A Formal Ontology for Special Needs Conditions

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ABSTRACT

Ontology deals with the conceptualization of domain concepts and the relationships among them while special needs conditions refer to any condition that requires assistance ranging from disability to giftedness and talentedness. Unified categorization of special needs conditions and the availability of comprehensive facts and knowledge about each category of special needs conditions have become major problems in the field of special education. It is, therefore, necessary to develop an ontology for special needs conditions that will unify the knowledge and fact about special needs conditions to support various decision-making in the special education domain. Hence, this research builds a formal ontology for special needs conditions that unifies the major categories of special needs conditions which are disability and giftedness, and talentedness, and includes various assistive technology that is applicable to each nature of special needs conditions. The knowledge engineering method was used to build the ontology while the language of formalization is Description logic. Web ontology language in protégé was used to implement the work and evaluated with competency questions in form of simple queries. This ontology can be adopted in all special education domains to forestall the problem of information overloading and inconsistency.

Keywords: Special needs conditions, Assistive technology, Ontology, Protégé.

1. INTRODUCTION

Ontology is concerned with what kinds of things exist and entities that exist in the universe. It is derived from the Greek "onto" (being) and "logia" (written or spoken discourse). Ding and Foo (2002) defined ontology as an important emerging discipline that has the huge potential to improve information organization, management, and understanding. In computer science, however, Gruber (1993) defines ontology as "a specification of a conceptualization". Keet (2020) opines that ontology is a text file containing structured knowledge about a particular subject domain. Special needs conditions, on the other hand, refer to any condition that requires assistance ranging from disability to giftedness and talentedness, with numerous sub-categories. A terminology being used generally for persons with disability is, "physically challenged" and there is no such terminology in special needs education. The term "Physically Challenged" describes only a limited portion of Persons with Special Needs (PSN) and it is wrongly used to mean "with special needs" (National Policy on Special Needs Education (NPSNE, 2015)). PSN conditions include persons with disability and gifted persons that require various adjustments throughout the study process and the environment because they inevitably encounter obstacles that prevent or impair their full and efficient inclusion and participation in the study process.

Understanding the nature of special needs conditions, their attributes and their causes go a long way in the early identification and categorization of special needs conditions. Searching for knowledge and fact about special needs conditions on the internet has always led to numerous discrepancies in answers about the categories of special needs conditions and knowledge engineering is one of the ways to solve this problem of information overloading and inconsistency.

Developing ontology for special needs conditions becomes necessary since ontology is a semantic web language that can solve the problem of information overloading and inconsistency. Bhogal et al (2007) stated that ontology is used to resolve ambiguities. Also, Julius et al (2011) opined that web personalization is one of the approaches to solving the problem of information overload which makes it easier for individuals to access relevant information on the internet. Ayorinde et al (2019) also stated that knowledge sharing over computer networks has made people more efficient in different tasks because it has broken down the barrier of time and distance.

Ontology is used to define classes or entities, individuals or instances, and relationships that exist between entities and instances of a particular domain with the use of formal languages such as resource description framework (RDF), web ontology language (OWL), extensible make-up language (XML), RDF schema (RDFS), Simple HTML Ontology Extensions (SHOE), ontology inference layer (OIL) as well as DARPA Agent Markup Language (DAML) + OIL. Ontology has been adopted in the special education domain to identify types of specific learning disabilities. However, no attention has been given to ontology building for categorizing special needs conditions as a whole. Global Education Monitoring (GEM, 2015) reported that the lack of data on individuals with disabilities is severely constraining the ability of the international community to monitor the situation.

Consequently, it is, therefore, necessary to develop an ontology for special needs conditions that will unify the knowledge and fact about special needs conditions to support various decision-making in the special education domain and to provide the person with special needs conditions an opportunity to have access to specific information about their nature of special needs. This will in turn enable the entire society, persons with special needs conditions, upcoming special educators as well as various decision-makers in the special education domain to become aware of the comprehensive fact and knowledge about special needs conditions to monitor the situation.

2. RELATED WORKS

Mythili et al (2013) stated that the cause of disease differs from one another but a common cause for most diseases is ignorance which is caused by the lack of knowledge about the symptoms indicated by the human body system. The authors developed an information system about diseases and symptoms using ontology with the aim of helping ontology users be aware of diseases and their symptoms to guide against their occurrence. However, the ontology developed did not cater to the disability that each disease can lead to. Similarly, Divakar et al. (2019) developed an ontology-driven machine learning model to foresee the occurrence of diabetes in females of the PIMA Indians database and make use of sensitivity (SN), Specificity (SP), Accuracy (ACC), and Matthew's correlation coefficient (MCC) to measure the classified efficiency.

However, the result of their model gives a 0.97% sensitivity score, 0.92% specificity score, 0.96% accuracy score and 0.88% MCC score with the use of a fine decision tree algorithm, and 0.97% sensitivity score, 0.97% specificity score, 0.97% accuracy score and 0.93 MCC score using support vector machine. Mohemad et al. (2017) developed an ontology model for classifying students with a learning disability using the top braid composer however, no ontology was built in this work but a model and learning disability handled in this work is one arm among various arms of special needs conditions.

Cramerottia and Ianesa (2016) developed a web-based decision support system, called ePlanning with the use of an ontology approach to support and facilitate the building of individualized education planning (IEP) however, this ePlanning web-based support system did not aim to classify special needs conditions but aimed at providing support for students certified for a disability. Cramerottia and Ianesa (2016) stated that IEP refers to the outcome of a collaborative activity that includes the school special education team, the teachers, the parents, if possible, the students, as well as other relevant educational and medical stakeholders. This type of plan is required by the Italian Law 104/1992 for students certified for a disability to promote inclusive education.

In the same vein, Julius et al. (2011) developed abilities and disabilities ontology for online learning and services (ADOOLES) with the aim of promoting inclusiveness among disabled students. However, some emotional disabilities are classified as mental disabilities in this ADOOLES. Mohemad et al. (2019) developed an ontology model for the early identification of children with specific learning disabilities meanwhile specific learning disability is one arm out of many arms of special needs conditions.

3. METHODOLOGY

Figure 1 shows the architectural design of the special needs conditions ontology. The system architecture analyzes the elicitation of knowledge which leads to the ontology model construction of two parts namely the knowledge base and the inference engine. The knowledge base part begins with the definition of terms and passes through the protégé processor to build the knowledge base using protégé (version 4.3.0). The bi-directional arrow between the knowledge base and inference engine indicates that communication is allowed to and fro the two links. The pointing arrow to a query in front of the user indicates that the query can be made by the ontology user to answer competency questions through the inference engine. The bi-directional arrow between the inference engine and answering of queries using some competency questions indicates that communication is allowed to and fro the two links as well.
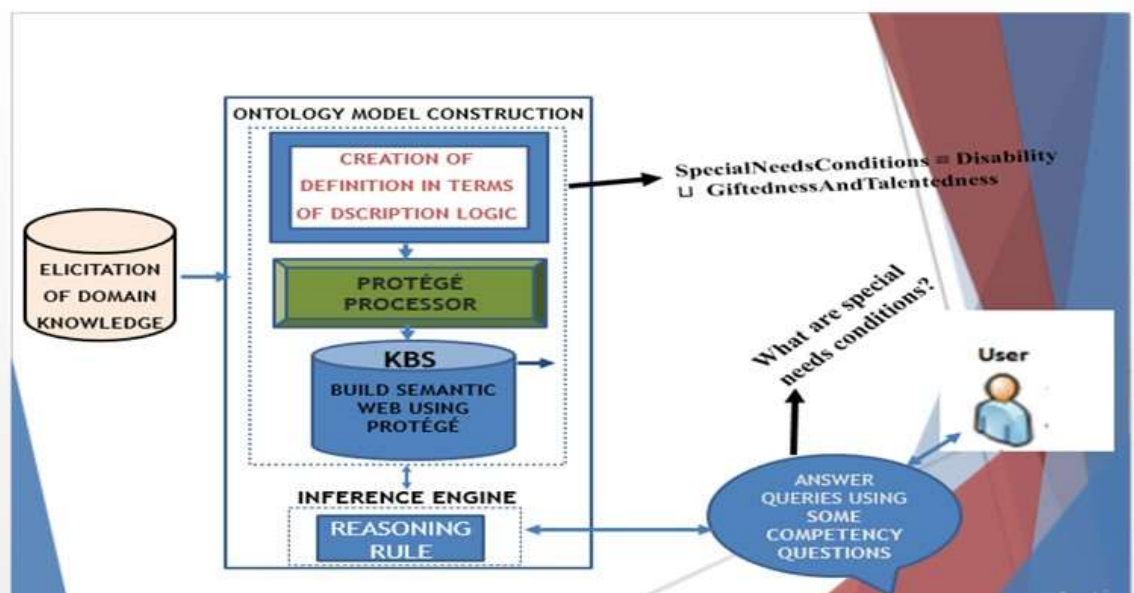

Figure 1: System Architecture

The principle of knowledge engineering was followed during the ontology-building process which includes the following:
A.   Elicitation of domain knowledge from expert sources (human, books, internet).
B.   Creation of definition for special needs conditions with the use of description logic.
C.   Generation of some competency questions for the purpose of testing.
D.   Implementation using Protégé.

