Towards Ubiquitous Learning Situations for Disabled Learners

Nesrine Ben Salah[a], Ines Bayoudh Saadi[b] and Henda Ben Ghezala[c]
National School of Computer Science, Manouba University, RIADI Research Laboratory, Tunis, Tunisia

Keywords: Ubiquitous Learning, Disabled Learners, Learning Situation, Learning Process, Situation Identification, Ontology Representation.

Abstract: Adaptation in ubiquitous learning environment is a major concern in research work, especially for disabled learners. A number of studies have examined context-aware learning systems, but the learning situation has rarely been taken into account, and mainly for learners with disabilities. There is a lack of studies on the description and identification of learning situations for disabled learners. Therefore, these situations need to be well defined, to ensure that all features, including the guidance of the learning process, are properly adapted to this particular type of learners. The identified situation is linked to a situation model called a typical situation. In this paper, we propose an ontology for ubiquitous typical learning situations relating to disabled learners and more specifically, to those with sensory disabilities. We will then be able to refer to these situations in order to identify the observed learning situations during the execution of the learning process. This identification will then be used to recommend and guide the learning process of learners with disabilities.

1 INTRODUCTION

In recent years, the Situation Awareness (SA) has become a critical success factor for adaptive systems (DAniello and al., 2014). As technology evolves, many complex and dynamic systems have been created, affecting the ability of humans to act as effective and timely decision-makers to exploit these systems (Endsley, 2017). The learner's situation awareness will be presented as a crucial construct upon which decision-making and performance in such systems lie.

In a situation-aware ubiquitous learning environment, everything is adapted according to the learning situation of the learner. And when it comes to a disabled learner, this adaptation also takes into consideration his type of disability. However, disabled learners may have a different learning context or experience a given learning context differently from non-disabled learners (Salah, N. B. and al., 2019). For instance, accessibility features are particularly important for disabled learners. This gives rise to the need to describe and identify a specific learning situation for them.

Several learning situations have been proposed in the literature. However, these situations are specific to non-disabled learners, as the case of learning situations proposed by Gwo-Jen Hwang in (Hwang, 2006). The situation awareness has been used to promote adaptation. We can cite the work described in (Saâdi and Hamdani, 2019) where authors proposed recommendations using ubiquitous learning situations. We also mention the work of DAniello (DAniello and al., 2015) in which authors proposes a prototypical Decision Support System supporting learners in self-regulating their learning processes based on Situation Awareness approach. Finally, in (Souabni, R. and al., 2019), authors propose a multidimensional framework dedicated for situation-aware u-learning systems. It helps to understand, analyse and describe in-depth a particular aspect of situation awareness in u-learning systems

There is a lack of description of ubiquitous learning situations for disabled learners. This description is essential for adapting learning systems to disabled learners according to their learning situation.

[a] https://orcid.org/0000-0001-7217-5676
[b] https://orcid.org/0000-0001-7419-3800
[c] https://orcid.org/0000-0002-6874-1388

Ben Salah, N., Saadi, I. and Ben Ghezala, H.
Towards Ubiquitous Learning Situations for Disabled Learners.
DOI: 10.5220/0009829201440151
In *Proceedings of the 15th International Conference on Software Technologies (ICSOFT 2020)*, pages 144-151
ISBN: 978-989-758-443-5

In this paper, we will propose an ontology to describe ubiquitous learning situations related to disabled learners and more specifically to those with sensory disabilities (visual or auditory). The main contribution of this paper is the proposal of new ubiquitous learning situations ontology for disabled learners.

The rest of the paper is organized as follow. Section 2 presents the conceptual background. The proposal of ubiquitous learning situation for disabled learner is given in Section 3 while Section 4 demonstrates an illustrative example through a typical case study. Finally, conclusions are presented in section 5. They review the main results and discuss future works.

2 CONCEPTUAL BACKGROUND

2.1 Ubiquitous Learning Systems

Several ubiquitous learning systems have been proposed in the literature. These systems support users in their learning and teaching activities using embedded and networked computing technologies, sensors and actuators. (Souabni and al., 2016)

Context is a key element of an architecture based on ubiquitous computing, because it is at the center of the adaptation mechanisms advocated by the so-called context-sensitive systems. These systems are characterized by their capacity to adapt their operation in order to increase their usability and efficiency by taking into account the surrounding context.

