

Perceptions of Students with Learning Disabilities Learning Science: A Narrative Study

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Thesis submitted to the University of Ottawa
in partial Fulfillment of the requirements for the
Doctor of Philosophy Education

Faculty of Education
University of Ottawa

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ABSTRACT

While there has been research regarding the effectiveness of teaching strategies to teach science to students with learning disabilities (LD), the viewpoints and experiences of students with learning disabilities using narratives have not received the same attention. This study was conducted to explore the beliefs and feelings of students with learning disabilities about their science learning experiences during their high school years. Vygotsky's theory on Social Constructivism was used to examine the interaction of cognitive processes such as perceptions and attributions; behavioral features such as social skills and communication difficulties; and, environmental factors such as teaching techniques and peer interactions. These factors are interacting determinants of learning and classroom participation. Due to the social nature of schooling and disability, the social model of disability approach was considered the most efficient way to address this issue of learning of science with learning disabilities.

Eight undergraduate students with LD were interviewed about their experiences of learning science in mainstream science classrooms. Four themes emerged after thematic analysis of the narrative interview data: a) understanding of learning disability; b) finding resources and strategies for learning science with LD; c) overcoming difficulties in learning science with technology; d) learner autonomy and science learning experiences with LD.

The salient feature of these themes showed that the participants had an adequate understanding of their LDs, and the difficulties they faced in learning of science subjects due to their learning disabilities. The stigmatizing experiences of low achievement in science subjects

and the initial reaction of some teachers triggered sad and angry feelings, and all the students longed to be more pushed to their higher potential in science learning. Participants then sought help from More Knowledgeable Others (MKO), they used assistive technology and developed their own strategies to overcome difficulties they were facing in learning science. The difficulties in learning of science subjects indicated by the participants have consequences; these difficulties may result in student's reduced motivation in learning, disengagement from school, leaving school prematurely, and may cause depression in students who drop out of school. These possible consequences and the dissatisfaction expressed by the participants in this study implicate a need to continually assess students with LDs knowledge of, perceptions of, and experiences with their science learning, both in research and actual practice. In turn, this greater consideration of participant's viewpoints may have a positive influence on the success of high school science education programs and the social-emotional development of students with LD.

DEDICATION

To my wife Qaisar my children Masooma, Rohan, Sukana and
to the participants of this research project.

ACKNOWLEDGMENTS

I honestly feel that it is almost impossible to express and condense into a few sentences, the intensity of feelings and gratitude, I owe to all those who helped and guided me in the preparation of this dissertation.

First among them is my benevolent and cooperative supervisor Professor Donatille Mujawamariya without her help and sincere advice all my efforts would have gone in vain. Her guidance helped me in overcoming all the difficulties I encountered during the time of my research and writing of this thesis. I can never thank you enough for all you have done for me.

My humble thanks to my thesis committee members Professor Giuliano Reis, Professor Carole Sénéchal and Professor Jessica Whitley, who in spite of their multifarious engagements helped me by their inspiring insightful comments which helped me to refine my research.

I am forever grateful to my friend Alishia Valeri for her friendship, support, and constant encouragement during my studies. My special appreciation to Dr. Maria Bastien who has been a wonderful mentor/ editor throughout my thesis writing process.

Last but not the least, I would like to thank my family particularly my wife Qaisara Naveed who has been extremely supportive of me and has made countless sacrifices to help me to finish this important work of my life. My children, Masooma Naveed, Rohan Naveed, and Sukana Naveed, thanks for being exceptionally tolerant and patient during tough times. My brother-in-law Zafar Ali and sister- in- law Saadia Saeed I do not know how to thank you for supporting me throughout my studies and in my life in general.

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CHAPTER 1

THE STATE OF LEARNING DISABILITIES IN CANADA

In Canada, people with learning disabilities (LD) are among the most marginalized individuals in the labor market (Prince, 2014). They have a lower level of labor force participation and a greater degree of unemployment than Canadian without disabilities (Statistics Canada, 2012). Peoples with disabilities including individuals with LD have a higher level of poverty and greater dependence on social assistance funding than other citizens (Park, Turnbull & Turnbull, 2002; Prince, 2014). In the Canadian Survey on Disability (CSD, 2012), 622300 Canadians aged 15 years and older, reported a learning disability, representing 2.3% of the adult population (Statistics Canada, 2012). The same survey further indicated that the employment rate among people with LD was 29% compared to 80.5% for people without disabilities (Statistics Canada, 2012). This high unemployment affects an individual with LD's social capabilities, poverty, opportunity to make friends, a feeling of social attachment, and chances for both professional and personal growth (Park, Turnbull & Turnbull, 2002; Smith & Twomey, 2002). With attention to unemployment, Jena (2013) showed that unemployment is closely associated with school dropouts. In Canada, the high drop-out rate for youths with disabilities including LD is 14.2%, compared to 9.7% for those without a disability (Statistics Canada, 2006). School dropout and alienation were also strong predictors of juvenile delinquency (Burrell & Warboys, 2000; Murray, 2003). Nearly one in four inmates in Canadian prisons have a learning disability

(Learning Disabilities Association of Manitoba, 2018).

According to recent Canadian statistics, adults with LD were more likely than adults without any disability to have not completed high school (33.0% versus 13.1%) (Statistics Canada, 2012). They were also significantly less likely to have completed post-secondary qualifications (35.6% versus 61.1%) (Statistics Canada, 2012). Furthermore, 61.3% students with LD revealed that learning disabilities have profound effects on the choice of their career (Statistics Canada, 2012). For example, enrollment statistics of post-secondary education in Canada showed that most students with LD enrolled in social studies and humanities as academic streams rather than more specialized branches of study such as engineering and advanced technology. According to the last survey, the enrollment of students with LD in scientific fields steadily decreased from 2008 (23.80%) to 2011 (17.30%) (Statistics Canada, 2012). In contrast, Ball (2008) argues that in the 21st century the continued economic success of a country is dependent upon a highly skilled workforce. For the progress of the Canadian economy, Canada needs a highly skilled workforce. With this in mind, a review of the Federal Budget 2014 showed that in Canada science-based occupations have a 5.8% vacancy rate, skill trades have 5.3% and all other professions 3.5% (Ministry of Finance, 2014). While trade and service sectors are already preferred fields of employment for peoples with learning disabilities (Siegel & Gaylord-Ross, 1991; Statistics Canada, 2012), scientific fields have the potential to increase the employment rate of individuals with LD who are under-represented in these areas. Although the role of education and particularly education in the scientific fields in the 21st century has been linked very much to the economic success, it is also essential for daily living, active participation in the society, and social cohesion (Levitt, 2002). Ontario Ministry of Education's Accepting Schools Act (2012) sets out expectations for all school boards to make available safe, inclusive

and accepting learning environments in which every student can succeed. While it is a fact that individuals with LD are intellectually average or above average and they can successfully overcome their difficulties in learning (Jena, 2013; Raskind, Goldberg, Higgins & Herman, 1999; Vogel & Adelman, 1992; Vogel, Hruba & Adelman, 1993); my argument is that by providing more career choices in the scientific fields we can improve the employment rate of students with learning disabilities. Therefore, I undertook this daunting task of asking students with learning difficulties who are enrolled in the scientific fields of studies at the University of Ottawa, what was their experience of learning science at the high school level. I wanted to know what inspired them to pursue their education in the scientific fields and what learning strategies and assistive technologies they used to learn science in inclusive science classrooms in high schools. Strategies employed by these students to learn science subjects will help administrators, policymakers, and teachers, to make decisions about science education teaching practices for inclusive science classrooms.

Researchers have previously studied issues related to students with learning disabilities by using surveys and web questionnaires for understanding difficulties students with LD are facing in their high school and post-secondary education. However, there is still a need to understand the experiences of these students in learning science at the secondary and post-secondary level. This thesis responds to this need and reports an exploratory study of the experiences of students with learning disabilities in learning science at the high school level. It is important to mention here that I am a person with a disability who already has a Ph.D. in Plant Genetics. I faced many difficulties in learning science (see biography in methodology section). This study was born out of a desire to make a difference to the everyday lives of persons with learning disabilities; by providing them additional career choices in the scientific fields along

with traditional fields of social sciences. This additional scientific fields of employment will help to reduce their unemployment and uplift them from poverty and reliance on social assistance in Ontario.

Over the last fifteen years as an educational researcher, I have developed a particular interest in the individuals with learning disabilities studying science at the University level. This interest has developed as statistics of University enrollment (Statistics Canada, 2012) showed that students with disabilities prefer non-scientific fields for their post-secondary studies. The literature on students with LD indicated that many of these students who struggle with their science subjects experience a resistance to any information which is not consistent with their self-schemas (Farmer, 2001). This kind of behavior is not unexpected as these students struggle with learning throughout their life. Students with LD feel a sense of conflict between their unclear sense of their internal resources and the external expectations which lead to a sense of cognitive dissonance (Farmer, 2001; Wong, Harris, Graham & Butler, 2003). This cognitive dissonance makes the efficient use of self-schemas often incompatible with new learning, which promotes poor self-esteem and exacerbates negative feelings. For example, after more than 150 years of Charles Darwin book "On the Origin of Species" teachers still find resistance to learning about biological evolution in students (Bramscheiber, 2013). Students with LD who are exposed to the evidence of evolutionary theory for the first time, who see evidence with new clarity, or who begin to make connections between bodies of supporting data may experience such mental strife if the information conflicts with their preconceived worldview. This study is an attempt to understand the struggles and conflicts students with learning disabilities experienced during learning of science subjects in their schools through their voices.

My experiences working with students with learning disabilities have shown that by

providing right help in science classes, science teaching can be a relatively easy process.

However, this can only be achieved, if professionals have an understanding of what it is like to be a student with a learning disability. This understanding will help in connecting the new scientific knowledge to some realities the student already understands. This may require that the student and the professional explore and create an understanding of the preferred learning style of the student and also of those strategies that the student may have learned to use, but which are not particularly effective due to improper use. Thus, feedback and one to one meeting with a teacher can become an active element of the learning process for the student with LD.

Meaningful feedback must be provided to the student with LD in a manner that makes contact with their reality. Levine and Edgar (1995) reported, that on one hand new information is best learned by associating it with a concept that is already well understood by all the learners but particularly students with LD. Associating with the known concept allows the learner to mentally explore how this new information is similar and dissimilar to his present understanding. Levine and Edgar further explained that a student's energy is dissolute when receiving new material without a personally meaningful context. The student then must occupy himself/ herself with looking for a schema to which he/she may associate this new information. This occupies much of the student's mental energy, frequently resulting in the loss of relevant parts of the new information. As much of the student's mental effort is already being spent in dealing with the inherent stress related to his/her learning problems; therefore, it is very important that the student with LD be given contextually relevant information for their science learning.

In addition to facilitating teachers and students with LD in building more efficient learning science strategies based on the findings of this study, my stake in this research was to feel more competent and better equipped to make interventions that assist students with LD to

learn science subjects more effectively.

Moreover, educational professionals have a responsibility in an understanding of the learning process for students with LD. This understanding will improve the opportunities for students with LDs to finish their formal science education and to be better prepared to cope with the demands of the selecting science careers. It is important to mention here that barriers to success for students with LD do not rest entirely on the shoulders of students with LD as learners but the barriers have also been created in the school environments due to the way the academic courses in general, and science courses in particular, have been taught in high schools. Despite the fact that, there has been much time and energy invested in developing better and more efficient teaching strategies to help students with LD to become competent science learners but then again, these strategies need to be chosen or formulated in a manner that is relevant to the resources and realities of the 21st-century science learner.

The teaching strategies developed by various educational professionals for students with LD in reading, writing, memorization, and organization have been researched in recent years (Klassen, 2010; Liederman, Kantrowitz & Flannery, 2005; Mercer, Mercer & Pullen, 2011; Mercer & Pullen, 2009; Molfese, Molfese, Key, Modgline, Kelley & Terrell, 2002). This study will examine these strategies by asking questions from students with LD about their effectiveness which will lead to a better understanding of the qualitative aspects of the struggles of students with LD to learn science subjects. Hofer, Yu and Pintrich (1998) also emphasized the need for such studies as, “more qualitative studies involving interviews of students are needed as they enroll in a course as well as when they leave the course, to understand their learning process.”

This educational study is based on the social model of disability, which is also the basis

of the United Nations Convention on the Rights of Persons with Disabilities (CRPD; 2006), which Canada ratified in 2010. The CRPD refers to people with a disability as those with “physical, mental, intellectual or sensory deficiencies which in interaction with various barriers may hinder their full and effective participation in society on an equivalent basis with others” (United Nations Enable, 2007, p.2). This statement blends the medical model with a social model and the core idea of social equality or parity (Rice & Prince, 2013). Human Rights Commissions across Canada interpret disability in broad and flexible terms by taking into account not only the functional/medical condition of an individual but also discrimination based on perceptions, stereotypes, and social constructs (Prince, 2009; Stienstra, 2012).

Keeping CRPD in mind if we look at special needs student’s education in Ontario, Bill 82 of Ontario Education Act, 2016 (Ontario Ministry of Education, 2016) defines exceptionalities of pupils and to prescribe classes, groups or categories of exceptional pupils and to require the use of these definitions by school boards. Rubinoff (2017) explained the process of special needs students’ education in Ontario as follows:

When it comes to placement decisions, regulation 181/98 of the Education Act stipulates that, ...the committee shall, before considering the option of placement in a special education class, consider whether placement in a regular class, with appropriate special education services, (a) would meet the pupil’s needs; and (b) is consistent with parental preferences. O. Reg. 181/98, s. 17 (1). (Regulation 181/98, 2012-2016). Although the intent is that regular class placement should be considered prior to a special class placement, there are a number of placement options available. These include a regular class with indirect support; a regular class with resource assistance; a regular class with withdrawal assistance; a special education class with partial integration; and a special

education class fulltime. The Ontario Ministry of Education also articulates the programming options available in terms of accommodations, modifications, and alternative expectations. According to The Individual Education, Plan Resource Guide accommodations are special teaching and assessment strategies, human supports, and/or individualized equipment required to enable a student to learn and to demonstrate learning. Accommodations do not alter the provincial curriculum expectations for the grade. Modifications are, changes made in age-appropriate grade-level expectations for a subject or course in order to meet a student's learning needs and alternative expectations are developed to help students acquire knowledge and skills that are not represented in the Ontario curriculum. Although the expert panel responsible for developing these documents has adopted what could be described as a social model inclusive, non-categorical - rather than exceptionality-based - approach to address programming for students with special education needs, the legislative context outlined above has not changed. Despite the inclusive leanings of these new documents, school boards are still required to comply with the regulations set out in the Education Act and to indicate how by creating a special education plan that meets the standards set out by the ministry requirements that can seem to run counter to a social model and notions of inclusion. These structures, along with accompanying processes like Individual Education Plans (IEPs) and Identification, Placement, and Review Committees (IPRCs), still reflect medical model thinking.

Although, Ontario Ministry of Education striving for inclusive education, however, Little (2017) states that, "many principals said it is difficult to meet students' needs without sufficient and skilled support from educational assistants and that the current ratio is insufficient to meet

demand”.

An effective approach regarding teaching science to students with LD in inclusive classrooms, therefore, would be to provide the recommended assistive technologies, enough support staff with the knowledge of accommodations including assistive technologies and teachers with the knowledge of teaching approaches to help these students overcome their problems in learning science (Little, 2017; Marino, 2010; Pavri & Monda-Amaya, 2001; Scruggs, Brigham & Mastropieri, 2013). For this reason, exploring perceptions of students with LD of learning science will help discover the strategies these students used to overcome the challenges they are facing in the science classrooms.

Keeping in view the lack of investigation regarding the voice of students with learning disabilities in learning science education in high schools; the present study was undertaken to fill the gap in research by listening to the stories of these students by answering the following question, “How do students with learning disabilities perceive the experience of learning high school science?”

Overview of Study

The dissertation for this narrative study includes seven chapters. The first chapter introduces the study with a broad overview. The second chapter provides a descriptive review of the literature related to students with learning disabilities and undertakes a review to see how the term learning disabilities are understood in educational circles. As well, literature containing strategies available to teach science and assistive technologies used by students with LD to learn science was also reviewed. The review also focuses on teaching strategies, teacher’s role, and the role of technology, which are also extremely relevant in researching on LD. The third chapter

provided the theoretical framework and the social model of disability is presented and explained. By framing the results of the research within this model, our understanding of various students' learning disabilities can be seen as a significant part of a broader theoretical construct. In the final section of the review chapter, the author introduces a conceptual framework based on the relevant review of the literature. In addition, the theoretical and methodological elements of the study are also identified in this chapter. In fourth chapter author states, the qualitative methodology adopted for the research identifies the participants, discusses the researcher's role and describes the procedures adopted for the study. The formal structure of the interviews is described. The parameters of data analysis and the limitations and implications of the study are then discussed. The fifth chapter introduces the study participants with a broader overview of demographics and a profile of each participant. The sixth chapter presents the findings of the study, organized by themes which emerged from the data analysis. Finally, the seventh chapter includes a discussion of findings organized by research questions which guided this study. The author then discusses the major implications of each profile and attempts to place the discussion in the context of current research on learning disabilities and science education. The author concludes the study with a discussion of the implications of this study and points to a direction for future research.

CHAPTER 2

LITERATURE REVIEW

This literature review intends to explore the complex range of issues surrounding studying science by students with learning disabilities in inclusive classes within secondary schools. The majority of research associated with this topic relate to documented experiences of reading, writing and learning math in middle school. However, learning disabilities are based on a continuum which initially becomes visible in the early years of schooling and extends into the secondary years and affects reading, writing, math including other areas of study such as the sciences.

The research presented in this literature review is widespread and interrelated. It begins with an opening discussion of the characteristics of students with learning disabilities. The literature further examines the complexities of the relationships between learning science subjects and different characteristics of students with LD. Correspondingly, it includes literature regarding students with LD and teachers' accommodations of students with learning disabilities in mainstream classes.

This review of literature further provides an overview of the research and perceptions of researchers who have contributed to the understanding of the complexities faced by students with LD at school while learning science subjects. Moreover, this literature provides context for the present study by enlightening its contribution to the field of learning disabilities by examining

strategies to overcome the complex range of issues in learning science that confront students with learning disabilities and their teachers, so that students may be nurtured and thrive at school and begin to have faith in their talents and capacities.

2.1. Students with Learning Disabilities

2.1.1. Defining Learning Disabilities

Learning disabilities (LD) is the term used to describe students who have “difficulties in literacy, numeracy and learning how to learn” (Ontario Ministry of Education, 2014). Learning disabilities have historically been used to describe students who have difficulties, particularly in literacy. In the United States of America (USA), the term learning disabilities was first used in 1963 by Kirk to describe people with unexpected difficulties in literacy and continue to be used today (Hallahan & Mercer, 2002). The concept of a discrepancy between achievement and potential, first introduced into the discussion in 1965 by Bateman, remains central to this particular definition (Hallahan & Mercer, 2002). Since education policies in Canada are set by provincial/territorial ministries of education, educational definitions of LD vary across the country. For example, Klassen (2002) states that “among the provinces, a number of different operational definitions are currently in use, with 8 of 10 provinces using some form of a 'traditional' IQ/achievement discrepancy method.” Similarly, D’intino (2017) explains that “the concept of LD is not uniformly defined across Canada.” The 2006 Participation and Activity Limitation Survey and the 2012 Canadian Survey on Disability, include attention deficit disorder (ADD), and attention-deficit/hyperactivity disorder (ADHD), along with dyslexia, and other developmental disabilities of scholastic skills in LD. While the Learning Disabilities Association of Canada (LDAC) does not share the same definition and makes no explicit mention of ADHD

and ADD in their explanations of LD. However, one thing is common in all the definitions of learning disabilities of the provinces, Federal surveys and Learning Disabilities Association of Canada that students with LD are considered to be at risk. Furthermore, the term learning disabilities, as used in these definitions, states that the origin of the disability is neurological.

Thus, research studies included in this chapter were selected when they focused on persons with LD who met defined and broadly recognized learning disabilities criteria as stated in the definitions of LD of provinces and Federal surveys and Learning disabilities association Canada. Most children and youth recognized under the respected definitions of LD by Ministries of Education would qualify the conditions for LD and likely would be included in the literature of this narrative study.

Over the years learning disabilities have been described by various scholars in different ways (Fletcher, Morris & Lyon, 2003). One such description suggests that learning disability is considered a specific category under the umbrella term learning difficulty, which includes disorders that are caused by environmental problems such as early neglect or isolation (Stone & La Greca, 1994). Learning disabilities are also thought to be biological in origin (Smith & Strick, 1997). More specifically, learning disability is a neurological condition that negatively affects academic functioning in a particular area of competence (Hagborg, 1999; Kavale & Forness, 1992; Masten & Coatsworth, 1998; Meltzer, Roditi, Houser & Perlman, 1995; Mungovan, Smith & Spurr, 2002; Nowicki, 2003; Tsatsanis, Fuerst & Rourke, 1997; Vallance & Wintre, 1997). The United States Department of Education's Individuals with Disabilities Education Act (2006) clearly defined learning disabilities and ensure that services (early intervention, special education, and related services) should be provided in each state to all the persons including individuals with learning disabilities.

Additionally, the presence of LD is usually indicated by a discrepancy between ability and achievement (Kavale, 2001, 2005) and interferes with the individual's daily learning activities (Flanagan, Ortiz, Alfonso & Mascolo, 2002). LD is a persistent and long-term condition (Kavale & Forness, 2000) which does not respond favorably to intervention measures (Kavale, 2005). Recent research in the field of genetics has indicated that LDs are inherited from previous generations (Marom et al., 2017; Robertshaw & MacPherson, 2006). Students with learning disabilities may also experience difficulties in the social domain including communication difficulties (Flax, Realpe-Bonilla, Hirsch, Brzustowicz, Bartlett & Tallal, 2003; Pearl, 1992; Schoenbrodt, Kumin & Sloan, 1997), social skill difficulties (Wainman, 2010) and inability to perceive nonverbal cues in communication (Baum & Owen, 2017; Myklebust, 1995).

Learning disability may happen along with other handicapping conditions such as sensory impairment, social and emotional disturbance (Svetaz, Ireland & Blum, 2000). It may also occur with socio-environmental influences such as insufficient or inappropriate instruction, cultural differences, and psychogenic factors all of which may cause learning problems. However, most of the above researchers believe that a learning disability is not the direct result of those conditions or influences as it is biological in origin and the above factors affect its degree of expression (Kavale & Forness, 1992).

A more comprehensive, and necessarily less concise definition is provided by the Ontario Ministry of Education (2014). This definition concurs with the majority of those available internationally while reinforcing or specifying particular points that have been open to interpretation in previous definitions. Additionally, specific mention of non-verbal difficulties is also made in the definition. Learning disability is defined as a range of disorders that affect the acquisition, retention, understanding, organization or use of verbal and non-verbal

communication (Ontario Ministry of Education, 2014). The above conditions cause impairments in one or more psychological processes related to learning in connection with at least average abilities necessary for thinking and reasoning. Other terms such as dyslexia and dyscalculia are used to refer to particular types of learning disability (Dore, 2006). Learning disabilities are specific impairments that require at least average IQ scores and as such are distinct from intellectual disabilities (Leach, Scarborough & Rescorla, 2003).

Furthermore, the Learning Disabilities Association of Ontario (2016) states that “learning disabilities interfere with the acquisition and use of the following essential skills: oral language (listening, speaking and understanding), reading (decoding and comprehension), writing (spelling and writing), and mathematics (problem-solving and computation).” In addition to the above difficulties, people with learning disabilities may also have problems with social interaction, social perception, and organizational skills (Hartas & Donahue, 1997; Ransby & Swanson, 2003).

Learning disabilities are life-long and people with LDs may face many obstacles throughout their life. There are many factors which can be manage to ensure that a person with learning disabilities reaches his full potential. The literature on LDs report that its effects may be expressed differently over time dependent upon the interaction between the demands of the environment and the individual’s personality. Some LDs may be noted during the pre-school years while others may not become evident until later in the life. In school learning disabilities are recognized by unexpectedly low academic achievement or achievement that is sustainable only by efforts and support (Wenz-Gross & Siperstein, 1998).

Learning disabilities are also not related to intelligence and may appear in severe, moderate or mild forms. People with learning disabilities have their profiles of strengths and

weaknesses; no two peoples are the same, and the impact on each is different (Mungovan, Smith & Spurr, 2002).

The Learning Disabilities Association of Canada's (2015) LD definition is also fundamental to the study of LD in Canada in that, primarily, it acknowledges that there is a group of individuals who have different learning needs from low-achieving peers. It also specifies that the disorder is etiologically distinct from general learning difficulties and highlights the social implications. Perhaps even more important is that it gives researchers a common ground from which to diagnose students and identify research participants reliably and consistently. Based on the right diagnosis, intervention strategies may be designed that take into account the differences and similarities between students with learning disabilities and other groups of students who have difficulties with their school work not related to LDs.

In addition to the identification of LD, the issue of labeling a person as having a learning disability has also received significant criticism in the literature. It has been said that labeling a child becomes a self-fulfilling prophecy in that if a child is continually told what he/she is, then the person will start to believe it (Ballantine, Roberts & Korgen, 2017). Further, the process of labeling encourages those involved to bring their preconceived notions of the label during interactions and making decisions about the child. In other words, people are encouraged to know the label, not the child (Sharp et al., 2017). This contention is not in question here.

However, to research the experiences of students with learning disabilities in schools, a method of identification is required to identify students who would be eligible for inclusion in such a project. At this juncture, the responsibility for identification remains with the researcher, which creates another set of difficulties, particularly regarding consistency. For example, the Ontario Ministry of Education revised its definition of learning disabilities to accept that some children,

such as those with dyslexia, dyscalculia, dysgraphia, et cetera, learn differently, therefore needing to be catered to differently.

Research in the field of LD recommends early intervention (Van Kraayenoord, Luke, Elkins & Land, 1999; Werner, 1990) that identifies students' differences in the formative years of schooling to enable proactive strategies to be put in place before the difficulties impact self-esteem and social status and before the onset of adolescence. This approach acknowledges that these challenges are related to individual characteristics and the environment in which the individuals participate. Such an approach avoids the negative attributes of labeling while identifying areas of additional support needs.

2.1.2. Types of Learning Disabilities

Learning disabilities can manifest in many different ways. Three most common are reading, writing and math disabilities. Reading disability is a language-based learning disability called dyslexia; students have difficulties with spelling and decoding skills, recognizing words, and comprehending text (Ehri & McCormick, 1998; Gersten, Fuchs, Williams & Baker, 2001; Liederman, Kantowitz & Flannery, 2005; Metsala & Ehri, 1998). Dysgraphia is learning disabilities related to difficulty in writing, such as forming letters or words or writing within a defined space. This also includes difficulties with spelling, semantic memory, morphological awareness, grammatical structures, organizing information, putting thoughts on paper, or working memory (Berninger, 2009; Swanson & Sáez, 2003; Zera, 2001). Math learning disabilities are known as Dyscalculia (Shaley, Manor & Gross-Tsur, 2005). Peoples with dyscalculia have difficulty understanding mathematical concepts and computation (Fuchs & Fuchs, 2002). This disability is closely related to problems of working memory and problem

solving (Swanson & Sáez, 2003; Swanson, Zheng & Jerman, 2009). It is not common that all students with LD have disabilities in all three areas, but a high percentage of students have multiple LDs (Bryant, Bryant, Hammill, Sorrells & Kethley, 2004). This poses significant challenges for teachers, who are responsible for remediating the weaknesses of students with LD, and for supporting them through the use of accommodations and modifications to the curriculum. Another characteristic related to the experience of having LD is that the difficulties encountered are long-term, and persistent (Kavale & Forness, 1996, 2000) which are not alleviated with intervention (Kavale, 2005). However, by adopting social model approach teachers can help students with multiple LD by removing barriers through assistive technology and accommodations.

The social model of disability can also help students with LD who have not been identified due to the lack of resources as the diagnosis of LD carries heavy medical connotations and is expensive for an ordinary family as it is not covered under Ontario Health Insurance Plan. While school boards all assess students, who faced difficulties in learning for LDs but due to limited resources wait times are quite long and that many families choose to pay out of pocket or go through insurance companies to have private psychological assessments done. As Rubinoff (2017) explained Ontario's education system school practices are still based on a medical model that seeks to provide resources for those with special educational needs. Unfortunately, when using this model needs cannot be identified, and associated funding cannot be accessed, without a diagnosis (Dowdy, Carter & Smith, 1990). Therefore, as stated above, teachers can help all students (students with LD, average students, and students who have LD but due to lack of funding not being identified) by adopting a social model of disability approach by removing barriers through accommodations and using available technology to teach all these students in

their science classrooms.

2.1.3. Prevalence and Characteristics of LD

According to the 2012 Canadian Survey on Disabilities (Statistics Canada, 2012), 2.3% Canadians aged 15 years and older reported a learning disability. While in Ontario 2013-2014 3.8% of the school population was identified for special education under learning disability (Learning Disabilities Association of Canada, 2015b). The study found that rates among men and women were not significantly different. Mercer and Pullen (2005) state that characteristics typical of students with learning disabilities include students being inactive and inefficient learners who are easily distracted and often off-task. They experience difficulties in integrating prior knowledge and expertise into what they are learning. Normally, these traits are combined with learned helplessness and are accompanied by socio-emotional problems, which every so often result in the development of poor self-esteem and expectation of non-performance in academic areas (Heath & Ross, 2000; Heath & Wiener, 1996; Learning Disabilities Association of Ontario, 2017; Svetaz, Ireland & Blum, 2000).

The section following is a review of the literature in the field associated with the barriers and challenges students with learning disabilities face while learning to read, write and take part in science education in high schools.

2.2. Barriers/ Challenges and Learning Strategies

Students with LD commonly experience difficulties with reading comprehension, organizing, retaining, and linking information to prior knowledge (Liederman, Kantrowitz & Flannery, 2005; Maccini, Gagnon & Hughes, 2002; Zera, 2001). Also, students with LD rarely

employ effective study strategies and note-taking skills and do not take an active approach to academic tasks (Maccini, Gagnon & Hughes, 2002). Anderson-Inman, Knox-Quinn & Horney (1996) described real-time note taking, studying a textbook, and synthesizing content material as potential barriers and challenges in secondary school classrooms for students with learning disabilities for successful completion of high school and higher education. One further difficulty for students with LD is task perseverance.

