Managing Affective-learning THrough Intelligent atoms and Smart InteractionS

D.3.8 Learner's Profile Repository

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Abstract:	This deliverable describes the final implementation of the Learner's Profile Repository as an infrastructure that stores information relating to individual learners (personal information, accessibility preferences, level of knowledge and learning styles). Such information serves as basis for the personalization and adaptation of the learning experience in MaTHiSiS.
Keywords:	Learner Profile Repository, accessibility, preferences, skills, competences, performance, learner information
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1.0	16/12/2017		FINAL VERSION TO BE SUBMITTED

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List of Acronyms

Abbreviation / acronym	Description
AES	Advanced Encryption Standard
ASC	Autism Spectrum Case
ASD	Autism Spectrum Disorder
CGDLC	Career Guidance Distance Learning Case
CLS	Cloud-based Learner's Space
ITC	Industrial Training Case
IWB	Interactive Whiteboard
LPR	Learning Profile Repository
LRS	Learning Record Stores
MEC	Mainstream Education Case
PMLDC	Profound and Multiple Learning Disabilities Case
SLA	Smart Learning Atoms
xAPI	Experience API

Table 1: Definitions, Acronyms and Abbreviations

Project Description

MATHISIS is a 36 month duration project co-funded by the European Commission Horizon 2020 Programme (H2020-ICT-2015) under Grant Agreement No. 687772. It started on 1st January 2016.

One of the core objectives of MaTHiSiS project is to enhance learning environments and make use of computing devices in learning in a more interactive way, which will provide a product-system to be used in formal, non-formal and informal education. An ecosystem for assisting learners/tutors/caregivers for both regular learners and learners with special needs will be introduced and validated in 5 use cases: Autism Spectrum Case (ASC), Profound and Multiple Learning Disabilities Case (PMLDC), Mainstream Education Case (MEC), Industrial Training Case (ITC) and Career Guidance Distance Learning Case (CGDLC).

MaTHiSiS product-system consists of an integrated platform, along with a set of re-usable learning components (educational material, digital educational artefacts, etc.), which will respond to the needs of a future educational framework, and provide capabilities for: i) adaptive learning, ii) automatic feedback, iii) automatic assessment of learner's progress and behavioural state, iv) affective learning and v) game-based learning.

Within MaTHiSiS, an innovative structural tool of learning graphs is going to be introduced to guide the learner through the process of learning in the given scenario. To reach a learning objective, learner will have to "follow the path" of the learning graphs, built up on Smart Learning Atoms, which are certain learning elements that carry defined learning materials.

To ensure barrier free integration in the market, MaTHiSiS makes use of a range of interaction devices, such as specialized robots, mobile devices and interactive whiteboards. The consortium ensures easy-to-use solution with e.g. specialized graphical editor-like tool, allowing to easily create educational materials as well as the reusability within both mainstream education and vocational training setups.

Objectives of the project

A Cloud-based Learner's Space (CLS) will be developed to provide a system for adaptation/personalization in learning, interaction, data acquisition and analysis as well as content creation on the fly. This is a core component of the MaTHiSiS system which includes 3 crucial subsystems which create an innovative smart learning ecosystem: i) the experience engine, a graph-based interactive storytelling engine, that manipulates interactive content that is later sent to a device of tutor's/learner's choice; ii) the learning graph engine, responsible for adaptation of the Learning Graph based on learner's behaviour and interaction; iii) the Decision Support System (DSS) providing directives for personalization and adaption based on the affective and performance information retrieved from learning analytics, and controlling synchronous and asynchronous interaction between devices. To ensure constant educational flow and augmented learner engagement, the emotion recognition and context aware cognitive/behavioural status extraction tools are introduced within the system addressed by the Sensorial Component (CS).