However, it is more convenient for ubiquitous learning systems to treat more significant data than low-level sensor ones. They must understand the meaning of what they perceive. It may be useful to interpret detected low-level context pieces or to combine low-level and/or interpreted ones to get more abstract and relevant context. Subsequently, it is of great importance for context-aware learning systems to proceed with a high abstraction of detected context information pieces which is known as the situation identification.

2.2 Situation and Situation Awareness

Recent attention to the learning situation was made by Pernas in (Pernas and al., 2014) in order to promote the detection of a rich learning situation and to provide a conscious learning of the situation.

The situation awareness process was widely defined in cognitive studies; the most referred definition, even in computer system field, is stated by Endsley as “the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future” (Endsley, 2000).

In human factor studies, the most referenced and recognized situation awareness process model is the one proposed by Endsley (Endsley, 2017). As stated by authors in (Kokar and al., 2009), Endsley's cognitive situation awareness process was used as a justification for the definition of the situation awareness process performed by the system.

The detection and the inference (interpretation and/or aggregation) are main steps of the situation awareness process. This process is able to abstract the current state of user's situation (Souabni and al., 2018).

2.3 Disabled Learners

A medical model approach to disability is still very common. This considers the disadvantages experienced by disability people to be the result of their disabilities and focuses on individual solutions of trying to overcome these disabilities and making the disabled person more like a non-disabled one. However, organisations of disabled people prefer a social model approach which focused on the barriers they experience, including as a result of both negative attitudes and the mismatch between their needs and the design of services, products and systems. (WHO, 1980)

A given learning environment may include several types of learners, including both disabled and non-disabled learners. We distinguish between learner with different and specific needs (disabled and non-disabled learners). Disability is still most commonly considered from a medical model perspective, leading to a deficit-based focus. This then leads to categories based on the particular impairment (WHO, 1980), such as physically disabled, visually impaired, hearing impaired and cognitively impaired.

In this paper, we are interested in sensory handicaps (Kavcic, 2005): Visual impairments (blindness, partial sight and color blindness): include the range from low vision to full blindness, where the user cannot use the visual display at all.

Hearing impairments (deafness and hearing loss): have difficulties detecting sounds or distinguishing auditory information from the background noise. Deaf individuals cannot receive any auditory information at all. Many of them communicate through the Sign Language.

Most learners with disabilities are able to employ technical aids usually referred to as assistive technology. Several assistive technologies are available in the different learning systems (Voice recognition programs, screen readers, etc.). However, the need is different when it comes to a situation-aware ubiquitous learning system. Indeed, learners are learning while moving and their context is also changing.

In addition to the accessibility of the course content, a disabled learner must be guided in his learning process. Since this is not a face-to-face learning and since it is without the presence of a teacher, the learner is generally not accompanied. It is for this reason that the identification of the learning situation is a fundamental step in ensuring a smooth learning process.

3 PROPOSAL OF UBIQUITOUS LEARNING SITUATION FOR DISABLED LEARNERS

For learning a new concept, the system must detect the context and analyze it in order to associate a typical learning situation (from a pre-established list of typical situations) with the contextual situation observed. In what follows, we define the process to follow in order to define the new learning situations for disabled learners in ubiquitous learning environment. The ubiquitous learning situation definition process for disabled learners, as depicted in Fig. 1, is a two-phase process and each phase contains two steps.

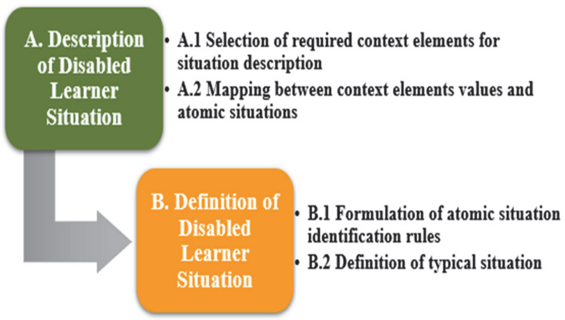

Figure 1: Ubiquitous Learning situation definition process for disabled learners.

3.1 Situation Description

A hierarchical approach that models the ubiquitous learning context is described in (Salah, N. B. and al., 2019). This approach presents an overview of an ontology-based context model for situation-aware ubiquitous learning systems. This context considers learners with and without disabilities.