Students with LD find many reading activities intimidating, which leads to feelings of disappointment, lowering their motivation, and adding anticipation of failure when faced with difficult academic assignments (Adelman & Vogel, 1990; Liederman, Kantrowitz & Flannery, 2005; McKinney, Osborne & Schulte, 1993; Pascual-Leone & Johnson, 2004). Similarly, McCray (2001) states that middle school students with reading difficulties express a desire to learn, but academic failure undermines that desire.

Keeping in view the above problems faced by students with LD in secondary classrooms hindering their efforts to learn science subjects, I argue that listening to students with LD who have experienced academic success regarding their challenges and learning strategies they use to overcome these problems offers great promise in improving the scientific literacy of students with LD. The more focused literature on reading, writing, science and math disabilities follow in the next section.

2.2.1. Reading

Approximately 80% of students identified with learning disabilities have their primary difficulties in reading (Lerner, 2002; Liederman, Kantrowitz & Flannery, 2005). While the overall goal of reading is to process meaning from text, converging evidence over the past

decade has indicated that many interrelated variables can impede a student's reading comprehension. These include difficulties in phonological and phonemic awareness (Miller, Snider & Rzonca, 1990; Peterson et al., 2017; Wilson & Lesaux, 2001) and alphabetic coding (Vellutino, Fletcher, Snowling & Scanlon, 2004). Likewise, many students with LDs struggle with decoding fluency (Chard, Ketterlin-Geller, Baker, Doabler & Apichatabutra, 2009); morph visual awareness (Bowers, Kirby & Deacon, 2010) and language proficiency (Cutting & Scarborough, 2006). Along with, adequate vocabulary skills, background knowledge, and metacognitive awareness (Berkeley, Scruggs & Mastropieri, 2009; Wong, Harris, Graham & Butler, 2003).

Most students with LD can acquire grade-level reading skills if they are identified early and provided with systematic and explicit reading instruction tailored to their difficulties. Changing reading instruction according to the learning disability of the student can remove barriers in reading and can help a student with LD to read according to his or her grade-level (Blachman et al., 2004; Slavin, Lake, Davis & Madden, 2011).

2.2.2. Writing

Students with LD have ideas. However, they often have difficulty using written language to convey them (Parette, Huer & VanBiervliet, 2005; Poplin, Richard, Stephen, Alison & Tes, 1980) or to generate stories (Barenbaum, Newcomer & Nodine, 1987). Many students with LD do not have the strategy knowledge available to help them in the writing process (Siegel, 2017).

Writing difficulties of some students with LD can be overcome if teachers use an instructional sequence that is aligned with that developed by Graham and Harris (2003) self-regulated strategy development (SRSD) model (Regan & Berkeley, 2012; and Schumaker &

Deshler, 2009). Within this sequence, students are taught some self-regulating strategies, such as goal setting, self-monitoring, self-instruction, and self-reinforcement, as well as receiving explicit instruction including basic genre-specific elements and how to use different types of writing (Schumaker & Deshler, 2009).

2.2.3. Science.

Science is one of the most difficult subjects for the majority of students, but it is especially difficult for students with LD. The reason is a thorough understanding of principles that reflect conceptual relationships between concepts, and theoretical nature inherent in scientific concepts and processes. Along with a theoretical understanding of clusters of events and terminology that share common attributes, knowledge of the factual information and complex vocabulary (Marino, 2010; Mastropieri et al., 2006; McCleery & Tindal, 1999). Also, students with LDs have difficulty activating prior knowledge and are reluctant to pose questions. Similarly, they are less likely to have systematic plan to approach problems, have difficulty making inferences during inductive, deductive reasoning processes, and seldom transfer knowledge across contexts (Dalton, Morocco, Tivnan & Mead, 1997; Jacobson & Archodidou, 2000; Mastropieri et al., 2006). Therefore, to learn science, students with LD require a high degree of structure and guidance to manage the extensive information and time restrictions (Samsonov, Pederson & Hill, 2006).

To help students with LD to learn science, Rose, Meyer and Hitchcock (2005) identified three principles regarding Universal Design for Learning (UDL) that can be used for science learning in inclusive classrooms. The first principle states that present scientific information using multiple flexible methods to support students' recognition networks. Second, provide

multiple flexible methods of apprenticeships and expression to support students' strategic networks. Third, provide multiple flexible options for engagement as a means to support students' effective learning. Similarly, McCleery and Tindal (1999) stated that scientific instruction should scaffold students' learning processes by highlighting critical information and helping them develop organizational clarity. By using mnemonic strategies, graphic organizers, text modifications, and exemplary models that are combined with explicit instruction. Additionally, research showed that differentiation of instructional materials and the use of peer partners during the learning process further facilitate students' knowledge acquisition (Mastropieri & Scruggs, 2004; Wiener, 2004). Instruction strategies regarding teaching science to students with LD follow in the next section.

2.3. Science Education and Instruction Strategies

While discussing the primary causes of underachievement or failure for students with LD, Westwood (2004) cited environmental factors, including pedagogy and curriculum as the main causes of failure. At the same time, the speed at which new concepts, skills and subject matter were introduced into secondary schools escalated the existing problems. Similarly, Ascherman and Shaftel (2017) recognized that the specific effects of school organization and the highly constrained organization of the classroom also had considerable impact. An analysis of the interaction of characteristics of the curriculum and features of the learner indicates that students with LD may have problems in language and literacy, attention span, semantic memory and working memory (Pullen, Lane, Ashworth & Lovelace, 2011; Scruggs & Mastropieri, 2010; Swanson, 1987; Swanson & Sáez, 2003; Swanson, Zheng & Jerman, 2009). These students may as well have problems with metacognition, social skills and peer relations (Estell, Jones, Pearl &

Van Acker, 2009; Montague, 1998; Pintrich, Anderman & Klobucar, 1994). Any or all of these characteristics can limit the potential for academic success in science for students with LD. A combination of strategy training and direct instruction has been effective for students with LD (Mastropieri & Scruggs, 2010; Swanson & Hoskyn, 2000).

Science education has been characterized by two principal models of instruction, i.e., Traditional textbook based and Constructivist hands-on activities based (Scruggs, Mastropieri & Okolo, 2008). Most academics and university science education programs have advocated constructivist, child-centered models of instruction (Anderson, 2007). In science, these models focus on concrete experiences with relevant, hands-on activities and an inductive, inquiry model for constructing content knowledge. In contrast to constructivist approaches are content-driven or textbook-based approaches to science. These approaches involve learning large amounts of factual content, lecture and worksheet activities, and independent study from science textbooks. Content-driven models typically emphasize breadth over depth of learning, and the acquisition of factual material, although they may also emphasize comprehension and application of learning (Cortiella, 2008). Overall, appropriately structured constructivist or hands-on approaches appear to interact more efficiently with the characteristics of LD, in that they emphasize relative strengths (hands-on learning, concrete learning experience) while de-emphasizing relative weaknesses (learning from text and abstractions) (Scruggs, Brigham & Mastropieri, 2013).

Furthermore, curriculum enhancements and peer mediation to increase learning of students with LD in general classes have positive outcomes for students with LD because they have influenced text vocabulary recall and acquisition of relevant concepts in the areas students with LD have problems learning (Marshak, Mastropieri & Scruggs, 2011).

In addition to the above strategies, teachers can use the Universal Design for Learning

(UDL) in their classes for teaching science. UDL is an educational framework that can meet the challenges of teaching science to diverse students' population (i.e., students with learning disabilities, students with physical disabilities and average students) in the classroom (Rose & Meyer, 2002). UDL emphasizes multiple means of representation, engagement, and assessment to offer a framework to enrich and differentiate instruction for diverse learners. UDL goals and methods are flexible. The teaching is customized to meet the individual needs. It prepares multiple means of engagement to tap into learners' interests and motivate learning. For example, a dyslexic child can learn to read by using a Rebus reading program, or by drawing pictures for vocabulary words (Armstrong, 2010). UDL, when embedded with constructivist or hands-on approaches for teaching science to students with LD, has been shown to improve engagement and learning (Baurhoo & Asghar, 2014; Colburn, 2008; Moon, Todd, Morton & Ivey, 2012).

As Universal Design of Learning may include technology, this framework can be used in the classroom, for all the students not just for students with learning disabilities (Perras, 2014). When technology is incorporated on purpose into everyday instructional practice, then technology becomes less stigmatizing and segregating for the student with a learning disability, for whom technology is indispensable. How technology helps students with LD explained in the next section.

2.4. Technology and Academic Instruction for Students with LD

Students with learning disabilities may require a variety of accommodations to access the curriculum, including technology. In my experience when technology is used seamlessly and integrated purposely in science classrooms to explain scientific concepts, all students including students with LD understand the concept more easily. Technology like an interactive whiteboard,

text to speech software and touch screen technology can be used in Biology for explaining genetic concepts, in chemistry chemical reactions can be manipulated. In the current educational climate, educators face increasing accountability and feel the pressure to increase the academic performance of all students, including those with LD, in preparation for high school graduation (Lancioni & Singh, 2014). For students with LD, assistive technology (AT) devices can promote access, and when combined with UDL principles facilitate academic success by fostering dynamic environments that support active learning and problem solving (Gardner, Wissick, Schweder & Canter, 2003).

Assistive technology can also improve student learning by supporting cognitive and metacognitive processes sharing the cognitive load (Marino, Sameshima & Beecher, 2009; Siegel, 2003; Wong, Harris, Graham & Butler, 2003). Furthermore, assistive technology allows users to conduct activities that would not be possible in a traditional classroom environment, as assistive technology lets users solve problems by making hypotheses, gathering data, and explaining results in a virtual environment. Assistive technology may also eliminate the overuse of expository texts, which hinders learning for students with reading difficulties (Lancaster, Schumaker & Deshler, 2002).

Computer-assisted instruction (CAI) in phonological skills decoding and computer supported practice reading can effectively supplement teacher instruction in reading (Higgins & Raskind, 2005; Lyytinen, Eklund & Lyytinen, 2003; Purvis & Tannock, 1997; Saine, Lerkkanen, Ahonen, Tolvanen & Lyytinen, 2011; Torgesen, Wagner, Rashotte, Herron & Lindamood, 2010) along with writing (Zhang, 2000), and mathematics (Chiang, 1986; Wilson, Majsterek & Simmons, 1996). Likewise, complex interventions that integrate computer-based instructions with teacher instruction have positive effects on comprehension and vocabulary acquisition

(Slavin, Lake, Davis & Madden, 2011). CAI also has been demonstrated to increase students' motivation (Okolo, 1992), time on task (Okolo, Bahr & Rieth, 1993), and independence (Manset-Williamson, Dunn, Hinshaw & Nelson, 2008). Concept mapping and other tools for planning are promising applications for students with LD (Englert, Zhao, Dunsmore, Collings & Wolbers, 2007).

Multimedia tools like an active agent or online digital coach give the student with LD the power to move from one topic to an associated explanation to answer a question or explore further (Anonymous, 2017). Students with LD can research the topic by enhancing text in a view to make computer connections between the text material and additional clarification material like identification of topic sentences, connection between propositions and pronoun clarifications (MacArthur, Schwartz, Graham, Molloy & Harris, 1996; Wissick, 1996; Wissick & Gardner, 2000). This freedom of movement from one idea to another related idea represents a powerful instructional enhancement for students with LD (Bender & Bender, 1996). Similarly, multimedia (graphics, animation, high-quality digitized speech, and motion video) can serve as another mode of instruction for students with LD (Orey, 2010).

Furthermore, one skill that many students with LD seem to lack is the ability to organize their daily life. Computerized applications of data management such as personal data assistants (PDAs) may assist them in organizational problems (Passey, 2014). Technology can provide means to promote students with LD academic achievement and attitudes toward science. The following are some details of assistive technology which can help students with LD to overcome difficulties in reading, writing, and science education.

2.4.1. Reading

Computer technology provides a multi-sensory delivery system in which words can be manipulated, heard, color-coded, and automatically linked with visual cues, for example, an e-reader (Silver-Pacuilla, Ruedel & Mistreet, 2004). While reviewing various assistive technology applications in the area of reading, Pilgrim and Ward (2017) identified some text-reading software which allows the computer to read the text and highlight text either word by word or letter by letter. These applications can significantly enhance reading instruction for many students with learning disabilities by increasing the span time of their concentration for the recognition of highlighted words.

Speech synthesis devices coupled with a screen reading device which highlights words while reading allow the computer to read text on a display to the students with LD (McArthur & Bishop, 2001; Raskind & Higgins, 1995) this can be an effective tool in teaching students to read, as well as in supplementing their study skills. Reading deficits of students with LD are improved or overcome by the use of text to speech systems (Leong, 1992; Lundberg, 1995). Additionally, Olson and Wise (1992) found that students with LD who read stories with speech feedback made significant gains in word recognition.

2.4.2. Writing

Williams (2002) showed how a speech feedback component and word prediction software greatly enhanced the written work of LD student. Word-processing systems allow students with LD to review their written work for errors in spelling and sentence formation before printing the work (Ashton, 1999; Raskind & Higgins, 1995). Likewise, proofreading programs that check for punctuation, grammar, and word usage, can significantly facilitate the

writing skills of students with LD (Purvis & Tannock, 1997; Schetz & Dettmar, 2000; Strassman & D'Amore, 2002). For individuals with LD, composing orally may allow them to circumvent transcription or text production problems (e.g., handwriting, spelling, and punctuation), which may allow greater focus on higher order concerns such as planning and content generation (De La Paz, 1999; Graham, 1990; Graham & Harris, 2003; Graham, Harris & MacArthur, 1993).

2.4.3. Science

Horney & Anderson-Inman, (1999) states that “technology can provide students with alternative pathways to access science curriculum materials by incorporating eight types of resources: translational, illustrative, summarizing, instructional, enrichment, notational, collaborative, and general purpose”. This quote suggests that technology can help students with LD to access the science curriculum in various ways. Technology not only helps to teach all the students who have different learning styles it also introduces various other resources. These resources allow learners to focus their energy on higher order thinking and critical analysis (Jonassen, 1996). Technology-based cognitive scaffolds such as captioned videos and films; visual, auditory, and tactile instructional demonstrations; and spellchecker and grammar checking technologies are beneficial for STEM learning (AccessSTEM, 2008). While research examining the use of games in science instruction is limited, games offer the potential to engage students with LD through alignment with the UDL framework. For example, using Alien Rescue technology-enhanced curriculum, Liu and Bera (2005) and Marino (2009) indicated that students demonstrated statistically significant learning gains as a result of using this simulation software. Similarly, Quest Atlantis allows students to participate in authentic social and academically meaningful activities, along with students can complete environmental studies, research common

problems, and examine events from multiple perspectives (Barab, Thomas, Dodge, Carteaux & Tuzun, 2005).

In sum, assistive technology devices and services enhance abilities and reduce barriers to achievement. However, it is important that assistive technology decisions be related to the function assistive technology helps an individual to perform rather than to a specific disability. Research indicates that assistive technology is used by a student with a disability to complete a learning task independently and at an expected performance level. More importantly, without assistive technology, the student would be unable to perform the task independently or proficiently. Moreover, Ontario's Accepting School Act (2012) requires that schools ensure assistive technology is provided when needed and that consideration of AT be part of each Individualized Education Program (IEP) planning process.

Assistive technology serves to provide the tools and techniques that teachers and students can use to bridge the gap between the ways in which students with LDs learn effectively. Therefore, in the following section role of the teacher's will be discussed in relation to teaching science to students with LDs.

2.5. Role of Teacher and Science Education

Teachers have a critical role in their students learning; various researchers emphasize that student achievement directly related to the quality of teaching (Cloutier, 2016; Katz & Dack, 2013). Educational researchers reported teacher's teaching quality is responsible for seven to 21 percent of student variance in achievement gains (Nye, Konstantopoulos & Hedges, 2004). Also, factors that affect student achievement: seven of the top 10 factors that affect student achievement were directly linked to the teacher such as the quality of their instruction, clarity,

and feedback (Cloutier, 2016; Hattie, 2008). In connection to science education, Meador (2017) suggests that a teacher is the single most crucial element in the quality of science education. Also, student's understanding of science education starts with the teacher (Chen, Morris & Mansour, 2015). Further, students want teachers who can deliver lectures with easy to understand, meaningful examples, and gave opportunities to learn science (Lewis, Baker & Holding, 2015). Chen, Morris & Mansour (2015, p. 371) state that presently there is a "lack of sophistication that students have with regard to their basic scientific literacy." The reason for this may be according to Schwartz and Gess-Newsome (2008) is that most elementary classroom teachers in the United States have limited experience with science, scientific investigation, and content area knowledge. This then translates into a lack of emphasis on science in the classroom (Gess-Newsome & Lederman, 1999; Ramsey-Gassert, Shroyer & Staver, 1996; Schwartz, Abd-El-Khalick & Lederman, 2000). Similarly, only 25% of classroom generalists in one large-scale survey classifying themselves as well prepared to teach science (Marx & Harris, 2006).

Advocates for science specialists argue that teachers are having more pedagogical and content area knowledge in their science subjects will increase student accomplishment and student achievement in science (Guerriero, 2017; Osborne, Simon & Collins, 2003; Schwartz, Abd-El-Khalick & Lederman, 2000). In Canada, researchers also reported low teacher confidence in science instruction and less self-efficacy and interest which may result in less time spent on science in the classroom (Hanson & Akerson, 2006). In addition, it has also found that learning to teach across all subject areas often left science content knowledge underdeveloped for primary teachers, which resulted in a lack of confidence to teach science (Ronan, 2014). However, the relationship between specialist teachers in science and student achievement in the research literature remains underdeveloped. Student science achievement was positively related

to the teacher preparation and previous coursework undertaken. Schwartz, Abd-El-Khalick and Lederman (2000) provide one empirical study that compared instructional planning and student achievement between science specialists and generalists. They found that students taught by the elementary science specialists were more engaged in inquiry-oriented activities and demonstrated critical thinking abilities.

The recent OECD's Programme for International Student Assessment (PISA) Canadian students are among the top performer in science, this was not possible without our science teachers. However, at the high school level to help students with LD in inclusive science classrooms to learn science, science should be taught by teacher's who have a respective degree in that science subject. As in high school a science teacher's background, belief, attitude, and confidence really matter as discussed above.

Students with LDs rarely ask questions in the classroom, however, after the class if the student with LD ask a question and providing an answer is a critical matter in the relationship between the student with LD and the science teacher. This relationship is explained in the next section.

2.6. Students with LD and Teacher Relationships

Research studies on students with LD and teacher relationships (Avramidis & Norwich, 2002; Kortering & Braziel, 2002; Kortering, Haring & Klockars, 1992; Martin & Marsh, 2005; Watson, 2006) underscore the importance of this central relationship in the lives of students with LD and their educational achievements. While exploring students' perceptions of school, research indicated that students with LD preferred teachers who were supportive, innovative, encouraged creative thinking and who were task-oriented with clear management procedures and

also gave individualized attention to students with LD (Kortering & Braziel, 2002; Kortering, Haring & Klockars, 1992). These students wanted to succeed in high school, liked some classes and enjoyed socializing with their peers. Furthermore, this study also stated that for students with LD poor teaching, negative attitudes of teachers and administrators, boring classes, and challenging text books were obstacles for the high school completion.

Early school leavers recognized the school as being boring and irrelevant along with the lack of understanding of the student/teacher relationships (Brooks, 1992; Watson, 2006). Teachers' preconceived judgments often in the face of contradictory evidence were also conceived as in just by the students with LD. These studies showed how much important is the students with LD's relationship with their teachers, and these relationships impacted upon students with LD's dropping out of school, their academic achievement and their attitude towards school. Also, students with LD identified poor student/teacher relationship, inflexible curricula, and teaching strategies as major factors in their poor academic achievement (Collins, Kenway & McLeod, 2000).

Positive student/teacher relationship result in improved student behavior, increase their engagement in class, which leads to higher academic achievement (Gallagher, 2017). In addition to these, adolescents with LD need opportunities to develop problem-solving skills, empathy and positive relationships with teachers, which result in higher academic achievements (Heiman & Precel, 2003; Watson, 2006). Similarly, Ayres, Dinham and Sawyer (2000) stated that teachers who had a personal knowledge of their students and treated their students with respect and were knowledgeable about their subject students with LD considered them as being approachable and available to them.

Furthermore, to facilitate students with LD to develop leadership skills Halia and

Mulford (2002) recommended that students who were at risk needed to be given leadership roles and opportunities to develop decision-making skills and to learn the importance of self-control. Students with LD should be encouraged to share the responsibility for their learning. Westwood (2004) noted that for learning to occur the student must like and respect the teacher. The three most important things in the classroom were a positive relationship with the teacher, respect between teacher and student and the relevance of the work being undertaken (McIntyre, McIntyre & Francis, 2017). Also, having a family member or friend with a disability made teachers more positive towards their ability to include students with disabilities in their classes (Lardieri, Blacher & Swanson, 2000; Subban & Sharma, 2005).

As stated in chapter 1, Canadian Survey on Disability (CSD) 2012 showed that most of the students with LD had experienced academic failure and underachievement in their high schools. Moreover, Westwood (2004) states that many academics put this failure as being the fault of the student with LD, rather than deficits in our education system. A student with LD's failure as being student's own fault and free the education system and our social environment from sustained social criticism (Toste, 2016). This responsibility of failure on the part of the student allowed school and teachers to feel a lack of responsibility for the learning of everyone in the class (Mampane, 2017).

Teacher's constructive relationships with students with disabilities really matter for the academic success of the student. Student's with LDs who have affirmative relation with their teachers have positive academic self-perceptions and were more likely to work hard and to use their strategies to overcome their difficulties in their schoolwork. In the next section, students with LDs perceptions of learning are going to be discussed in detail.

2.7. Student with Learning Disabilities' Perception of Learning

Perception is defined as the organization, identification, and interpretation of sensory information to represent and understand the environment (Schacter, Gilbert & Wegner, 2011). It is also the ability to see, hear, or become aware of something through our senses. Perception is not the passive receipt of these signals but is shaped by learning, memory, expectation, and attention (Bernstein, 2010). Perceptions are essential to both the practice and research in education, as researchers, learners and practitioners of education are always trying to understand why a person thought or behaved in a specific way (Johnson, 1994; Lewis, 1999).

Kuhn and Rundle-Thiele (2009) while exploring student's perception of learning stated that in the education process learning objectives can be established at different levels, for example, teachers have to learn goals at the course level, which are addressed through the course plan and course level assessments (AACSB, 2007). However, if we have to understand learning, educators need to consider the students' learning experiences, and it should guide course design (Kuhn & Rundle-Thiele, 2009; Pratt, 1997; Shesell & Reiff, 1999). Student's perspectives enable educators to develop a richer understanding of various learning activities to the achievement of specific learning outcomes (Karns, 2005; Kuhn & Rundle-Thiele, 2009). Student's perceptions of their learning achievement for course learning goals can provide insightful information for the course development. It also provides additional insight for teachers to understand a student's viewpoint of which learning objectives were being met and which learning areas could be improved (Kuhn & Rundle-Thiele, 2009). This insight could help educators in planning teaching and learning activities to enable students to achieve the intended learning goals. Delivery of learning material is an important learning dimension in achieving student's learning goals (O'Toole, Spinelli & Wetzel, 2000). When a student's preferred learning

activities were used as a delivery of learning material, student learning outcomes (e.g., actual grades) improved (Jimerson, 1999; 2001; Young, Klemz & Murphy, 2003). Perceptions vary from person to person, and different persons perceive different phenomena about the same situation in a different way. Furthermore, people assign different meanings to what they perceive, and the meanings might change for a certain person. In this research project, the term perception refers to taking possession of or to seizing, be it clutching something or mentally seizing something with one's senses (Lewis & Short, 1975). To understand how humans give meaning to their world, one has to understand the perceptual process as well as the various influencing factors affecting this perceptual process.

As a mature student with a disability, I perceive learning as a process which offers opportunities for involvement, a meaningful talk, write, read, listen and reflect on the subject's content, share ideas, give an opinion on issues and show concern on the subject. Moreover, teachers should provide an active learning environment in which students become involved rather than simply listen to their lecturers. Further, an active learning environment is one where students with LD are involved and are doing something such as discovering, processing and applying new and old information for learning new science topics. Learning is improved when students with LD become actively involved in the learning process. Students with LDs insights are very important as a basis for their active and productive involvement. Therefore, listening to students with LDs views, opinion and insights through their voices and stories bring to light what these students want, need, like and dislike about their science learning experience in high school. This topic of listening to the voices of students with LDs is going to be discussed in detail in the next section.

2.8. Listening to the Voices of Students with Learning Disability

Gaining a view on learner voices will enable teachers, administration and policymakers to have a further insight while engaging in a simple piece of triangulation drawing upon the three key perspectives at play in education; the teacher, the institution and the learner. Listening to the student's voice will explore a range of ways in which policies and practices relating to inclusive science education are understood, implemented and experienced. By examining the above three perspectives from students with learning disabilities lenses, one can see it from different ways of seeing and, in particular, various constructions of and responses to the difference in unfamiliar contexts. We will then be able to look back on the familiar from fresh vantage points and in the light of alternative interpretations and different values systems.

Listening to the learner's voice is based on the assumption that students with LD have something of importance to say about teaching and learning and that there are benefits for schools, teachers, and students with LD where such practices and expectations are encouraged (Flutter & Rudduck, 2004). Research evidence supports the perspective that by listening to what students say, teachers can more effectively understand how they learn. It is also a means of encouraging self-criticism about the interests, styles, and outcomes of teaching (Pufall & Unsworth, 2004). Another positive outcome of the practice is that student's self-esteem, confidence, and motivation to learn are enhanced (Pascual-Leone & Johnson, 2004). Further, it is necessary to understand these voices by focusing on the context in which they are expressed, the content, purpose, and outcomes of such voices. Students have a great deal to teach practitioners and researchers about how they learn and what prevents them from learning. Therefore, as Mariani (1991) states: "voice is the key to the truths of experience, sometimes consciously forgotten but remembered when heard again, and understood fully for the first time, in the

intuitive recounting of the life experience of others” (p. 55). Listening to the students with LD provides insights that cannot be gleaned in other ways. Being young (and disabled) does not mean that students have nothing to say (Thomson, 2008), however, one may need creative ways of listening. Until very recently, student's voice has been marginalized or neglected by educational researchers (Jenkins & Nelson, 2010). Students have been regarded as objects of study, particularly in respect to their conceptual or emotional development, progression, assessment, behavior, and learning, rather than as partners in their educational process (Jones & Charlton, 1996). In the case of science education, it may also reflect both the academic background in the natural sciences of many researchers that continue to emphasize science as a body of established knowledge to be learned. If so, the assumption would be that students are not really in a position to make informed judgments about what they should be taught in their school science courses.

However, Beaudoin (2005) suggests that establishing and responding to the student's voice is central to creating effective conditions for science learning and therefore raises the standards of science education in schools. The benefits of listening to students' voices may stem from giving students a sense of ownership of what they are required to learn (Davie & Galloway, 2013). Alternatively, from recognizing that students' experience of education may be very different from that perceived or assumed by those who teach them (Lloyd-Smith & Tarr, 2000). Most of the research on learning disability was done by using web-based questionnaire and by focus groups that have been directed towards, for example, establishing students' interests in, or attitudes towards, science or scientists (e.g., Jenkins & Nelson, 2010; Osborne & Collins, 2001; Osborne, Simon & Collins, 2003). Studies that focus more narrowly on students with LD views about the experience of learning science in high schools through their narratives are relatively

scant (Jenkins & Nelson, 2010). For this reason, in this research project life stories of students with LD provides insights into the experiences of learning science by this marginalized group. These insights I hope will help us in understanding the needs of students with LD in our school system. As stated by Goodley (1996) it is often by telling stories that people have come to understand the needs of individuals with disabilities.

This literature review identified numerous efficacious pedagogical practices, UDL principles and technological applications, which should serve as a foundation for research in inclusive science classrooms.

Summary

Students with learning disabilities (a variety of disorders that affect the acquisition, retention, understanding, organization or use of verbal and non-verbal information) are the largest group of students with special educational needs (CSD, 2012). These students continue to experience school failure and underachievement and are largely alienated and disengaged from school (CSD, 2012; Dovigo, 2017; McCoy & Reynolds, 1999; Watson, 2006). Young peoples with learning disabilities due to their difficulties at school are unable to complete their education on time and with subjects through which they can be admitted to post-secondary education programs in science-related fields. Due to career choices, their unemployment rate is almost double that of youth without disability (CSD, 2012). Due to this high unemployment poverty level is also high in peoples with learning disabilities as compared to persons without disabilities (Fujiura & Yamaki, 2000; Gerber, Price, Mulligan & Shessel, 2004; Goldstein, Murray & Edgar, 1998; Park, Turnball & Turnbull, 2002).

The current state of outcomes and accountability in schools reflect the dominant

discourses of society rather than providing caring and nurturing communities for students with learning disabilities (Cousik, 2017; Watson, 2006). Evidence has been provided that by adopting the teaching strategies and UDL approach students with learning disabilities can learn science and perform better in schools. Studies showed that a positive attitude by teachers towards students with LD combined with effective pedagogy and management of classroom change the experience of school failure for these students (Rubin, 2003; Watson, 2006). Educational researchers showed evidence that to successfully teach science to students with learning disabilities, a variety of teaching strategies should be utilized (Marshak, Mastropieri & Scruggs, 2011; Scruggs, Brigham & Mastropieri, 2013).

Researchers showed evidence that technology can provide students with alternative pathways to access science curriculum materials (Horney & Anderson-Inman, 1999). These resources allow learners to focus their energy on higher order thinking and critical analysis (Jonassen, 1996). Technology-based cognitive scaffolds are very beneficial for STEM learning (AccessSTEM, 2008). The use of games in science instruction is a new area of research; it has the potential to engage students with LD through alignment with the UDL framework.

Student perceptions of their learning achievement can provide insight for teachers to understand a student's viewpoint of which learning goals are being met and which learning goals can be improved. This will help educators in planning teaching and learning activities to enable students to achieve the intended learning goals. When students prefer learning activities used as a delivery of learning material, student learning outcomes improve (Young, Klemz & Murphy, 2003).

