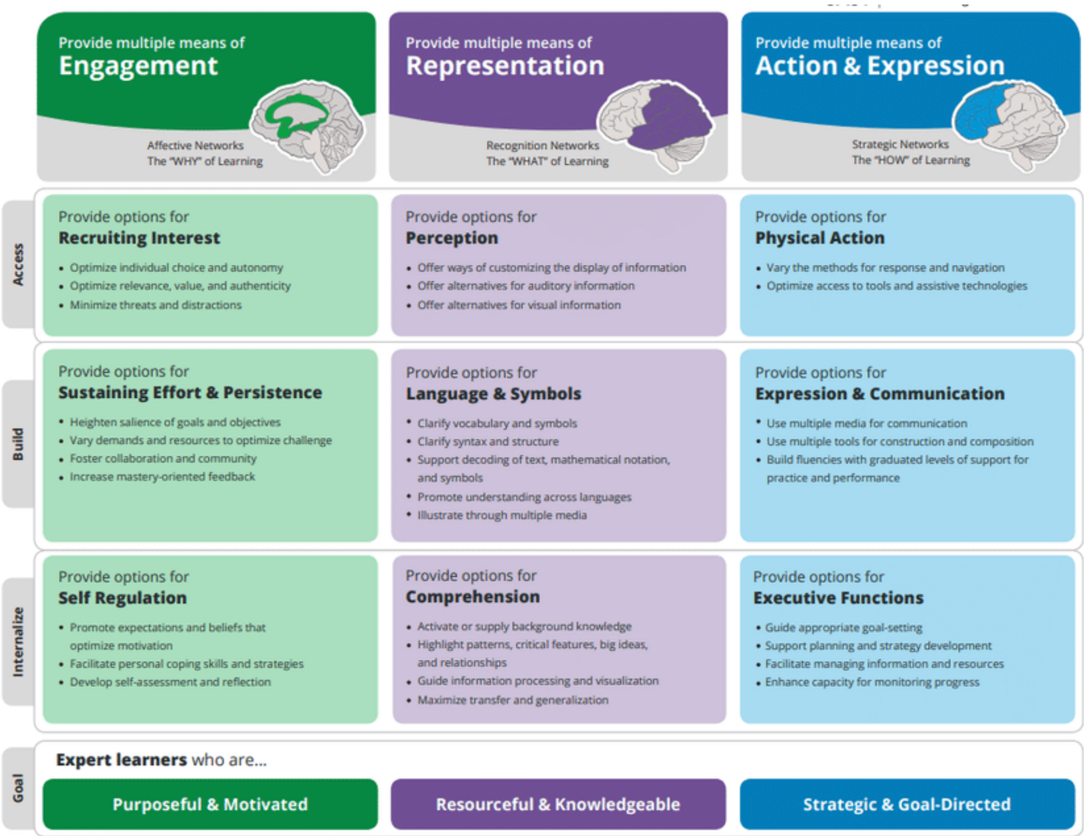

Figure 2. An Image of the UDL Guidelines Based on Brain Networks.

UDL aligns with the STEAM education. UDL stipulates that curriculum, instruction, and related materials should provide multiple representations of key concepts, principles, and vocabulary. Curry, Cohen and Lightbody (2006) explain that in a technology-enhanced STEM context, this can be accomplished by presenting information using graphics, simulations, video, and sound. From the UDL guideline, a curriculum encompasses everything that a learner encounters within a learning experience including curricular standards and goals, instructional materials and tools, and instruction, as well as the means by which outcomes are assessed. UDL applies instructional practices and modern teaching approaches, such as technology and assistive technology. Keeping in mind the three learning networks (affective, cognitive, and strategic) UDL falls within the principles of STEAM education, especially the blending of several disciplines with the arts which resonate well with the needs of students with SLD. With a specific focus on making all learners "expert learners." Basham and Marino (2013) suggests that four critical elements be present within an instructional environment for it to be considered UDL-based: clear goals, intentional planning for learner variability, flexible methods and materials, and timely progress monitoring.

Final Thoughts

Students in the technology era of the 21st century in a big need for a well-designed curriculum that is meaningful, learner centered, flexible, matching the rapid growth of technological revolution. Such curriculum that does not exclude any group of students, especially students with SLD who comprise at least ten per cent of the students' population at any grade level. The UDL approach along with the opportunities that can be offered by STEAM education in a rich learning environment would definitely account for a positive change for the future of all learners.

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