We briefly recall the ontology described in (Salah, N. B and al., 2019) so that we can use it in the rest of our process. Fig. 2 presents the hierarchy of the classes of the proposed ontology as well as the data property and object property.

3.1.1 Step A.1 Selection of Required Context Element for Situation Description

Many valued context elements are used to infer a situation however only some context information values associated to some context elements are used to describe a typical situation. In order to define typical ubiquitous learning situations for disabled learners, we consider the following contextual elements, which are useful for the definition. Each contextual element is described by values.

To facilitate this step, we consider in this paper only one value of the two contextual information "Learning preference" and "Facilitation preference" which are "Real World Learning" and "Online Guidance" respectively. The following table (Table 1) describes the contextual elements as well as the values taken into account in our study for the proposition of the typical learning situations.

We recall that the notion of "learner's peers" was introduced by authors in (Hwang and al., 2008). This notion has been detailed by the authors in (Souabni and al., 2018) who describe peer helper as a person who help the learner during his/her learning for a given concept and the peer learners as learners who cooperate with the learner to learn the same learning concept.

Table 1: Required context elements.

Context Elements	Values
Cooperation Level	Non-Cooperative
	Communicative
	Participative
	With Initiative
	Insightful
	Useful
Disability Type	Hearing Impairment
	Visual Impairment
Facilitation Preference	Online Guidance
Learning Preference	Real World Learning
Learning Style	Reflector
	Pragmatist
	Theorist
Peer Helper	Boolean
Peer Learner	Boolean

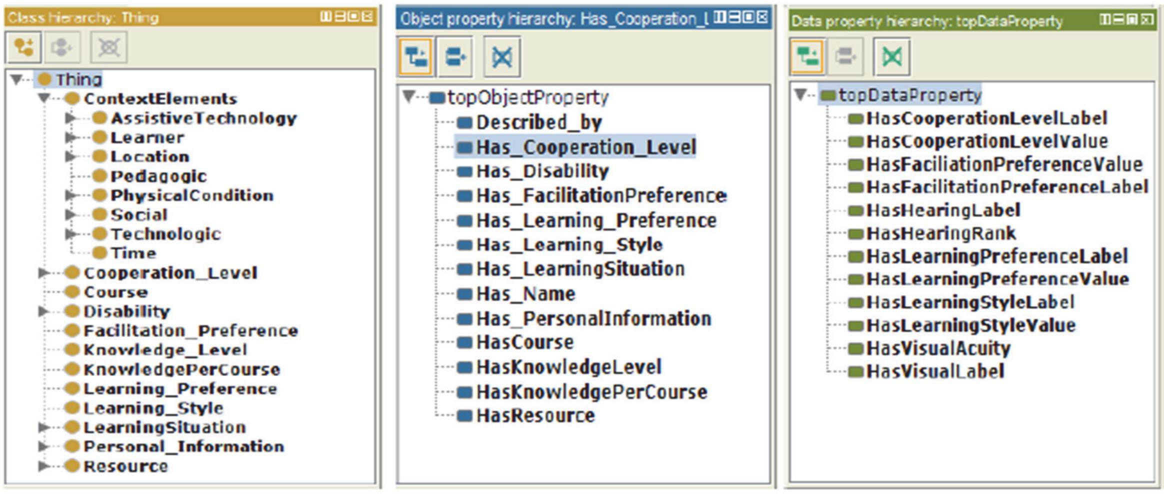

Figure 2: A hierarchical view of the key ontology classes, object-properties and data-type properties.

3.1.2 Step A.2 Mapping between Context Elements Values and Atomic Situations

The current learning situation definition of the disabled learner is done by referring to typical learning situations. Each typical situation is composed by a list of atomic situations. These latter are described by values of contextual elements that represent the identification criteria. The relationships between these concepts are described in Fig. 3.

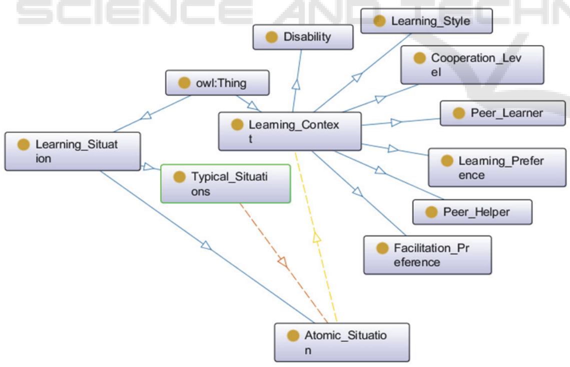

Figure 3: Relation between Typical Situation, Atomic Situation and Context Elements.