The basis which influences the academic achievement of students with LD in science subjects has been discussed. Instead of students with LD positioned as responsible for failure to

learn, it was revealed through this review of literature that it is the school system which needs to be changed to accommodate these students learning science subjects. The discourse of individual deficit rather than the need to implement the many innovative and compassionate solutions was also discussed as well as responding to the student's voice as central to creating effective conditions for science learning, raising the standards of science education in schools.

For listening to the student's voices this study was undertaken to answer the following questions which are presented here in their entirety and again for the reader's convenience in the chapters that detail methodology and analysis as well as the results.

How do students with learning disabilities perceive the experience of learning high school science?

More specifically:

- What teaching approaches did students with LD find most useful in learning science?
- What difficulties, if any, did students with LD encounter while learning science, and what learning strategies do they use to manage these difficulties?
- How do students with learning disability perceive the role of assistive technology in learning science?

Chapter three, which follows, examines the conceptual framework that underpinned this research project which explores the experiences of students with LD's learning of science subjects in high schools.

CHAPTER 3

THEORETICAL FRAMEWORK

3.1. Conceptual Framework

Conceptual framework as defined by Robson (2011) is the system of concepts, assumptions, expectations, beliefs, and theories that support and informs our research. It is primarily a conception of what is out there that we plan to study, and of what is going on in these topics and a tentative theory of the phenomena that we are investigating. Theory guides us to assess and refine our goals, develop relevant research questions, select appropriate methods and identify potential threats to our conclusions and help us in justifying our research. In this section, I discuss the conceptual framework which has shaped my understanding of learning disability and its linkages to education, particularly science education. A qualitative approach was selected for this study to align the research design with the overall purpose and research questions.

Considering the relativist ontological position that multiple realities exist, qualitative research provides the vehicle with which to understand the sometimes-chaotic nature of the human experience by creating space for, and acknowledging multiple truths (Creswell, 2013). This research project is framed within Social Constructivism (Vygotsky, 1978) and the Social Model of Disability (Goodley, 2001; Oliver, 1990) frameworks. It focuses on inclusive learning in contrast to the Medical Model of Disability that support segregation. Before elaborating the social model of disability, it is better to discuss the medical model of disability which currently

forms the basis for creating individual educational plans (IEP) in schools for special needs students, including students with learning disabilities.

3.2. The Medical Model of Disability.

The primary assumption of the medical model is based on the perspective that a person with a learning disability has a medical condition that needs to be first diagnosed, then treated to become normalized through the use of medicine (Lee, 2013). It is the person that should be changed according to the norms of the population. In this model, a learning disability is a problem, and it belongs to the disabled person. Therefore he/she should make extra efforts to ensure not doing inconvenience to anyone else in the classroom, school or society. Ule (2017), while discussing the medical model of disability, states that non-disabled persons see themselves as normal in the light of their medical view of health, while disabled persons are seen as abnormal. Hence, these abnormal peoples should be treated or cured to make them normal through medical interventions. However, when the disease that is making them disabled cannot be cured, then this individual is the responsibility of the family. If the family is unable to provide the necessary care for that person, then the family puts him/her into the care of institutions and on social assistance. As this model believes that disability adversely affects a disabled person's work opportunities, therefore, this individual should be under special care. This care resulted in higher health care and social service costs for the government (Lee, 2013; Rioux & Valentine, 2006; Zigmond, 2003).

In simple terms, the medical model states that the first solution is to find a cure to make learning disabled people normal. Most of the time this strategy fails because learning disabled people are not necessarily sick or cannot be improved by curative treatment. With this in mind,

the only solution is to admit the abnormality and provide the necessary care to help the incurably impaired person. Policy makers have very few options for learning disabled persons, like a plan of rehabilitation, occupational training for employment, income allowance programs and the endowment of aids and equipment (MDRC, 2016).

Until now the medical model has controlled the creation of disability policy. However, it does not offer a genuine perception from the viewpoint of disabled peoples themselves. Disabled peoples reject the conceptualization of being abnormal (Gans, Kenny & Ghany, 2003). Likewise, the medical model enforces an authoritarian style of problem-solving, which even well-intentioned, focusses on care and finally offers to the reason for institutionalization and segregation. An authoritarian style limits disabled people's chances to make choices, control their lives and develop their potential (MDRC, 2016).

Also, this model nurtures existing biases in the minds of employers, therefore suggesting that a person with a learning disability will be prone to ill health and will be on sick leave frequently. Further assumptions might be that his or her health is likely to deteriorate, and he or she will be less productive as compared to other able workers. An economic view narrows the complexity of disability to limitations and restrictions, with implications of whether disabled people can be educated or productive (MDRC, 2016).

Finally, due to the medical model, many individuals with disabilities internalize negative opinions of themselves and create feelings of low self-esteem and under accomplishment which support non-disabled people's assessments of their personality and value. The medical model, plus the social environment it creates, leads to a cycle of dependency and exclusion which is hard to break into work and education (MDRC, 2016).

Today, due to the development of the disability movement the medical model is losing its hold; now many people feel that treating disabled people as though they need to adapt to prevailing circumstances or, if this is not feasible, be cared for in specialized institutions, is wrong (MDRC, 2016). While the social model of disability is advocating for change in social constructs, perceptions, and stereotypes in society as explained in the next section.

3.3. The Social Model of Disability

In recent years, the disability movement has promoted a different way of looking at disability, which they call the social model. The origins of the social model lie with Victor Berel Finkelstein, the founding father who, together with Paul Hunt, set up the Union of the Physically Impaired Against Segregation in 1972 as a resistance movement against oppression (Porter, 2015). The social approach was elaborated on by Oliver, who introduced the term “social model” (Oliver, 1983; Goodley, 2001). According to Oliver (2004), the social model gives importance to policies that promote participation and empowerment to bring about environmental and organizational transformations. That is, individuals are not just a product of either their biological makeup or their environment but a combination of internal and external influences (Bandura, 1977). Through this model, we look at the strengths of the person with the impairment and the physical and social barriers that obstruct them, at school, university, work or at home. The social model distinguishes between impairment and disability. Impairment is the deficit or restriction of physical, mental or sensory ability on a long-term or permanent basis, while disablement is the loss of opportunity to take part in the standard life of one’s society on an equivalent basis with others due to physical and social barriers (Anonymous, 2007).

In short, the social model believes that disability is not the fault of the individual and considers impairment as a difference instead of an anomaly, which can be overcome by changes in the political and social environments (Lee, 2013). Social and political policy changes, as well as the inclusion of disabled persons as equal members, can lead to equal benefits, protection and improved quality of life for everyone. These changes can only be achieved by addressing stigma related to equal opportunities in education and work. While it has been more than fifty years since the parents of disabled children started the inclusion movement, improvements and changes in the attitudes of our thinking as a society are still needed. The stigma related to disability still hurts disabled children in our schools.

The social model suggests disabled people's disadvantage is due to a complex form of institutional discrimination in the foundation of society. Therefore, the cure to the problem of disability lies in changing society. It also states that unlike medical model cures, this goal is achievable, and it benefits everyone. A social model of thinking has significant effects on the education system, as biased attitudes toward disabled people are not innate. They are learned through contact with bias and unawareness of others. Therefore, it is important that the challenge to discrimination against people with disabilities should begin in schools (Anonymous, 2007). Keeping in view the social model of disability, if we look at Vygotsky (1978) theories of child development and learning, we find he believed in deep links between normal and abnormal behavior and that he considered both to be parts of human development following certain patterns of formation (Gindis, 1995). In this respect, his general developmental theory is relevant to the study of students with learning disabilities as well. In his view, human development is a socio-genetic process carried out in the social activities of children with adults. Moreover, education generates and leads development which is the result of social learning through the

internalization of culture and social relationships. Also, development is not a straight path of quantitative gains and accumulations; it is a series of qualitative, dialectic transformations and a complex process of integration and disintegration (Gerber, 1994; Gerber, Schnieders, Paradise, Reiff, Ginsberg & Popp, 1990; Gindis, 1995). Vygotsky (1978) put particular emphasis on the more knowledgeable other (MKO). More knowledgeable other is the one who has more knowledge, advance or a higher ability than the learner, for accomplishing a particular task or process. This MKO approach has a direct link in learning science of students with learning disabilities and the present study.

3.4. More Knowledgeable Other (MKO)

The more knowledgeable other in Vygotsky's (1978) theories may be a teacher, an older adult, a child's peers, or adult children (McLeod, 2014). Vygotsky considers MKO to be an individual with more knowledge or experience (McLeod, 2014). For example, who is more likely to know more about the science lesson they are reading, how to do a biology experiment, how to search online. In fact, the MKO may not be a person at all as now technology can also act as MKO, for example, students can watch a video of an experiment before actually experimenting in the laboratory. Moreover, after the laboratory experiment student can understand better a science experiment after watching that video. Electronic tutors have also recently been used in educational settings to facilitate and guide students through the learning process. The key concept in MKO is that they must have more knowledge about the topic being learned than the learner does (McLeod, 2014).

Therefore, keeping in view the MKO and the social model of disability the roles of the school and teacher are very important for students with learning disabilities in learning science.

Due to the current inclusion policy in our schools, however, implementation of full inclusion is not without challenges (McGhie-Richmond, Irvine, Loreman, Cizman & Lupart, 2013). The findings of these researchers revealed that most teachers favor inclusion of students with physical disabilities above cognitive or behavioral impairments. This preference was due to the manageability of the students; teachers favor the inclusion of students whom they can manage more than the students whom they see more disruptive in the class (Avramidis & Norwich, 2002; Idol, 2006; McGhie-Richmond, Irvine, Loreman, Cizman & Lupart, 2013; Subban & Sharma, 2005). Also, school staff believes that they are underprepared to deal with successful inclusion of students with special needs. The reasons for unpreparedness are lack of teacher preparation, under-funding and growing classroom demands as persistent obstacles to successful integration (Forlin & Chambers, 2011; Glazzard, 2011; Idol, 2006; Kantor, 2011; Loreman & Deppeler, 2002; McGhie-Richmond, Irvine, Loreman, Cizman & Lupart, 2013; Winzer & Kas, 2012).

It is interesting to note that special education teachers have more positive attitudes towards inclusion than general education teachers (McGhie-Richmond, Irvine, Loreman, Cizman & Lupart, 2013; Woolfson, Grant & Campbell, 2007). The reason may be that special education teachers have had more training and more confidence in teaching within an inclusive classroom. They have more trust in the abilities of children with special needs (McGhie-Richmond, Irvine, Loreman, Cizman & Lupart, 2013; Pavri & Monda-Amaya, 2001; Woolfson, Grant & Campbell, 2007).

The social model approach is constructive for both general and special education teachers as it provides a framework to understand the location of disability or disabilities, and reveals the problems found in the school boards and the society. It identifies the disability and the barriers that make the individual disabled. The social model of disability advocates a collective action for

the removal of obstacles that renders a person disabled through social movement (Lee, 2013; Melucci, 1996). According to Melucci (1996), a social movement is regarded as engagement in a conflict to address valued resources, and actions to challenge the power and limits of a system. In Canada, according to Lee (2013), the disability movement arose out of dissatisfaction regarding the lack of availability of disability services in the late 1960s. The disability movement began the paradigm shift from a medical model of disability to the social model of disability by identifying disability barriers created by the medical model of disability in our society rather than individual impairments and try to remove these obstacles in our community.

This current research study is based on the relationship of disability, unemployment, and education, and Oliver's social model of disability (1990) provides the right framework to enables people to understand the relationship between collective identities and social barriers. Through this model, Oliver postulates that it is the social barriers that produce disabled peoples. Therefore, when discussing students with learning disabilities, we must not only look at the direct link between learning disabilities and academic difficulties, as it relates to the medical model of learning disabilities; while this is concerned merely with the personal and behavioral domains within the social model of disability. The social model in addition to these difficulties also includes a focus on personal and environmental factors. Therefore, attention must also be given to the environment by the consideration that the individual is created by, and creates, the world around them in equal measure with the individual's biological predisposition. This includes the school environment (for example teaching strategies, teaching aids) in interaction with social behavior and cognitive processes (Siegel, 2003; Wong, Harris, Graham & Butler, 2003). These aspects are influenced by each other and contribute to academic difficulties. Which, in turn, contributes to the way a person thinks, acts and learns in their environment.

In schools and workplaces, the social model of disability is the framework which unites disabled persons to resist the dominant ideology of non-disabled worldviews and disabling social structures which can result in marginalization and oppression, along with reducing the stigma associated with disability (Lee, 2013). It is the result of this collective action that United Nations in 2006 adopted the CRPD. CRPD 2006 in relation to students with learning disabilities consider that it is the institution of schooling which should be the focus of change rather than the individual child (Porter, 2015).

A given trajectory and speed of development, occurring across a range of different activities that a child may attempt in an educational program, is only rendered problematic when framed in reference to a series of cultural expectations that confer poor judgment (Danforth, 2008, p.59).

This quote, which is based on a social model of disability, offers the perspective that, although children may have strengths and weaknesses, the benchmark for what is considered a strength or a weakness is culturally and politically determined. Therefore, the social model of disability framework significantly influenced the fabric of this study by considering the influence of the school environment and framing the research issue of prevalence of high unemployment and career choices for learning disabled persons within its sociocultural context. The subsequent chapters will each illuminate a particular facet of this research study with the intent to address the research question and begins to recommend a social change in the schools. The question “How do students with learning disabilities perceive the experience of learning high school science?” was aroused in my mind and helped me in understanding the perceptions of students with learning disabilities in learning science.

This question is important to ask and answer since high school graduation with science subjects open up the avenues of science majors which can help in reducing the high unemployment in persons with LD. The high unemployment results in negative consequences including financial burdens for disabled individuals along with society (Fourqurean, Meisgeier, Swank & Williams, 1991). Furthermore, research showed a high prevalence of substance use among individuals with learning disabilities (Maag, Irvin, Reid & Vasa, 1994; Weinberg, 2001). It is also important to note that learning disabilities affect individuals all across Canada in the range of 5-10% but in a correctional facility, the percentage is as high as 25 percent (Alberta Correctional Education Association, 2017; Svenson, Lundberg & Jacobson, 2003). I will now proceed to describe the methodology in the next chapter to explore the perceptions of students with LDs learning science experience in their high schools.

Summary

This chapter provided an overview of the current literature on the issue of learning disabilities and its associations to education and especially science education. This chapter reviewed the conceptual framework of Social Constructivism and the Social Model of Disability to do research with peoples with learning disabilities and explained the qualitative approach to study the phenomena of LD. Theoretical models of disabilities i.e., Medical Model of Disability and Social Model of Disability were explained for conceptualizing disability and particularly learning disabilities. More Knowledge Other as explained by Vygotsky for accomplishing a particular task in learning was also reviewed.

CHAPTER 4

RESEARCH METHODS

This chapter outlines a description of, and basis for, the chosen methodology and research design. The first section discusses the aims and objectives of the research and restates the research question. The next two sections address the epistemological beliefs and paradigm of inquiry that informed the overall study, followed by a discussion of methodology choice. The fourth section focuses on elements of the research design including a rationale and discussion of the data collection, management and analysis methods employed. The final section examines issues of trustworthiness and ethics.

4.1. Aims, Objectives and Research Question

The overall purpose of this study is, from a selected group of students with learning disabilities, to describe and interpret the perceptions of students with LDs learning science. This study is based on a social model of disability, as opposed to an individual deficit model. The social model of disability considers the learning challenges these people faced at school a result of many interacting determinants, including the academic environment which does not adequately support these individuals with academic and social difficulties.

Using Vygotsky's theory on Social Constructivism (Vygotsky, 1978), the study examined the interaction of cognitive processes such as perceptions and attributions; behavioral features such as social skills and communication difficulties; and, environmental factors such as teaching techniques and peer interactions. These topics are interacting determinants of learning and classroom participation. Due to the social nature of schooling and disability, the social model of disability and the constructivist research approach were considered the most efficient ways to address the research question:

How do students with learning disabilities perceive the experience of learning high school science?

More specifically:

- 1) What teaching approaches did students with LD find most useful in learning science?
- 2) What difficulties, if any, did student with LD encounter while learning science, and what learning strategies do they use to manage these difficulties?
- 3) How do students with learning disabilities perceive the role of assistive technology in learning science?

4.2. Research Framework

This study was grounded in a constructionist epistemology and situated within the paradigm of qualitative inquiry. Aligning with this paradigmatic view, a qualitative approach of case study methodology with elements of narrative inquiry was chosen to provide a detailed understanding of the process or experience of learning science by learning disabled students (Reis, Neu & McGuire, 1997). A narrative inquiry, described in detail below in sections 4.6, was used to determine the boundaries or characteristics of the investigated issue and to gather

intensive and extensive information from a purposively derived sample. These elements are now discussed in more detail, beginning with the foundation on which the study rests:

Constructionism.

4.3. Constructionism

Using a social cognitive framework, this study sought to discover the relationship between two constructs: the science classroom environment, and students with LD's learning of science (Samuelsson & Lundberg, 2003; Wong, Harris, Graham & Butler, 2003). This research focus reflects a constructionist epistemology which claims knowledge is constructed through social activities and interactions and is peculiar to a time and place (Vygotsky, 1978; Young & Collin, 2004). In the constructionist paradigm, the focus is on the interactions and social practices of the participants rather than on the individual (Vygotsky, 1978; Young & Collin, 2004). This understanding of interaction and social practices is the keystone of a social model of disability (Danforth, 2008).

Constructionism underpins interpretive approaches to research (Glesne & Peshkin, 1992). This is because the process of interpretation is necessarily a subjective approach, that is, interpretation involves seeing something a certain way based on tacit knowledge. The resulting interpretation is only one of a plethora of interpretations available. This approach was chosen based on the examined phenomenon of learning science (Silverman, 2001). Learning of science is a subjective experience. Both participant and researcher come with knowledge of what learning science is, but it is reasonable to assume that their notions of learning could be very different, based on the learning of science subjects during their time in high school (Crotty, 1998). The same could be said of research projects in general as Silverman (2001) states that the

participant comes to the interview with some notion of what the research is about, what the researcher wants, what they do, and do not, want to tell the researcher about their experience. Perhaps this is on a subconscious level, or perhaps it is more explicit. The researcher often comes to the interview armed with knowledge about the world in general and a wealth of observational data about the participant plus knowledge gained by other researchers studying similar phenomena in similar (or different) contexts. The participants have an agenda to tell their stories, their way, or to tell their story the way they would like the researcher to see it. The researcher has an agenda to understand the participant's experience and discover patterns and relationships in the data that might explain something that the participant might not know.

The positivist would see this form of bias as a problem (Silverman, 2001). However, the constructionist acknowledges the bias of the researcher as a valuable aspect of the data as long as it is articulated, as the researcher is also considered an active participant in the creation of meaning and, therefore, forms part of the data along with the participant (Crotty, 1998). The participants then relate information about their learning of science experiences and their school experiences on their own (Shesell & Reiff, 1999). After listening to participant's subjective voice, the researcher asks further questions and again listens, not objectively, but using a variety of filters based on knowledge of science teaching strategies. In this way, the researcher and researched are both participants in the creation of meaning.

The aim of the constructionist research is not to discover the truth about a phenomenon, but to construct an understanding that would probably differ from that constructed by different participants and researchers trying to understand the same phenomenon. To gain knowledge about the phenomenon, first, it must be acknowledged that the truth is unknown, and must be

constructed using an appropriate framework. The framework for this study is provided by the paradigm of qualitative inquiry.

4.4. Qualitative Research

In keeping with the constructionist belief about the construction of knowledge, and based on the phenomenon under investigation, the present study was framed by the paradigm of qualitative research. The qualitative research is often defined as an approach concerned with exploring phenomena from the interior (Flick, 2009) and qualitative research takes the perspectives and accounts of research participants as a starting point. The qualitative research is a paradigm of the investigation, i.e., a larger framework that supports research (Schwandt, Lincoln & Guba, 2007). This type of inquiry is considered an appropriate framework when the research project is designed to investigate social or behavioral phenomena (Guba, 1981).

A key tenet of qualitative research is that research must occur in the real world as opposed to clinical settings (Guba & Lincoln, 1982). The main reason for this is supported by a social cognitive perspective as qualitative research contends that human behavior cannot be separated from context (Silverman, 2001; Wong, Harris, Graham & Butler, 2003). As Tesch (1990) suggests:

Laboratory research studies phenomena in an artificial environment. Therefore, all conclusions drawn are valid only in artificial environments. If we want to know about human beings in their natural habitat, we have to study them in their normal surroundings (pp 37-38).

Denzin and Lincoln (2011) propose that in spite of the inherent diversity of qualitative research, “it is a set of interpretive, material practices that make the world visible”. The

qualitative research does not consider that the project a controlled experiment (Oakley, 2002), but rather an inquiry that invites “whatever interference the real world can provide” (Guba, 1981, p. 79).

The qualitative research is characterized by a “reluctance to impose meaning” (Silverman, 2001, p.38), instead of observing the subject of inquiry first-hand and by letting it speak for itself. Research in this paradigm must be emergent rather than imposed; the theory must be grounded (Guba, 1981). This means that qualitative researchers should approach projects without any preconceived ideas about what they expect to find. The qualitative approach is an acknowledgment of “not knowing what is not known” (Lincoln & Guba, 1985, p. 235) as opposed to having expectations about what will be found. However, as previously discussed, qualitative research is a subjective experience. This means that while the researcher is open to what is to be found within the boundaries of “what has not known” the meaning of the resulting data is necessarily a negotiated one.

Emergent designs, however, should not be interpreted as “a license to engage in undisciplined and haphazard poking around” (Lincoln & Guba, 1985, p. 250). It is not possible to conduct a research project without knowing what the focus of the study will be (Lincoln & Guba, 1985). As Silverman (2001) put it, “without some conceptual orientation, one would not recognize the field one was studying” (p. 72). He claimed that the theoretical orientation of research within this paradigm is often not articulated. Lincoln and Guba (1985) argued for the explicit articulation of those elements of the design that are possible, such as the participants and the setting, but argued that a detailed research design be impossible to articulate before the data collection phase. Instead, the research must remain flexible to enable the design to “emerge, develop, and unfold” (Lincoln & Guba, 1985, p. 225).

Qualitative inquiry demands that data occur naturally rather than being researcher provoked. However, Silverman (2001) contended that this is not feasible. Naturally occurring data is collected when the researcher utilizes phenomena that would occur without the researcher's intervention, such as learning and social interactions, whereas researcher provoked data emanates from the deliberate act of inducing behavior, namely the interview. Usually, data is a product of both naturally occurring and researcher provoked activities, as even the process of observing interactions involves the conscious recording of events. Silverman (2001. P111) contends, "naturalism unwittingly agrees with positivism that the best kinds of data are somehow untouched by human hands neutral, unbiased and representative; however, everything depends on the status which we accord to the data gathered."

In such an approach the researcher is explicit about which data are naturally occurring or research provoked. The researcher also acknowledges that the participants might have been subconsciously influenced by the presence of the researcher or something they have seen or heard. As a result, the data is considered a negotiation between researcher and the participant, as discussed earlier. The researcher is the primary data collection instrument and therefore forms part of the data (Silverman, 2001).

The notion of a human as a tool is a fundamental element of qualitative inquiry (Guba, 1981; Tesch, 1990). That is, the researcher becomes the scientific instrument by which data is gathered, or rather the notion of scientific measurement with all its connotations is dismissed in favor of a more personal, intuitive relationship with the data (Silverman, 2001). Lincoln and Guba (1985, p. 224) have described this "human as device" as a sensitive tool that sorts out salient elements and targets in on them. Implicit in this idea is the notion of calibration, through activities such as pilot-testing interviews and observation strategies, to ensure reliable data

collection (Silverman, 2001). Pilot testing subverts the nature of new inquiry as, within emergent designs, interview questions cannot be prepared before the start of the study. However, it is possible to pilot interview skills.

The aim of research within the paradigm of qualitative inquiry is to provide provisional application of the emergent theories, but not to generalize (Tesch, 1990). The nature of the investigation is such that it is not possible to generalize from the data and this should not be attempted (Guba, 1981). This is due to the key understanding within qualitative inquiry and constructionism that there is no one reality that is relevant or applicable to everyone, but that there are multiple realities (Guba, 1981; Guba & Lincoln, 1989). The data, therefore, must be: 1) a negotiated outcome of the interaction between the participant and the researcher (Tesch, 1990), and 2) be context specific (Young & Collin, 2004).

Because the aim of qualitative inquiry is not to generalize, participants do not have to be representative of the population. Instead, designs within this paradigm use purposive sampling, which is the deliberate selection of participants for a specific purpose based on emerging theory. For the present study, participants were selected based on the theoretical issues that emerged from the initial observation stage of data collection and their compatibility with a set of specific criteria which informed by the literature. This process enabled the selection of participants deemed most able to provide the necessary data to address the research question. In this study, appropriate participants were students with learning disabilities who have experience and information about the phenomenon of studying science at the high school level and are now studying in scientific fields at the post-secondary level. This sample of students fulfilled the criteria of qualitative inquiry, as Patton (2002) explains, a qualitative inquiry has more to do with the information richness of the cases selected than with sample size.

Designs of this nature are necessarily flexible and, therefore, open to criticism. Qualitative inquiry provides clear criteria for trustworthiness to avoid the accusations of ‘undisciplined and haphazard poking around’ discussed earlier. Trustworthiness refers to the extent to which data is credible, transferable, dependable and confirmable, in contrast with the more rationalistic notions of validity, reliability, generalizability, and objectivity. Trustworthiness is discussed in more detail later in the chapter in relation to the chosen methodology.

4.5. Narrative Inquiry

Narrative inquiry methodology influenced the research design for this study. Narrative inquiry is “the study of experience as a story” (Connelly & Clandinin, 2006, p.477). Put differently; a narrative inquiry is individuals telling stories about themselves and their experiences as the focus of critical research. It has been said that humans “organize our experiences into narratives and assign meaning to them through storytelling” (Smith & Sparkes, 2008, p. 18). Stories are personal, but also social and cultural (Smith & Sparkes, 2008) in that they not only give insight into how people view themselves but also how they create the world around them (Kenway & Fitzclarence, 1997). For this reason, it was considered a highly appropriate methodology for listening to the students with LD about their experiences of learning science within a science classroom environment. Also, a narrative approach should allow opportunities for participants to demonstrate different selves in different contexts at different times (Bamberg, 2004), as this study did, to allow these stories to develop texture and substance. This study uses narrative methods to enable students with learning disabilities to recall, recount

and review their lives, valuing them as expert witnesses rather than mere sources of data (Atkins, 2004).

Developing these stories necessitates “intimate involvement, engagement and embodied participation with [the] stories” (Smith & Sparkes, 2008, p.21) and, as a result, the researcher becomes part of the story. Also, the researcher must engage the audience with a style that makes the story, “palpable and comprehensible, and compelling,” (Barone, 1992, p. 146) to effect educational reform if necessary.

Because of the friendly nature of stories, a narrative inquiry is considered a highly effective strategy to engage diverse audiences rather than the usual “expert readers of academic journals” (Smith & Sparkes, 2008, p. 25). Reaching these alternative audiences, particularly when the research concerns them, and providing them with provocative, inspirational insights is a worthy goal.

There are three common places, or areas of focus in narrative inquiry and all of these commonplaces must be addressed concurrently for a project to be deemed narrative inquiry (Connelly & Clandinin, 2006). Commonplace one, temporality, is the assumption that events, people, and places are always in transition, always changing (Connelly & Clandinin, 2006). The present study took a snapshot of life at science based undergraduate faculties at a specific university with the understanding that experience dictated much of the story. The story would probably have been different had the snapshot being taken at any other time or in any other place, meaning transferability relies very much on the thick description of the context and the participants.

Commonplace two, sociality, refers to the personal and social conditions that form the context for the stories (Connelly & Clandinin, 2006). This relates to the “feelings, hopes, desires,

aesthetic reactions, and moral dispositions” (Connelly & Clandinin, 2006, p. 480) that the researcher and participants bring to the event and the factors that form the context. In the present study, these aspects were articulated in a conscious attempt to understand how the construction of meaning was established between the researcher and the participant and the context that influenced the actions, thoughts, and feelings of all involved.

Commonplace three, place, refers to the physical environment from which the stories emerge (Connelly & Clandinin, 2006). Understanding of the site is crucial to understanding the activities and behaviors of those who dwell there. Therefore, the site encourages and stimulates an interviewee to tell a story about some significant event in their life and social context. The basic idea is to reconstruct events from the perspective of participants as directly as possible. As the present study was conducted at the Faculty of Education, the University of Ottawa, the idea of place becomes particularly relevant. In fact, it is hard to conceive a school-related research project that does not take into account the myriad of consequences of the place. More so than a workplace, for example, because students usually have less choice about being there and the resulting resignation and lack of control, amongst other things, surely impacts their stories. All these influences fit together with the present design as narrative inquiry can be located within a constructionist epistemology as the story is created by the individuals participating in the making of meaning. A narrative inquiry methodological approach fits in with the paradigm of qualitative inquiry as the story is one that occurs naturally in the field and emerges over time. Each of the aspects described here were used to construct a research design that emphasized the relationship between the participant and researcher and used real events in the construction of a story about a group of individuals within a shared culture, within the boundaries of time and place. Elements of this design were piloted, and an overview is provided below.

4.6. Research Design

The final research design used previously piloted methods which identified areas for improvement in the design. The data were used formatively to strengthen the final layout. Therefore, a brief overview of the pilot study is provided below.

4.6.1. Pilot Study

For the pilot study, the participant was a student from the science faculty, at the University of Ottawa. He had been registered with Student Academic Success Services (SASS). Participant confirmed that he had an IEP at high school and have a significant learning disability. The participant attended a single interview that included questions relating to his experience of learning science subjects in high school, social status, learning contexts, plus a series of questions related to his science teachers' backgrounds and learning strategies he used to learn his science subjects.

Some important themes were gleaned from the data, both anticipated and unanticipated. While the research design was considered successful in bringing forth these issues, there were some limitations in the original design, which led to several lessons learned for future research and the final design. These can be summarized as:

- Questions related to participants' background on the nature of the learning disability and related scholastic information.
- The questions related to the presence of LD and type of LD seem to be a crucial aspect of the study, and identification needs to be achieved more accurately.