3. ELICITATION OF DOMAIN KNOWLEDGE

Figure 2 shows the relationship between the categories of special needs conditions as elicited from expert sources (humans, books, internet).
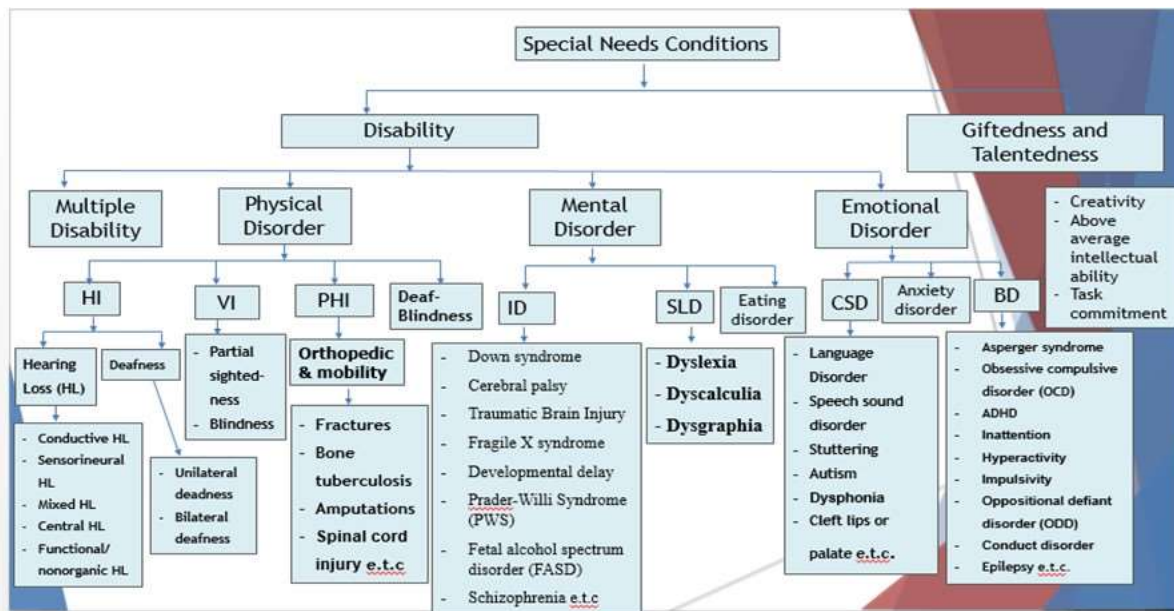
Figure 2: Special Needs Conditions Relational Diagram

3.1 Creation of definition for special needs conditions with the use of description logic

More than two hundred (200) axioms were created, documented, and implemented in this ontology for special needs conditions (OSNC). T-Box was used to define domain concepts while A-Box was used to define all domain facts and instances such as causes and features of each nature of special needs conditions, various Assistive Technology available for each nature of special needs conditions and R-Box were used to define the relationship that exists between the domain concept (T-Box) and the domain facts (A-Box). Below are some examples of the definitions created:

3.2 Domain Concept Definition (T-Box)

Definition 1:
Special needs conditions can be disability or giftedness and talentedness.

$$\text{SpecialNeedsConditions} \equiv \text{Disability} \sqcup \text{GiftednessAndTalentedness}$$

Definition 2:
Disability refers to mental, emotional, physical, and multiple disabilities and has assistive technology as a remedy.

$$\text{Disability} \equiv (\text{MentalDisability} \sqcup \text{EmotionalDisability}$$
$$\sqcup \text{PhysicalDisability} \sqcup \text{MultipleDisability}) \sqcap \exists\text{hasRemedy. AssistiveTechnology}$$

Definition 3:
Giftedness and talentedness refer to creativity, above-average intellectual ability or task commitment, and assistive technology as support.

$$\text{GiftednessAndTalentedness} \equiv (\text{creativity} \sqcup \text{AboveAverageIntellectualAbility} \sqcup \text{TaskCommitment}) \sqcap$$
$$\exists\text{hasSupport. AssistiveTechnology}$$

Definition 4:
Assistive technology refers to devices, software, or services and it is for special needs conditions and needed by a person with special needs conditions.

$$\text{AssistiveTechnology} \equiv (\text{devices} \sqcup \text{software} \sqcup \text{services})$$
$$\sqcap \exists\text{IsFor.SpecialNeedsConditions}$$
$$\sqcap \exists\text{NeededBy.PersonWithSpecialNeedsConditions}$$

Definition 5:
Creativity refers to fluency, flexibility and originality of though, curious, open to new experiences and ideas.

$$\text{Creativity} \equiv \text{fluency} \sqcup (\text{flexibility} \sqcap \text{OriginalityOfThought})$$
$$\sqcup \text{curious} \sqcup (\text{OpenToNewExperiences} \sqcap \text{ideas})$$

Definition 6:
Above-average intellectual ability refers to a high level of abstract thought, adaptation to a novel situation, rapid and accurate retrieval of information

$$\text{AboveAverageIntellectualAbility} \equiv \text{HighLevelOfAbstractThought}$$
$$\sqcup \text{AdaptationToNovelSituation} \sqcup (\text{Rapid} \sqcap \text{AccurateRetrievalOfInformation})$$

Definition 7:
Task commitment refers to hard work and determination in a particular area, self-confidence, and drive to achieve, capacity for a high level of interest, enthusiasm

$$TaskCommitment \equiv ((HardWork \sqcap DeterminationInAParticularArea)$$
$$\sqcup (SelfConfidence \sqcap DriveToAchieve)$$
$$\sqcup CapacityForHighLevelOfInterest \sqcup enthusiasm$$

Definition 8:
A person with special needs conditions is defined as an individual with a disability or born with giftedness and talentedness

$$PersonWithSpecialNeedsConditions \equiv PersonWithDisability$$
$$\sqcup GiftedPerson \sqcap \exists (hasCondition. Disability \sqcup bornWith. GiftednessAndTalentedness)$$

Definition 9:
A person with a disability refers to a person that has a condition called disability which is caused by disease or injury.

$$PersonWithDisability \equiv Person \sqcap \exists hasCondition.Disability$$
$$\sqcap \exists PersonDisabilityCausedBy. (Disease \sqcup Injury)$$

Definition 10:
A gifted person refers to a person born with giftedness and talentedness which is caused by genetic makeup and environmental simulation.

$$GiftedPerson \equiv Person \sqcap \exists bornWith. GiftednessAndTalentedness \sqcap$$
$$\exists GiftednessAndTalentednessCausedBy. (GeneticMakeup \sqcup EnvironmentalSimulation)$$

Definition 11:
Special needs conditions cause refers to disease or injury or environmental simulation or genetic makeup

$$SpecialNeedsConditionsCause \equiv (Disease \sqcup Injury)$$
$$\sqcup (EnvironmentalSimulation \sqcup GeneticMakeup)$$

Definition 12:
Multiple disabilities refer to concomitant (simultaneous) impairments but do not include deaf-blindness

$$MultipleDisability \equiv ConcomitantImpairments$$
$$\sqcap \exists \neg (DeafBlindness)$$

Definition 13:
Physical disorder refers to hearing impairment, visual impairment, physical and health impairment, or deaf blindness.

$$Physical\ disorder \equiv HearingImpairment \sqcup VisualImpairment \sqcup$$
$$PhysicalAndHealthImpairment \sqcup DeafBlindness$$

Definition 14:
Mental disorder refers to an intellectual disability, specific learning disability, or eating disorder

$$MentalDisorder \equiv IntellectualDisability$$
$$\sqcup SpecificLearningDisability \sqcup EatingDisorder$$

Definition 15:
Emotional disorder refers to communication and speech disorder, anxiety disorder, or behavioural disorder

$$\text{EmotionalDisorder} \equiv \text{CommunicationAndSpeechDisorder}$$
$$\sqcup \text{AnxietyDisorder} \sqcup \text{BehaviouralDisorder}$$

Definition 16:
Hearing impairment refers to hearing loss or deafness

$$\text{Hearing impairment} \equiv \text{HearingLoss} \sqcup \text{deafness}$$

Definition 17:
Hearing loss refers to conductive hearing loss, central hearing loss, sensorineural hearing loss, mixed hearing loss, functional or nonorganic hearing loss

$$\text{Hearing lossH} \equiv \text{ConductiveHearingLoss} \sqcup \text{CentralHearingLoss}$$
$$\sqcup \text{SensorineuralHearingLoss} \sqcup \text{MixedHearingLoss} \sqcup$$
$$(\text{Functional} \sqcup \text{NonorganicHearingLoss})$$

Definition 18:
Deafness refers to unilateral deafness or bilateral deafness

$$\text{Deafness} \equiv \text{UnilateralDeafness} \sqcup \text{BilateralDeafness}$$

Definition 19:
Visual impairment refers to partial sightedness or blindness

$$\text{VisualImpairment} \equiv \text{PartialSightedness} \sqcup \textbf{blindness}$$

Definition 20:
Physical and health impairment refers to orthopedic and mobility disorder

$$\text{PhysicalAndHealthImpairment} \equiv \text{OrthopedicAndMobilityDisorder}$$

Definition 21:
Orthopedic and mobility disorder refers to spinal cord injury, bone tuberculosis, amputations, or fractures

$$\text{OrthopedicAndMobilityDisorder} \equiv \text{SpinalCordInjury}$$
$$\sqcup \text{BoneTuberculosis} \sqcup \text{amputations} \sqcup \text{fractures}$$

Definition 22:
Deaf-blindness refers to concomitant (simultaneous) hearing and visual impairment.

$$\text{DeafBlindness} \equiv \text{ConcomitantImpairment}$$
$$\sqsubseteq (\text{HearingImpairment} \sqcap \text{VisualImpairment})$$

Definition 23:
Intellectual disability refers to Down syndrome, cerebral palsy, traumatic brain injury, fragile x syndrome, prader-willi syndrome (PWS), developmental delay, fetal alchohol spectrum disorder (FASD), or schizophrenia

$$\text{IntellectualDisability} \equiv \text{DownSyndrome} \sqcup \text{CerebralPalsy} \sqcup$$
$$\text{TraumaticBrainInjury} \sqcup \text{FragileXSyndrome} \sqcup \text{PraderWilliSyndrome}$$
$$\sqcup \text{DevelopmentalDelay}$$
$$\sqcup \text{FetalAlcoholSpectrumDisorder} \sqcup \text{schizophrenia}$$

Definition 24:
Specific learning disability refers to dyslexia, dyscalculia, or dysgraphia

SpecificLearningDisability ≡ dyslexia ⊔ dyscalculia ⊔ dysgraphia

Definition 25:
Communication and speech disorder refers to language disorder, speech sound disorder, stuttering, autism, dysphonia, cleft lips.