Subsequently, we adopt the approach described in (Hwang and al., 2011), in order to add new atomic situations that are specific to disabled learners. For example, if the context element "Cooperation level" has the value "Insightful", "Useful", "With initiative" or "Participative", and the learner is in an environment where there are Peer helper and / or Peer Learner, we can say that we are in the learning atomic situation "Cooperative learning".

We also take the example of a learner who has a visual impairment. The type of visual impairment is "Blindness". The learners atomic learning situation will then be "Learning with blindness disability". The atomic situations and their identification criteria are listed in table 2.

Table 2: Identification criteria for atomic situations.

Identification criteria	Identification Value		Atomic situations
Learning preference	Real World		Learning in the Real world
Facilitation preference	Online Guidance		Learning with Online guidance
Learning Style	Type	Nature	
	Hearing Impairment	Hearing Loss	Learning with hearing loss Disability
		Deafness	Learning with deafness disability
	Visual Impairment	Partial Sight	Learning with partial sight disability
		Blindness	Learning with blindness disability
Cooperation Level	Non cooperative		Individual Learning
	Insightful Useful With initiative Participative		Cooperative Learning
Peer Learner	True		
Peer Helper	True		

3.2 Situation Definition

The definition of the learning situation is composed of two steps. The first deals with the formulation of atomic situation identification rules while the second presents the definition of typical situation. Indeed, the identification of the learning situation for learners with disabilities is the ability to deduce the situation from the aggregation of atomic situations already identified.

3.2.1 Step B.1 Formulation of Atomic Situation Identification Rules

In order to determine the situation that most characterizes the disabled learner's current learning situation, we propose the identification rules for the atomic situations that will later compose the typical learning situations.

Here are three examples of rules that describe the following atomic situations: “Learning with hearing loss Disability”, “Learning with partial sight disability” and “Cooperative Learning”. These rules are described in Fig. 4, 5 and 6.

```
• Learning_with_hearing_loss_Disability
• LearningSituation and Described_by some (
    Learner and
    HasHearingRank value 1 or HasHearingRank value 2 and
    Has_Disability some Hearing_Impairment)
```

Figure 4: Identification rule of the atomic situation “Learning with hearing loss Disability”.

```
• Learning_with_partial_sight_disability
• LearningSituation and Described_by some (
    Learner and
    HasVisualAcuity value 1 or HasVisualAcuity value 2 and
    Has_Disability some Visual_Impairment)
```

Figure 5: Identification rule of the atomic situation “Learning with partial sight disability”.

```
• Learning_by_problem_solving
• LearningSituation and Described_by some (
    Learner and
    Has_Learning_Style value Pragmatist and
    Has_Learning_Style value Theorist)
```

Figure 6: Identification rule of the atomic situation “Learning by problem solving”.

Taking the example of a learner with a hearing impairment and to whom we have performed a test to determine his hearing level. If the result of this test gave that learner has a hearing level equal to “Mild hearing loss” or “Moderate hearing loss” (represented by the values “1” and “2” respectively in the ontology described in (Salah, N. B. and al., 2019)), the learner will be in the atomic situation “learning with hearing loss disability”.

3.2.2 Step B.2 Definition of Typical Situation

A typical situation is considered as a composite one for which a list of atomic situations is attached. Based on those atomic situations, we propose twelve typical situations for disabled learner in a situation-aware ubiquitous learning environment. The mapping between atomic situations and typical situations is given in Table 3.

Table 3: Atomic and typical situations.