The aspects raised above by the pilot study have been addressed to provide a more robust research design for the final study. The following section describes the setting and participant's

selection for the final study in addition to an explanation of how the issue of identification was addressed.

4.6.2. Setting and Participants

4.6.2.1. Setting

To decide on a setting for the present study, the researcher engaged in a period of reflection, as suggested by Glesne and Peshkin (1992), to ascertain the most desirable location considering the aims of the study and the target participants. Two key issues for consideration when choosing a site are: whether the school supports research; and whether the researcher would be comfortable conducting a project within this setting (Glesne & Peshkin, 1992). To this end, the present study was confined to the University of Ottawa. The University was selected for the following reasons: its proven commitment to research; the presence of the Student Academic Success Service (SASS) from which to coordinate the study; the perceived helpfulness and efficiency of the administration and staff of SASS; and its convenient geographical location. Before selecting the University of Ottawa, the researcher sought advice from the University's ethics office and the staff of SASS to consider the compatibility of the University and the investigator.

As will be discussed in a further section, a detailed articulation of the context of the study is necessary to enable the reader to make decisions about the applicability of the study (Guba, 1981; Guba & Lincoln, 1989). To this end, the science-based faculties are located at the University of Ottawa main campus, and the students originate from vastly diverse cultural and ethnic backgrounds. A description of the participant recruitment and student participants is now provided.

4.6.2.2. Participant Recruitment

Gaining access to participants in order to collect data most of the time involves going through gatekeepers (Lennox et al., 2005). This means first contacting the senior management in an organization and working through to people with the first-hand contact with people with learning disabilities (Nind, 2008). As all the participants of this study were registered with Student Academic Success Service (SASS) University of Ottawa, therefore, manager of SASS was the gatekeeper in this case. She was contacted by the researcher and briefed with all the information about the study, its benefits for the students with LD. In addition, University of Ottawa Ethics Board's approval of the study was also provided for her consideration. She was requested to contact potential volunteers to participate in this study. Development of rapport and trust with the gatekeeper is very important before doing so with the potential/ actual participants (Nind, 2008). Researcher due to his own disability was a participant of the SASS activities, which fulfilled the rapport and trust requirement. Keeping all the above facts in her consideration manager granted the required permission and allowed the SASS advisor to contact all the students with learning disabilities in science faculties through SASS e-mail.

As already discussed in the qualitative research section, designs within this paradigm use purposive sampling, which is the deliberate selection of participants for a specific purpose. For the present study, participants were selected based on a set of specific criteria which enabled the selection of participants deemed most able to provide the necessary data to address the research question. In this study, appropriate participants were students with learning disabilities who have experience and information about the phenomenon of studying science at the high school level and are now studying in scientific fields at the post-secondary level. More than twenty students from all the faculties including humanities, arts along with sciences showed their willingness to

participate in this research and SASS forwarded their emails to the researcher. However, only ten students were from the science faculties. From these only eight students fulfill the criteria of selection as described in the next section.

4.6.2.3. Selection of Participants

To ensure the study could be replicated in similar contexts using similar participants, full descriptive data about the participants and the context has been included. The term participant refers to those students who have been identified as experiencing a learning disability. Each student participant forms a case in the multiple case-study designs. A key tenet of qualitative study is the theoretical sampling of participants, the present study used a set of criteria as described below to identify the most appropriate candidates for the study. Eight students met the criteria for learning disabilities having been identified in their IEP in high school. Eight students/ volunteered were selected to develop a richer understanding of a phenomenon, as Glesne and Pashkin (1992) advice there should be a small sample of participants, and because the criteria as explained below were particularly rigorous.

All of the participants:

- Are students in a program in a science-based faculty at the University of Ottawa;
- Had taken science subjects in high school
- Had a learning disability documented in their high school IEP
- Registered with SASS at the University of Ottawa as a student with a learning disability.

Students were selected on a first come first served basis. Following table shows some characteristics of the participants.

Table.1. Participants Characteristics

| <i>Pseudonyms</i> | <i>Age</i> | <i>Gender</i> | <i>Family Income</i> | <i>Area of study</i> | <i>Year of study</i> |
|-------------------|------------|---------------|----------------------|----------------------------|----------------------|
| Brenda | 23 | Female | Upper middle class | Health Science | First year |
| Britney | 20 | Female | Middle Class | Biomedical | First year |
| George | 19 | Male | Upper class | Biotechnology | First year |
| Lila | 25 | Female | Low to middle class | Biology & Computer science | First year |
| Lisa | 25 | Female | Upper middle class | Health science | First year |
| Owen | 21 | Male | Middle class | Computer Science | First year |
| Sarah | 20 | Female | Lower middle class | Engineering | First year |
| Ursa | 20 | Female | Middle class | Health science | First year |

Having described the setting and participants and recruitment process, the discussion now moves to a description of the data collection methods utilized for this study.

4.7. Narrative Collection Methods

The data was collected using participant interviews. This technique is the most common method used in qualitative research (Glesne & Peshkin, 1992) and the preferred method for qualitative inquiry (Silverman, 2001). One limitation of retrospective data collection in qualitative research, in general, is related to the accuracy and reliability of the information provided by the participants. Harrison, Veeck & Gentry (2011) suggested that researchers have no method of evaluating to what degree the memories approximated a true representation of the experiences of these participants. While, Richardson et al. (2009) suggest that recall and reconstruction are interrelated concepts and that in qualitative research, the accuracy of the recalled information is less important than meaning and experience. In this study we were not only interested in participant's science learning experiences, but also the subjective experiences and meanings of their science learning, and how these science learning experiences influenced and changed the science learning of the participants. In the following section, the precise data collection method is discussed.

4.7.1. Interviews

The project was approached from a socio-constructivist position. In a constructivist position, knowledge is characteristic of perspective (Schwandt, 2000); therefore, it is important to explore and negotiate meaning through interviews. This approach offers the most promising opportunity to better understand a learner's beliefs, assumptions, and experience (Merriam, 1988). To gain access to the "inner world of our research participants: the world of thoughts, feelings, attitudes, and opinions" (Greig & Taylor, 1999, p.125) it is necessary to ask and have the participants tell their stories.

In educational research, informants with learning difficulties have often been regarded mainly as sources of data for researcher's narratives rather than people with their own stories to tell (Booth & Booth, 1996, p. 56). The former approach might be considered as belonging to the interview method whereas the latter belongs to narrative approaches (Booth & Booth, 1996). However, such a belief is problematic: narrative designs use interview methods. It is the firm commitment to listening that identifies a narrative approach (Nind, 2008) and an understanding that the participants are not merely sources of data, but expert witnesses to their own life experiences (Atkinson, 2004; Shesell & Reiff, 1999). The current study utilized students' stories to construct narratives about the lives of these participants to provide insight into the nature of learning disabilities and the learning of science (Smith & Sparkes, 2008). For the current study, narrative methods were used to draw the reader into the story and encourage emotional investment in the characters.

An important aspect to remember in interviewing is that the respondent's words cannot be taken as facts, even if they are relaying information about their own experience. Wolcott (1994) states: "There is no such thing as immaculate perception, and there is no immaculate description, either" (p. 15). The respondent might knowingly give a false response: to protect his or her self-image; to try and give the right answer; as a result of their own misinterpretation of a situation or action (Creswell, 2008) or lack of perception. Perhaps it is more helpful to consider the utility of the individual's responses rather than their truthfulness (Neimeyer & Neimeyer, 1993). From a constructionist perspective, this allows us to see the world from their perspective while mediating individual's view with the researcher's own view of the situation.

It has been suggested that students with learning disabilities pose a problem for qualitative researchers (Booth & Booth, 1996). Inherent in such a view is the belief that the

problem lies in the individual's inability to articulate and provide quotable data, rather than, as suggested by Booth and Booth (1996), that research method is ineffective in capturing the available data. Interviews can, however, provide this information if the researcher is willing to adopt more responsive interview techniques (Booth & Booth, 1996). Such an approach allows marginalized individuals to have their stories heard through narrative inquiry (Booth & Booth, 1996). That is, during the semi-structured interviews, the study allowed for opportunities for participants to freely discuss any topic of interest to them including family interactions and relationships, past and present schools and teachers, and general talk about learning science; student participants could discuss anything that would help understand their stories. Therefore, interviews were utilized to explore the narratives of the participants.

The following sections provide an overview of the sequence of data collection procedures and the focus of these activities. This includes information from initial engagement on-site through recruitment to the complicated process of interview and analysis.

4.7.2. Recruitment

As discussed in the participant selection section above, the eight volunteered students who full fill selection criteria of the study were contacted individually by e-mail for the interview date and time. During the interview, the focus of the project was explained in approximately the following terms: "the project is about your experiences of learning science, and I want to know your perceptions about your learning of science in high school." The information and consent pamphlet (see Appendix A: Information & Consent) was discussed in appropriate terms to the student, and they were asked to sign a consent form if they wanted to participate. Eight students participated, two males and six females. All were in first-year undergraduate science faculties

and were identified as having a learning disability, experiencing significant learning difficulties in the absence of any generalized intellectual or sensory impairments in their IEP in high schools.

4.7.3. Participant's Interviews

Each student attended one 45 to 60-minute semi-structured interview over the course of a three-week period. The interviews took place at Unité de Recherche Educationnelle sur la Culture Scientifique (URCES) lab, Faculty of Education, University of Ottawa, during school hours to enable open communication. The interviews were audio-recorded and transcribed by the researcher. The researcher endeavored to ensure that the participant perceived the interview process as a pleasant experience (Greig & Taylor, 1999). To accomplish this, the interviews were organized in a manner that took into account students' levels of comfort and ability in communication by the use of familiar settings (Greig & Taylor, 1999). The students' level of comfort was assessed by asking, "are you okay with everything we talked about today?"

The interview was semi-structured (see Appendix B: Interview Guide) using questions first about the participant's family life. This part of the interview was, essentially, to build rapport with the participant, and to develop an understanding of the participant's background (Schaefer, 2017). The interviews began in a quite free-form manner, encouraging the participant to tell his or her story (Greig & Taylor, 1999). The interview then moved to more structured questions relating to the participant's science learning experiences during high school. The third part addressed more about science classroom teaching strategies and their role in understanding in science education. The last part of the interview was a conclusion period where the researcher asked for clarification or expansion of issues raised during the interview.

As the interview was much less structured and allowed the students to talk freely about their school experiences of learning science, the students differed in the length of their answers. Consequently, there were differences in the total time for all the interviews. Most of the interviews were completed in around 60 to 70 minutes while one interview lasted for about 150 minutes. Every student has a different story, and everyone appeared to try their best to answer all the questions. The interview also allowed the researcher to ensure the students were comfortable with their participation in the project.

This form of data collection provides a valuable perspective in that it allows the students to contribute to the researcher's understanding of the phenomenon. Although the students were not expected to be able to answer the question "what is the role of the background of teacher and science education for students with learning disabilities?" their contribution is considered significant in that they were able to provide valuable insight into the issues. The researcher did not find, as has been suggested elsewhere (Booth & Booth, 1996), that the participants were unable to articulate their experiences. The majority of the participants were relaxed, talkative and demonstrated a willingness to discuss their experiences, but perhaps this is due to the differences in participant pools in the two studies i.e., the present study and Booth & Booth, 1996 study.

The interviews were transcribed verbatim by the researcher, using voice recognition software, and imported into QSR NVivo a computer-aided qualitative data analysis package. Although initial analysis of the data occurred concurrently with data collection, the majority of the analysis occurred once the data had been collected, transcribed and imported into the qualitative data management tool NVivo. This process is now discussed in the next section.

4.8. Data Analysis

It is suggested that data analysis within a qualitative research design not be a distinct process (Bryman & Burgess, 1994; Richards & Richards, 1994) but the analysis necessarily occurs throughout the entire study (Merriam, 1998; Stake, 1995) to the extent that, “the field worker cannot separate the act of gathering material from that of its continuing interpretation,” (Oakley, 2002, p. 20-21). In this study, Hays and Singh (2012) approach which incorporated a data analysis method with the cyclic process of analysis of Miles and Huberman (1994) applicable to analyzing text derived from interview transcripts was used as described by (Lux, 2016). The following structure as described by (Braun and Clarke, 2006; Creswell, 2008) was utilized for analysis and dissemination of findings of the current study:

- Transcribing interview data into text, reading through the text and noticing down initial ideas through a process of synthesis or data reduction.
- Creating initial codes (indexing): coding interesting features of the data in a systematic fashion across the entire dataset; collating data relevant to each code. Codes were theory-driven, i.e., the researcher reading the data with specific questions in mind.
- Searching for themes: collating codes into potential themes and gathering all data relevant to each potential theme.
- Reviewing themes: checking if the themes work in relation to the coded extracts, and the entire dataset; and generating a thematic map of the analysis. This involves refining the candidate themes.
- Defining and naming themes: ongoing analysis to refine the specifics of each theme and the overall story the analysis tells, generating clear definitions and names for each theme.

This study further used Moustakas (1994) method of analysis and process as defined by Lux, (2016) as follows:

a) a horizontalization of every idea or expression related to the experience; b) reducing data by identifying and eliminating overlapping components; c) clustering and thematizing by grouping and labeling components; d) validating themes by examining them in relation to the person and experience, as a whole; e) constructing textural and structural descriptions for each participant as it relates to themes; and f) synthesizing the textural structural descriptions into a composite descriptions that fully conveys the essence of the phenomenon and illustrates the experience in its entirety.

For the present study, the following suggestions put forward by Merriam (1998) were also adopted. The reason for including multiple cases is to provide more information or different perspectives, not to support the findings of the other cases. Guba (1981) and Guba and Lincoln (1989) agreed, claiming that variance should not be seen as an error, but another chance to learn. It has also been said that a typical case might provide more insight into data found in other cases (Stake, 1995).

Effective qualitative researchers understand that to prevent data from being omitted; it is necessary to avoid using a restrictive framework (Oakley, 2002). For this reason, data for the present study was gathered using a semi-structured interview that allowed freedom to gather information that did not, at first, seem relevant. This process gives the freedom to reflect on the data as a whole and add detail that “may not, cannot be cerebrally written down at the time. It is recorded in memory, body and all the senses” (Oakley, 2002, p.21).

An approach such as this allows for the use of intuition based on knowledge of the subject and its participants. The use of intuition should not be underestimated, particularly in

research using narrative inquiry. As Wolcott (1994) has admitted, “some eminent qualitative researchers work on a highly intuitive basis, and all research depends on intuition to a greater extent than anyone ever seems to acknowledge” (p. 60). From being a disabled science student, the researcher was able to “judge the authenticity of his or her conclusions and interpretations regarding (the) total experience,” (Oakley, 2002, p. 31), but dialogic reliability also verified this. This process was made more methodical and more attentive through the use of the qualitative data analysis program NVivo (Bazeley, 2007) as discussed in the coming section.

4.8.1. NVivo

NVivo version 10 is one currently available computer-assisted qualitative data analysis software’s (CAQDAS) developed by QSR International making analyzing qualitative data easier and yielding more professional results. This software allows for qualitative inquiry beyond coding, sorting, and retrieval of data. It is also designed to integrate coding with qualitative linking, shaping, and modeling. The software indeed reduces a significant number of manual tasks and provides the investigator more time to determine tendencies, identify themes, and develop conclusions (Wong, 2003).

To manage the data, the researcher used the qualitative data analysis package, NVivo version 10. The program developers, Richards and Richards (1994), suggest that the traditional method of qualitative coding data, what they call the “code and retrieve” system, was very limiting for analyzing the data. Using this traditional method for an extensive qualitative research project the authors discovered “the data had become stuff, physical stuff that must be put somewhere, not ideas to be explored” (Richards & Richards, 1994, p. 150).

4.8.2. Steps for Data Analysis

4.8.2.1. Transcription.

The transcription of interview data was conducted by the researcher using Express Scribe Transcription Software as recommended by Bazeley and Jackson (2013, p. 57) to build familiarity with the research data. Transcribing involves translating from an oral language, with its own set of rules, to a written language with another set of rules. The researcher's goal in transcribing was to be as accurate to the conversation as possible, yet pragmatic in dealing with the data as stated by Kvale (1996). To work with NVivo version 10, first, the researcher created a project to hold the data named "Students with LD's perceptions of learning science."

4.8.2.2. Preparing transcription data for NVivo.

Data analysis in NVivo started by importing the interview transcripts of all eight participating students. Heading styles were used for easy differentiation and creation cases or coding categories from sections of transcription documents. Heading styles in NVivo are hierarchical, breaking a transcription document into parts, with subparts. A heading level allows NVivo to select all of the text between it and next point where there is another heading of the same degree. The participants' names were set out as heading two so that turns in the conversation were separated in the document. It helped to auto code for who is speaking, and then to run a text query to look for the word *science*, for example, and limit its findings to occurrences within the participant's text. Consistency in the level of heading chosen helped for a particular kind of item across all documents and facilitated the use of auto coding and query tools in NVivo (Bazeley & Jackson, 2013).

4.8.2.3. Storing qualitative data in NVivo.

Qualitative data in NVivo 10 are held as internal documents (transcripts of interviews data) in NVivo were imported from MS Word into the project.

- Internal documents are my primary sources for my project, and these include interviews transcripts.
- The memos are my reflective thinking about the whole project, particular sources or cases and about particular concepts as coded in nodes.
- I used cases for interviews of students with learning disabilities and sorted them in list viewed alphabetically by name.

Qualitative analysis is about working intensively with rich data. The tools provided by NVivo helped the researcher in the analysis by making use of multiple strategies like reading, reflecting, coding, annotating, memoing, discussing, linking, visualizing with the results of those activities recorded in nodes (points at which concepts potentially branch out into a network of sub-concepts or dimensions). All these strategies are integrated into a process of learning from data, like the course of thinking about a code prompts a memo, and the process of writing an annotation or a memo assists in clarifying what code is about, or which codes are most appropriate.

4.8.2.4. Coding.

The code is an abstract representation of an object or phenomenon (Corbin & Strauss, 2008); it is a way of identifying themes in a text (Vaismoradi, Jones, Turunen & Snelgrove, 2016). While coding is a method of working with and building knowledge about data, the merit of the research depends upon the quality of coding (Strauss, 1987). Coding in qualitative research is a way of

tagging text with codes, of indexing it, to facilitate its retrieval later on. Naming a concept or topic aids organization of data and helps analytic thinking (Corbin & Strauss, 2008). It also allows us to recontextualize our results (Tesch, 1990), assisting us as we move from document analysis to theorizing.

The coding approach used in this research project was broad-brush or bucket coding (Bernard & Ryan, 2010) in which I was looking for overarching themes. The text was recorded at a node and then chunked into a broad topic as the first step for seeing what is there. Each passage was read carefully to identify who and what was present, and when, where and how they were present, with each of these components potentially recorded as a separate code. Thus, multiple codes were used simultaneously to capture what was happening in a single passage of text.

At the first level of interpretation, this type of coding allowed the researcher to review each component code independently, giving a recontextualized perspective on each concept as all text relating to it is brought together. Seeing the data regarding the category rather than the interview transcripts gives a sense of what the category is about (Richards, 2009). At the second level of interpretation, slicing data into further parts opens up more logical possibilities through the recombination of coded passages. NVivo showed researcher how often students with LD stated overcoming difficulties in learning science associated with a teacher's help. This can be understood by turning on the coding stripe for one node while looking at the other or by using a coding query to locate the exact text coded by both nodes. Each node corresponds to one category or concept. Students with LD repeated ideas that were of significance for them. Repetitions, therefore, suggest useful concepts as a basis for nodes. Along with repeated ideas, prior theoretically derived codes came from my prior reading and theoretical understanding to

give a starting list of concepts to work with (science education, teacher's role, and motivation). Strauss (1987) and Patton (2002) consider these as sensitizing concepts, rather than fixed categories.

Furthermore, the researcher took account of how things were said as well as what was said, transitions and turning points in the narrative, signifying a change of theme, and repetitions (Poirier & Ayres, 1997). Second, the sequence, structural elements of a narrative (Elliott, 2005; Riessman, 2008); and third, the use of articles pointing to particularized or generalized referents (Morse, 1999). Then the discourse was explored in a manner that reflects a particular construction of the topic (Willig, 2001). What has led to these constructions? What are the implications of seeing the world in this way? While looking at the data if it was observed that something significant or notable occurring, it was described, as seeing it provides us with a link between a new or emergent pattern and any and all patterns that were observed and considered previously. It also provides a link to any and all patterns that others have observed and discussed previously through the reading of literature (Boyatzis, 1998).

Additionally, similar techniques are foundational to qualitative analysis, and as the participants belong to different socioeconomic, age, sex and educational groups, therefore it was also interesting to see the connection between these various kinds of data. The relationship between these different kinds of data occurs through our cases – the units of analysis we have established for our study. Cases in NVivo were stored as nodes, which allowed much flexibility in the kinds of data that could be associated with the case. Because they were nodes, they could reference (i.e., code) one or whole documents. Case nodes function in much the same way as any other nodes in that they were containers for qualitative data, but they differed from other nodes in two primary ways:

- A case relates to a limited, definable unit of analysis. In my study, a case was a person, rather than a concept.
- Instead of just having qualitative data in them, case nodes differ from other nodes because they also have demographic, categorical data referred to as attributes associated with them. A case node is a tool for holding together everything we know about a particular case.

In this project, as only one case type of individual participants was included, therefore, any particular segment of data was coded to only one case node.

4.8.2.5. Identifying and validating themes.

Having coded ideas and concepts identified in the data, the next step was to group concepts and themes and labeling components. Themes and patterns emerge from the data as chunks of meaning that often refer to themes, causes or explanations (Hays & Singh, 2012). The themes which emerged through the data provide means for making sense of the vast amount of data collected. Maxwell (2013) describes categorizing as grouping codes or meaning units based on similarities, whereas identifying relationships among codes, provides contextual patterns and themes. After validating themes by reviewing the data multiple times keeping in view the conceptual framework of the study, the purpose of the study as well as research questions (Hays & Singh, 2012). From this step in the analysis process, four themes emerged as study findings, which are discussed in the sixth chapter.

4.8.2.6. Constructing descriptions.

To construct descriptions of each participant's experience of learning science, particular attention was given to the phenomenon being studied (Moustakas, 1994). Textural descriptions included rich text quotes which spoke to the feelings and emotions of the participants. While the structural descriptions served as the meaning of those experiences as interpreted by the researcher; the integrated description was constructed for each of the four themes from the vantage point and experiences of each participant. Finally, a composite description was developed from this process to convey the essence of the experience as a whole (Sullivan & Bhattacharya, 2017).

4.9. Trustworthiness and Criteria for Goodness

Qualitative research is different from quantitative research studies in many respects for example how data is collected, analyzed, results are interpreted and communicated. Keeping in mind these differences it is important to note that qualitative research is an exploratory research and it provides an understanding of underlying reasons, opinions, and motivations. It is also used to uncover trends in thought and opinions and dive deeper into the problem. The trustworthiness of the study is judged by the quality and rigor of the research based on the criteria that are consistent with how the study is epistemologically, theoretically, and methodologically situated (Lux, 2016). Even though the findings of the qualitative research are always subjective, it is researcher's evidence of the interpretation which made it trustworthy (Lux, 2016). This section explains the steps taken to demonstrate trustworthiness and the criteria for goodness in this narrative research.

4.9.1. Credibility

Credibility means how credible research study findings are in representing reality (Lux, 2016; Merriam, 2014). The following strategies were used to address potential questions concerning credibility.

4.9.1.1. Triangulation of interview data.

Merriam (2014) described that data triangulation is a strategy in which data collected by a researcher is cross-checked by multiple sources. Similarly, Wargo (2014) stated that by using a three-step approach: a) audiotaped interviews; b) transcription of audio recorded interviews and member checking; c) outside evaluator during data analysis full fill all the conditions of triangulation in case study research. In this study, in-depth interviews with multiple participants were conducted and data was triangulated as described by Wargo (2014). However, Goodley (1996) suggested that the question of whether the informant is telling the truth is irrelevant. The important question is: Why are they telling their story in that way?

4.9.1.2. Member checking.

According to Merriam (2014), it is important that authentic participant voice come through in qualitative study. In this study, a rigorous criterion was put forth for selecting the participants as described in the section selection of participants. After transcription of the interview data, the draft of each participant interview was sent through e-mail to the respective participant to clarify or correct. All the participants were satisfied with their responses on their interview drafts.

4.9.1.3. Prolonged engagement.

An in-depth interview is a strategy often used as a prolonged engagement (Gilgun, 2014). In this research study researcher spent from 1 hour to 3 hours with various participants for in-depth interviews, this opportunity of extended periods of time with each participant provides an opportunity to get the understanding of the phenomenon (Creswell, 2009; Lux, 2016).

4.9.1.4. Reflexivity.

Creswell (2013) describes reflexivity as an opportunity for the researcher to reveal his/ her experiences, values and biases for the study. Researcher himself is a person with a disability, and he earned a Ph.D. in Plant Genetics with seven years' experience as a full Professor of Plant Genetics and 15 years' experience as a Plant Geneticist at various international research organizations. Therefore, he is bringing with him experience as a science student along with the experience of teaching science to both able and special undergraduate and graduate students. As explained in my personal biography next section. According to Creswell (2013), the qualitative study required the researcher to look at the phenomenon of interest (learning of science) in a fresh perspective.

4.9.2. Trustworthiness

In qualitative studies, trustworthiness is very challenging and lies with consistency (Grossoehme, 2014). According to Leung (2015) "A margin of variability for results is acceptable provided that the methodology and epistemologically logistics consistently yield data that are ontologically similar but may differ in richness and ambiance within similar dimensions." As data was produced through interviews researcher must verify its accuracy in its

form and context with constant comparison either alone or with peers (Patton, 1999). In this study, to enhance the trustworthiness, I conducted all the interviews face to face. The reliability of the question schedules was further enhanced by presenting the questions in the same order. Even though additional questions were added for some participants, these only occurred to elicit further responses on an issue or to clarify ideas that were being presented. The interviews were also transcribed by the researcher himself. The interview transcripts for individual participants were verified from the participants through e-mail. Furthermore, for trustworthiness purposes epistemologically (social model of disability) and methodologically (qualitative narrative approach) were constantly used to fulfill the reliability condition.

4.9.3. Transferability

Mostly, generalizability in qualitative research studies is not an expected attribute as these studies deal with a particular issue or phenomenon in a certain population and of a focused locality. However, it is important that qualitative study should use the same criteria for validity which is, “use of systematic sampling, triangulation and constant comparison and documentation” (Leung, 2015). Similarly, Merriam (2014) use the full description from the participant's interviews, detailed presentation of the setting and the finding of the study. Keeping this in mind in this study in-depth interviews settings, description and conclusions were discussed in rich details.

Personal Biography

I am a person with a disability and for this paper, I will only comment on my formal educational experiences of learning science and my struggles with my speaking disability as it

affected my time spent in school. My speaking disability (stuttering also called stammering) is a speech disorder that involves repeating or prolonging a word, syllable or phrase, or stopping during speech and making no sound for certain syllables. People who stutter know what they want to say, but have difficulty saying it (Klompas & Ross, 2004). My stuttering falls under the chronic condition, which means that stuttering persists into adulthood. This type of stuttering can have an impact on self-esteem and interactions with other people (Guitar, 2013).

Stuttering had a very drastic effect on my educational as well as social life, and it limited my daily activities involving oral communication. I always tried to hide my disfluency in speech (refers to breaks that are abnormal) from others by rearranging the words in my sentences. I opted not to talk on the telephone or before large groups in my childhood. Due to my stuttering, I never pose questions in any of my classes. I also have some difficulty making inferences during inductive, and reasoning processes by which I faced difficulties in my science classes. I limited my participation in class activities and games because I was always concerned that other kids would make fun of the way I spoke. Nevertheless, kids always made fun of me and teased me.

I will never forget one incident when one of my high school science teachers asked me to sit down after it took me too long to answer a question he had asked me because of sudden blocks (when one trying to speak but no voice comes) which can come in my speech at any time. In my point of view, teacher's professional development is very important in regard to dealing with the students with disabilities. However, this science classroom incident did not stop me from pursuing my science education.

I changed my school and ended up with a highly professional science teacher, who had professional development training in dealing with students with disabilities and this school also had a very good science lab. The teacher explained everything in his lecture and then he gave us

time for practical experiments in the lab. Due to the hands-on activities, extensive instructions and with my curiosity and interest in science subjects, I became one of the favorite students of my science teacher. I took control of my science studies and worked very hard such that I rose to the top of my science classes.

The reason, behind this achievement, was my professional and competent science teacher, as I recall, he listened to me, allowed me to take whatever time I needed to complete my response to his questions in his science classes. Second, when I dealt with him I rarely stuttered. He was my mentor and he guided me in my choice of subjects at college, and I will always appreciate his mentorship because he helped and guided me in becoming a plant geneticist.

I completed my post-doctorate from Department of Plant Science, McGill University and joined Employment and Social Development Canada as a policy analyst. I worked on a project “Skills shortages in Canada”. This project opened my eyes and as a person with a disability, I become interested in employment status of a person with disabilities. The data from Statistics Canada (2012) showed that the unemployment rate in peoples with disabilities is very high as discussed in chapter 1. The main findings of skills shortages in Canada project was that: a) Canada has labor supply-demand mismatches; b) geographical mismatches; c) under-employment mismatches; and d) under-skilled mismatches (need more people with scientific skills).

To solve the first and foremost labor supply-demand mismatches, Canada needs more workers who have scientific skill sets. To achieve this goal, we need to concentrate our efforts on increasing labor force participation rates among historically underrepresented groups, i.e., persons with disabilities, youth, aboriginals, immigrants and older workers (Miner, 2014). The high unemployment and low enrolment in scientific disciplines in post-secondary institutions

among peoples with disabilities made me interested in finding the reasons for low enrolment of students with disabilities in science disciplines for their post-secondary education.

Limitations and Delimitations of the Study

This study enriches literature on qualitative research on learning disability. It provides insights into the perspective of students with learning disabilities learning science with LD in high schools. This area of educational research is relatively sparse in proportion to its student's population in our schools. This research project scope was delimited to participants who were full-time undergraduate students of science-based faculties of the University of Ottawa, who were diagnosed with a learning disability and who had LD indicated on their IEP in high school. This also delimited the participant pool size to allow for sufficient data collection through in-depth interviews with each participant. Furthermore, the fundamental delimiters of this research study were the purpose of the research project, the guiding questions, and the research framework.