CommunicationAndSpeechDisorder ≡ LanguageDisorder ⊔ SpeechSoundDisorder
⊔ Stuttering ⊔ Autism ⊔ Dysphonia ⊔ CleftLips

Definition 26:
Behavioural disorder refers to Asperger syndrome, obsessive-compulsive disorder (OCD), attention deficit hyperactivity disorder (ADHD), inattention, hyperactivity, impulsivity, defiant behavior, oppositional defiant disorder (ODD), conduct disorder, and epilepsy.

Behavioural disorder ≡ AspergerSyndrome ⊔ ObsessiveCompulsiveDisorder
⊔ AttentionDeficitHyperactivityDisorder ⊔ inattention ⊔
Hyperactivity ⊔ impulsivity ⊔ DefiantBehavior ⊔
OppositionalDefiantDisorder ⊔ ConductDisorder ⊔ epilepsy

3.2.1 Facts (A-Box)

i. Causes of Each Nature of Special Needs Conditions (A-Box)

1. Abnormal brain development causes cerebral palsy

causes (AbnormalBrainDevelopment, CerebralPalsy)

2. Accidents cause concomitant disorder or orthopedic and mobility disorder

{accidents} ⊑ ∃causes. {ConcomitantDisorder}
⊔ {OrthopedicAndMobilityDisorder}

3. Age-related hearing loss causes deaf-blindness

causes (AgeRelatedHearingLoss, DeafBlindness)

4. Age-related macular degeneration causes partial sightedness or blindness

{AgeRelatedMacularDegeneration} ⊑ ∃causes. {PartialSightedness}
⊔ {blindness}

5. Albinism causes partial sightedness

causes (albinism, PartialSightedness)

6. Arthritis causes deafness or spinal cord injury

{arthritis} ⊑ ∃causes. {deafness}⊔ {SpinalCordInjury}

7. Auditory nerve dysfunction causes sensorineural hearing loss

causes (AuditoryNerveDysfunction, SensorineuralHearingLoss)

8.   Bacterium mycobacterium tuberculosis cause bone tuberculosis
                    causes (BacteriumMycobacteriumTuberculosis, BoneTuberculosis)

9.   Blow to the head causes traumatic brain injury
                    causes (BlowToTheHead, TraumaticBrainInjury)

10.   Poor body shape causes an eating disorder
                    causes (PoorBodyShape, EatingDisorder)

11.   Poor body weight causes eating disorder
                    causes (PoorBodyWeight, EatingDisorder)

12.   Brain damage causes sensorineural hearing loss or behavioural disorder
                    { BrainDamage} ⊑ ∃causes. {SensorineuralHearingLoss}
                                   ⊔ {BehaviouralDisorder}

13.   Brain injury causes partial sightedness or ADHD or cerebral palsy
                    { BrainInjury} ⊑ ∃causes. {PartialSightedness}
                                   ⊔ {ADHD} ⊔ {CerebralPalsy}

14.   Break in bone causes fractures
                    causes (BreakInBone, fractures)

15.   Bump to the head causes traumatic brain injury
                    causes (BumpToTheHead, TraumaticBrainInjury)

16.   Cancer causes spinal cord injury
                    causes (cancer, SpinalCordInjury)

17.   Cancer of the eye causes partial sightedness
                    causes (CancerOfTheEye, PartialSightedness)

18.   Car accident causes traumatic brain injury
                    causes (CarAccident, TraumaticBrainInjury)

19.   Cataracts cause blindness
                    causes (CerebralPalsy, DeafBlindness)

20.   Cerebral palsy causes deaf-blindness
                    causes (CerebralPalsy, DeafBlindness)

21.   Chicken pox causes deafness
                    causes (ChickenPox, deafness)

22. Chromosome abnormalities cause concomitant disorder or intellectual disability or specific learning disability

$$\{ChromosomeAbnormalities\} \sqsubseteq \exists causes. \{ConcomitantDisorder\}$$
$$\sqcup \{IntellectualDisability\} \sqcup \{SpecificLearningDisability\}$$

23. Cochlea dysfunction causes sensorineural hearing loss

causes (CochleaDysfunction, SensorineuralHearingLoss)

24. Coercion from parent causes behavioural disorder

causes (CoercionFromParent, BehaviouralDisorder)

25. Complete retinal detachment causes blindness

causes (CompleteRetinalDetachment, blindness)

26. Complication during birth causes specific learning disability

causes (ComplicationDuringBirth, SpecificLearningDisability)

27. Congenital anomaly causes orthopedic and mobility disorder

causes (CongenitalAnomaly, OrthopedicAndMobilityDisorder)

28. Constant hunger causes obsessive compulsive disorder

causes (ConstantHunger, ObsessiveCompulsiveDisorder)

29. Cytomegalovirus causes deafness

causes (cytomegalovirus, deafness)

30. Damage to the ligaments causes spinal cord injury

causes (DamageToTheLigaments, SpinalCordInjury)

31. Damage to the spinal cord itself causes spinal cord injury

causes (DamageToTheSpinalCordItself, SpinalCordInjury)

32. Damage to the vertebrae causes spinal cord injury

causes (DamageToTheVertebrae, SpinalCordInjury)

33. Defective eardrum causes conductive hearing loss

causes (DefectiveEardrum, ConductiveHearingLoss)

34. Defects in the central nervous system causes central hearing loss

causes (DefectsInTheCentralNervousSystem, CentralHearingLoss)

35. Deletion of a part of chromosome 15 passed down by the father causes prader-willi syndromw

causes (DeletionOfAPartOfChromosome15PassedDownByTheFather,
PraderWilliSyndrome)

36. Delayed puberty causes obsessive compulsive disorder

causes (DelayedPuberty,ObsessiveCompulsiveDisorder)

37.   Delay in learning to read causes dyslexia
                         causes (DelayInLearningToRead, dyslexia)

38.   Diabetes causes deafness or partial sightedness
                         {diabetes} ⊑ ∃causes. {deafness} ⊔ {PartialSightedness}

39.   Diabetic retinopathy causes blindness
                         causes (DiabeticRetinopathy, blindness)

40.   Difficulties after birth causes concomitant disorder
                         causes (DifficultiesAfterBirth, ConcomitantDisorder)

41.   Direct hit or kick to the body causes fractures
                         causes (DirectHitOrKickToTheBody, fractures)
42.   Disease causes orthopedic and mobility disorder
                         causes (disease, OrthopedicAndMobilityDisorder)

43.   Disk degeneration of the spine cause spinal cord injury
                         causes (DiskDegenerationOfTheSpine, SpinalCordInjury)

44.   Drinking alcohol during pregnancy causes fetal alcohol spectrum disorder
                         causes (DrinkingOfAlcoholDuringPregnancy,
                              FetalAlcoholSpectrumDisorder)

45.   Ear drum and the ossicles damage causes mixed hearing loss
                         causes (EarDrumAndTheOssiclesDamage, MixedHearingLoss)

46.   Ear infection with inflammation and fluid buildup causes conductive hearing loss
                         causes (EarInfectionWithInflammationAndFluidBuildUp,
                              ConductiveHearingLoss)

47.   Emotional upset at home causes behavioural disorder
                         causes (EmotionalUpsetAtHome, BehaviouralDisorder)

48.   End stage of glaucoma causes blindness
                         causes (EndStageOfGlaucoma, Blindness)

49.   Excessive buildup of ear wax causes conductive hearing loss
                         causes (ExcessiveBuildUpOfEarWax, ConductiveHearingLoss)

50.   Falls causes fractures
                         causes (falls, fractures)

51.   Genetic disorder causes concomitant disorder or intellectual disability

$\{GeneticDisorder\} \sqsubseteq \exists causes. \{ConcomitantDisorder\}$
$\sqcup \{IntellectualDisability\}$

52.   Genetic factor causes communication and speech disorder or ADHD or eating disorder

$\{GeneticFactor\} \sqsubseteq \exists causes. \{CommunicationAndSpeechDisorder\}$
$\sqcup \{ADHD\} \sqcup \{EatingDisorder\}$

53.   Genetic make-up causes giftedness and talentedness

causes (GeneticMakeUp, GiftednessAndTalentedness)