Atomic Situations	Typical situations
Cooperative Learning, learning with deafness disability, learning with online guidance, learning by data collection, Learning in the real world	ST_H1= Cooperative data collection with deafness disability
Individual Learning, Learning with deafness disability, Learning with online guidance, Learning in the real world, Learning by object identification	ST_H2= Identification of real-world object with deafness disability
Individual learning, Learning with deafness disability, Learning with online guidance, Learning in the real world, Learning by experimentation, Learning by problem solving	ST_H3= Problem solving via experimentation with deafness disability
Cooperative Learning, Learning with hearing loss disability, Learning with online guidance, Learning by data collection, Learning in the real world	ST_H4= Cooperative data collection with hearing loss disability
Individual Learning, Learning with hearing loss disability, Learning with online guidance, Learning in the real world, Learning by object identification	ST_H5= Identification of real-world object with hearing loss disability
Individual learning, Learning with hearing loss disability, Learning with online guidance, Learning in the real world, Learning by experimentation, Learning by problem solving	ST_H6= Problem solving via experimentation with hearing loss disability
Cooperative learning, Learning with blindness disability, Learning with online guidance, Learning by data collection, Learning in the real world	ST_H7= Cooperative data collection with blindness disability

Table 3: Atomic and typical situations (cont.).

Atomic Situations	Typical situations
Individual learning, Learning with blindness disability, Learning with online guidance, Learning in the real world, Learning by object identification	ST_H8= Identification of real-world object with blindness disability
Individual learning, Learning with blindness disability, Learning with online guidance, Learning in the real world, Learning by experimentation, Learning by problem solving	ST_H 9= Problem solving via experimentation with blindness disability
Cooperative learning, Learning with partial sight disability, Learning with online guidance, Learning by data collection, Learning in the real world	ST_H10= Cooperative data collection with partial sight disability
Individual learning, Learning with partial sight disability, Learning with online guidance, Learning in the real world, Learning by object identification	ST_H11= Identification of real-world object with partial sight disability
Individual learning, Learning with partial sight disability, Learning with online guidance, Learning in the real world, Learning by experimentation, Learning by problem solving	ST_H12= Problem solving via experimentation with partial sight disability

We consider the example described in Section 3 (Step A.2) where the atomic situation of the learner was “Learning with blindness disability”. If in addition, the system has detected through the value of the detected contextual elements that this learner is also in the following situations: “Individual learning”, “Learning with online guidance”, “Learning in the real world”, “Learning by experimentation” "and “Learning by problem solving”.

According to the identified atomic situations, we implement rules to define the learner’s learning situation. OWL does not provide facilities to create inferences about individuals. This is possible through the combination of OWL with SWRL (W3C Semantic Web Rule Language), since it allows the definition of rules expressed in terms of OWL concepts. Thus, SWRL was chosen to describe the situation definition rules. It will then detect that the typical learning situation of this learner is “STH9 = Problem solving via experimentation with blindness disability”. This rule and other rules examples are descripted in Table 4.

4 ILLUSTRATIVE EXAMPLE

Let’s consider the learner “Learner 1” who has a partial sight disability (Visual Impairment Class). He prefers online guidance (Facilitation Preference Class) to support learning. The learner like to understand the theory behind the actions and need to be able to see how to put the learning into practice in the real world (Learning Style and Learning preference Classes). He is learning on his own and did not enjoys interaction (Cooperation level Class).

Table 4: Learning Situation Definition rules.

Learning Situations	Rules definition
$S_{TH}9$	(HasVisualAcuity (?a,3) ∨HasVisualAcuity (?a,4) ∨ HasVisualAcuity (?a,5) ∨ HasVisualAcuity (?a,6)) ∧ Has_Disability (?a,Visual_Impairment) ∧ HasLearningPreference(?a,RealWorllearning) ∧ Has_Learning_Style (?a,Pragmatist) ∧ Has_Learning_Style (?a,Theorist) ∧ (HasFacilitationPreference(?a, OnlineGuidance) ➔ Has_Situation(?a, Problem_solving_via_experimentation_with_blindness_disability)
$S_{TH}1$	Has_Disability (?a, HearingImpairment) ∧ ((HasHearingRank(?a,3) ∨ HasHearingRank(?a,4)) ∧ HasLearningPreference(?a,RealWorllearning) ∧ HasLearningStyle(?a,Reflector) ∧ (HasFacilitationPreference(?a, OnlineGuidance) ➔ Has_Situation(?a, CooperativeDataCollectionWithDeafnessDisability)
$S_{TH}2$	Has_Disability (?a, HearingImpairment) ∧ ((HasHearingRank(?a,3) ∨ HasHearingRank(?a,4)) ∧ HasLearningPreference(?a,RealWorllearning) ∧ (HasFacilitationPreference(?a, OnlineGuidance) ∧ Has_Learning_Style (?a,Reflector) ➔ Has_Situation(?a, Identification_of_real-world_object_with_deafness_disability)

In what follows, we will try to identify the typical situation of this learner. Through the described scenario, we can extract the identification criteria and their values which are described in table 5.