While there were many limitations both in scope and methodology of the study as described above these should be considered while interpreting the overall findings of this study. This is also explained by Denscombe (2010) and Lux (2016), the limitation of the study informed us that readers should keep these limitations in their mind and should not draw unwarranted conclusions. The scope of this research study was to seek the perceptions of students with LDs learning of science in high school; therefore, in this study, only participants who enrolled in science faculties of the University of Ottawa and were pursuing science career were selected as participants in this study. This study did not include students with LD who studied science but did not pursue science careers while they can be included to know more

about their perceptions why they did not pursue a science career. Secondly, this research did not take into account students with LD's demographics, such as socioeconomic background, the educational attainment of the parents, sexual orientation and ethnicity.

The data collection method in this narrative study was in-depth interviews, and sample size in narrative studies will be typically small because of the time-intensive, in-depth interviews (Creswell, 2013). In this study, eight participants were selected on first come first serve basis who were currently enrolled as full-time student at science-based faculties of the University of Ottawa. While this purposeful sample from science-based faculties was an intentional delimitation of this research project, further insights may have been gained by also having participants from science-based programs from public colleges.

In the end, findings from narrative studies are always conveyed through the participant's perspective but some participants due to their learning disability may not be able to articulate or describe their experiences fully. The results of this research study are communicated with the belief that participants fully understood the question, and they were replying and providing the information truthfully based on their experiences.

Summary

This research aimed to gain the perspectives of the students with LDs learning of science in their high schools. The specific interest of this study was to understand the experiences of these students of learning science subjects. During their science learning process if the participants encountered any difficulties of learning or not, if they encountered any difficulties how they overcome these challenges. In this chapter framework used to conduct this study was explained by situating this qualitative study within the theoretical and philosophical paradigms

that align with the constructionist epistemology and situated within the paradigm of qualitative inquiry. It also presented a qualitative approach of case study methodology with elements of narrative inquiry to provide a detailed understanding of the process or experience of learning science. This chapter also provides a detailed description of the research method, along with selecting research interview site, selecting study participants, collecting data through in-depth interviewing and finally data analysis through NVivo software. In the end, strategies used to ensure the trustworthiness and goodness of the findings were discussed along with the researcher's personal story.

Chapter 4 described the methodology of the study. Data collection method included was narrative in-depth interviews focused on eight students with LD. Data were analyzed qualitatively and these data are reported in the next chapter.

CHAPTER 5

EXPERIENCES AND PERCEPTIONS OF RESEARCH PARTICIPANTS

This chapter introduces all the eight research participants alphabetically by their pseudonym. This first section of this chapter is meant to provide a snapshot of student's life, including their demographic details, educational history, social life, and significant moments in their lives as students.

Brenda

“For me, everything in life is bigger and harder.”

Brenda is a 23-year-old woman who comes from an upper-middle-class family. Both of her parents work outside the home. She attended a private high school. Now she is in her first year of Health Sciences programme. She is the only child but has three cousins, one of whom has ADHD. She was diagnosed with LD in elementary school when she failed in math. For her, structuring and organizing sentences are challenges along with processing while reading.

Brenda considers social skills as assets for peoples with LD. However, friends should be accommodating and have an understanding of learning disabilities and should “give you, your space.” In her opinion, persons with LD develop more skills/ tools to deal with their LD problems with age. She believes LD affected her family life, as due to LD she did not have as much time to spend with her family as she wished because for her “everything in life is bigger and harder to go through as normally is”.

Brenda believes that socioeconomic conditions have nothing to do with the development of LD. However, socioeconomic conditions played a crucial role in the diagnosis of LD and later on developing the tools to deal with it. As for herself, she was fortunate as her mother took her to a neurophysiologist and she was diagnosed with LD, which assisted her in getting related accommodations at the school. Accommodations at school helped her to develop skills and tools to deal with difficulties in her reading, writing, and math.

Brenda described her school life in one word, “difficult.” For her, school life was very slow in comparison to other students; she states: “They are working part-time jobs, but they still have full course load, and they can do it very easily. While it is so much difficult and longer with LD.” As far as science subjects were concerned, she considers her biology courses were fine, however, in physics and chemistry subjects she faced a lot of difficulties, and it took a lot of her energy and efforts to understand those subjects.

Brenda thoughts that science teachers’ backgrounds “definitely” affected a student with LD’s science learning. The science teacher’s role “is crucial, probably the most important.” She further emphasized that science teachers should explain the lessons according to the level of the students, they should not skip things that are easy for some students in the class, and the teacher should consider all the students in the class including students with LD.

Brenda thought her high school science teachers were “not flexible, not flexible at all.” She thought her questions were always different from other students and educators considered her “questions weird.” She felt hat it was because “she processes the information differently.” Due to this, she felt she was “cold-shouldered.”

Brenda explained that the process she used to learn science in high school was to memorize the science lessons first. After that, to understand the topic she had to “work a little bit

harder.” She had to do the example questions before exams “three times” then she starts understanding what she was learning. She plans one month before the exam, and she met with the teacher once or twice before the exam to clarify difficult questions. She thought of herself as a “distracting kid.” She wanted teachers to be “patient” with her, stay calm, repeat, repeat and repeat, if it did not work with her, then repeat it differently like making sketches, and concept maps. She had always learned difficult topics by memorization. She never asked questions during the class, as “I do not understand anything in the class.” She always went to the teacher before an exam to ask questions, as at that time she processed the information in her ways by memorizing and understanding.

In conclusion, Brenda’s learning of science topics process consisted of:

- reading the class notes,
- memorizing the class notes,
- making the web (concept map)
- writing her definition of each concept,
- making a picture of what was related to what, and
- asking herself what the most important thing in that concept map was.

It was like memorizing the whole question. Chemistry was hard for Brenda, and she liked molecular biology as it was fascinating, but it took longer for Brenda to understand Chemistry. Labs were helpful for her to understand and process scientific concepts.

Brenda learned science by reading books suggested by her teachers, and she had bought all of the books. Talking about the role of books in learning science, she said that books have a “vital role” as they have graphics, examples, and stories. She needs books because she had to

memorize first to understand the topic. She did not like only class notes; she used textbooks in addition to class notes.

While discussing assistive technology in learning science, Brenda states that “yes, it had a critical role.” She used online videos and particularly used “Khan Academy” because Khan Academy tutors explained the concepts and explained the science topics by using videos that were only fifteen minutes long. The time span is critical as fifteen minutes timing is the best time span of concentration for a student with LD. She used her computer to read e-books, but she prefers hardcover books.

Brenda liked a combination of both of direct instruction and hands-on activities as teaching strategies. She preferred a teacher to explain the science topic first in the class, and then she processed it, as it took some time for her to process what teacher told in the class about the science concept. Later on, when she had a chance to do it by the hand she had already processed the idea, and it was easier to understand for her at that time. Hands-on was more practical for her than the direct instruction approach.

Brenda thoughts about blended learning were that “if the student with a learning disability had an interaction with the teacher in the online environment it would be more beneficial than simply online learning.” She thought that it was better for a student with LD that while reading and listening to the lectures of the teacher, the student had some interaction with the teacher by submitting question aroused while reading and listening to the lectures online. This interaction would help more in understanding concepts of the online lecture. Online learning was also better as other students have already asked some related questions which assisted in processing the information.

Assistive technology, like computers and Kurzweil (a reading application that allows the user to view a scanned document on the computer screen while listening to the text being read aloud), makes Brenda's life very easy. Kurzweil helped her process concepts faster, as her processing was slow.

Brenda's suggestion to teachers was that "if a student wants to record the lecture, allow the student to record it, as it would help the student to listen to the lecture again and again until he/she could process the information". Teachers should be more knowledgeable about learning disabilities and more flexible in using teaching technologies. They should not always use powerpoint but also use videos, stories, and the blackboard to explain the process or draw a concept map.

Brenda did not want to be treated differently. Therefore, she never told any teacher about her learning disability, but if they found it out or it came up in conversation, she never hides it. She had one bad experience with a high school science teacher when she told one teacher that she had LD. He told her that he was a science teacher not a disability professional. She wished that teachers know much more about LD, she thought that right now teachers have not been trained in how to deal with students with learning disabilities. She said that "It is your passion what you are teaching, you are not getting through to students, what is the point of teaching." Therefore, she always used her tools (memorizing, reading, again and again, making concept maps and asking questions to the teacher after she processed the information after memorization) to overcome her LDs.

Britney

“They did not trust me and never challenged me.”

Britney is a first-year biomedical student specializing in Biostatistics. She is twenty years old and has one brother. She belongs to a middle-class family. There is no prior history of learning disability in her family. She has no friends with a learning disability. However, some have anxiety disorders. She loves playing piano, reading books and cleaning. She thought that age had an effect on LD and it had affected her family life. She thought as she becomes older she developed strategies to deal with her learning disability, therefore age really helped in coping with LD. She was diagnosed with LD in elementary school. Therefore, her parents pushed her hard in studies, and they were very strict on her about her studies, which was perfect for her future. However, she missed her childhood as she spent most of her time in overcoming her challenges in studies. She was good in music and dance, so they enrolled her in many activities. Therefore, she did not have much time left to play around and enjoy her childhood. Due to a learning disability, she told that “her dad gave most of his time to help her in her studies and very little time to her brother; therefore, her brother felt that she received more attention when he needed it”.

While talking to her friends, Britney told that “she has more friends who do not have LD, but they have anxiety problems.” She described her learning disability “is about reading comprehension. She takes a long time to understand texts, and it affects how she interprets questions.” To overcome her challenges, she had tutoring in elementary and secondary schools. In grade six, due to her IEP, she told that “she was separated from her classmates for English and math subjects and in the special class, she was taught with other special students and the level of English and math was just a basic level.” While describing her experience in the special class,

“she thought that teacher did not give enough attention as there were so many students in the class.” In the special class, each student had a different disability, and the teacher “taught all the students the same things in the same manner, while each student had different disabilities and each student learned differently.” She thought that “in segregated classes, the level of teaching was shallow, the teachers did not trust her, and they did not challenge her by not giving her tough exercises.” Her family pulled her from the segregated classes and put her in the normal classes in grade eight. In grade eight in the normal class, she was behind in class work as compared to other students, as she never learned those topics in the segregated classes. To overcome this challenge, she worked hard to learn all those topics from her tutors at home by spending 4 to 5 hours each day. Her style of learning was that she wrote down everything, one time, a second time, and a third time, or a fourth time until she could recall it and had memorized it. She memorized every single topic in science and math in grade eight.

In grade eleven, Britney took an interest in science and tried to understand science topics in addition to memorizing. To understand the topic, she first wrote what her classroom teacher taught her in the class. After that, she wrote it in her own words and then she went to the book website and explored the topic and tried to do all the examples on the site. The examples on the website helped her a lot in learning and understanding her science topics, as examples vary from simple examples to the tough examples and in exams teachers always gave the tough questions which they never taught in class. However, as she already practiced the complex examples from the book website, she easily understood the exam questions. Sometimes she also memorizes the complex examples and concepts. However, she tries different methods to solve the exam questions as explained in the examples of the website.

In Britney's opinion, the science teacher's role is crucial for a student to learn science; her biology teacher helped her a lot in learning biology in high school. She taught her human disease lessons with practical examples by making students act like doctors. She took extra care to teach her biology by using websites, and by giving her extra time and reviewing with her what she learned last time before starting a new topic. She explained in basic words the book definitions of different biology terms, and she always took a different approach to reviewing the last topic. Britney said that "the teacher made me so interested in science that I pursued the medical science field because of her." She was not good in science in grade nine as she was getting C and D grades, however, with this grade ten science teacher everything changed for her. Her grade ten teachers taught her in a way she could understand, and she learned. While talking about math, she said: "Math, I never have a great teacher."

Britney learned in biology a physiology theory topic "ON- and OFF-center Receptive Fields" through the diagram. She cut and pasted each step to try and understand what was happened at that particular step. She did this until the very end and then she started understanding it by getting the overall picture. Her advice for science students to understand a topic is, "start from the first step and understand it about the overall picture. You have to figure out in parts the overall picture. You add on step by step understanding of the phenomena."

In biology Britney liked the topic of evolution as it was interesting to know why we have been here, and why we ended up here. She thought that teachers should make the topic interesting so that students become engaged in discussions and ask relevant questions. She told that "topic like Darwin and theory of evolution was mind-blowing, engaged students by asking questions and make them think like scientists, ask one question to another and my grade ten biology teacher made it interesting by asking relevant questions." In comparison, "in chemistry,

teachers did not ask questions, as they thought chemistry have straight equations and the teacher would tell you this was a molecule and this molecule would do this. The teacher did not ask a question that was why students were not interested in chemistry; teachers did not involve students in discussions.” It was more memorization than engaging. Furthermore, she stated that “while to memorize a science topic was very difficult with a learning disability, but she was doing it in her science classes by writing the topic three or more times.” She liked questions that did not need much information to answer the question, as they boosted her confidence. She suggested making the students with LD engaged in the learning process, and interested in the topic to learn, then they would put their effort to learn the topic, and it would increase their confidence.

Britney only used books when she could not understand the topic teacher taught, as most of the time teachers were reading and getting information from the textbooks. She liked math textbooks as it showed different methods of solving a problem, first by explaining the concept of the problem, and then how to use the concept to address the problem step by step. While talking about technology, she used many websites like YouTube and Khan Academy to learn and understand science topics. Khan Academy always asked simple questions. However, she believed that they should ask hard questions as teachers are going to ask hard questions on exams. She printed hard questions from various websites and practiced those hard questions to learn the topic.

Britney always went to her science teachers when she needed help. However, when teachers tried to help her, they told her the same things as they did in class. She felt that teachers were not aware of different types of disabilities and how to teach special students. They might be good at giving instruction visually because they learn visually, but they were not good in other

ways like caring and trying to connect with her by using different methods of teaching. Now at the University, she is an instructor, she was using her knowledge of LD and different strategies to teach science in her classes. She felt that “there are various methods of teaching like providing information and another method to make the student involved in learning.” She thought that “teachers always tried to teach in their normal way, as they very rarely encountered a student with LD in their class. However, teachers should try to teach in different ways so that they could connect with all the students in their classes including able and disabled students.” She suggested that “students with LD should inform the teachers about their disability and the way they learn differently, then the teacher would understand how to teach students with LD.” She loved her biology teacher as she taught the same subject in different ways.

Britney found math and chemistry subjects very hard to learn, while biology, physics, and statistics were fascinating subjects due to their real-life examples. She learned by writing, along with visual methods like animated videos which she could pause and look at how that function happened. In assistive technology, she liked Kurzweil which helped her in reading a science textbook by highlighting and reading it to her. It helped her to read difficult words she did not know. In addition to Kurzweil, she also used Sky pen (a smart pen that enables users to capture, search, and share handwritten notes) to take notes in the science classrooms, as she could go back and listen to the teacher’s lecture again. She used her computer and iPad to watch videos of science lectures and to read e-books. She took her iPad to chemistry classrooms and wrote in PowerPoint to take notes and draw diagrams. As she learned visually, she watched animations of muscles movements that could be stop and start whenever she liked.

Britney’s major difficulty while learning science was, “not understanding the questions” as she had to read the question a few times to fully understand the question. Her biggest barrier

was how she applied what she learned, for example, in chemistry. She did not like the blended learning approach; she took a blended learning genetics course and was always behind on the online part of the course, and she had to go to the professor to understand the topics. Time management was another issue in blended learning as she was always in a rush to learn.

Britney went to the International Baccalaureate (IB) high school, and she worked very hard to be successful in that program. She took notes in every class, and every day at home she reviewed all the notes and understood the concepts before completing her homework. She practiced 4 or 5 different examples of a math question every day. She passed the IB program by taking extra help after school from the teachers by letting them know that she had a learning disability and that she needed extra contribution from them to understand the different science topics. In grade nine she did not tell them about her LD, and she got poor marks, but in grade ten and eleven she always asked for help from her teachers. She completed the IB program by telling her educators and friends that she had a learning disability, by pushing herself to review all the notes before completing all the homework, and by practicing questions teacher gave her. She said:

We are not stupid, we worked so much hard we are limited by something, and we have to push ourselves more. Society should not have lower the standard for us, we feel it, and it sucks. However, it is in the genetics, and they cannot change us. I have a disability do not lower the standard for us we can compete with other students.

George

“You have to understand that it is going to be hard”

George is nineteen years old and studying in the first year of biotechnology degree. He has two older brothers, both of whom graduated with science degrees in engineering and medicine. His father is a Federal Government employee and mother is a dental surgeon. He belongs to an upper-class family. Nobody in George family has learning disability. George started his education in a private school for with peoples with disabilities, as he started speaking late, around age four. Due to his speech impairment, he did not get along very well with other kids in the school. His performance was not very strong in his early grades. At around eight or nine years of age, he realized that something was different with him and at that time he asked his parents, “is something wrong with [me]”? His mother went to a psychologist and told about George difficulties in school; the psychologist told his mother that the school should help George and consider him a student with a learning disability. His mother tried her best to convince the school to consider George as a student with LD. However, it did not happen until she hired a lawyer and he sent a notice to the school. After the lawyer's interference, the school hired a special teacher to help George in his studies. Her mother’s intervention at school helped him in school. However, at home one of his older brothers was not very helpful. His one brother has a friend who has a learning disability, he understands George’s difficulties, but the oldest brother always picked on him and discouraged him. George has one friend who was diagnosed with depression. George was not aware of depression; he researched about depression and after researching, George thought that he also has all the symptoms of depression.

Things started improving at school when George got a math teacher who had a son with dyslexia. The teacher without reading his reports noticed that George had a learning disability.

The teacher gave the same exercise to him as other students. However, he wrote the exercise for him in a different way similar to what his son was receiving. His way of teaching made everything easy for George. He was able to understand all the subjects and gets excellent grades in all his subjects except French. At one time in the whole school year, he submitted all right exercises. In studies, George was performing very well with the help of his teacher, however, socially in school, kids at that time had no idea about learning disabilities, and therefore some of the students picked on him and left him alone. Their attitude bothered him a lot. The math teacher treated him like his son and gave extra time after school and taught him how to look at things differently. He took his advice, and by looking things in different perspectives, changed his learning style. The style the teacher told him was that looking around in your world you will learn everything as science and math are directly related to our world. Before this, he was used to learning science and math thinking they were different from the world. Now he knew that he had to observe first in the world and then he can make connections with what he learned in science and math. He needs some time to observe the things around him. Therefore, he takes extra time for his exams and assignments. The teacher gave him courage and helped him in practice the art of observing and making the connections between theoretical knowledge and practical knowledge. He also learned that he has to take responsibility for his learning; he cannot rely on other persons to always help him out.

George thinks that socioeconomic status was a significant factor in dealing with his learning disability, both in getting services and additional help by hiring tutors and getting learning aids. In getting aids and tutors for your kids, George thinks that “If you are poor and you told your children that you are poor, it will have a harmful effect on them.” He also thought that science teachers’ backgrounds matter, as one of his teachers, had a Master degree in Science and

he had a passion for science. He was an excellent science teacher as compared to other teachers who had Bachelor degrees in other fields. His personal experience with two of his teachers showed him that a teacher's background matters. He took two physics courses in high school from two different teachers, one teacher's background was in Physics and the second teacher's background was in chemistry. The depth and passion he saw in the Physics class from the teacher with the Physics background were amazing as compared to the chemistry background teacher teaching Physics. Therefore, he believed that teacher's background in the subject really matters. He also thought that science teachers at his school were harsh and did not respect students who did not complete their homework.

George always used two different science books to understand the topic, as the first time when he consulted one book it never helped him to understand the topic. However, when he used another book to learn the same subject, he always succeeded in understanding the topic. It was strange, but it always happened to him. As he understands it differently, he always used the complex science books first and then he consulted the practice books. To learn equations, he first tried to understand the theory behind the equation and then how to solve those equations. Then he read another book to understand that equation and its use in real life. It always took him a long time to understand the equation and then to solve the problems.

George used electronic books, but those books did not connect with him at first. He had to listen to it as he was a slow reader, and then he had to read it aloud to comprehend a textbook. However, if he reads aloud and pretends that he was teaching, then he comprehends it, and it worked for him to understand the topic. He prefers e-books as he could listen to it as well as read it aloud and they were very effective for him to learn science. His style of learning science topics was first to understand the basic overall theory, and then act as a teacher to teach other

students. Sometimes when he was studying in a group, he served as a teacher and explains the topic to other friends, and in this way, he was teaching himself the science topic. He also does extra exercises and when he was stuck on something he used several science books to learn that topic and does the related exercises three or more times. He reads aloud and makes sure that he was doing the same thing as he was on the exam. As the exam was a stressful and time-consuming environment, he simulates the exam environment and does the exercises so that at exam time he would not be distracted or stressed.

Although George is studying biotechnology, since childhood he has been interested in stars and cosmology. He found physics very easy for him compared to chemistry. He owned many physics books, and he read many textbooks related to physics early on. He did not know why he liked physics as his grades in physics were not very good in high school, and his physics teacher always discouraged him from taking physics.

While talking about the role of assistive technology, George said, "I used the internet a lot in learning physics." He watched videos to grasp the concept of the phenomena and tried to simulate the action, particularly of cosmology, as he had his telescopes. Therefore, he watched the stars and Milky Way. He also used an iPad for looking at stars and cosmology related maps, and he used his telescopes to watch Jupiter's moon, Saturn and glimpse of Mars. He liked physics, as it is more interesting as compared to chemistry. Moreover, if he asked one question of physics on the internet ten more questions come up related to that question, however, in chemistry only one question may be emerging. He used many apps, like Kurzweil, and notepad to read and write notes. So, when he wrote and speaks aloud, if it did not sound nice, he knew that something was wrong in his writing.

George thinks that nothing was difficult to learn, however, the only difficult thing is motivation to learn and science always motivated him. He can learn the most difficult topic in a week. He thought that his mentality of learning in a specific way, in general, was the best approach to learning science. He said: "Do not try to learn by heart, try to be the person who discovers it." He also stated: "For me, you cannot love what you are doing, if you do not love to learn it." The most difficult thing for him to learn was concentration; he had to try a few times to concentrate, and when he concentrates he learns science through the applied method as his teacher suggested. His method of learning was first to clear the theoretical part, then do some unusual examples, and then solve those examples by his methods. He starts with simple examples, and as his confidence builds by solving those simple examples he moves on to complex examples, and when he solves those, he becomes confident that he can do it. He explained that his teacher showed him how an equation he just solved could be used to address complex problems in our daily life. George told that "The teacher showed the value of the things that he thought had no value in our lives, by just looking from a different point of view. Just by walking on the street and looking at things he could see the value of stuff in the perspective of science, and it motivated him to discover new things and their values." The ways of looking at things from a values perspective and why we learned it opened the way of thinking.

George liked hands-on learning teaching approach to learning science after he understands the theory. This method helps to manipulate things in different ways, and this was the way to learn science instead of listening to the teacher as in a direct instruction approach. People should be involved in learning in his opinion, as his teacher showed him the value of the equation and how this equation could solve the real-life problems. He also liked the style of his science teacher, who always asked students who missed homework to solve the equations on the

blackboard. It was forced learning, but it worked as next time that student always completed his homework. He always volunteered himself to work on the blackboard in that teacher's class.

Blended learning is a good technique if there would be less distraction. In George's experience, younger students become distracted easily and abuse the technology. For him, the internet was the biggest distraction in a classroom. However, he liked smart boards and iPad with pen input to be used in learning science. He was using it at the University. However, he wished he had it in his high school then things would have been much different and more organized. It is always a wise decision to use advanced technology in learning science. He liked the combination of direct instruction and hands-on technology best for learning science. He considers "Teachers input, at the beginning of the coursework, is always necessary to explain the theoretical part and then the applied part would be easy to understand and complete."

George advice for students with LD is:

You have to understand that it is going to be hard if you know that you have this disability expect much judgment. You have to be strong because no matter children always are ignorant it is a natural thing. Therefore, students with disabilities should accept to be some bullied. They should be able to withstand that pain, but they should be ready to show off their colors.

Second,

A student with LD should learn to be patient, other kids will learn it. Think of Superman, do not try to destroy the other kid's world, they will understand it. Kids with disabilities should be taught that they have a purpose that they can do something good, do not sit down that you are disabled, look at Dr. Steven Hawking he discovered the end of the world on a wheelchair. Do not give up, learning is hard, but you can show your teachers

that you can do it. You have to be motivated, be ready for the storm to come, it may never come but always ready for it.

In George's opinion,

teachers should know what this disability is, how much pain a disability can create, and then they might change the way of teaching to students with LD. Teachers should have training about mental health and how their teaching impact the students with disabilities. They should know the consequences of the things.

George cited that in the media for the last couple of years

Whenever there is a report of shooting in the world, the shooter mostly is a person with a mental disability. These individuals lost the purpose of their lives and if the society helps them in making them believe that they have a purpose in life to do better things, then these peoples will not do these things. I saved a kid in school who was bullied by other students, and I became a friend of that student and sat around him and saved him from another student's bullying.

In his opinion, teachers should know about these mental illnesses and their consequences.

George believes that parents should also learn about learning disabilities and how to deal with it. He remembered his mom become frustrated when he was doing his French homework and making mistakes, again and again. He said, "My mother was so mad at me that she just moved out of the room and I felt that I am not useful anymore." However, it was his mom who fights for him with the school for the assessment and for hiring a special teacher for him. Moreover, she was the one who saw things as he sees, and she completely changed herself, she devoted her time and energy to him and motivated him to learn and see the things in different ways. George

believes that parents should try to be heroes for their kids as parents have a strong influence on the child.

George believes that the role of friends is also crucial in the life of a student with LD, and friends should understand that students with LD are different, but not that much different. George's advice to students with LD was, "You can see the world but differently and you also aim high." He has many difficulties with his friends, but friends are critical in one's life, and they should understand that you have something different which cannot be changeable, that you cannot see the same way as them. However, they should treat you in a normal way, not a particular way.

Lila

"I do not understand why you have the problems with this."

Lila is a twenty-five-year-old student and doing a combination of Biology and Computer science degree. She has one sister who has anxiety problems, and her mother has a learning disability for which she is getting services from her college disabilities services.

Lila came from a small town and was diagnosed with learning disabilities in her school, and she has an IEP. As her father died and her mother was the only earner, she considers herself to be from a low to a middle-income family. In her opinion, resources certainly have an impact on LD regarding getting resources from school and out of school. She had many friends at the school and back home with LD, and it was not an uncommon disability in her opinion. She loves cooking and listening to music and walking around the city in her extra time.

Lila suggests that one of her high school science teachers was not very accommodating, as he was strict and always said, "I do not understand why you have the problems with this." She

received more help at home from her father who was very good in computers; he looked for programs on the computer to help her in learning science. Her mother read the books which were hard for her to read due to her learning disability. Three science teachers taught her all of her science classes at her high school. She thought that “it would be helpful if the teachers have specialization in their science subjects.” Her biology teacher got her degree in coaching, and she felt that her teacher did not know what she was talking about and “it hindered my learning progress and it would be nice if she had the science degree instead of coaching degree.” While, she had another biology teacher who had his Ph.D. in biology, and biology was his life. He gave a lot of different examples and was a very passionate person. He used the hands-on technique to teach instead of reading from books. He was very accommodating with everything.

While talking about the science teacher’s role in science learning, Lila thought that “teachers might be brilliant in their subjects, but they did not remember how to take things back to square one and teach the student from the lowest level so that student could understand it.” Also, she said that “teachers should be patient and have to be very organized to teach students with learning disabilities.” Her biology teacher who had a Ph.D. in biology taught them DNA transcription and translation by cutting the piece of papers and putting it together like DNA. She learned it very easily by doing it with her own hands rather than reading it from the books. He passed his passion for biology on to her, and she sees things from a different perspective. She always asked for help from the teacher on a one-on-one basis as in the classroom she cannot ask questions due to her anxiety. In her opinion:

Teachers have a huge role in making a student with a learning disability feel comfortable in learning a science subject. If the student with LD has a bad experience with a teacher, they will be put off by the subject and not go to pursue it.

She had this experience with a math teacher who made her uncomfortable in learning math. However, then she got a calculus teacher who turned it around and gave the help she needed. She said, “It made the difference and had an enormous impact on students with LDs life.” She thought that:

If there is somehow in the start of the semester, teachers have better access to seeing the IEPs of the students with disabilities in their classes and be able to educate themselves about student’s disabilities better, and related accommodations it would make a big difference.

Lila uses assistive technology (i.e., the natural reader) for reading science books and watches YouTube videos related to science topics. She used e-books on her computer, and the natural reader reads it for her, and it made her life of learning science very easy. Then she watched YouTube videos related to the topic. If she still could not understand, then she asked for help from a teacher during their office hour’s one-on-one basis as she did not like to put questions in the classroom. It was crucial for her to start from a small grasp of the basics then build upon it. If the teacher did not cover the basics, then she was lost and asks for help from her teacher about the basic stuff. Chemistry and physics were difficult subjects for her in high school. Chemistry was hard due to its abstractness and physics due to math calculations.

Lila’s strategy to learn science was that first the teacher should present the topic in an organized way, topic, subtopic, and then the related books. She learns basics from the books and found it better to discuss the topic with her friends after covering the basics from the books. She used colors in her notes to distinguish between different important points of the subject. Then she watched videos related to the topic and takes notes while watching videos which solidify her learning. So, she used, visual, audio and hands-on learning to learn science. She used a lot of

flash cards, online and hand-made which helped her see things in smaller pieces and makes it easy to remember. Peer study groups were also essential for her to learn science but the most important one was the accommodative teacher who makes a big difference.

Lila liked the blended learning approach, as she could message the teacher without the class anxiety issues. She liked that half the time teacher taught in the class and half the time she can work on her peace on the computer to learn what the teacher taught in the class. She liked the hands-on approach to teaching as you can visualize it and handle it in your own hands as compared to a direct instruction from the teacher who reads from the books.

Lisa

“I just do not understand how everybody is capable of doing so much work.”