For the purpose of validating MaTHiSiS approaches in learning environment, a set of Smart Learning Atoms (SLA) is going to be created for defined use cases. Such SLAs will adapt to each learner in a different way based on her/his particular needs, profile, cognitive affective state, relevance to specific learning requirements and previous performance. Further, an editor-like tool is introduced to be able to transform educational material into MaTHiSiS Learning Materials usable by SLAs through Learning Actions. The learning graphs then are going to be deployed to interact with the CLS as well as some front-end tools for tutors and caregivers to enable creation, editing and authoring of the learning contents and learning experiences.

MaTHiSiS will support learning across a variety of learning contexts and, with the use of a variety of devices (robots, interactive whiteboards, mobile devices and desktop/laptop computers), with personalized and adaptable, time and location independent learning paths, being transferred between the agents, always taking into consideration best knowledge and practices learnt from the previous device.

By the end of the project, MaTHiSiS will introduce a marketable innovation, aimed at the re-usability of educational and training content and fostering the interactivity between technology and learners/tutors/caregivers.

Executive Summary

This document constitutes the second and final version of the Learner Profile Repository (LPR) report of the MaTHiSiS project.

The learner profile repository is a cloud-based infrastructure that stores information relating to individual learners who are engaged in the learning environment. Developing a learner profile will enable MaTHiSiS to provide a personalized learning experience to the learners taking into account to the learners' specific needs.

The OpenAPI LPR manages the Learner Profile Repository. This API is responsible for receiving and transmitting the learners profile data to the Leaner Profile Repository. In short, the OpenAPI exposes services to:

- Retrieve all the leaners profiles from the MaTHiSiS database.
- Retrieve a learner profile attached to a particular user identifier.
- Update a specific profile.

The Learner Profile Repository appears under the User Manager tab of the MaTHiSiS front end. In the User Manager all the Learner Profiles created by MaTHiSiS users and stored in the Learning Profile Repository, can be browsed, viewed and edited.

The following set of details can be accessed by the user:

- *Personal information* including his first and last name
- *Accessibility* preferences which are the set of features that characterize the learner's behaviour during his/her interaction with a Technology Enhanced system
- Details regarding the *level of knowledge*: On one hand the curricular level which is the educational stage of the learner and on the other hand the competencies which are the knowledge and skills of the learners that will be used for the personalization of the learning experience in MaTHiSiS.
- *Learning style* that is the referential way in which the learner prefer to learn.

1. Introduction

D3.8 MaTHiSiS Learners Profile Repository is the second and final report of the MaTHiSiS Learners Profile Repository. This document is an updated version of D3.7 [1].

This document is organized as follows:

- Section 1 introduces the purpose and structure of this deliverable.
- Section 2 introduces the Learner Profile Repository, the integration with the MaTHiSiS platform and the implementation of the library that is responsible for receiving and transmitting the learners profile data to the Leaner Profile Repository. Furthermore, it describes the interface of the Learner Profile Repository in the MaTHiSiS front end.
- Section 3 presents the conclusions of the document.
- Section 4 includes the references.
- Section 5 presents the Learner profile information in JSON format.
- Section 6 presents the OpenAPI LPR calls.

2. Learner Profile Repository

2.1 Definition

The learner profile repository is a cloud-based infrastructure that stores information relating to individual learners who are engaged in the learning environment. Developing a learner profile will enable the teachers to provide a personalized learning experience to the learners taking into account to the learners' specific needs.

2.2 Integration with MaTHiSiS

The integration of the LPR with the MaTHiSiS Platform is done through the OpenAPI. The platform exchanges information with the LPR in a bidirectional way:

- *From the platform to the LPR*: The platform stores the learner-related information in the LPR.
- *From the LPR to the platform*: LPR will provide information about the learners in order to personalize the learning experiences.

2.3 Data structure

Different sources of information and the feedback from the psychologists, pedagogical and accessibility experts from MaTHiSiS have been key to the definition of the data structure.

The following aspects had been considered:

Accessibility: The overall set of features that characterize the learner's behaviour during his/her interaction with a Technology Enhanced system.

Disabilities[1]: The set of learner special needs that could affect the educational process.