54.   Environmental simulation causes giftedness and talentedness

causes (EnvironmentalSimulation, GiftednessAndTalentedness)

55.   Genetic passed on by either parent cause epilepsy

causes (GeneticPassedOnByEitherParent, epilepsy)

56.   Glaucoma causes partial sightedness and blindness

$\{glaucoma\} \sqsubseteq \exists causes. \{PartialSightedness\} \sqcup \{blindness\}$

57.   Glue ear causes conductive hearing loss

causes (GlueEar, ConductiveHearingLoss)

58.   Having an extra 21st chromosome causes Down syndrome

causes (HavingAnExtra21stChromosome, DownSyndrome)

59.   Hereditary factor causes behavioural disorder

causes (HereditaryFactor, BehaviouralDisorder)

60.   Hypothyroidism causes deafness

causes (hypothyroidism, deafness)

61.   Inflammation causes spinal cord injury

causes (inflammation, SpinalCordInjury)

62.   Exposure to alcohol, drug, or other toxins causes intellectual disability

causes (ExposureToAlcoholDrugOrOtherToxins, IntellectualDisability)

63.   Infections cause concomitant disorder, hearing loss, intellectual disability

$\{infections\} \sqsubseteq \exists causes. \{ConcomitantDisorder\}$
$\sqcup \{HearingLoss\} \sqcup \{IntellectualDisability\}$

64.   Inherited condition causes specific learning disability

causes (InheritedCondition, SpecificLearningDisability)

65.   Inherited disorder of the eye causes partial sightedness

causes (InheritedDisorderOfTheEye, PartialSightedness)

66.   Phenylketonuria causes intellectual disability

causes (phenylketonuria, IntellectualDisability)

67.   Injury from accidents causes concomitant disorder or fracture

{InjuryFromAccidents} ⊑ ∃causes. {ConcomitantDisorder} ⊔ {fracture}

68.   Inner ear dysfunction causes sensorineural hearing loss

causes (InnerEar Dysfunction, SensorineuralHearingLoss)

69.   Intentional malingering causes functional hearing loss

causes (IntentionalMalingering, FunctionalHearingLoss)

70.   Jolt to the head causes traumatic brain injury

causes (JoltToTheHead, TraumaticBrainInjury)

71.   Lyme disease causes deafness

causes (LymeDisease, deafness)

72.   Malnutrition causes behavioural disorder

causes (malnutrition, BehaviouralDisorder)

73.   Medication side effect causes hearing loss

causes (MedicationSideEffect, HearingLoss)

74.   Meningitis causes epilepsy and deafness

{meningitis} ⊑ ∃causes. {epilepsy} ⊔ {deafness}

75.   Mother's illness during birth causes specific learning disability

causes (Mother'sIllnessDuringBirth, SpecificLearningDisability)

76.   Mumps causes deafness

causes (mumps, deafness)

77.   Obsession with food causes eating disorder

cause (ObsessionWithFood, EatingDisorder)

78.   Ossicles malfunction causes conductive hearing loss

causes (OssiclesMalfunction, ConductiveHearingLoss)

79.   Opening in the mouth causes cleft lips

causes (OpeningInTheMouth, CleftLips)

80.   Oxygen deprivation causes intellectual disability
                        causes (OxygenDeprivation, IntellectualDisability)

ii.   **Attributes of each Nature of Special Needs Conditions (A-Box)**
1.   Hearing impairment in both ears is a feature of bilateral deafness
                  featureOf (HearingImpairmentInBothEar, BilateralDeafness)

2.   Hearing impairment in just one ear is a feature of unilateral deafness
                  featureOf (HearingImpairmentInJustOneEar, UnilateralDeadness)

3.   Similar intelligence with their hearing counterpart is a feature of hearing impairment
                  featureOf (SimilarIntelligenceWithHearingCounterpart,
                              HearingImpairment)

4.   Difficulty in speech and language development is a feature of hearing impairment
                  featureOf (SpeechAndLanguageDevelopmentDifficulty,
                              HearingImpairment)

5.   Similar social development with their hearing counterpart is a feature of hearing impairment
                  featureOf (SimilarSocialDevelopmentWithHearingCounterpart,
                              HearingImpairment)

6.   Reliant on lip-reading is a feature of hearing impairment
                  featureOf (ReliantOnLipReading, HearingImpairment)

7.   Problems in understanding speech is a feature of hearing impairment
                  featureOf (ProblemsInUnderstandingSpeech,
                              HearingImpairment)

8.   Delayed in educational achievement is a feature of hearing impairment
                  featureOf (DelayedInEducationalAchievement,
                              HearingImpairment)

9.   Unclear utterances is a feature of hearing loss
                  featureOf (UnclearUtterances, HearingLoss)

10.   Produce louder than normal noises is a feature of hearing loss
                  featureOf (ProduceLouderThanNormalNoises,
                              HearingLoss)

11.   Unusual turning of the head is a feature of visual impairment
                  featureOf (UnusualTurningOfTheHead, VisualImpairment)

12.   Unusual turning of the body is a feature of visual impairment
                  featureOf (UnusualTurningOfTheBody, VisualImpairment)

13.   Unusual turning of the eye is a feature of visual impairment
                  featureOf (UnusualTurningOfTheEye, VisualImpairment)

14.   Holding reading materials extremely close to the face is a feature of visual impairment
                  featureOf (HoldingReadingMaterialsExtremelyCloseToTheFace,
                                          VisualImpairment)

15.   Excessive rubbing of the eye is a feature of visual impairment
                  featureOf (ExcessiveRubbingOfTheEye, VisualImpairment)

16.   Eye fatigue is a feature of visual impairment
                  featureOf (EyeFatigue, VisualImpairment)

17.   Frequent eye pain is a feature of visual impairment
                  featureOf (FrequentEyePain, VisualImpairment)

18.   Shades the eye to view object is a feature of visual impairment
                  featureOf (ShadesTheEyeToViewObject, VisualImpairment)

19.   Squints the eye to view object is a feature of visual impairment
                  featureOf (SquintsTheEyeToViewObject, VisualImpairment)

20.   Reason and think abstractly is a feature of giftedness and talentedness
                  featureOf (ReasonAndThinkAbstractly,
                                          GiftednessAndTalentedness)

21.   Acquires information easily is a feature of giftedness and talentedness
                  featureOf (AcquiresInformationEasily,
                                          GiftednessAndTalentedness)

22.   Enjoys learning is a feature of giftedness and talentedness
                  featureOf (EnjoysLearning, GiftednessAndTalentedness)

23.   Highly inquisitive is a feature of giftedness and talentedness
                  featureOf (HighlyInquisitive, GiftednessAndTalentedness)

24.   Intellectually curious is a feature of giftedness and talentedness
                  featureOf (IntellectuallyCurious, GiftednessAndTalentedness)

25.   Risk taker is a feature of giftedness and talentedness
                  featureOf (RiskTaker, GiftednessAndTalentedness)

26.   Concern for social issues is a feature of giftedness and talentedness
                  featureOf (ConcernForSocialIssues,
                                          GiftednessAndTalentedness)

27.   Loss in body movement is a feature of cerebral palsy
featureOf(LossInBodyMovement,CerebralPalsy)

28.   Loss in muscle control and coordination is a feature of cerebral palsy
featureOf(LossInMuscleControlAnd Coordination,CerebralPalsy)

29.   Loss in basic motor skills is a feature of cerebral palsy
featureOf(LossInBasicMotorSkills,CerebralPalsy)

30.   Confusion is a feature of traumatic brain injury
featureOf (Confusion, TraumaticBrainInjury)

31.   Blurry vision is a feature of traumatic brain injury
featureOf (BlurryVision, TraumaticBrainInjury)

32.   Difficulty concentrating is a feature of traumatic brain injury
featureOf (DifficultyConcentrating, TraumaticBrainInjury)

33.   Preference to be alone feature of autism
featureOf (PreferenceToBeAlone,autism)

34.   Intense reactions to sounds, smells and lights feature of autism
featureOf (IntenseReactionsToSoundsSmellsAndLights, autism)

35.   Language development delayed feature of autism
featureOf (LanguageDevelopmentDelayed,autism)

36.   Abnormal thought is a feature of mental disorder
featureOf (AbnormalThought, MentalDisorder)

37.   Abnormal perceptions is a feature of mental disorder
featureOf (AbnormalPerceptions, MentalDisorder)

38.   Abnormal behaviour
featureOf (AbnormalBehaviour, MentalDisorder)

39.   Late talking is a feature of dyslexia
featureOf (LateTalking, dyslexia)

40.   Learning new words slowly is a feature of dyslexia
featureOf (LearningNewWordsSlowly, dyslexia)

41.   Disorder of attention is a feature of specific learning disability
featureOf (DisorderOfAttention, SpecificLearningDisability)

42. Poor motor abilities are a feature of specific learning disability
featureOf (PoorMotorAbilities, SpecificLearningDisability)

43. Lack of cognitive strategies is a feature of specific learning disability
featureOf (LackOfCognitiveStrategies,
SpecificLearningDisability)

44. Quantitative disorder is a feature of a specific learning disability
featureOf (QuantitativeDisorder, SpecificLearningDisability)

45. Social skill deficits are a feature of specific learning disability
featureOf (SocialSkillDeficits, SpecificLearningDisability)