Lisa is a twenty-three-year-old first-year health sciences student. She has an older brother and one younger sister. Lisa belongs to an upper-middle-class family. She has two cousins from her mother’s side who have learning disabilities, and some of her friends also have learning disabilities. Her particular learning disability is processing speed; she took some time to grasp the things she is learning. Also, she has ADHD, and she thinks that “it is interesting to learn science with these disabilities”. Having a learning disability is hurting her family life, as due to her processing speed, miscommunication happens which leads to misunderstanding between her and her family and friends “who have no comprehension as to why she is doing certain things which they cannot understand.”

Lisa thought that socioeconomic status has no relation with LD, but that it plays a major role in accessing the treatments and equipment to overcome LDs. She is interested in the fields of human kinetics and physiotherapy. Therefore, she took science classes in high school. She

loves to help people, and as she likes to play hockey, she wants to help injured players. She was diagnosed with LD in grade 11 when she felt that she could not finish her school work on time. She was a smart kid but as the course material became more and more complex and challenging she felt that something was wrong with her, as she was putting more effort and time but struggling with the school work. Her school referred her for assessment, and she was diagnosed with LDs. The diagnosis of LD helped her get services from school and extra time and a computer for writing exams.

In grades eleven and twelve, Lisa took all the science subjects. Therefore, she encountered six different science teachers. Most of the teachers were very helpful after her assessment for LDs. However, one science teacher was strict, he always reluctant to accommodate her. She particularly talked about her biology teacher and chemistry teacher; these two teachers always helped her after class by going through the topics with her again. They also gave her their notes and told her if she could not understand they always available for her to answer any question she might have. She thinks that a teacher's specialization is critical and she was lucky that her science teachers had their Masters degrees in their respective science subjects, and due to this, they took an interest in their classes. They gave different engaging examples related to their science topics.

Lisa liked to study with a friend as it helped her in understanding the topic, and they together went to the teacher to learn chemistry which was hard for her to learn. She always asked for help from her chemistry teacher and together with her friend she went to her teacher after the class. The teacher taught her by explaining through different examples which gave her the opportunity to work it out in a variety of ways.

Lisa likes anatomy and physiology in her human kinetics major. She developed her interest in human kinetics in grade 11 when a new science teacher who had a degree in human kinetics from University of Ottawa taught one course and took the class to the trauma center, General Hospital, the University of Ottawa, where the Body World exhibition was going on. After that, the teacher took them to the hockey hall of fame and anatomy lab at the University of Ottawa. Therefore, this science exercise course gave her an opportunity to visit all these places and have an experience with human kinetics. In that course, she built a model of a human joint. This hands-on exercise gave her the experience of human body parts. Then, on the same course, they had to develop a diet for an athlete and then explained why they used those ingredients. She liked these hands-on examples. She said that the teacher makes 100% difference in learning science.

Lisa used books to understand the science topics, but with ADHD and LDs it was hard to grasp the concept with the books, she wished that books should be designed in such a way that students with ADHD could understand them. She liked books which have online editions, and students could use the online edition to do the exercises like understanding the human body. One time she got one book in which she has to color the different muscles to understand the various muscles in human body. That book was beneficial for her to the understanding of the muscles in the human body. Otherwise, most of the books were dry and very difficult to grasp the concept; after reading three to four pages if the student with LDs cannot understand a thing that the author is trying to teach, then that book is not very useful for students with LDs. Books should be written by keeping students with LDs in minds by the authors.

Lisa learns science by putting in lots of efforts as it was a “long interactive process.” First, she took notes in the class, then rereads the notes, consults the textbooks, visually saw the

process happening in a video. Then she asked for help from friends, and at the end asked the teacher for guidance to understand the topic. Labs did help, but after she understood the topic, otherwise, she could not do the lab as she needs the connection. According to her, “it was a very long process for me, and it took lots of study hours, and it is very frustrating.” She liked hands-on teaching strategies better than direct instruction and a combination of direct instruction and hands-on activities always very helpful for her to understand the science topics. She loved when a teacher explains briefly about the topic and then allowed students to experiment themselves. She learned a lot this way as compared to reading a book.

According to Lisa, if she was taught about the working mechanism of assistive technology then it always helped her in understanding and using that assistive technology. She gave an example of a computer program used in her lab ‘Lab Quest’ to help her to understand the chemistry experiment. However, this program was contour productive at the start of the semester as nobody taught her the mechanism of its working. However, as soon as she learned the mechanism of the program and how it worked after inputting the data how the program processes the data then she started using it and understanding the results of the analysis of the Lab Quest program. She used different assistive technologies for learning science, like “Dragon Natural Speaking” for reading books, “Smart Notepad” for taking class notes, and a clicker to submit an answer to the smart board. According to her, “Overall technology did help. However, it must need to be individualized.” She liked the blended learning approach, and she took those classes in her undergraduate program, she liked that in ECO 360 you can access the PowerPoint slides of the lecture with professor's voice. With ECO 360 if you missed something in class, you can access the PowerPoint and listen to what the professor was telling at that particular point on the topic. Blended learning was productive when she took part in the online portion, and it made a

huge difference; if no participation then it was counterproductive. Teachers have to take care of the student's involvement in the online discussions. The interactive website of her genetics course was the most interesting part of that website she performed the cross between two genomes and saw the phenotype of the test cross. The interactive website helped her in understanding various genetics concepts.

Lisa thought that she was lucky as she got the assessment for her LD and had her IEP, which made a huge difference in the understanding of the teachers and she was able to have accommodations that helped her in her science learning.

Owen

“Teachers make the science course harder or easier”

Owen is a twenty-one-year-old young man doing his first-year undergraduate degree in computer science. He belongs to a middle-class family. He has one sibling, and there is no history of LDs in the family. However, he has some friends who have been diagnosed with LDs. He has a learning disability along with Asperger's syndrome and attention deficit hyperactivity disorder. He got his IEP in high school. He thought his LD affects his family life, as it was hard for people to understand why he was not responding to their questions in a conversation. He went to a private elementary school and then a public high school.

Owen liked his science teachers except for his physics teacher as he was not accommodating. All other teachers were very accommodating and provided him extra time for tests and assignments. He liked his biology teacher very much, as she taught her biology topics like stories. All his science teachers have degrees in their science subjects. A class trip to a

chemistry lab at Carleton University made him interested in pursuing his undergraduate degree in the sciences.

While no one in Owen's family has a science degree, his parents encouraged him to pursue a science career due to his interest in science books from a young age. Additionally, his parents advised him that scientific fields have more job opportunities as compared to social sciences. He was curious about things from a young age and read many science books on Astronomy and Biology. He developed an interest in stars, plants and ecosystems, and the environment.

Owen's process of learning science was fascinating. For him to remember compounds names was a difficult task; he overcome this difficulty by singing the compounds name, and it makes a rhythm, and he wrote a poem on the compounds names. He thought that in learning science his parents' role was significant and without their encouragement and support, it would be difficult for him to pursue the scientific field. In his opinion, the role of technology was vital in learning science, as, due to web technology, he used chat rooms, discussion boards and asked help from other people in those rooms regarding his science subjects.

In Owen's opinion, teachers made the science course harder or easier to learn. He found physics courses harder than other courses, due to much math in the courses. He experienced direct instruction and hands-on activities for learning science in high school. He liked hands-on activities more in learning science and spent extra time in the lab in his school to learn science subjects. He liked that teachers gave at school homework and additional examples which prepared students in science subjects for the tough questions teachers going to ask in the exams.

Owen liked assistive technologies, but his experience with some assistive aids was not helpful. In his opinion, these technologies should be tested on a larger population before

becoming available for use by LD students. He liked the blended learning approach, but it should be more interactive and should involve the students in the learning process, so the student stays focused on learning. He liked to study in groups where all the students studying the same subject. In his opinion, “two minds always better than one to study together.”

Sarah

“LDs affected her life a lot”

Sarah is twenty years old. She has two sisters and one brother. There is no history of LD in her family. She has friends from high school as well as university who have learning disabilities. In her opinion “age definitely has an impact on learning disabilities, as LD was more obvious in younger age” because, at that age, she did not know how to deal with her LD. She said, “because you do not know how to manage your LD, however, when you are older, you can learn how to handle it with proper guidance and assistive technologies.”

Sarah thought that “LDs affected her life a lot”, particularly in career choice and deciding schools and fields of interest. LDs also affected her family life as it creates misunderstandings between her parents and siblings due to miscommunication. Socioeconomic status also plays a significant role in creating stressful conditions for persons with LDs. As she belongs to the lower middle class and attending a university with LDs, it creates much social pressure on her. LDs have a stressful effect on her school life, and she took a longer time to complete her high school. She had to work long hours to complete her assignments (e.g., if an average student completes his/ her assignment in one hour it took her 5 hours to complete that assignment. For a project, it took her months to complete it).

In her high school, Sarah had interactions with four science teachers. She thought that teachers have an important role in a student's future career choices, as in high school she did not like biology and never took biology. However, at the time of admission to the university, because she never took biology in high school she could not apply to medical school or any other health-related fields, although she liked health sciences fields. Therefore, science teachers have an important role in a student's life. She liked her chemistry teacher who made the learning chemistry fun, while on the other hand, a physics teacher made it a challenging subject to understand and learn. She wanted to be an engineer from very young age, however, in high school she was not a good student in physics and when she told her teacher about becoming an engineer, she discouraged her. With this discouragement from a physics teacher, she thought that due to a disability she could not go to her field of choice as teachers know better about their students. It tears her down, and she thought that "due to a disability I cannot grow or spread my wings and become what I want to be."

In Sarah's opinion, in high school, the language teachers and humanity teachers taught their students how to learn a language or to study humanity courses. However, science teachers never told their students how to learn science. In high school her average was 90% in all the courses, however, at the university, she failed for the first time in a Physics course. The reason was that she was not aware of how to learn physics at the university level. Her English high school teacher prepared her for university English courses. However, her science teachers did not prepare her for the University science courses. She was not the only one who faced this challenge; many other students faced the same challenge. She was a visual learner. Therefore, she had to watch a related video of the scientific process which teacher taught in the class; then she had to take notes and wrote the question and then she had to go to her teacher, who explained

the process on a one-on-one basis. Most of the time the teacher read books, and she could not understand the topic until she rereads it by herself. She could not ask questions in the class with 100 students around her. Therefore, she always asked the teacher after school time for meeting to explain it to her. She also records the lecture and listened to it at home while reviewing the lecture. She watched Khan Academy videos, and it had helped her understand her science subjects.

In Sarah's high school, she did not have an understanding of how to overcome her difficulties. Therefore, she just ignored the subject if she could not understand. This attitude hurt her in the end as the teacher did not know that she did not understand and when she asked for help at the end it was always too late to cover all the topics. She told me that:

My teacher did not know how to help me, and she gave up her efforts that I could not learn it and I am stuck, and I feel ashamed. However, it was different in university, then in high school, I just ignore the difficult topics at high school, but at the University I have the tools to learn the difficult topics. I also watched Khan Academy videos related to the topic to learn science.

The high school had a huge impact on Sarah as she did not like biology and she wanted to become an engineer, but her teacher told her that engineering was not a good fit for her. Her parents were also in agreement with the teacher, and it put much pressure on her. Parents suggested law or a social science field as a career choice, but she did not want that career. Therefore, to prove herself right she tried her best in the school and the University for her first year. She was on probation in the first year of Engineering at her university, which depressed her, and she wanted to prove it that she can do it. She thought that her teachers did not know how to teach her, as she never made a connection with the science teacher. It was hard for the teachers

to learn about so many disabilities and to make adjustments in the curriculum for each student. She was treated as any other person with a disability, which puts disabled students down. Teaching should be based on the strengths students with disabilities possess, and it would have huge effects on the students with LDs learning.

Mathematics was a hard subject for Sarah in high school as she could not visualize it and how to apply it in real life situations. Similarly, the mathematics part of physics was also difficult for her due to visualization of the equations. She liked her chemistry classes as they could do the experiments in the lab and the teacher explained that what they learned in theory as it was applied in the lab experiment (e.g., making solutions from mixing two liquids or mixing solid plus liquid). The teacher explained the ratios of the different substances in the mixture. It was straightforward to understand when doing it through hands-on activities. For this reason, she liked hands-on activities to learn science subjects, which were difficult in math for her in high school. Labs covered a lot of different strategies, and in labs, one can visualize what was happening at each step of the experiment. In making a solution when we combined two different liquids, the color changed which she could visualize. She always got above 90% marks in her labs in high school.

Assistive technology has an enormous effect on Sarah's learning, she used online books and watched Khan Academy videos on the bus coming and going to the school. She understands equations from watching these videos. Khan Academy videos explained step by step, how to solve the equations. She was using the online edition of textbooks as it was less expensive as compared to paper textbooks. She would like it if the teacher knows more about her learning style and used a combination of hands-on activities and direct instruction approaches to teaching her science subjects. She wished it could have happened with her in her high school science

classes. She liked that she had an interaction with the teacher while taking science classes instead of blended learning in high school. She believes that avoiding distraction in high school in blended learning classes is hard. While it is easy to control oneself in the university from distraction, she thinks that blended learning may be useful at the university as students have more time to understand the concepts.

Sarah wished that high school teacher would teach students how to comprehend science subjects, rather than just preparing the students to get good marks and pass science subjects and go to the university. Those two years of high school dictate the students' next 60 years of life. The last two years of high school were the most important part of a student's life in which contribution of teacher's matters; it could break or make a student. That is why high school teachers should help students with LD learn how to learn and understand science subjects rather than how to get marks. There is a huge difference between learning science in the high school and the university, as at the secondary level teacher's involvement is very important, while at University students have to take their own responsibility to learn. Sarah believes that students with LD are not prepared to learn science at the University level. Therefore, they prefer to go to humanities and social science majors as there are not huge steps to overcome to learn these subjects as compared to science subjects.

Ursa

“A science teacher who can motivate you in studies has a very critical role.”

Ursa was born in Quebec and completing the first year of her health science degree. She moved to Ontario in grade eight and started in a private school, and then she switched to public school two times during her high school. She was assessed for a learning disability in grade

seven. She is in her twenties now and has two older siblings and two younger siblings. She belongs to an upper-middle-class family. She has friends who also have learning disabilities. LD only has a minor effect on her family life, and she thinks that LD is a lifelong disorder. In her opinion, high socioeconomic status certainly helps in getting a psychological assessment and related services, which certainly assist in mitigating the drastic effects of LD.

Ursa divided her school life into two parts, grade 8-11, and grade 12. In grades 8-11, she was not concentrating on her education, and her report cards always stated that she was “not reaching full potential.” She never understood why she was getting those comments on her report cards, while she always attended her classes and submitted her homework on time. She was getting 65s in science subjects and math, the 70s in English and 80s in arts and music. She was also more interested in social life than school life at that time. However, in grade 12 she became serious about her studies because she wanted to go to the University and join a science major. She started asking for help from her science teachers after school and during lunchtime. Talking to teachers and getting their support turned things around for her and there was considerable improvement in her grades; her marks came into the 80s range. She knew that she had LD. However, she was not aware how to handle it in grade seven to eleven. However, in grade twelve, when she took help from her teachers, they helped her while keeping her learning style in mind.

Ursa’s parents, particularly her mom, identified that something was different with her while trying to help her in her studies. She tried to get her assessed for LD, and it was because of her mom’s efforts that Ursa was evaluated for her learning disabilities in grade seven. Her learning disabilities involved, processing speed, decision-making, reading fluency and word discretion. The school provided all the support, like teacher-parent interviews, and referred her to

a learning strategist where she went once a week, but she never paid much attention to her LD until grade twelve. She had a total of four science teachers during her high school and only one biology teacher. Her Biology teacher paid particular attention to her and helped her by giving extra time after class and at lunchtime to discuss the lecture again with her. In Ursa's opinion, "a science teacher who can motivate you in studies has a very critical role."

Ursa learned science by visualizing all of the topics in front of her. She put all the information related to the topic on a big poster and developed her narrative about the science topic. She put all the themes on a separate big single poster and thought about possible questions the teacher could ask about each item and has all the theme in front of her so she can understand all the steps related to answer the question. In this way, she put long hours in developing posters and visualizing all the information. She applied all the related information by visualizing and looking at the poster in front of her and by using her memory and her overall understanding of the topic to solve the question. She spent much time to create that narrative and lot of different drafts to develop a final draft. Her other friends learned science by memorizing the facts and recalling the description of facts, while she found that she cannot learn science that way; the words and memorizing the phrase were not her way to learn science. Her teacher liked her idea of creating the big poster and asked her to give it to her after her exams.

Ursa did not like science textbooks because those books were weighty, too much information to process, many questions, and their format was not very LD reader's friendly, and the print was tiny. On the other hand, she liked popular science books. These books gave her a clear picture to understand what it was all about. After reading a popular science book related to the science topic the teacher taught in the class, she went to the teacher and asked related questions that had arisen in her mind after reading the popular science book on the same topic.

Then she did the practice questions. First, she learned the bigger picture and then the details of the related topic.

Ursa also used assistive technology to memorize science facts. She used an app called “study blue” <https://www.studyblue.com/> which creates flashcards and quizzes and provides digital tools and study material for the memorization of facts. To learn pathways of different human mechanisms she made a binder to have a quick reference to relevant information to practice and to develop her narrative. This narrative helped her a lot in recalling the particular information. She had a binder for every subject which contains her narrative of each topic. She also met with each teacher after the class with her binder which had an introduction, of the subject and relevant information about the topic and the related questions she wants to discuss with the teacher. This narrative was developed in such a way that it flows and she can teach herself. It took a long time, but she loved it and loved these small textbooks she made by herself. These little books have pictures, important things with big fonts and in different colors, which made it easy for her to remember which things were more important to remember than others.

Ursa does not like physics, as it had too many numbers and equations and it needs full concentration, which was very difficult for her to give to a subject. She liked a combination of hands-on and direct instruction teaching strategies. First, she wants to do something with her own hands and then she wants a teacher to help her and explained it to her. She wants an interactive way to learn science. She wants assistive technology to be user-friendly and easy to understand and use. In her opinion, a blended learning approach should be interactive and engaging and not an online course. There should be discussions, and it should be rated according to engagement. It is useful for students with LD, as they can ask questions and answer questions, which was very difficult for them in a real classroom full of students and the teacher.

Ursa would like teachers to be more knowledgeable about learning disabilities, and more willing to help. Also, she found that the high school science curriculum was not the best to learn science, as it was inaccessible and it is more inquiry-based and needs curiosity to understand the science topics, which can be a challenge. It should celebrate the learning of science and not punish the student by not understanding it and the way it was taught in the high schools it does not fit with standardized testing.

Summary

Eight students with learning disabilities participated in this research project by telling their science learning experience through in-depth semi-structured interviews. Each of the participants was identified as having a learning disability at different stages in their lives. This research project examines how their science learning experience influenced their educational path. This chapter presented each of the participants with a short description of their family life and provide a detailed description of their science learning experiences. The next chapter continues their stories by bringing their science learning experiences to the forefront and organized them into four themes. These themes emerged from the interview data qualitatively collected and analyzed from semi-structured interviews with each of the participants.

CHAPTER 6

RESEARCH FINDINGS

6.1. Voices of the Students with LD on Learning Science

During the data analysis, the researcher inferred and constructed meaning from the students with LDs voices by returning to the experience of their learning about science subjects in high school (Lux, 2016). This narrative study aimed to understand the core of the phenomenon of interest, which was the experience of being a learning disabled high school student learning science. Focusing especially on this phenomenon of learning science with LD and more generally on the participants of this studies lived experiences with LD allowed for a way to intertwine the structural and textual dimensions together to convey the core of the phenomenon (Lux, 2016).

Four themes emerged from this qualitative, narrative study, each of which shares and lives within multiple environmental contexts:

- understanding of learning disability;
- finding resources and strategies for learning science with LD;
- learning science with the help of assistive technology
- learner autonomy and science learning experiences with LD.

In this chapter, the study findings are discussed using these above four central themes. Each of the themes is introduced with a short description followed by an examination of each theme explored through the view of each participant.

6.1.1. Understanding of Learning Disability

One common idea among all participants in this study was that at first none of them comprehended why they initially did not understand what the science teachers were trying to teach them in their classes. Second, it was always somebody else who identified their learning disability. For all of them, their parents acted as their primary source of knowledge, who helped them recognize their learning disability. None of the participant's parents had prior experience of learning disability. However, parents helped their children understand this disability and provided resources and extra help in developing strategies to overcome their difficulties in learning science and other subjects. After the diagnosis, all the participants never took their LD seriously until they were in high school and started to fall behind in learning science and math subjects. At that time participants realized that something was wrong, as they could not understand what the teachers were teaching in their science classes.

This awareness of their disability and the meaning-making that resulted from their experiences in the science and math classrooms have evolved for all of the participants. As the participants started to understand more about their learning disabilities and the difficulties associated with it in learning science, they tried to understand it through more knowledgeable persons (parents or disability counselor) or internet searches. This path to understanding their learning disability through new experiences and knowledge provided them opportunities to reconstruct or deconstruct their schemes of the learning disability. Some of the students, while

now in the university, still do not feel comfortable talking with teachers about their learning disability. However, in high school, they already developed their tools to overcome associated difficulties in learning science. In the next part of this chapter, we will see how these students understand their learning disabilities.

Brenda

Brenda's family had knowledge about ADHD but no knowledge about learning disabilities. Her family knew about ADHD as one of Brenda's cousins was diagnosed with ADHD when she showed difficulties in learning. When Brenda faced difficulties in learning at school, her parents thought about family genetics without any testing. They thought that as her cousin from her father side was diagnosed with ADHD therefore, Brenda got it from her dad who may be the carrier of this gene. Since family members already had direct experience with ADHD and its effects on different aspects of learning and life, her mother took it very seriously and took her to a neuropsychologist for assessment. Brenda diagnosed with a learning disability. As she belongs to the upper middle class, her mother put her in a private school. Brenda was performing very well in all the subjects above 85% except math in which she failed in elementary school. However, with her mother's efforts, she received accommodations (such as extra time and a computer) at school, with which she overcame her difficulties in learning science and all other subjects.

Britney

Britney diagnosed with a learning disability in her elementary school when her school referred her for assessment. It was a new thing for her and her family as nobody in their family

or friends had been diagnosed with LD before. Her family took it very seriously and put all their effort towards helping her succeed in school and in life. They arranged tutors and bring it in extracurricular activities such as music and dance so that if she did not perform well in school, she has some other choices for her life. Her father gave extra time to her to help her in studies and put special interest in school.

In grade six due to her IEP school administration enrolled her in a separate class for math and English. However, the level of segregated classes was not very challenging for Britney, and she did not like segregated math and English classes. She knew that her learning disability was in math and reading comprehension. It took her long time to understand a word and it affected her understanding of reading books and interpreting questions. In high school, she understood fully about her learning disability.

George

Learning disability was a new thing for George and his family, while George started speaking late due to which he was already in private special school, his family was not aware of his learning disability until grade eight. It was George who asked his mom that “is something wrong with him?”. He tried hard in school, but for some reason, he wasn’t making it. He wasn’t getting the grades he thought he should have had, and he wasn’t getting what most of the others around him did. He was confused and disoriented but thought nothing of it. Later on, he was diagnosed with a learning disability when his mom took him for his educational evaluation. Things were not easy for George at school and at home, however, with the help of his mom, he was able to get required help at school. George family has the resources, but it was also George who took first steps to understand his problems in learning. George was not aware of

depression, but he went online and got information about depression and then talked to his mom about it. Although his mother helped him a lot it was a math teacher who has a son with LD that recognized George's LD and started working and guiding George in his studies according to what he was doing with his son. George took his advice, and by looking things in different perspectives, changed his learning style.

Lila

Learning disability was not new to Lila's mom, as she faced some difficulties in learning at school but was never diagnosed with LD. Similarly, Lila's older sister also had some difficulties in learning. However, she was also never diagnosed with LD. Therefore, when Lila showed signs of difficulties in learning her family recognized that it was the same thing which her mother and sister faced in their respective schools. Lila herself took some time to understand it, why she was facing difficulties in her math and English learning. As Lila came from a small community where everybody knows each other, her teacher knew about her difficulties in learning and helped her in her studies. She was not aware of her learning disability at that time and was not sure how to explain in specific terms the nature of her disabilities and how they interfered in her studies.

She was assessed for learning disability in high school when Lila's family moved, and she enrolled in a high school in a big community. In high school when she started facing difficulties in math and science she asked her parents if there was something wrong with her. Lila's parents asked the school for her educational assessment, and the school referred her for the assessment. Lila was diagnosed with a learning disability. It was not a surprise to her parents. However, she was not sure about it. She did some online research and then she found all the

difficulties related to math, reading, and processing information students with LD faced in their studies. She compared herself and her difficulties in those subjects and understand the reason for her difficulties is the learning disability. Therefore, she took it seriously and worked very hard to overcome these challenges. She also has one friend who has a learning disability

Lisa

Lisa has no history of LD in her family. However, her two cousins from her mother's side have learning disabilities. Even at a young age, her father started teaching her math and other subjects at home after school, and she always faced difficulties in understanding math and science. Her father first understood her difficulties as a miscommunication on his part and lack of teaching experience. However, after her grades continued getting worse, he consulted her teachers, and they recommended evaluation for learning disability. Her parents had her assessed privately, and the result indicated learning disability along with processing speed.

Owen

There is no prior history of learning disability in Owen's family. His parents took notice of it when he started facing difficulties in completing assignments and could not finish his exams in the regular time. They talked with his teacher, and they recommend his assessment. His parents took him for evaluation and results showed that he had a learning disability. He specifically has a problem with concentration and attention deficit. After a diagnosis of LD, Owen developed his strategies in the light of the recommendations made by the neuropsychologist.

Sarah

Sarah has no history of learning disability in her family. She has friends with dyslexia, ADHD, and ADD. In high school, Sarah had difficulties learning math and science subjects and her parents, with the guidance of her chemistry teacher, took her for educational assessment. Sarah was diagnosed with a learning disability. However, she did not take it seriously until grade 12. In grade 12 Sarah became serious about her studies as she wanted to be in a science major in the University. Therefore, she researched her learning disability and developed her learning strategies for learning science.

Ursa

Ursa diagnosed with a learning disability in grade seven. She has a blended family but no history of LD in her family. Although she was diagnosed first time with LD in grade seven, however, Ursa did not care about her LD until grade eleven. She was mostly involved in social activities and where she had no problems due to her learning disability. Ursa did not take school seriously and had no idea how it would impact her field of employment. She also did not know how each grade builds on the year before; therefore, she had never cared about her learning disability until grade eleven. Ursa remembered that her mother noticed first time in grade three, that something was wrong with Ursa as she showed signs of struggles in her studies. Her mother put in long hours to make Ursa sit and study, as she could not concentrate on her studies. However, until grade seven Ursa did not get her educational assessment as her mom was not sure what was wrong with Ursa. After her educational evaluation, Ursa was diagnosed with a learning disability, and she received accommodations from school.

Theme Summary and Discussion

The research data in this study showed how participants developed their knowledge about learning disability. Specifically, knowledge construction about participants own identity as learning disabled played a role in their life. This knowledge construction about learning disability started with the family and within the family as it was always the parents who first introduced them with knowledge about participant's LDs. In one way of looking at it, it is always someone else who constructed the knowledge and introduced the participants to their learning disabilities. This knowledge about their LDs remains with the participants throughout their life, despite participants reconstructing or reframing the knowledge about their LDs years later. For example, Ursa was showing signs of struggling to start in grade 3 and was diagnosed with LD in 7th grade. However, it was in grade 12 that she reconstructed the knowledge about her LD again, and with this new awareness, she developed strategies to overcome her difficulties associated with LD in learning science.

In contrast, Britney's family helped her in every possible way, i.e., academically and by extra-curricular activities, because they wanted her to overcome her challenges in her studies. However, all participants in the beginning never understood about learning disability, as most of them were young when they first identified as a learning disabled, and their parents never discussed it openly with them. However, when they reached high school and faced difficulties in learning science and math, the participants realized that they had some problems in understanding these subjects. Most of them never took help from their teachers and schools as they considered it is labeling and they did not want to be labeled as having a learning disability. The participants' knowledge about learning disability evolved with time. The concept of learning disability and its role in their lives continued to be fluid, reshaped by the environments in which

they interact (Samuelsson & Lundberg, 2003). This evolution of the idea of a learning disability can be understood through transformative learning theory, which provides an additional framework to conceptualize the fluidity within this theme. Transformative learning theory is rooted in a constructivist epistemology, and it assumes that an individual's experiences and interactions with the world inform how knowledge and meanings are constructed. Also, one's experience and the meaning constructed from those experiences influences how he or she interprets and constructs meaning from future experiences (Lux, 2016). It is known that learning happens when a different viewpoint calls into question a previously held perspective (Cranton & Taylor, 2012). Therefore, transformative learning theory helps individuals remain open to new alternatives and leads them to accept change (Mezirow, 2012). Mezirow (1997) further states that a person's paradigm or worldview is transformed through a process of reflections of assumptions, validating beliefs through discourse, taking action on one's thoughtful insight, and critically assessing it.

In this study, transformative learning theory directly connected to the present theme of understanding of learning disability and Ursa's experience is one of the examples. She was able to understand to reconstruct the meaning of her learning disability and her socioeconomic status and how her parents afforded her tutoring by doing two jobs. Similarly, Britney told her parents that "in pull out classes she is not improving as teachers do not challenge her in her studies." She wants to be challenged so that she can work hard to learn math and science. The work of Gerber, Ginsberg, and Reiff (1992) is very significant in reinterpreting the learning disability experience more constructively by individuals with LD. Gerber, Ginsberg, and Reiff (1992) distinguished four steps, first a recognition of the learning disability. Second, accepting the LD as a part of oneself. Third, awareness about the LD's impact on the abilities of the individuals. Fourth taking

control to mitigate any barriers to success. In this study, all the participants reflected on their experiences as learners and how they perceived themselves and were perceived by others as students with LD. Therefore, all the participants in this study follow the above four steps of the reframing process of Gerber, Ginsberg, and Reiff (1992).

6.1.2. Finding Resources and Strategies for Learning Science with LD

Participants in this study emphasized the importance of having and using resources in developing their strategies for learning science. Among the resources noted, the most striking one is someone who is more knowledgeable (teacher, parent, peers) and who knows about the student's learning style. Vygotsky's (1978) theory of cognitive development (Eddy, 2010) explained about more knowledge other, in this theory Vygotsky explained that language is the most important means of gaining the knowledge and the student can learn from other people through language. If we see Vygotsky's definition of intelligence, which he defined as "the capacity to learn from instruction," this highlights the fact that there is a requirement for a more knowledgeable person. Vygotsky referred to this as more knowledgeable other (MKO). MKO's can be parents, teachers, coaches, friends and nowadays computers and the internet (Eddy, 2010).