Table 5: Values of the identification criteria.

Identification criteria	Values
Disability = Visual Impairment	Partial sight disability
Facilitation preference	Online Guidance
Learning Style	Pragmatic / Theorist
Learning Preference	Real world learning
Cooperation Level	Non-Cooperative

Some context information, are detected using sensors. They come in part from the answers to questionnaires or tests, such as the visual impairment test. Generally, a Snellen chart is used for visual acuity testing. The different values and levels of visual acuity are described in (Salah, N. B. and al., 2019).

During execution, identification rules are verified. Based on the detected context in the described scenario, the inference engine will execute the rules that correspond to the mapping between the detected contextual elements, their values and the corresponding atomic situations (AS).

The different atomic situations identified in this case are:

AS1: Learning with partial sight disability
AS2: Learning with Online guidance
AS3: Learning by problem solving
AS4: Learning in the Real world
AS5: Individual Learning

The application of the rules for defining learning situations allows us to define the current learning situation of this learner which is in this case, STH12 “Problem solving via experimentation with partial sight disability” for the learner “Learner 1”. The definition rule applied to define this situation is described as follow:

HasVisualAcuity (?a,1) ∨ HasVisualAcuity (?a,2)) ∧ Has_Disability (?a,Visual_Impairment) ∧ HasLearningPreference(?a,RealWorllearning) ∧ Has_Learning_Style (?a,Pragmatist) ∧ Has_Learning_Style (?a,Theorist) ∧ (HasFacilitationPreference(?a, OnlineGuidance) ➔Has_Situation(?a, Problem_solving_via_experimentation_with_partialSight_disability)

Fig. 7 illustrates a simplified representation of the typical learning situation definition process for this illustrative example.

5 CONCLUSIONS

This paper presented an approach for proposing new ubiquitous learning situations for disabled learners. A brief review of the literature showed the lack of a specific learning situation for the disabled learner. This proposal was illustrated by a case study through which we developed a reasoning that describes the typical learning situation for a disabled learner given according to the proposed identification rules.

The proposal of typical learning situations for learners with disabilities will enable us to provide accessible guidance for these learners, based on their

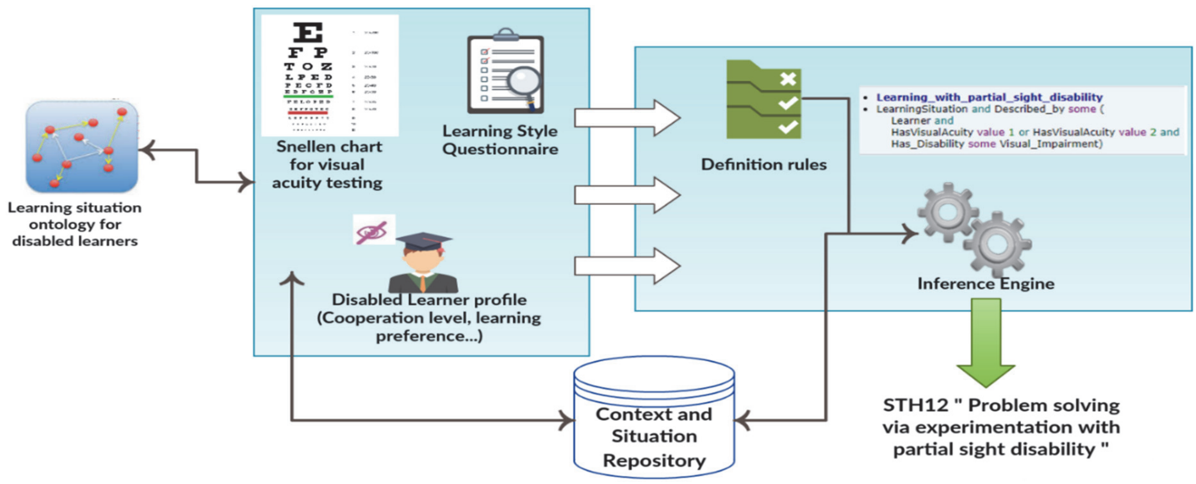

Figure 7: Illustrative Example.

identified ubiquitous learning situation. With these tips, we can recommend the most appropriate learning strategy for the learner in a given ubiquitous learning situation. Another future work that concerns uncertainty in these ubiquitous environments, we will then consider, to give a degree of confidence by proposing a fuzzy ontology to describe the context and ubiquitous learning situations. Large-scale experimentation is feasible for future work.