46. Calculation problem is a feature of dyscalculia
featureOf (CalculationProblem, dyscalculia)

47. Reading difficulty is a feature of dyslexia
featureOf (ReadingDifficulty, dyslexia)

48. Writing difficulties is a feature of dysgraphia
featureOf (WrittingDifficulties, dysgraphia)

49. Uncontrollable jerking movements is a feature of epilepsy
featureOf (UncontrollableJerkingMovements, epilepsy)

50. Loss of consciousness is a feature of epilepsy
featureOf (LossOfConsciousness, epilepsy)

51. Unexplainable fear and anxiety is a feature of epilepsy
featureOf (UnexplainableFearAndAnxiety, epilepsy)

52. Hostile is a feature of oppositional defiant disorder
featureOf (Hostile, OppositionalDefiantDisorder)

53. Irritable is a feature of oppositional defiant disorder
featureOf (Irritable, OppositionalDefiantDisorder)

54. Uncooperative attitudes is a feature of oppositional defiant disorder
featureOf (UncooperativeAttitudes, OppositionalDefiantDisorder)

55. Inappropriate yypes of feelings or behaviour under normal circumstance is a feature of emotional disorder
featureOf (InappropriateFeelingsOrBehaviorUnderNormalCircumstances, EmotionalDisorder)

56. General pervasive mood of unhappiness is a feature of emotional disorder
featureOf (GeneralPervasiveMoodOfUnhappiness,

EmotionalDisorder)

57.   Depression that cannot be explained by sensory, intellectual, or health factors is a feature of emotional disorder
featureOf (DepressionThatCannotBeExplainedBySensoryIntellectualHealthFactors, EmotionalDisorder)

58.   Poor attitude towards education feature of behavioural disorder
featureOf (PoorAttitudeTowardsEducation, BehaviouralDisorder)

59.   Putting blame on others is a feature of behavioural disorder
featureOf (PuttingBlameOnOthers, BehaviouralDisorder)

60.   Arguing and throwing temper tantrums is a feature of behavioural disorder
featureOf (ArguingAndThrowingTemperTantrums, BehaviouralDisorder)

61.   Having difficulty in handling frustration is a feature of behavioural disorder
featureOf (HavingDifficultyInHandlingFrustration, BehaviouralDisorder)

62.   Self-injury is a feature of behavioural disorder
featureOf (SelfInjury, BehaviouralDisorder)

63.   Physical aggression is a feature of behavioural disorder
featureOf (PhysicalAggression, BehaviouralDisorder)

64.   Verbal aggression is a feature of behavioural disorder
featureOf (VerbalAggression, BehaviouralDisorder)

65.   Non-compliance is a feature of behavioural disorder
featureOf (NonCompliance, BehaviouralDisorder)

66.   Disruption of the environment is a feature of behavioural disorder
featureOf (DisruptionOfTheEnvironment, BehaviouralDisorder)

67.   Inappropriate vocalizations is a feature of communication and speech disorder
featureOf (InappropriateVoicalizations, CommunicationAndSpeechDisorder)

68.   Various stereotypies is a feature of communication and speech disorder
featureOf (VariousStereotypies, CommunicationAndSpeechDisorder)

69.   Severe back pain is a feature of bone tuberculosis
featureOf (SevereBackPain, BoneTuberculosis)

70.   Swelling is a feature of bone tuberculosis
                      featureOf (Swelling, BoneTuberculosis)

71.   Stiffness is a feature of bone tuberculosis
                      featureOf (Stiffness, BoneTuberculosis)

72.   Abscesses is a feature of bone tuberculosis
                      featureOf (Abscesses, BoneTuberculosis)

73.   Neurological complications is a feature of bone tuberculosis
                      featureOf (NeurologicalComplications, BoneTuberculosis)

74.   Paraplegia is a feature of bone tuberculosis
                      featureOf (Paraplegia, BoneTuberculosis)

75.   Limb-shortening in children is a feature of bone tuberculosis
                      featureOf (LimbShorteningInChildren, BoneTuberculosis)

76.   Bone deformities is a feature of bone tuberculosis
                      featureOf (BoneDeformities, BoneTuberculosis)

77.   Fatigue is a feature of bone tuberculosis
                      featureOf (Fatiguee, BoneTuberculosis)

78.   Fever is a feature of bone tuberculosis
                      featureOf (Fever, BoneTuberculosis)

79.   Night sweats is a feature of bone tuberculosis
                      featureOf (NightSweats, BoneTuberculosis)

80.   Weight loss is a feature of bone tuberculosis
                      featureOf (WeightLoss, BoneTuberculosis)

81.   Loss of movement is a feature of spinal cord injury
                      featureOf (LossOfMovement, SpinalCordInjury)

82.   Loss of sensation is a feature of spinal cord injury
                      featureOf (LossOfSensation, SpinalCordInjury)

83.   Loss of bowel is a feature of spinal cord injury
                      featureOf (LossOfBowel, SpinalCordInjury)

84.   Exaggerated reflex activities is a feature of spinal cord injury
                      featureOf (ExaggeratedReflexActivities, SpinalCordInjury)

85.   Changes in sexual function is a feature of spinal cord injury
featureOf (ChangesInSexualFunction, SpinalCordInjury)

86.   Changes in sexual sensitivity is a feature of spinal cord injury
featureOf (ChangesInSexualSensitivity, SpinalCordInjury)

87.   Changes in fertility is a feature of spinal cord injury
featureOf (ChangesInFertility, SpinalCordInjury)

88.   Difficulty breathing is a feature of spinal cord injury
featureOf (DifficultyBreathing, SpinalCordInjury)

89.   Difficulty coughing is a feature of spinal cord injury
featureOf (DifficultyCoughing, SpinalCordInjury)

90.   Difficulty in clearing secretions from your lungs is a feature of spinal cord injury
featureOf (DifficultyInClearingSecretionsFromYourLungs,
SpinalCordInjury)

iii.   **Various Assistive Technology (AT) Applicable to Each Nature of Special Needs Conditions (A-Box)**

1.   Hearing aid is for hearing impairment or communication and speech disorder
{HearingAid} $\sqsubseteq$ $\exists$IsFor. {HearingImpairment}
$\sqcup$ {CommunicationAndSpeechDisorder}

2.   Sign language is for hearing impairment
IsFor (SignLanguage, HearingImpairment)

3.   Total communication is for hearing impairment
IsFor (TotalCommunication, HearingImpairment)

4.   Computer-aided learning is for hearing impairment
IsFor (ComputerAidedLearning, HearingImpairment)

5.   Cochlear implants is for sensorineural hearing loss
IsFor (CochlearImplants, SensorineuralHearingLoss)

6.   Braille machine is for visual impairment
IsFor (BrailleMachine, VisualImpairment)

7.   Braille sheet is for visual impairment
IsFor (BrailleSheet, VisualImpairment)

8.   Stylus is for visual impairment
IsFor (stylus, VisualImpairment)

9.   Typewriter is for visual impairment
IsFor (typewriter, VisualImpairment)

10. Talking calculator is for visual impairment

   IsFor (TalkingCalculator, VisualImpairment)

11. Talking wristwatch is for visual impairment

   IsFor (TalkingWristwatch, VisualImpairment)

12. Talking computer is for visual impairment

   IsFor (TalkingComputer, VisualImpairment)

13. Kurveil reading machine is for visual impairment

   IsFor (KurveilReadingMachine, VisualImpairment)

14. Braille recorder is for visual impairment

   IsFor (BrailleRecorder, VisualImpairment)

15. Earphone is for visual impairment

   IsFor (EarPhone, VisualImpairment)

16. Tape recorder is for visual impairment

   IsFor (TapeRecorder, VisualImpairment)

17. JAWS is for visual impairment

   IsFor (JAWS, VisualImpairment)

18. Ultra-cane is for visual impairment

   IsFor (UltraCane, VisualImpairment)

19. Look tel is for visual impairment

   IsFor (LookTel, VisualImpairment)

20. Around me is for visual impairment

   IsFor (AroundMe, VisualImpairment)

21. Computer software tutorials is for giftedness and talentedness, communication and speech disorder

   {ComputerSoftwareTutorials} $\sqsubseteq$ $\exists$IsFor. {SpecificLearningDisability}
   $\sqcup$ {IntellectualDisability} $\sqcup$ {GiftednessAndTalentedness}

22. Multimedia devices are for a specific learning disability or intellectual disability

   {MultimediaDevices} $\sqsubseteq$ $\exists$IsFor. {SpecificLearningDisability}
   $\sqcup$ {IntellectualDisability}

23. Compact disk (CD) is for a specific learning disability or intellectual disability

   {CompactDisk} $\sqsubseteq$ $\exists$IsFor. {SpecificLearningDisability}
   $\sqcup$ {IntellectualDisability}

24.   Taped books is for a specific learning disability or intellectual disability
{TapedBooks} ⊑ ∃IsFor. {SpecificLearningDisability}
⊔ {IntellectualDisability}

25.   Devices that read printed books aloud are for a specific learning disability or intellectual disability
{DevicesThatReadPrintedBooksAloud}
⊑ ∃IsFor. {SpecificLearningDisability} ⊔ {IntellectualDisability}

26.   Talking computer programs is for a specific learning disability or intellectual disability
{TalkingComputerPrograms}
⊑ ∃IsFor. {SpecificLearningDisability} ⊔ {IntellectualDisability}