All the participants in this research project identified their teachers as their MKO's, who provided support to them specifically relating to learning science with their learning disability. In addition to MKO's students also identified the use of a computer to access the internet to gain knowledge that aided their learning of science subjects. It was also evident, though, that the students were aware of their deficiencies and unpreparedness for learning science subjects when the MKO's or resources were altogether inadequate or absent. Participants with the guidance of

MKO's developed their strategies to enhance their learning capabilities by using assistive technologies to learn science subjects.

Furthermore, Eddy (2010) states that Vygotsky in his theory of cognitive development described the zone of proximal development (ZPD), as:

- Level 1 – the “present level of development.” Level 1 describes what the child is capable of doing without any help from others.
- Level 2 – the “potential level of development.” Level 2 means what the child could potentially be capable of with help from other people or teachers.

The gap between levels 1 and 2 (the present and potential development) is what Vygotsky (1978) described as the zone of proximal development. Vygotsky believed that through help from other, more knowledgeable people, the child could potentially gain knowledge already held by the MKO. Further, the knowledge must be appropriate for the child's level of comprehension. Anything that is too complicated for the child to learn that is not in their ZPD cannot be learned at all until there is a shift in the ZPD. When a child does attain their potential, this change occurs, and the child can continue learning more complex, higher level material (Eddy, 2010). In this study, all the students stated that in their science classrooms they did not understand what the teacher was teaching them about science topics. However, when at home with the help of MKO, i.e., computer and internet technology to access various websites they gained the basic knowledge of the subject and after that, they ask questions one on one with their science teachers, then they understood the science topics. The scaffolding provided by their teachers helped these students to overcome the difficulties these students were facing while learning science topics as explained below by the individual participants.

Brenda

Brenda was tested for LD two times, one in her elementary school, and again in grade 11. She was facing difficulties in her learning due to her processing speed. However, after getting accommodations at school and after getting help from her science teacher at school she was able to understand the science topics. Brenda told that “during the class, I had no questions as I did not understand anything during the class, my questions always be few days before the exam.” She further states that “when I do the problems of chemistry third time then I start discriminating and start understanding what I was learning in science subjects.” Also, “computer helps me try to keep up, with everything.”

Britney

Britney was in a segregated classroom for math and English in grade three. However, Britney was not satisfied with the level of teaching material in those segregated classes. She described how teachers in segregated classes, “did not teach us individually and I felt that it did not reach my level of understanding. The teacher did not trust me, they never challenged me.” Her parents took her from segregated classes and put her in general classes. She struggled in general classes at first. However, she developed her strategies, to overcome the difficulties she was facing in science classes. She stated that “in grade eight, I always wrote down everything, I learned to memorize everything, every single topic in science.” While, in grade eleven, “I started to take an interest in science and I was not memorizing anymore.” She began understanding the science topic. The way she was able to understand a science topic was, “to write to what my teacher told and then write it in my own words, in a way I could understand it. However, if I still

could not understand what the teacher was saying, I will go to the website of the book and look at how they explain.” She described her learning science as “it is all about practice.”

While describing the role of science teachers’ in learning science, she stated that “teacher helped me.” Her advice to the students with LD to learn science is that “You have to understand in parts the overall picture and add-on from the beginning to the end.”

Visuals, like diagrams, helped her in learning science. She stated that “I like most e-books which have animations. Like in her physiology e-book it showed animated muscles movement. This animation was moving, having a pause and going forward functions.” These features helped her in understanding the muscle movement as she can start and pause the muscle movement at any place and study in detail how the muscle system works.

George

While describing the role of science teachers in motivating his pursuit of a science field after high school, he still admired his one high school teacher who helped him in learning science. George said:

I cannot understand the theory of science subjects, so the teacher goes through with me with all the topics which I have difficulties in understanding. He gave me the unusual type of examples and allowed me to solve those examples in my way. He taught me how to look at the things in our lives in a different way. He showed the art of seeing the value in science. Now I know the values of science equations, and it motivated me in learning science. He opened a new way of thinking for me.

As for the role of science books in learning science, George said: “I always had two books on the same subject because when I read one book, it did not go through with me, but when I read the second book I understand as it explained the same science topic differently.”

George also discussed the role of assistive technology in learning science, he liked smart boards and a small iPad, and he thought the most amazing thing about the iPad is that one can use a special pen to write on the notes of the teacher's slides while the teacher was explaining about a science topic. He thought that technology did not help in motivation for learning. However, it assisted in keeping us working to learn science subjects.

Lila

According to Lila:

Our science program in high school was not very good. Science teacher was not much accommodative and was very strict. He always says that he does not understand why she has the problems with science topics, so it was little challenging in science with my disability.

On the other side, while describing her parents, Lila stated that:

My dad was very good with the computer, so he always looked for programs that could help me in learning science. I like my e-textbook on the computer. Sometimes my mom helped me by reading my science books to me, so help was more from home than school.

While describing the science teacher's role in her learning science, Lila stated that:

I had one fantastic biology teacher, who has a Ph.D. in biology and was very passionate about his subject, and biology was his life. Comparatively speaking he was the best among the three science teachers. He had extensive biology background experience that

is why he explained different biology topics with the various examples. He was not teaching by reading from the book, but he used hands-on stuff to teach us biology, and it was fun. He did not even make me feel bad while asking the question.

She further described the role of the teacher in a student life as:

While discussing the role of assistive technology, she stated that:

I obtained the pdf of the science books and put it on my computer and make the computer read to me. First, I tried myself to understand the topic by looking at YouTube videos to find the solution, and if I cannot, I go to the teacher.

She described her learning style as:

I found that I learned better by talking with peers. Sometimes books did not explain things you needed to understand the topic, so I would like to have a study group with my friends. I used many colors in my notes, it is easier for me to see the difference on the page and I like to paint important stuff in one color. Therefore, visual, audio and hand on learning all I used to learn science in my life.

Lisa.

Lisa got tested for a learning disability in grade eleven when she took the initiative and asked her mom: "I just do not understand how everybody is capable of doing so much more work than me how he or she manages their time." She found that as her science classes were starting to get more and more challenging, she was not able to finish her homework on time. Lisa went to her school physiologist and had referred for educational assessment where she was diagnosed with LD. Due to her Individual Educational Plan (IEP), she got extra time, a computer in the class, and teacher's notes. All these accommodations helped her overcome her difficulties

in science classes. After her documentation of LD, her science teachers became aware of her situation and accommodated her.

Lisa said that “chemistry teacher helped me by going through with me several chemistry examples where I can manipulate different variables, and it has helped me a lot in learning chemistry.” Lisa finds it very helpful to study together with a friend because if she does not understand something her friend can help her and they can work together to grasp the concept of the topic.

Lisa also consulted books to understand the science topics. However, she did not like the books as books are dry/boring, and it is a big hassle for her to read from a textbook. She thinks that textbooks should be designed according to peoples with learning disabilities and ADHD.

Owen

Owen liked his science teachers as most of them were very supportive of his learning disability. All of his science teachers were pretty understanding and gave him extra time for exams and assignments. He thinks that his teachers influenced him in choosing the scientific field for his further studies. Teachers made their science classes very interesting, and that makes him want to learn more. Science classes’ field trips invoked his interest in science as he could see real science and its direct effects on everyday life.

Owen got encouragement from his parents as they provided him science books when he was a young child. He read many books about stars and plants due to which he was interested in our ecosystem. He wrote a poem on plants’ respiration cycle.

Sarah

Sarah thinks that high school science teachers have huge effects on a student's choices of scientific fields in the university. She stated that "because when students were choosing what field they will go to the university, they considered the high school science classes they liked the most." While describing the influences of these school subjects, Sarah gave the examples of her chemistry and physics classes. She said:

I had an outstanding chemistry teacher who showed us not only the educational aspects of chemistry but also how fun it could be and what you could do with it. My physics teacher, on the other hand, did not do the same thing.

Sarah described her high school science teachers as: "they did not teach me how to learn science scientifically with LD, while my social science teachers taught us how to learn those subjects in the university."

She failed her first physics course in the University, and the reason she gave was that "I never failed a school subject in my life and was a 90% student in high school." However, I failed in the University Physics class, and the main part of why I did so poorly in that class was because I did not know how to learn or to study science course or learn those courses in university." She thinks that there is a huge gap between high school science and university science classes.

Ursa

Ursa's mom in grade three felt that Ursa was struggling at school as she was not getting good reports about her academic achievements. Her mom took charge and spent many hours after school to help Ursa to finish her homework and to concentrate and stay at her study desk.

Due to her mom's efforts, she was tested for learning disability in grade seven. After her IEP she was provided with support from the school. However, she did not receive any help from grade eight to eleven in school.

One of her grade twelve teachers noticed her potential in science and that was the turning point for her. It was her biology teacher, and she encouraged her to go for a biology major in the university. The teacher noticed that Ursa was trying her best to learn science by putting in an effort by asking questions, sitting in the front row, and seeing teachers after school and at lunch. Ursa stated that "I think having you know a science teacher who favors you is very important regarding motivating in studies." Ursa further elaborated her science learning as "science is learned, differently it was learned by the facts, memorizing the facts and recalling the description of facts." However, Ursa told that "I do not learn that way the words are not supportive of me along with remembering or memorizing the facts."

While talking about textbooks, she said:

I never liked the textbooks because there was too much information and I did not like the format. However, I liked the popular science because it gave me a bigger understanding of the topic. After understanding the topic then I would go to the teacher and I would ask them for practice questions, and then I would do the practice questions. However, I had to understand the bigger picture before diving into the detail part because I have to get around.

She described her process of learning science as follows:

My science learning process was to identify what learning strategy I have to use for science facts memorization; I took help from technology there is an app called study blue. I can access it anywhere as it is on the internet. This app uses flash cards turns the

flashcards into quizzes so that you can play with the material a bit more, so I am using this app for the memorization of science facts. Along with this app, I have one binder that I carry around with me at all times, and it is a key and a quick reference of important information which I can easily access at all times. I used material from lectures handouts and meetings with teachers. I arranged it in a way that it makes sense for me. It has an introduction, it has a beginning, and it just flows in a way that I can teach myself. It has many pictures, and I emphasized more important things in red font, bigger and highlighted so in that way when I go through it I know what to look at where I have to spend more time.

Theme Summary and Discussion

Participants recognized the importance of seeking help in learning science, as well as finding and using resources to learn science subjects at their high schools. The quantity and quality of support differed by a participant to participant. The help provided by participants' parents and families in the shape of their time or by providing resources such as tutors, books, and technology exerted a positive impact on all the participants' educational journey. Along with parents and family, participants also recognized the importance of their science teachers and some of them acknowledged their teacher's as helping individuals and partners in the participant's science learning. Peer support, school support services, and technology were resources that the study participants identified as influential components of their environment.

For most of the participants, their parents acted as an advocate and were actively involved in addressing the participant's learning needs throughout their K12 education. Participants who had effective parent support often sought out resources at school. Holt (2014)

stated that students with LD who had a positive relationship with their parents were less likely to feel shame and embarrassment with seeking academic help. These students would most often consider academic challenges as opportunities for engagement with their teachers and other resources. This also helps in effective academic behaviors including better preparation, organization, and engagement in classes.

The positive influence of More Knowledgeable Other (teachers and peer) as part of the institutional culture was noticeably evident among the participants in this research. Renn and Arnold (2003) examine the peer culture and said that peer culture's persistence and student success is very interrelated. A rich and deep peer culture likely helps the student to acquire the knowledge, confidence, and skills in the education system. George clearly benefited from his involvement with his peer's group discussions. Similarly, Brenda benefited from her involvement with her study group.

This theme, finding resources and strategies for learning science with LD, affirms the role of help-seeking behavior in science learning. Help-seeking behavior includes the awareness that help or support is needed. The kind of help needed is based on student's individual needs, and the motivation or willingness to request help (Newman, 2000; Pascual-Leone & Johnson, 2004). Help-seeking behaviour is necessary as it shows self-regulated learning along with cognitive and social skills with motivational attitude. These characteristics are required for a student with LD to acquire high-level thinking approaches needed for science learning (Newman, 2000; Pascual-Leone & Johnson, 2004; Wigfield, Eccles & Rodriguez, 1998; Wong, Harris, Graham & Butler, 2003). Participants of the study told about their strategies of learning science. These creative strategies for learning difficult subjects showed self-regulated learning. Owen's poem of names of compounds and George's techniques of look around in the world to

see the practical use of the scientific equations showed deep thinking skills and self-regulated learning.

6.1.3. Learning Science with the Help of Assistive Technology.

Assistive technology [AT] term is used for different devices that individuals with learning disabilities can use to learn at school and complete their homework at home (Flanagan, Bouck & Richardson, 2013; Martinez-Marrero & Estrada-Hernandez, 2008). Assistive technology is defined by Netherton and Deal (2006) as “any equipment that is used by a disabled person to accomplish specific tasks, improve functional capabilities, and become more independent.” Therefore, broadly speaking any technology used by the students with learning disabilities comes under the assistive technology e.g. internet, computer, computer software and YouTube etc. The Ontario Human Rights Commission (2014) states that “the Ontario Human Rights Law assures the right to same level treatment in education, without discrimination by disability, as part of the protection for equal treatment in services.” Education providers under the *Education Act* and *Ontarians with Disabilities Act* have a duty to accommodate students with learning disabilities up to the point of undue hardship as well.

It is essential for the teachers to be aware of these assistive technology tools, how to incorporate these tools into their classrooms, and how to provide support and instruction for students who use them (Flanagan, Bouck & Richardson, 2013; Karchmer-Klein, Mouza, Shinas & Park, 2017). These tools facilitate students with learning disabilities to overcome their impairment and be more independent in participating at school. It is also important to note that assistive technology devices as reported by Flanagan, Bouck and Richardson, (2013) had the highest report of never being used. The reason is the lack of support in training in the utilization

of the AT devices, which may result in creating hardships for students with LD's educational progress. In addition to students, teachers of students with LDs also stated that they did not feel prepared, were unsure of how to use technology, and they were unaware of how to effectively implement, integrate, and evaluate AT (Flanagan, Bouck & Richardson, 2013).

In Ontario students with learning disabilities are in general education settings and assistive technology can make it easier for students with and without disabilities to learn together (Kelker & Holt, 1997; Lewis & Struthers, 2000). The following statements from the participants of this study indicate that when students with learning disabilities are given assistive technology supports, students feel more self-confident (Martinez-Marrero & Estrada-Hernandez, 2008). Furthermore, assistive technology enables students to use tools that they feel at ease in handling to complete assignments, which in turn helps them feel proud of their work (Martinez-Marrero & Estrada-Hernandez, 2008).

Brenda

In Brenda's opinion, "Assistive technology helps things goes faster, as I am saying my whole process is going so slow my computer helps me try to keep up, with everything, so I think yes, it helps it just helps in keep up." She used her computer to access various websites to research and learn science topics. She used the Khan Academy website to make things clear and solidify her science concepts. She also used Kurzweil software to read online books it helps her to concentrate on the important concepts while reading the books by highlighting the relevant information.

Britney

While explaining the role of assistive technology in her science learning, she states that she used computers to explore books' websites along with Khan Academy and YouTube to learn science. She used Kurzweil software in reading, while it highlighted the word and lines while reading a textbook. Because the wording used in science textbooks is hard and it took many efforts to understand the message which is very difficult for a student with an LD. The Sky pen is also very helpful for her as if she missed something while taking her class notes, the Sky pen will record it, and she can go back and listen and understand that missing passage. The teacher's explanation about a specific topic is much better than the book for understanding. The notepad all on an iPad helped her in understanding Chemistry as she can write on the pdf notes her notes, and she can draw the chemistry diagrams. She is a visual learner, and she used videos and animated websites, where she can pause and understand the phenomenon what is happening at a particular moment. This visual and Kinetic function helped her in understanding science topics.

George

In George's opinion e-books are more efficient for him in learning science. He is using computers to access the internet to explore websites to learn science. He is interested in astronomy and cosmology, and reading software helped him in reading books. While reading books he used Kurzweil to read, and notepad to write notes on his iPad. In his opinion, "students with LD should have accesses to resources for learning how to use the assistive technology."

Lila

Lila used the natural reader. According to her, “while using a natural reader, I do not have to be reading, it can read to me. My main problem is solved by using a natural reader and watching YouTube videos for understanding science topics for most of the part.” In her opinion, assistive technology is helping her a lot in learning science. She said that “Science is pretty abstract and peoples become discouraged very easily. Assistive technology is playing a critical role in my life for sure.”

Lisa

Lisa is using assistive technology in understanding her lab work along with reading the books. In her opinion, she states: “I think assistive technology is beneficial and exciting in learning science.” Lisa uses a computer to access interactive websites on which to understand Genetics; she is performing the cross between different genomes, to see the effects of hybridization. She could see the transfer of the various genes from parents to offspring. These interactive websites are helping her in understanding various genetics concepts.

Owen

Owen likes assistive technology as it makes his reading textbooks very easy and exciting to know more about science topics. It also helps him study for exams as there are different formats for books and Kurzweil helped him by reading the books. However, he was of the opinion that students must be trained to use these technologies; otherwise, it is a waste of time and money. He used computers at school for distance learning for automobile courses which were not available at his high school.

Sarah

Sarah is using assistive technologies to record her class lectures which are very helpful when she studies at home for her homework. It is challenging for her to concentrate in class while surrounded by one hundred people. She said: “It makes me uncomfortable surrounded by so many people in the class, therefore, having recorded my lecturer I can go back and listen to the lecture.” She is also watching videos of Khan Academy to learn science topics by using her computers. She said that “at Khan Academy, they taught you to like as you are the only person. They also used different colors to highlight the important stuff.”

While talking about the role of assistive technology in learning science she stated that, I think it helps me. I have a laptop I put it on my lap, all my textbooks, all my notes open at the same time. I have a video of my lab experiment being conducted opened for me in which they explained how to perform the experiments and how to analyze the data. I can listen to music; I can listen to the audio textbook. Also, I can open another tab to look for something else.

Moreover,

On my phone, there is Khan Academy app on the bus I always watched the video lecture from Khan Academy on my way to the University or home. I have e-textbooks, which I cannot buy if they are only hardcover technology has an enormous impact on me as a student with LD.

Ursa

While talking about the role of assistive technology, Ursa stated that “I think it helps if the medium does not interfere with the learning.” She uses assistive technology in the shape of

an app called study blue, it creates flashcards and quizzes and develops study material for the memorization of facts. She wants assistive technology to be user-friendly, easy to understand and use.

Theme Summary and Discussion

Most of the assistive technology devices and software students with LDs now a day are using mainly helps students with LD in the areas of reading and writing. Although these devices and software programs are beneficial, they are costly and require significant training for the students. One of the software programs that students with LD are using is text-to-speech, Kelker and Holt (1997), as well as Raskind and Higgins (1998), wrote about the usefulness of the text-to-speech software. This software enables students to listen to a text and also interact with it (i.e., highlighting the relevant information, finding visuals, determining synonyms and antonyms of words). For example, if the students in a class are reading about the Genetics of some plants, the student who use this software can pull up the text on his computer. Therefore, this enables the student to read the same material as their peers. In turn, students can participate in the classroom discussions and works on assignments because they can hear the text. If a student wants to read an article that he founds on the Internet, the software will read it to the student. iPad and iPod are other devices that students can use to download apps (i.e., reading apps and math apps) to practice grammar. Dragon Naturally Speaking (DNS), is another app that helps students with learning disabilities, this app is a speech-to-text app (Chapelle & Sauro, 2017; Martinez-Marrero & Estrada-Hernandez, 2008) recommended this app due to its usefulness for the speech-to-text functionality. The speech-to-text app is beneficial in aiding those students with reading and writing disabilities in accessing the science textbooks. This app empowers the student to talk into

his iPod or iPad. While the student verbally dictates, DNS converts the speech into text. Once the student has completed the assignment by using DNS, he can listen to what he has dictated and revise his/her writing. After the proofreading process, the student may email his writing assignment to his teacher or save it in Dropbox app. The Dropbox is a free download app that can be shared with both the student and teacher. It can be accessed from a computer or tablet. There are different versions of DNS and some spell check and place punctuation in the appropriate locations.

Some obstacles need to be addressed when working with assistive technology. Most of the assistive technology devices and software are expensive, whereas others, like apps, are not. Another drawback to overcome is a lack of training; students must be trained fully to take full advantage of the assistive technology and software (Flanagan, Bouck & Richardson, 2013).

6.1.4. Learner Autonomy and Science Learning Experiences with LD

Encountering and responding to the expectations of increased self-sufficiency is a recognized developmental task in human development, particularly for adolescents and young adults (Howard & Tryon, 2002). One of the themes that emerged from the data was the process of moving toward increased learner self-sufficiency. Participants discussed the varied ways in which they refined their practice of learning, whether through metacognitive reflection or by responding to external expectations to adopt more autonomous learning behaviors.

How participants perceived and responded to this developmental task largely depended upon previous experiences in their high school networks of Microsystems, both at home and at school. Those who were accustomed to having advocates in their learning looked to resources available on campus. Other participants who entered university with a history of having minimal

advocates or neutral support systems primarily relied on metacognitive reflection and continued skill building in self-regulated learning strategies. Regardless of their pre-university experiences, all participants encountered relationships with others and themselves that evolved, pushing them toward becoming more autonomous learners.

Brenda

Brenda reflected on her high school science learning experiences; she indicated that she could have been a more engaged learner. She indicated a lack of motivation to be her biggest problem. Once in grade twelve when she decided to go to a science major, Brenda's academic motivation and performance improved. Even though she excelled academically in grade twelve, she felt that she could have invested herself more, particularly when she compared her effort then with her workload now. "I was not getting 80 or 90% marks, and I was not putting all of my efforts in my studies." She compared her high school self to how she responds to expectations for increased self-regulated learning now. Brenda has observed a certain resilience in herself.

Brenda stated that "in grade eleven when I decided to go to a science major, and I was not performing well, I told myself that I have to do this, I am capable of doing this."

Reflecting on those experiences, she realized that she is capable of self-discipline and perseverance, after all. She stated that

I have my tools, I have my stuff to manage I am a student like anybody else, and I can have good grades like anyone. I do not accept to be treated differently, although I accept some passion, I do not accept to be treated differently.

Britney

Britney reflected on her high school science learning, stating: “I do not understand chemistry questions, which is one of my main issues for me in learning science.” Another problem which she stated,

I feel teachers are not educated enough about how to approach different types of disabilities so that they might be good at teaching visually, but they are not good in other ways, like caring and trying kinetics to help me.

Furthermore, “even in my elementary school, my learning disability teacher taught everyone the same way while it should be taught separately based on their disabilities.” She thought that lack of experience of educating differently to different students was a factor when she went to the teacher to get help and teacher again taught her in the same way she was taught in the class which did not help her at all. Her experience with group projects was also not very pleasant. At the start of the school year as nobody in her group knows about her LD. Therefore, no team member understands why she was making mistakes in the group assignments. However, when she explained her disability, then they were able to understand her work and tried to help her. She worked very hard to pass the International Baccalaureate (IB) program.

George

George’s overall experience of learning science is, in his words:

I pretend that I am teaching someone and educating someone I have to know it by myself first. It helped in putting the theory like organic chemistry in my mind. I also usually tried to study in the same environment as I am in the exam. By trying to stay in that

environment which is very stressful and time-oriented environment very effective for me in learning science equations.

He further stated that

For students with LD, I think the most important thing would be to understand that it is going to be hard. Expect much judgment; you have to be strong. Science, teachers, should motivate the kid with LD to be involved in science learning.

Lila

Lila thinks that her school life was awesome, she loved science, and she like knew from the start that she wants to go to a science major in university. She stated:

When I was little, I want to go to science and there were a few bounces in the road, like some teachers who were not that much accommodative. I have to cross some hurdles with my disability, but I still think it was fun. I think science enhanced my learning experience in school and having a wonderful teacher who is willing to accommodate you, actually made a difference.

Lisa

According to Lisa her science learning experience was mixed but, she states:

I would say once I had my IEP the teachers were very understanding and accommodated. I was lucky again, and I know some people who did not get that kind of understanding, but I think overall, they were outstanding teachers.

Owen

Owen says: "I find that studying in a group helped me to learn science." He said that this process of learning science was very enjoyable, as he makes songs of the difficult compound names of chemical substances for memorizations. He spent more time in the labs to do hands-on activities to learn science concepts. He found that the lab experiments help him in learning science concepts. He remembered that his interest in science was developed by a chemistry lab visit at Carleton University.

Sarah

Sarah described her experience of learning in science class as:

I know for me if there are more hands-on learning during high school it was more beneficial for me. Having a teacher be more personal is better, and so the teacher will know how to teach you if he knows you.

Sarah also thinks that

LD brings student down in their education but having a teacher who is helpful is very beneficial for the student. Furthermore, I wish I was taught how to learn how to understand rather than how to get marks. It is a huge gap between learning science in university and learning science in high school.

Ursa

According to Ursa, her best strategy was trying to learn the topic and then meeting with the prof to clarify any misinterpretation she had about the science topic she had. Just by talking

to the teacher and clarify the misinterpretations put her on the right path. She stated that a “teacher’s nonverbal cues and their verbal cues helped me a lot.”

Sarah also adds that studying with somebody who is willing to help her in learning is very helpful for her in learning science; she says: “It is best to learn while study together.”

Theme Summary and Discussion

Greater learner autonomy was the desired outcome of reconstructed knowledge, self-assessment through social comparisons, and successfully identifying support or learning resources. It is for that reason, perhaps, that moving toward increased learner autonomy seemed to be the ultimate task the participants faced (Deci, Hodges, Pierson & Tomassone, 1992; Vogel & Adelman, 1992; Vogel, Hruby & Adelman, 1993). They described how they refined their practice of learning, whether through metacognitive reflection or by responding to external expectations to adapt more autonomous learning behaviors, such as self-regulation (Bandura, 1991; Zimmerman, 2002; Wong, Harris, Graham & Butler, 2003).

From an ecological lens, the force, resource, and demand characteristics (Bronfenbrenner & Morris, 2007) of each study participant influenced how this theme, the process of moving toward greater learner autonomy, presented itself within each of the participant’s stories as they talked about and reflected upon their experiences. The characteristics of each participant played particularly pivotal roles in how they cruised, climbed, or stumbled toward increased learner autonomy. Study participants had a wide variety of demand characteristics that could “invite or discourage reactions from the social environment” (Bronfenbrenner & Morris, 2007, p. 796). As an example, Britany archiving lecture PowerPoints on her iPad might invite a positive response from faculty who might view her as a serious and organized student. The variation in how

participants respond to their environments may also play a role in their progress (Samuelsson & Lundberg, 2003). George relied heavily on the support and mentoring that the math teacher provided him. How participants chose to engage or not engage in increasingly challenging activities and how they perceived their level of control influenced their progress toward greater learner autonomy. As an example, Britney and Sarah both stated that the academic success they experienced when taking science classes made them feel more in control of their learning as well as hone some helpful study strategies.

Self-regulation appeared to be a key component when study participants spoke of their movement toward becoming a more autonomous learner. Zimmerman (2002) described self-regulation as “the self-directive process by which learners transform their mental abilities into academic skills” (p. 65). This transformational process of proactively using one’s cognitive abilities to hone effective learning strategies consists of several related components:

- a) Setting goals and developing strategies to achieve the goals.
- b) Self-monitoring performance and progress toward goals, directing one’s own time and efforts towards a goal in an efficient manner.
- c) Sufficiently connecting cause and effect in one’s learning strategies, and
- d) Being able to make adjustments, as needed (Zimmerman, 2002).

CHAPTER 7

DISCUSSION, CONCLUSION, AND IMPLICATIONS

7.1. Discussion

This study aimed to investigate students with learning disabilities perceptions of learning science in high school and sought to understand the relationship between school environment and student with LDs acquisition of science concepts. This chapter presents an overview of the thesis chapters followed by a summary of the study. Subsequently, a discussion of the study's significance advocates its relevance in terms of reducing unemployment in individuals with learning disability by increasing their enrolment in the scientific fields. This thesis considered that currently, every field of employment make increasing use of technology, new prospects arise for people with a variety of abilities and disabilities. When students with learning disabilities and science teachers form good learning relationships, the potentials for academic and career success increases.

Learning disabilities are invisible disabilities and each individual's situation is distinctive. The best solutions for maximizing participation come about when the student and teacher work together to develop innovative alternatives to challenges faced by students with disabilities in their science learning. Such problems may arise when gaining and demonstrating scientific knowledge. Research (e.g., Dalton, Morocco, Tivnan & Mead, 1997; Jacobson & Archodidou, 2000; Marino, 2010; Mastropieri et al., 2006; Mastropieri & Scruggs, 2010;

McCleery & Tindal, 1999; Samsonov, Pederson & Hill, 2006; Scruggs, Mastropieri & Okolo, 2008) showed that students with LD faced difficulties thorough understanding of principles that reflect conceptual relationships between concepts, theoretical nature inherent in scientific concepts and processes. Most of the time, it takes just a little imagination, persistence, and good judgment to make it possible for everyone to contribute and learn.

This thesis argued that solid foundation for learning the skills and concepts of science are laid at the foundational level of school science by involving the students with learning disabilities in their science education. Listening to the students with LDs views about their learning science could contribute to the alleviation of the decreasing science enrollment in scientific fields in the post-secondary education.

This chapter continues with explaining the study's limits and directions for future research. The major implications for educators, policymakers and administrators are considered. Prior to the main deliberations of this chapter, this section recapitulates the development of the thesis.

7.2. Overview of Chapters

While chapter one established the research problem, aim and research foci of this study, chapter two positioned the thesis within current literature and offered an enlightening review of the literature pertaining to learning disabilities, types and characteristics of LDs, barriers/challenges and learning strategies, science education and instruction strategies, assistive technology, role of teacher and science education, student with LDs and teacher relation, student perception of learning, listening to the voices of student with LDs, theoretical perspectives and historical contexts. Empirical studies relating to learning disability and learning science were

reviewed validating the inclusion of the effect of the school environment in learning of science by the student with a learning disability.