REFERENCES

DAniello, G., Granito, A., Mangione, G. R., Miranda, S., Orciuoli, F., Ritrovato, P., & Rossi, P. G. (2014, July). A city-scale situation-aware adaptive learning system. In 2014 *IEEE 14th International Conference on Advanced Learning Technologies* (pp. 136-137). IEEE.

Endsley, M. R. (2017). Toward a theory of situation awareness in dynamic systems. *In Situational awareness* (pp. 9-42). Routledge.

Salah, N. B., Saadi, I. B., Hersh, M., & Ghezala, H. B. (2019, August). Ontological Modeling of Ubiquitous Accessible Learning Context for Disabled Learners. In 2019 IEEE SmartWorld, Ubiquitous Intelligence & Computing, Advanced & Trusted Computing, Scalable Computing & Communications, Cloud & Big Data Computing, Internet of People and Smart City Innovation (SmartWorld/SCALCOM/UIC/ATC/ CBDCom/IOP/SCI) (pp. 968-973). IEEE.

Hwang, G. J. (2006, June). Criteria and strategies of ubiquitous learning. *In IEEE International Conference on Sensor Networks, Ubiquitous, and Trustworthy Computing* (SUTC'06) (Vol. 2, pp. 72-77). IEEE.

Saâdi, I. B., & Hamdani, A. (2019). A semantic approach for situation-aware ubiquitous learner support. *International Journal of Smart Technology and Learning*, 1(2), 162-187.

DAniello, G., Gaeta, M., Loia, V., Orciuoli, F., & Sampson, D. G. (2015, September). Situation awareness enabling decision support in seamless learning. In 2015 *International Conference on Intelligent Networking and Collaborative Systems* (pp. 440-445). IEEE.

Pernas, A. M., Yamin, A. C., Lopes, J. L., & de Oliveira, J. P. M. (2014, May). A semantic approach for learning situation detection. In 2014 IEEE 28th *International Conference on Advanced Information Networking and Applications* (pp. 1119-1126). IEEE.

Endsley, M. R., & Garland, D. J. (2000). Theoretical underpinnings of situation awareness: A critical review. Situation awareness analysis and measurement, 1, 24.

Kokar, M. M., Matheus, C. J., & Baclawski, K. (2009). Ontology-based situation awareness. Information fusion, 10(1), 83-98.

Souabni, R., Saâdi, I. B., Kinshuk, & Ghezala, H. B. (2018). Context Weighting for Ubiquitous Learning Situation Description: Approach Based on Combination of Weighted Experts' Opinions. *International Journal of Information Technology & Decision Making*, 17(01), 247-309.

WHO, 1980, International Classification of Impairments, Disabilities and Handicaps, Geneva, Switzerland, World Health Organisation, 1980.

Hersh, M. A., & Johnson, M. A. (2008). On modelling assistive technology systems–Part I: Modelling framework. Technology and disability, 20(3), 193-215.

Kavcic, A. (2005, November). Software accessibility: Recommendations and guidelines. *In EUROCON 2005-The International Conference on" Computer as a Tool"* (Vol. 2, pp. 1024-1027). IEEE..

Hwang, G. J., Shi, Y. R., & Chu, H. C. (2011). A concept map approach to developing collaborative Mindtools for context - aware ubiquitous learning. *British Journal of Educational Technology*, 42(5), 778-789.

Souabni, R., Saadi, I. B., Salah, N. B., & Ghezala, H. B. (2016, July). Approach based on fuzzy ontology for situation identification in situation-aware ubiquitous learning environment. *In 2016 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE)* (pp. 1805-1812). IEEE.

Souabni, R., Saâdi, I. B., & Ghezala, H. B. (2019). A multidimensional framework to study situation awareness in u-learning systems. Telematics and Informatics, 43, 101246.