27.   Wheelchairs is for behavioural disorder or physical and health impairment
{wheelchairs} ⊑ ∃IsFor. {BehaviouralDisorder}
⊔ {PhysicalAndHealthImpairment}

28.   Scooters walkers is for behavioural disorder or physical and health impairment
{ScootersWalkers} ⊑ ∃IsFor. {BehaviouralDisorder}
⊔ {PhysicalAndHealthImpairment}

29.   Canes is for behavioural disorder or physical and health impairment or visual impairment
{Canes} ⊑ ∃IsFor. {BehaviouralDisorder}
⊔ {PhysicalAndHealthImpairment} ⊔ {VisualImpairment}

30.   Crutches is for behavioural disorder or physical and health impairment
{crutches} ⊑ ∃IsFor. {BehaviouralDisorder}
⊔ {PhysicalAndHealthImpairment}

31.   Prosthetic devices are for behavioural disorder or physical and health impairment
{ProstheticDevices} ⊑ ∃IsFor. {BehaviouralDisorder}
⊔ {PhysicalAndHealthImpairment}

32.   Orthotic devices are for behavioural disorder or physical and health impairment
{OrthoticDevices} ⊑ ∃IsFor. {BehaviouralDisorder}
⊔ {PhysicalAndHealthImpairment}

33.   Cognitive aid is for communication and speech disorder
IsFor (CognitiveAid, CommunicationAndSpeechDisorder)

34.   Augmentative communication device is for physical and health impairment
IsFor (AugmentativeCommunicationDevice, PhysicalAndHealthImpairment)

3.2.2   Relationship between Classes and Instances (R-Box)

1.   Gifted persons are born with giftedness and talentedness

$$bornWith.\ GiftednessAndTalentedness \equiv GiftedPerson$$

2.   Persons with a disability have a condition called disability

$$hasCondition.\ Disability \equiv PersonWithDisability$$

3.   Disability has a remedy called assistive technology

$$hasRemedy.AssistiveTechnology \equiv Disability$$

4.   Giftedness and talentedness have a support called assistive technology

$$hasSupport.\ AssistiveTechnology \equiv GiftednessAndTalentedness$$

5.   A person has a condition called disability is a person with a disability

$$hasCondition.\ Disability \circ IsA.\ PersonWithDisability$$

6.   A person with giftedness and talentedness is a gifted person

$$bornWith.\ GiftednessAndTalentedness \circ IsA.\ GiftedPerson$$

7.   Special needs conditions attributes are features of special needs conditions

$$featureOf.\ SpecialNeedsConditions \equiv SNCAttributes$$

8.   Special needs conditions causes can be disease or injury or genetic makeup or environmental simulation

$$Causes.SpecialNeedsConditions \equiv SpecialNeedsConditionCause \sqsubseteq disease \sqcup injury$$
$$\sqcup GeneticMakeup \sqcup EnvironmentalSimulation$$

9.   Assistive technology is for special needs conditions

$$IsFor.SpecialNeedsConditions \equiv AssistiveTechnology$$

10.   Person with special needs conditions needs assistive technology

$$NeedsAT.AssistiveTechnology \equiv PersonWithSpecialNeedsConditions$$

3.3   Generation of some competency questions for the purpose of testing: Below are some of the competency questions that were used to verify and validate the efficiency and effectiveness of the special needs conditions ontology.

a.   What are the categories of special needs conditions?
b.   What are the causes of special needs conditions?
c.   What are the features of intellectual disability?
d.   What is an Assistive Technology?
e.   Is there any assistive technology for specific learning disability?
f.   Is there any person with disability?

g. What are the causes of visual impairment?
h. What are the features of giftedness and talentedness?
i. Who is a gifted person?
j. What are the features of emotional disorder?
k. What are the categories of specific learning disabilities?
l. What are the causes of mental disorders?
m. What are the examples of Assistive Technology suitable for each nature of special needs conditions?

4. IMPLEMENTATION

The special needs conditions ontology was built using ontology web language (protégé 4.3.0) in other to share knowledge about special needs conditions. Figure 3 shows the protégé design of the special needs conditions ontology main classes. The top class comprises all the classes of ontology such as assistive technology, the person with special needs conditions, special needs conditions attributes, special needs conditions cause as well as the special needs conditions. All these main classes gave birth to their subclasses and descendant classes.

Figure 4 shows the individual/instances of each class of the ontology, the instances show the number of axioms that were stored into the ontology. Finally, figure 5 shows the object property hierarchy of the ontology. The object property shows the properties of all the classes in ontology. For example, the property *hasCondition* belongs to the domain: PersonWithDisability with the range: *Disability* which means that a person with a disability has a condition called disability.
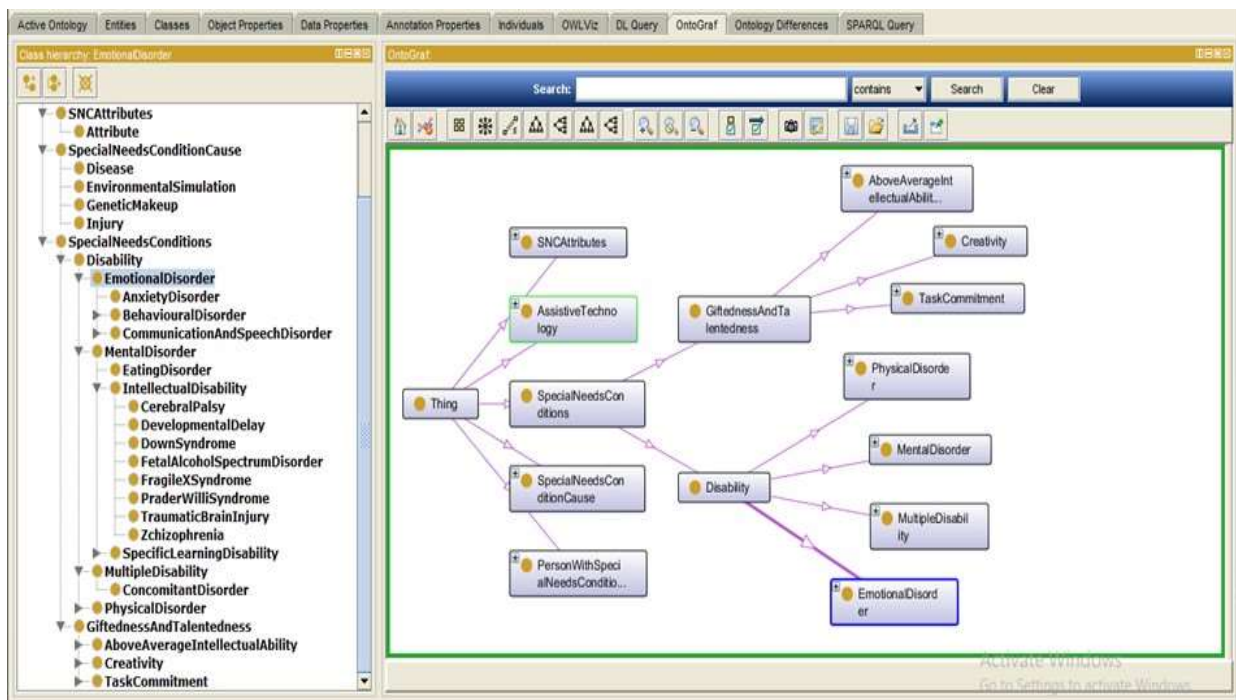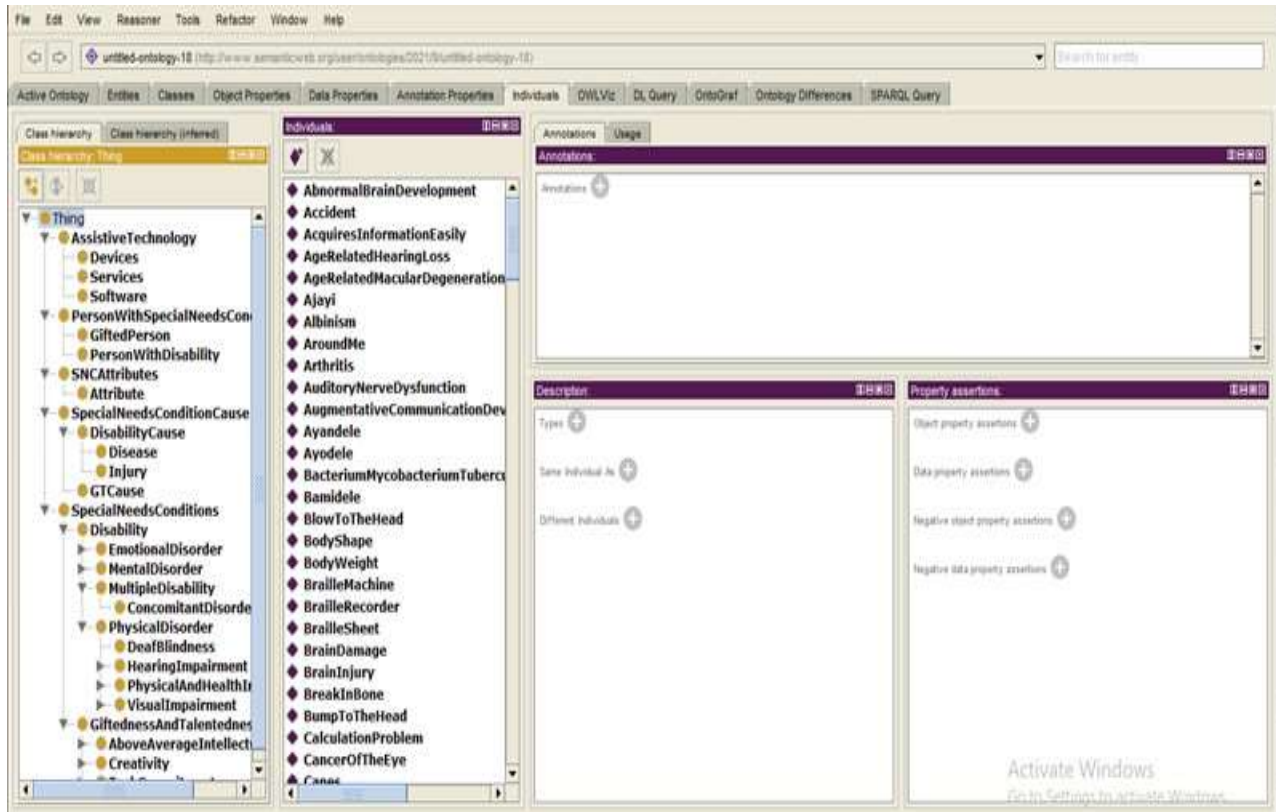