Chapter three detailed the theoretical framing for this narrative study. Social Constructivism (Vygotsky, 1978) and Social Model of Disability (Oliver, 1990) were used as theoretical bases for this study. Vygotsky's Social Development theory is one of the foundations of constructivism. Social Development Theory asserts the fundamental role of social interaction in the development of cognition (Vygotsky, 1978), as he believed strongly that community plays a central role in the process of making meaning. Vygotsky (1978) put particular emphasis on the more knowledgeable other (MKO). More knowledgeable other is the one who has more knowledge, advance or a higher ability than the learner, for accomplishing a particular task or process. This MKO approach has a direct link in learning science of students with learning disabilities and the present study. And the Social Model of Disability (Oliver, 1990) believes that disability is not the fault of the individual and considers impairment as a difference instead of an anomaly, which can be overcome by changes in the political and social environments (Lee, 2013). The social model suggests disabled people's disadvantage is due to a complex form of institutional discrimination in the foundation of society. This study is influenced by Freire (2000) his research focused on those who were oppressed, dehumanized and made responsible for their own problems as are students with learning disabilities. Freire advocated radical change within schools and systemically to transform the individual, society, and education. Bauman (1976) claimed that institutions distort reality and that the voices of the marginalized needed to be included to redress this and challenge and change dominant perceptions.

The social model of disability paradigm by using the elements of challenge, empower and change is the base of the United Nations Convention on the Rights of Persons with Disabilities

(CPRD), adapted in 2006. The CPRD sets a paradigm shift for disability (Kayess & French, 2008). The paradigm shift consists in moving towards the inclusion of rights holders, using a social model framework that reclassifies disability as a human rights issue (Quinn & Degener, 2003). Shakespeare (1996) indicated that a researcher working in disability research was required to spend time with those who have disabilities and research conducted in this paradigm was not regarded as valid unless the researcher had extensive life experiences and involvement with individual or group under investigation.

Due to my own stuttering disability, I fulfilled this criterion. The social model of disability allowed the voices of the students with disabilities to be heard and allowed me to convey on their behalf to challenge and to hopefully initiate changes in school systems which will directly benefit students with learning disabilities and their teachers (see chapter 4).

The methods of the study were described in chapter four. It provided an overview and justification for a qualitative approach of case study methodology with elements of narrative inquiry to provide a detailed understanding of the process or experience of learning science (Reis, Neu & McGuire, 1997). To establish trust and rapport with students with learning disabilities I always identified myself as a person with a disability who also have a Ph.D. in one of the science subjects. The personal involvement and identification with disability community were regarded as integral to the paradigm of disability which informed this research (Oliver, 1997; Shakespeare, 1996). In particular, the analytical tools which guided the study were also comprehensively described.

The fifth chapter described the participant's overview of their demographic and a vignette of each and presented the findings, organized by themes which emerged from the data analysis. The chapter six interpreted and discussed the major finding in relation to the theoretical

perspective of this study. The findings were situated within current literature. Finally, the following seventh chapter reconstructs the study in summary. It reiterates the purpose and theoretical perspectives of the study and presents the major findings of the study according to the following main and three specific research questions.

How do students with learning disabilities perceive the experience of learning high school science?

More specifically:

- 1) What teaching approaches did students with LD find most useful in learning science?
- 2) What difficulties, if any, did students with LD encounter while learning science, and what learning strategies do they use to manage these difficulties?
- 3) How do students with learning disability perceive the role of assistive technology in learning science?

7.3. How do Students with LD Experience Learning Science?

The main research question broadly asks about the overall educational experience of students with learning disabilities learning science in high school and in chapter six the findings were discussed in more depth and according to different question themes of the main research question. While this chapter concisely summarizes the participants' science learning experiences and focuses how the social model of disability connects with the theory of cognitive development and more knowledgeable other (MKO). All of the participants talk in detail about the various factors that have affected them throughout their educational journey of learning science. They talk about how they came to understand the learning disability, how to live with it, who helped them in understanding about LD. They also spoke of the input of family and their

parents. They told their stories about learning specific science topics, what difficulties they faced in learning those science topics. How they manage those difficulties by having conversations with their peers; the help from their teachers; and the use of assistive technology (AT). In addition to helping from teachers, peers, and AT they also talked about developing their strategies to learn science topics. As a result, social cognitive processes of self-monitoring (Bandura, 1991; Siegel, 2003; Wiener & Siegel, 1992; Wong, Harris, Graham & Butler, 2003), as well as the development of and refining one's help-seeking behaviors, emerged as one of the themes in the findings of this study. This theme is crucial for students with LD learning of science as this quality of seeking help from more knowledgeable others support the role of mastering self-regulative learning which is essential for learning science.

In addition, the participants also discussed the mixed feelings of marginalization and associated labeling of LD at the school which impacted their educational experiences of learning science. As well as the participants talked about the development and advancement of assistive technology and it's positive and negative role in their journey of learning science. Student's family backgrounds and their relationships with other family members and family's role in their science learning were reviewed. Moreover, participants examined the effects of age at which the disability identified and its influence on their science learning. Furthermore, the participants explained how family socioeconomic status and parent's involvement influence their educational achievements. Finally, many students discuss the stigma associated being labeled as having a learning disability and due to the stigma, they choose not to disclose their disability to their teachers while learning science. These themes are going to be discussed as follows:

7.3.1. Family and Parental Involvement

Bronfenbrenner's Ecological Model (1979) can be used to understand the findings of this study. This model explains a child's development within the context of the system of relationships that form his/ her environment. It explains that the interaction between factors in the child's maturing, school's environment, immediate family environment and the societal landscape fuels and steers child's development (Samuelsson & Lundbeerg, 2003). The findings of this study confirm that the participant's age at which the disability identified influences the meaning the students with LD construct related to their LD and themselves as a learner. Along with identification of LDs the parent's involvement in child's education at home and in school together with their socioeconomic status has a direct impact on students with LDs educational achievements. These findings are in line with the Deslandes, Royer, Potvin & Leclerc (1999), they explained that home and school partnerships are very important for the learning-disabled student's educational achievements. As discussed in chapter 5 all of the participants consider the role of family and how parental guidance and support facilitate their growth as a science learner. These results were also supported by the research of Dyson (2003) who also observed that family support facilitates the individuals with LD to develop tools to overcome the difficulties related to learning disabilities.

All of the participants benefit from having parents who are supportive and advocate to ensure that their child's specific learning needs should be met at home and the school. Most notable is George's mother who not only helps him at home for his homework but also fought for her son's right to have special assistance in reading and math at the private French school. According to George, "My mother tried her best to convince the school to consider me as a student with LD. However, it did not happen until she hired a lawyer and he sent a notice to the

school. After the lawyer's interference, the school hired a special education teacher to help me in studies.” Other participants also talk about their positive parental involvement, including providing help in reading, doing the math, looking for software, providing tutors. For example, according to Britney, "she was diagnosed with LD in her elementary school, her parents pushed her hard in studies, and they were very strict on her about her studies. Due to the learning disability, dad gave most of his time to help me in studies."

7.3.2. Educational Environment

A few of the participants had access to science teachers in their high school experience that went above and beyond to assist them in learning science subjects. George had one teacher who has a son with dyslexia, and due to his own experience with his son, he taught George how to understand the science subjects. According to George, “the teacher gave me the same exercise as he gave it to other students. However, he just wrote the exercise for me in a different way as his son was receiving a similar type of exercises.”

The quality and nature of their science education were important for all the participants, as all of them want to go for a science career in their future life. All of the participants agree that a science teacher with a degree in their respective science subject has a huge difference in their learning of that science subject as compared to a science teacher with a degree in other disciplines. George personal experience with two of his teachers showed him that teacher's background matter. He took two physics in high school from two different teachers, one teacher's background was in Physics and second teacher's background was in chemistry. The depth and passion he saw in the physics class from the teacher with Physics background were amazing as compared to the chemistry background teacher teaching physics.

Furthermore, Brittney found her educational experiences to be frustrating when it came to the school's approach in how it addressed her learning challenges. According to Brittney, "while each student had a different disability but the teacher in the segregated classes taught all the students the same things in the same manner, while each student had different disabilities and each student learned differently." She thought that in segregated classes the level of teaching was shallow, teachers did not trust her, and they did not challenge her by not giving her tough exercises. Due to this, she has a stressful effect on her school life. These results of teacher's involvement in teaching science to learning disabled students are in agreement with earlier studies of (Chen, Morris & Mansour, 2015; Cloutier, 2016; Hattie, 2008; Katz & Dack, 2013; Lewis, Baker & Holding, 2015; Meador, 2017; Nye, Konstantopoulos & Hedges, 2004) who also states that teaching quality has a tremendous effect on the academic achievement of a student in the science subjects.

7.4. Teaching Approaches for Students with LD to Teach Science

The first sub-question deals with the approach of instruction students with learning disabilities liked to use in science classes which help them understand science subjects; because science learning involves the use of the "complex cognitive skills such as problem-solving, critical thinking, evaluating, analyzing and interpreting data" (Hartas & Donahue, 1997; Steele, 2007). These complex cognitive skills require high-level thinking skills because of that science courses may be especially difficult for students with LD (Steele, 2007; Wong, Harris, Graham & Butler, 2003). The participants in this study have the deficit in processing skills which is a common characteristic of students with LD (Salend, 2005; Wiener & Siegel, 1992). For example, Brenda described her learning disability as, "structuring and organization of sentences are the

significant problems along with processing while reading." Britney said that her learning disability is about reading comprehension, she took a long time to understand and it affects how she interpret questions. Lila has compromised visual processing skills, and she experiences difficulty interpreting what she sees. Students with compromised visual processing may have difficulty in interpreting illustrations of electrons. Memory deficits is another problem among all the participants of the study, with this deficit students with LD often have problems remembering what they see and hear (Steele, 2007; Swanson & Sáez, 2003).

The processing deficiencies are the most common deficiencies among the students with LD, and the participants in this study also experienced these problems. Among processing deficiencies, are the receptive language problems, with this shortcoming, students with LD have difficulty in understanding the language of others. Understanding the language is a particular challenge in science classes where teachers often used difficult vocabulary, scientific terminology, and abstract concepts, for example, geologic column, homeostasis, and hypothesis (Steele, 2007; Wiener & Siegel, 1992). Due to the language problem and processing speed students with LDs often reluctant to ask questions in the class and if some student with LD asks a question, it is always different from other students (Flax, Realpe-Bonilla, Hirsch, Brzustowicz, Bartlett & Tallal, 2003). For example, Brenda thinks her questions were always different from other students, and teachers consider her "questions weird." She feels that it is because she "processes the information differently." She felt being "cold-shouldered."

Most of the participants in this research project liked a combination of both of the direct instruction and the hands-on activities as teaching strategies for teaching science subjects. They liked that teacher explained first in the class about the topic and the procedure of doing experiments. By explaining first to the class students with LD processes the information and

when they got the chance of doing it by the hand in the lab, it becomes more understandable for them. Hand on teaching strategy as compared to direct instruction was more practical for all the students with LD in this study.

Similarly, blended learning is another teaching strategy which is getting importance nowadays at the school and at the University level. Blended learning approach will be helpful if the student with a learning disability has an interaction with the teacher in the online environment. This interaction with the teacher is important for the students with LD, as they need teacher assistance in understanding the concept. Blended learning approach is also useful as other students are asking different kinds of questions which will be helpful for students with LDs to process that information from those answers again.

In conclusion, participants in this study emphasized that science teachers should learn about different types of learning disabilities so that they have some understanding that how to teach these students. Dunham, Multon and Koller (1999) and Shafir and Siegel (1994) emphasized the classification of the subtypes of learning disabilities to understand the students with LDs needs in the classrooms. Teachers should be caring and try to connect with the students by using different methods of teaching. They should be aware of various methods of teaching so that they should connect with all the students in their class including able and disable students.

7.5. Strategies to Overcome Difficulties in Learning Science

The second sub-question deals with how the students with learning disabilities overcome difficulties if they faced while learning science subjects in their high schools. In pursuing scientific knowledge students with LD undoubtedly encountered obstacles due to the reasons beyond their control as admitted by all the participants. Moreover, most of the participants admit

that their early attempts to understand science subjects were not as successful and they faced challenges in understanding the science subjects especially physics and chemistry. Chemistry and Physics are the most important branches of science as these disciplines directly related to our living environment. These science subjects interplay between macroscopic and microscopic levels of thought which are central to further learning in both chemistry and other science subjects (Taber & Coll, 2003). To learn the science subject's learners, need a high-level skill set (Cronin, 1996; Taber & Coll, 2003). However, as stated by (Anonymous, 2015) "the best response to the inevitable stumble or obstacle is not to give up but to reflect on what you can do better, make adjustments, and persist." The participants in this study acted upon this advice and made adjustments according to their needs and overcame their struggles with learning science subjects.

Participants reflected that they need, time, guidance, and encouragement to be successful with new ways of learning science subjects, besides, they also devised their strategies to learn difficult science topics. For example, Owen devised his strategy to acquire scientific names of the compounds. He made a poem consisting of compound names. Similarly, Lila told that "she learned DNA transcription and translation by cutting the piece of papers and putting it together like DNA. She learned it very easily by doing it with her own hands rather than reading it from the books." Lisa used two different textbooks to understand the same topic. Brenda has to do the example questions before exams "three times" then she starts understanding what she was learning. She also makes the concept map and writes it in her own words. Britney learned in biology a Physiology theory topic "ON- and OFF-center Receptive Fields" through the diagram. She cut and pasted each step to try and understand what is happening at that particular step. She did this until the very end and then she started understanding it by getting the overall picture. Her

advice for science students to understand a topic is, "Start from the first step and understand it with the overall picture. Students have to figure out in parts the overall picture. Students add-on step by step their understanding of the phenomena." Lila said "I learned DNA transcription and translation by cutting the piece of papers and putting it together like DNA. It is straightforward by doing it with own hands rather than reading it from the books." According to Lisa, "it is a very long process for me, and it took many study hours, and it is very frustrating." She likes hands-on teaching strategies better than direct instruction strategies and a combination of direct instruction and hands-on activities always very helpful for her to understand the science topics. She likes when a teacher explains briefly about the topic and then allows students to experiment themselves. Ursa learned science by visualizing all of the particular topics in front of her. She put all the information related to the topic on a big poster and developed her narrative about the science topic. She put all the themes on a separate big single poster and thought about possible questions the teacher could ask about each subject and has all the theme in front of her so she can understand all the steps related to the answer of the question. George learned science by looking at the things in different perspectives. He looked around in the world and made connections between the science topic he is learning and how it is related to the world. He told that "science and math are directly related the world around us." His style of learning science topics is "to first understand the basic overall theory, and then act as a teacher to teach other students." He also simulates the exam environment and does the exercises so that at exam time he will not be distracted or stressed.

The strategies used by the participants to overcome difficulties in science are supported by research results of Liederman, Kantrowitz & Flannery, (2005) and Maccini, Gagnon & Hughes, (2002) who reported that students with LD faced difficulties in reading comprehension

and linking information to prior knowledge. Similarly, earlier research on learning disability showed that students with LD are less likely to have systematic plan to approach problems, have difficulty making inferences during inductive, deductive reasoning processes, and seldom transfer knowledge across contexts (Dalton, Morocco, Tivnan & Mead, 1997; Jacobson & Archodidou, 2000; Mastropieri et al., 2006). In addition, Samsonov, Pederson and Hill (2006) reinforced these findings by saying that to learn science, students with LD require a high degree of structure and guidance to manage the extensive information and time restrictions.

7.6. Students with LD and Role of Assistive Technology in Learning Science

Students with learning disabilities are using assistive technology for their daily life and especially in schools to work, play and associate with others. Ladner (2010) states that the social model of disability guides research for the development of assistive technology where consumers can participate to configure technology to suit their own needs and desires. In a social model of disability peoples with disabilities are part of the diversity of life they may not need any treatment, cure or special assistance, but by using AT, they can participate as full members of the society (Ladner, 2010). The term accessible technology employed by Ladner (2010) seems to fit better than the term assistive technology with the social model of disability because it focuses on alternative approaches to achieving goals rather than the paternalistic notion of needing assistance. Furthermore, Riemer-Reiss and Wacker (2000) also advocated that accessible technology devices help students with LD to learn and participate in society as contributing members by achieving their optimal functional ability and independence. Similarly, most of the participants acknowledged the importance of AT devices for learning science subjects. However, some of them are dissatisfied with these AT devices and services. Dissatisfaction regarding some

of the devices results in discontinuance of these AT devices which represents a waste of time and money (Riemer-Reiss & Wacker, 2000; Zigmond, 2003). Therefore, there is a need to gain an understanding of the factors associated with this discontinuance of these AT devices. According to the participants, the usability of AT devices depends upon how easy it is to learn, configure and use, these are the determining factor for the utilization of the AT device.

While discussing assistive technology devices, Brenda states that "Kurzweil make her life very easy. Kurzweil helps make concepts processing faster, as her processing is slow therefore it helps her to learn and process the information much faster." Britney also liked Kurzweil; she said that "Kurzweil helped me in reading a science textbook by highlighting and reading it to me. It assisted in reading the difficult word which she did not know." In addition to Kurzweil, "I also used sky pen to take notes in the science classrooms, as I can go back and listen to the teacher's lecture again." Lila said that "I used the natural reader for reading science books and watched YouTube videos related to science topics."

Lisa said, "Assistive technology is helpful for me after I got the understanding of its mechanism of working, I used lab quest a program in my lab. However, it was contour productive in the beginning, but, after learning what is happening behind the process, then she started liking it." Lisa is using different assistive technologies for learning science, like "Natural dragon speaking" for reading books, "Smart notepad" for taking class notes, clicker to submit an answer to the smart board. According to her, "Overall technology does help; however, it must need to be individualized."

Owen described his experience with the technology as, "technology is fundamental in learning science, as due to web technology, I am using chat rooms, discussion boards and asking help from other peoples in those chat rooms regarding my science program difficulties." He liked

assistive technologies, but his experience with some assistive aids was not helpful, in his opinion these technologies should be tested on a larger population before available for use by LD students.

Sarah told that “assistive technology has an enormous effect on her learning, she used online books and watched videos of Khan Academy on the bus coming and going to the university.” Ursa said that “I took help of the assistive technology to memorize the science facts, I used an app “study blue” which creates flashcards and quizzes and provides digital tools and study material for memorization of facts.” George used many apps like Kurzweil and notepad to read and write notes. So, when he wrote and spoke it aloud, if it did not sound nice, he knew that something was wrong in his writing.

The participants in this study share the same goal that they are all human beings with some limitations, and they want to work in science fields, and they are overcoming their limitations with their determination, motivation, with the help of their teachers, family, and accessible technology (Wehmeyer & Schwartz, 1997; Wigfield, Eccles & Rodriguez, 1998). They all believe that there are still barriers (for example diagnosis of LD, accessible technology, fellow students, faculty, and administration attitude) in high schools for students with LD to learn science. Through a social model of disability approach, these barriers can be removed by educating our society that everybody has limitations and by changing our behaviors and designing accessible technology anybody can overcome their limitation and become a contributing member of the community.

These results are supported by the research of Gardner, Wissick, Schweder & Canter, (2003) who stated that technology-enhanced learning activities foster dynamic environments that support active learning and problem-solving. Assistive technology can improve student learning

by supporting cognitive and metacognitive processes sharing the cognitive load (Marino, Sameshima & Beecher, 2009; Siegel, 2003; Wong, Harris, Graham & Butler, 2003). AT also eliminate the overuse of expository texts, which hinders learning for students with reading difficulties (Lancaster, Schumaker & Deshler, 2002). AT can provide students with alternative pathways to access science curriculum materials by translational, illustrative, summarizing, instructional, enrichment, notational, collaborative, and general purpose (Horney & Anderson-Inman, 1999).

The study's findings contribute significantly to the theoretical literacy perspectives in terms of understanding learning disability, school science pedagogy, science curriculum, and educational science policy.

7.7. Conclusion and Implications

This thesis is significant both theoretically and methodologically. On a theoretical level, it contributes new understanding by informing perspectives on the intricacies of learning disability and its relation to learning of science through the lenses of Vygotsky's Social Constructivism and Social Model of Disability. Methodologically, it contributes an analytical framework in the form of a matrix which used narrative inquiry to understand the perceptions of student's learning in the science classrooms. This allows a researcher or teacher to see what teaching practices encourage students with LDs to understand the science topic by asking and discussing the related question comfortably.

Moreover, the findings from this study move researchers and teachers toward a deeper understanding of how the experiences of students with LD of learning science contribute to the students' learning of science subjects. The four themes, which emerged from a thorough analysis

of the qualitative data collected, provide a foundation for further research and help to inform policies and practice for particularly secondary science education and along with post-secondary science education. This section discusses potential implications and opportunities for future studies, implications for practice, and recommendations for science teachers.

7.7.1. Implications for Research

As discussed in Chapter 1, significant research challenges exist as the result of noted gaps in the literature on science education and students with learning disabilities. This dissertation only provides information about a small portion of that gap. However, these findings may provide a snapshot for the researchers by contributing the true experiences of the students with LD of learning science during their school years. Moreover, this study also showed how students with LD experience and make meaning from their school environment as it developed them as a self-science learner. This particular study only deals with the science learning of students with learning disability. Therefore, it contributes to student development literature that is specific to students with disabilities. This study will facilitate future researchers to consider pursuing related topics in the learning disability field such as:

- What are the reasons why 35% of students with LDs drop out of school?
- What are the reasons why 62% of students with LDs unemployed a year after graduation?
- Why do 36% of youth in correctional facilities have learning disabilities?
- What are the reasons why 50% of adolescents who die by suicides have learning disabilities? (Learning Disabilities Association of Ontario, 2017).

Furthermore, this research project only deals with the experience of Undergraduate university students with LD in science faculties; there are opportunities for further research as to

study with students with LD in non-science related faculties and their experience of learning science. This study does not specifically take into account demographic variables within the participants. Future research should take into consideration specific demographic variables, for example, parents educational background, their socioeconomic statuses and different school boards like public school boards and Catholic school boards. Moreover, in this study, only eight students participated, future research could consider larger participants sample from the same institute or different institutions.

Additionally, in future studies along with students with LD, their parents, teachers, staff, friends, and peers could be included. Along with expanding participants' database, different data collection techniques may be employed such as focus groups and written narratives.

7.7.2. Implications for Practitioners

This study was conducted to understand the lived experiences of students with LD of learning science during high school. The findings of this research showed the experiences of these eight students and the meaning these students assign to the interactions of learning science with their learning environments. Therefore, these findings may help teachers, administration, parents, and students with LDs to understand the phenomena of studying of science in high school. The implications of these results are:

- The participants talked about their self-assessment by comparing themselves with their peers. They also talked about studying together with friends and peers. High schools may look at this finding as a way for the encouragement of peer mentoring.
- This study also showed that students with LD developed their strategies with the guidance of more knowledgeable others to learn science topics which revealed that

students with LD could become independent learners. Through metacognitive reflection, they work toward refining their practice of learning science through increased self-regulation. Teachers can help students with LD by providing more opportunities to reflect on their learning, study strategies, and their study behavior.

- All the participants agree that they benefitted from talking about their learning disability or learning challenges with their teachers. By acknowledging their learning disability and describing their style of learning they open up with the teacher and then the teachers took it as their responsibility to help these students by employing different strategies to explain science concepts to these students.
- Students with LD's face many challenges in the transition from high school to the university and especially in learning science subjects at the university (Halpern, 1985; Haring, Lovet & Smith, 1990). This study highlights the importance of this transition, high school teachers and administrators can help these students in improving their communications skills and science learning skills for a smoother transition to the University science faculties.

7.7.3. Implications for Parents and Families

Participants emphasized the role of their parent in their lives concerning their learning disability. All of them talked about the diagnosis of their learning disability and the role their parents played in this identification process. They also recognized their parents' efforts in making them understand their learning disability and how to overcome struggles in learning different subjects including science subjects at school. Parental contributions acknowledged by giving references how they helped in reading and writing from their elementary schools. Regarding the

conceptual framework of this study, i.e., a social model of disability, we can conclude that parents helped these students by interacting with external systems (schools, neuropsychologist) as described by Bronfenbrenner (1986).

It is critical that we learned from the experiences of these participants that self-regulated learning is a key to overcome difficulties at school and especially in learning scientific subjects. Parents and other family members can help students with LD in providing an environment where these students feel comfortable in seeking help or support from "More Knowledgeable Others" when they need. This comfortable environment will assist in developing behavior of these students of seeking help when they face difficulty in their studies and including science subjects. This seeking support from MKO and other available resources is a responsible and acceptable way to overcome difficulties (Lux, 2016).

In science learning, self-regulated learning is essential as described in one of the themes of this research thesis and it plays a major role in developing an independent learner. Therefore, parents and other family members can help students with LD to draw attention to self-regulated learning, and self-regulatory behaviors. This attention will help students with LD to develop their strategies for managing their struggles in learning difficulties in difficult learning situations (Denckla, 1996; Lux, 2016).

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APPENDIX A: CONSENT TO PARTICIPATE

Study Title: Perceptions of Students with Learning Disabilities Learning Science: A Narrative Study.

Researcher: Naveed Murtaza, University of Ottawa, Faculty of Education

The Study

I am conducting a study, as part of my Ph.D. at Faculty of Education, University of Ottawa, to understand the perceptions of students with Learning Disabilities learning science. The study intends to listen to student's views and perceptions about the science subjects and their learning in the science classrooms. I would like to discover what challenges these students are facing in science classrooms. Further, I would like to know if these difficulties have any influence on their selection of scientific fields in their future studies. The study is timely as an unemployment rate of youth with disabilities is doubled as compared to youth without disabilities. I would like to invite you to participate in this study. Your views and perceptions about studying science subjects will be very helpful. The study will help educators, administrators, and policy-makers who make informed decisions about the ways they use, develop and understand science curricula in Ontario.

Your Participation

You are completely free to participate or not. You may refuse to participate or decide to leave the study at any time. Your decision will not affect the study. If you do change your mind, any information that was collected from you (from conversations, interviews, and documents)

will not be used in the study. I invite you to participate in an individual interview. During the individual interview, you will spend about one hour speaking with me, face-to-face. You will be asked about your experience in science classrooms in learning science education. The interviews will be recorded. You have the right to ask me any question about any part of the research being conducted. The interview will be conducted at the University of Ottawa in working hours.

Confidentiality

All your responses to the interview questions and our conversations are strictly confidential. I will not use your name but will use a pseudonym. I will keep records in a safe location. The Research Ethics Board of the University of Ottawa may look at research records from this study. This is to verify that the research is done in agreement with the university's regulations for research involving people.

The research will be disseminated online and in printed form in the following ways:

- Ph.D. dissertation and potential book based on the dissertation
- Articles submitted to journals, and/or papers presented at conferences and possibly printed in proceedings
- A report and/or short articles for the field

You will be able to read an account of your interview and make changes to the text before it appears in its final form within an article, report, dissertation, etc. No personally identifying information will appear in the text.

Risks and Potential Benefits

There are no foreseen risks for you to participate in this study. There are no immediate benefits either.

Contact Persons

If you have questions about your rights as a participant in this study, please contact the university's research ethics representative.

For information requests or complaints about the ethical conduct of the project can be addressed to the Protocol Officer for Ethics in Research at University of Ottawa.

I understand the information in this form.

- I was able to ask questions and I am satisfied with the answers.
- I agree to participate in an individual interview.
- I have been given a signed copy of the consent form.
- I do not give up any of my legal rights by signing this form.

Signed by Participant

Print name

Signed by researcher

Print name

Date:

APPENDIX B: INTERVIEW GUIDE

Introduction of the interviewer

Hello, my name is Naveed Murtaza, and I am conducting a study, as part of my Ph.D. at Faculty of Education, University of Ottawa, to understand the perceptions of students with Learning Disabilities learning science. The intent of the study is to listen to student's views and perceptions about the science subjects and their learning in the science classrooms. I would like to discover what challenges these students are facing in science classrooms and what strategies they used to overcome these difficulties.

During the interview, I would like to discuss the following topics: science education and learning disability, difficulties and barriers in science learning, strategies used for learning science, the perception of learning science and the role of assistive technology in learning science. With these topics in mind

Demographic Questions:

| Main questions | Additional questions | Clarifying questions |
|--|----------------------|----------------------|
| Oh, you live in Ottawa. What do you like to do for fun? | | |

Science Education & Learning Disability Questions:

| Main questions | Additional questions | Clarifying questions |
|---|---|---|
| Can you tell me about your school life? | How did you learn that particular topic? | Can you expand a little on this? Do you have anything else to add? |
| How many science teachers you worked with? | Why were you interested in that topic? | |
| What do you think about science teacher's role? | What particular thing did you like on that topic? | |

| | | |
|--|--|--|
| Can you describe your science teachers? | What was the role of the teacher? | |
| How many science classes you took in your high school | Which books did you consult for learning that topic? | |
| Can you please tell me a story of learning any science topic? | Have you used any technology for learning that topic? | |
| Can you please tell me a story of your life about learning science? | Did you take help from your teacher or anybody else in understanding that topic? | |
| How do you see your school life related to science learning? | How do you explain the process of you learning science? | |
| In your experience, which science topics bother students the most? | | |
| In your opinion, what were the most difficult science topics in high school? | Why? | |
| Or | | |
| what were the easy ones? | | |

Learning Strategies and Assistive technology

| Main questions | Additional questions | Clarifying questions |
|---|---|---|
| Generally speaking, which learning strategies helped you in learning science? | If not, what are the main problems that you have encountered or faced while learning science? | Can you expand a little on this? Do you have anything else to add? |

| | | |
|--|--|---------------------------------------|
| <p>In your opinion, how assistive technology helped you in learning science?</p> <p>Do you know of any instruction strategy which helped you more in learning science?</p> <p>If so, ask the participant a question dealing specifically with this instruction strategy.</p> | | <p>Can you give me some examples?</p> |
|--|--|---------------------------------------|

Conclusion of interview

| Main questions | Additional questions | Clarifying questions |
|---|-----------------------------|--|
| <p>Are there any other learning strategies, particular assistive technology?</p> <p>Or</p> <p>Any problems that we have not discussed and that you find beneficial or worrisome while learning science in your school life?</p> | | <p>Can you expand a little on this?</p> <p>Do you have anything else to add?</p> |