Figure 3: Classes of the Ontology

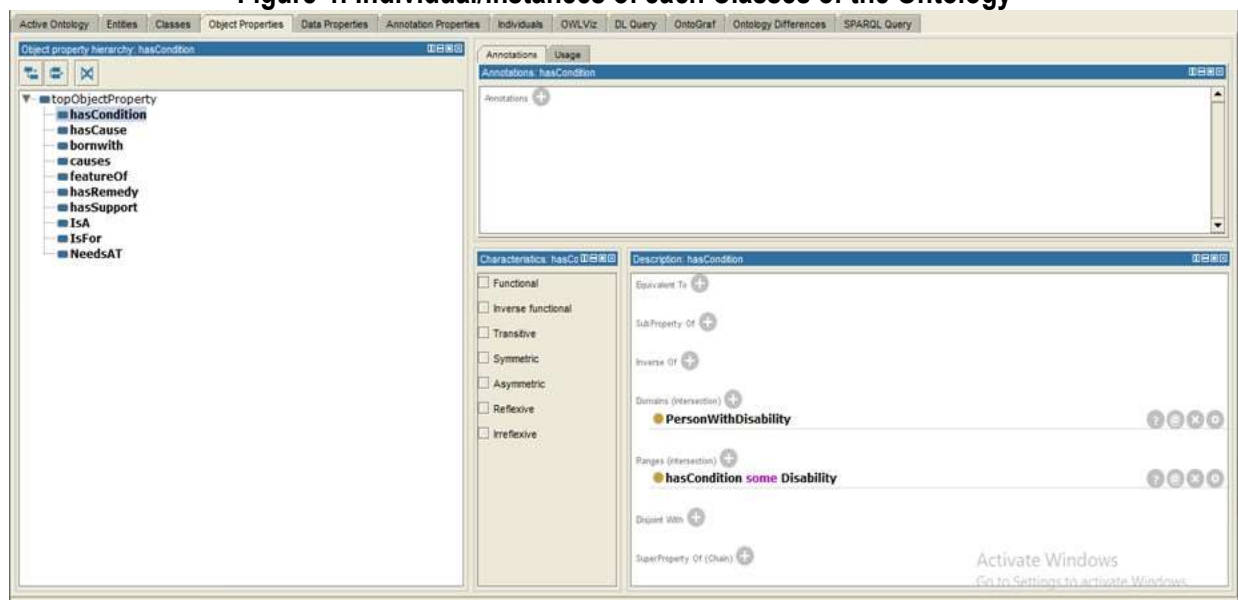**Figure 4: Individual/instances of each Classes of the Ontology**

Figure 5: Object Property Hierarchy of the Ontology

4.1 Results of Some Competency Questions

Competency questions are the list of questions that ontology should be able to answer. Competency questions are also used to determine the scope of the ontology and test its validity. Some of the competency questions that were used to test the validity of the special needs conditions ontology were listed and explained below. The questions were inputted into the description logic (DL) query view of the protégé 4.3.0 ontology development environment tool.

4.1.1 Result of Competency Question 1: "What are the categories of special needs conditions?" This question queries the ontology for all the sub-classes and descendant classes of special needs conditions available in the special needs conditions ontology with axiom

"SpecialNeedsConditions ≡ Disability ⊔ GiftednessAndTalentedness"
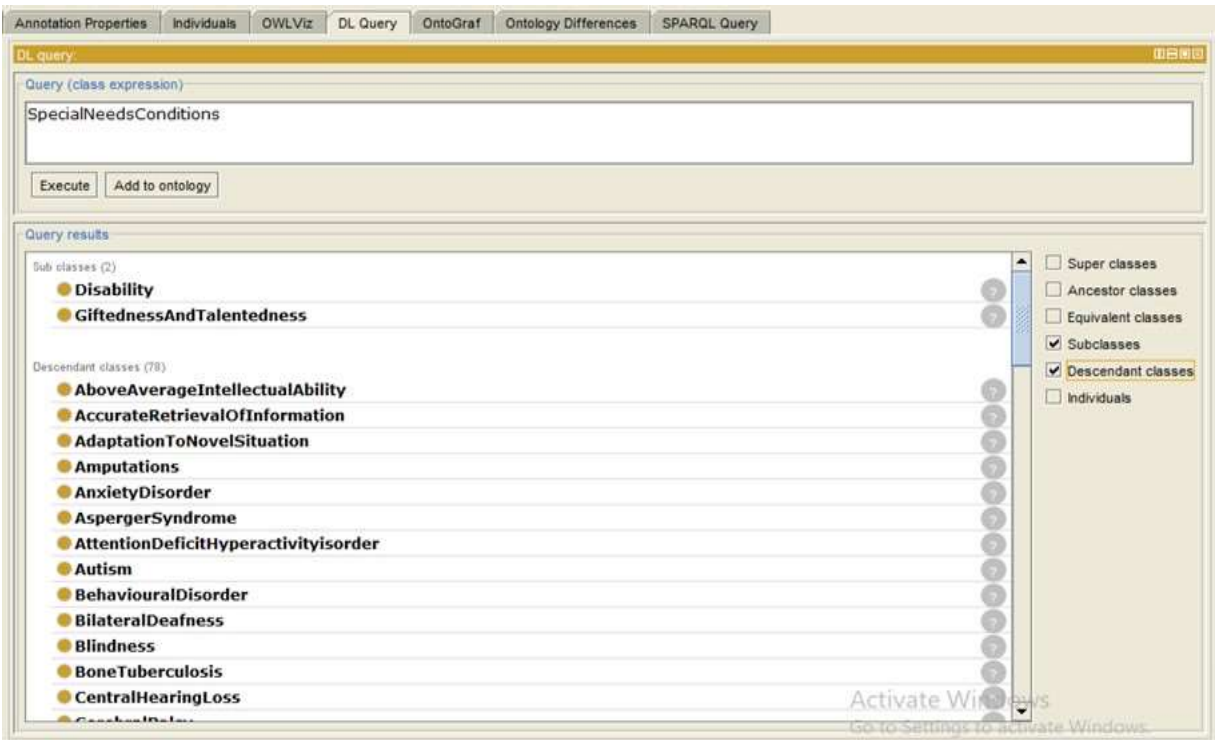on definition 1. The result of the query is presented in Figure 6.

Figure 6: Competency Question One (1) Description Logic Query and Result

4.1.2   Result of Competency Question 2: "What are the causes of special needs conditions?" This question queries the ontology for the equivalent class, sub-classes and the instances of special needs conditions causes that are available in the ontology with the axiom

"SpecialNeedsConditionsCause ≡ (Disease ⊔ Injury) ⊔ (EnvironmentalSimulation ⊔ GeneticMakeup)" The result to the query is presented in Figure 7.
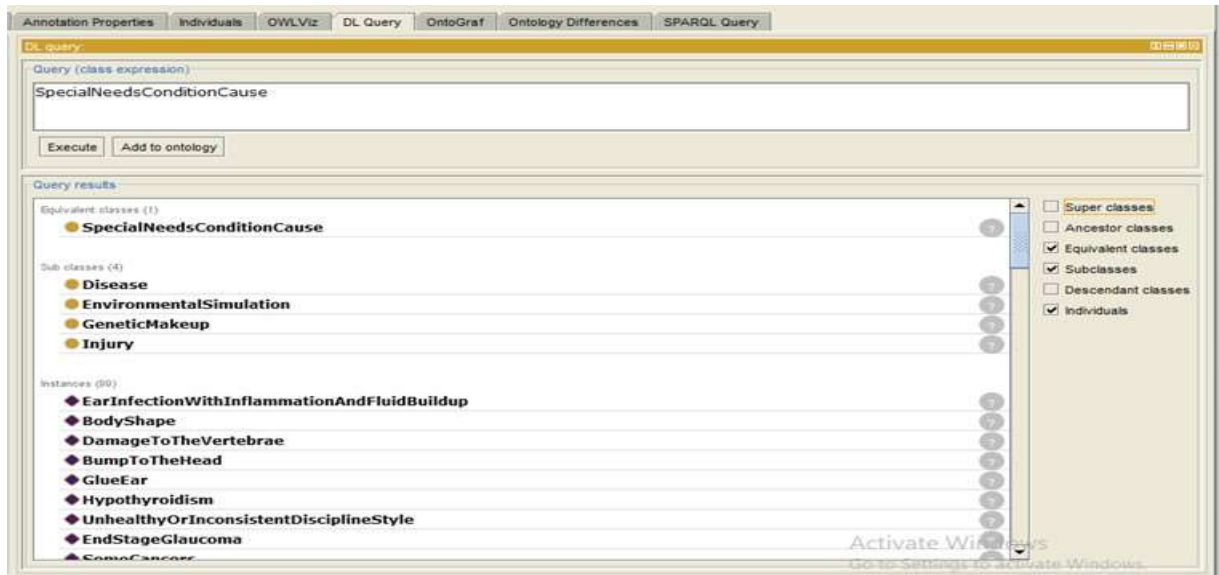

Figure 7: Competency Question Two (2) Description Logic Query and Result

4.1.3   Result of Competency Question 3: "What are the features of intellectual disability?" This question queries the ontology for the super class, ancestor class and all the individual features of intellectual disability available in the ontology with axiom

"featureOf. SpecialNeedsConditions ≡ SNCAttributes",
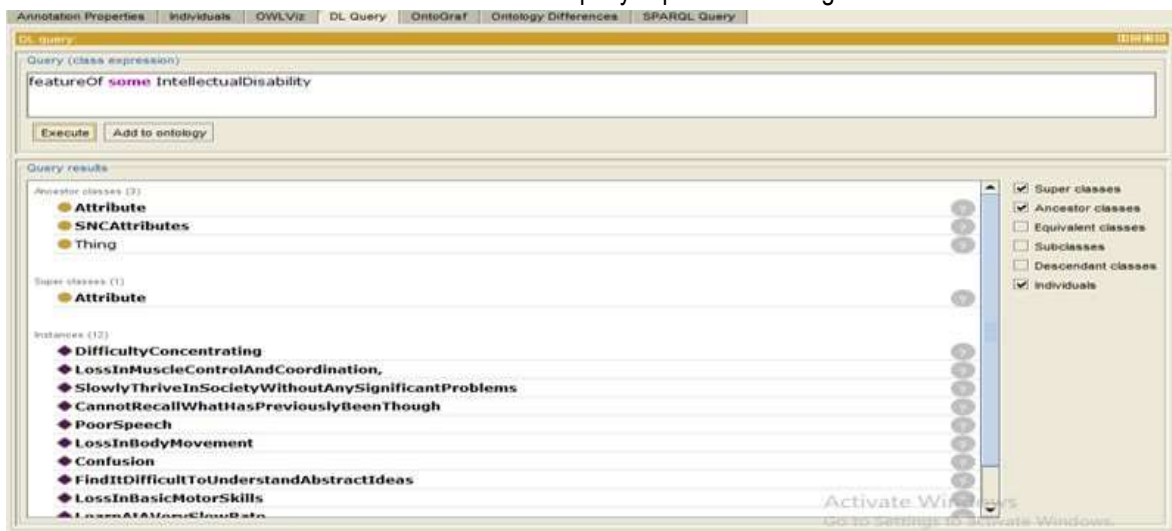
The result to the query is presented in Figure 8.

Figure 8: Competency Question Three (3) Description Logic Query and Result

4.1.4   **Result of Competency Question 4:** "What is assistive technology?" This question queries the ontology for the equivalent class, sub-classes and all the instances of assistive technology available in the ontology with axiom "AssistiveTechnology ≡ devices ⊔ software ⊔ services ⊓ ∃IsFor.SpecialNeedsConditions ⊓ ∃neededBy.PersonWithSpecialNeedsConditions" on definition 4. The result to the query is presented in Figure 9.
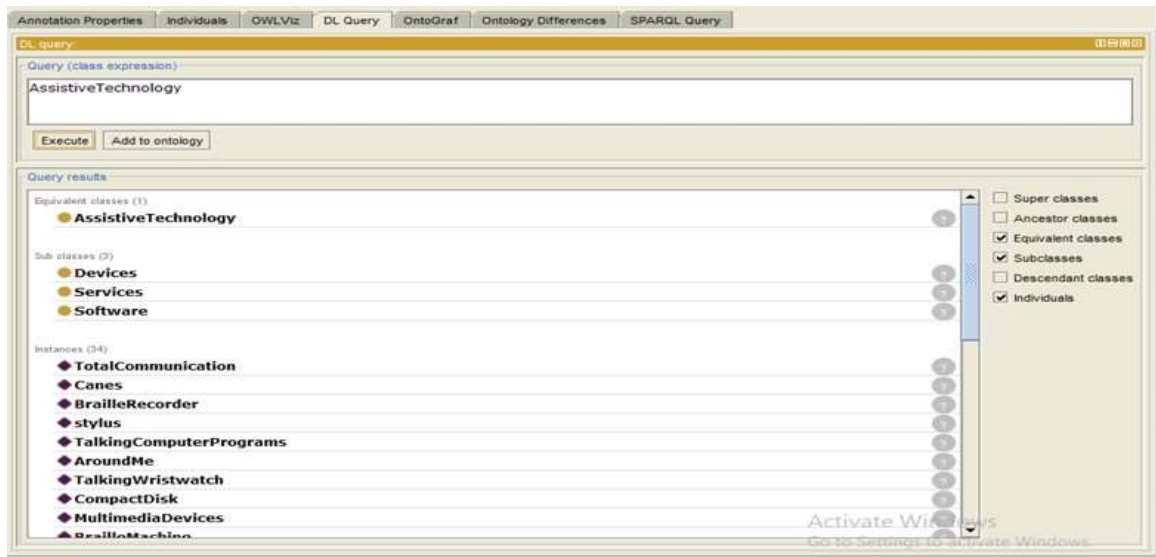

Figure 9: Competency Question Four (4) Description Logic Query and Result

4.1.5   **Result of Competency Question 5:** "Is there any assistive technology for specific learning disability?" This question queries the ontology for all the assistive technology available for specific learning disability as contained in the ontology with axiom

"IsFor.SpecialNeedsConditions ≡ AssistiveTechnology",
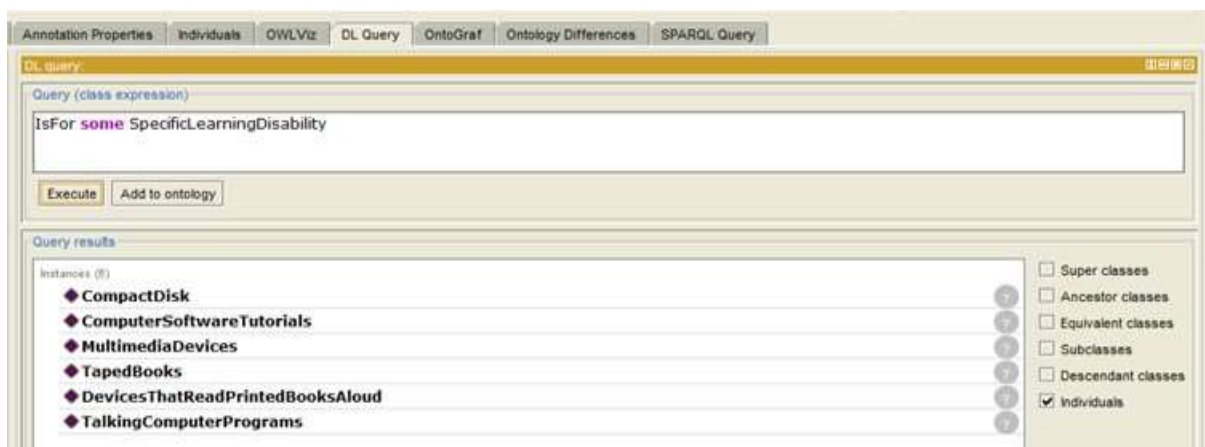The result to the query is presented in Figure 10.

Figure 10: Competency Question Five (5) Description Logic Query and Result

5. CONCLUSION

A semantic web representation tagged ontology for special needs conditions was built with the use of protégé 4.3.0. Ontology schema was used to describe the entities, classes, properties as well as the instances of special needs conditions, and more than two hundred (200) definitions of special needs conditions were created in terms of description logic using the knowledge elucidated from expert sources (human, books, internet). Competency questions were generated to test the correctness, effectiveness, and efficiency of the ontology.

The ontology for special needs conditions (OSNC) built in this research work comprises the Assistive Technology categories and major categories of special needs conditions which are disability and giftedness and talentedness and their subsets were also covered. The ontology can provide answers to all the competency questions that were used to test its effectiveness and efficiency. This ontology can, therefore, be used by the entire society, persons with special needs conditions, and upcoming special educators as a training tool. It can also be used by the various decision-makers in the special education domain in structuring special education for persons with special needs conditions. The ontology can as well be reused by ontology system developers who are interested in the special education domain.

6. RECOMMENDATIONS

As a result of the findings made from this study, the following recommendations are offered:
i.   Special needs conditions ontology should be adopted for use across all the special education domains to minimize the problem of special needs conditions information overloading and inconsistency.
ii.   This available special needs conditions ontology should be used in structuring the special education for persons with special needs conditions.
iii. More medical conditions regarded as special needs conditions can be added to the ontology to enlarge the range of its application.
iv.   Special needs conditions ontology should be used as a training tool for newly recruited special educators.

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