Level of knowledge: The score that the Learner has in the different competencies that is used to take into account the learner's background when delivering learning material to the learners. The performance is used to calculate the level of competence of new learners in order to initialize the SLA weights when a new learner is added into the system. A detailed explanation can be found in D6.2 [2].

The level of competences is composed by:

- Curricular level that indicates the educational stage of the learner
- Competencies that specifies the score that this learner has in different aspects.

Learning Styles: According to the Felder-Silverman theory [3], all the learners can be classified according to their preferred way to learn.

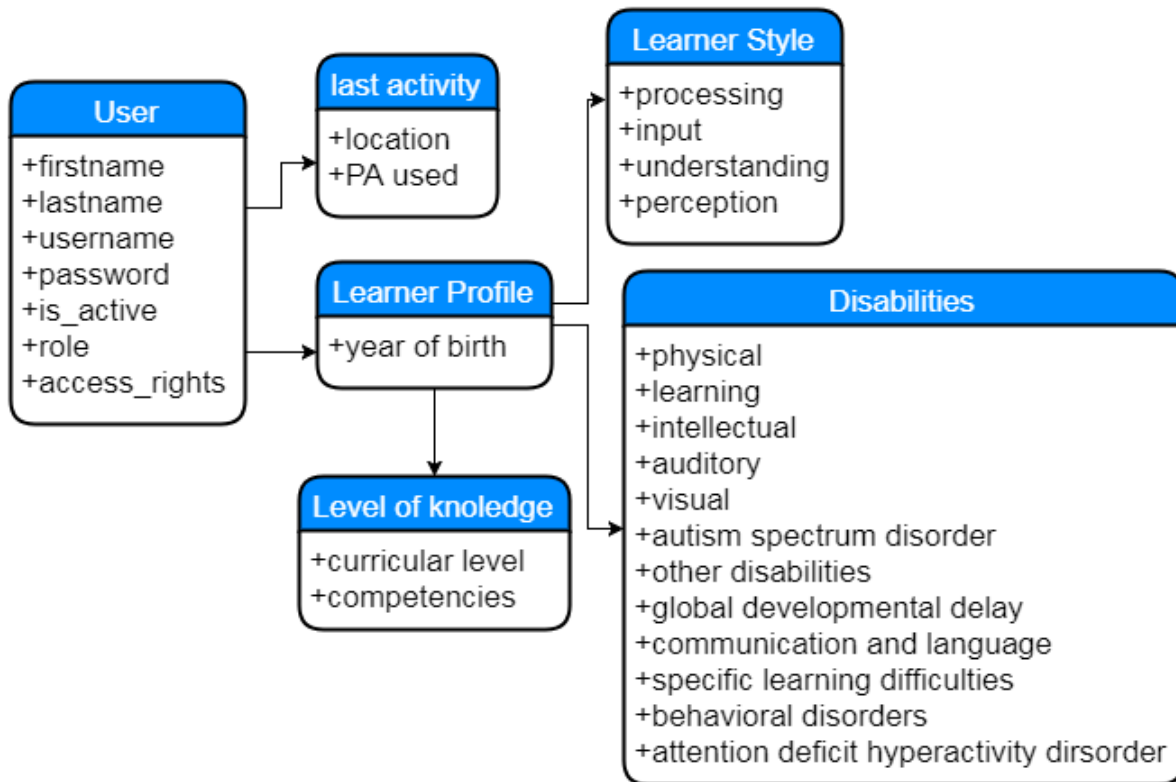The diagram of the MaTHiSiS User data model is shown in Figure 1.

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[1] [1] http://www.disability.net/page4.html

Figure 1: User data model

The Learner profile information in JSON format is presented in Annex 1.

All the sensible data from the learners -that could be used to identify them- are saved encrypted with AES (Advanced Encryption Standard) in this database, to ensure the security and confidentiality. The encryption has been applied to all the values of each learner. AES uses a very secure symmetric-key algorithm that is used widely by big corporations and by the U.S. government, in order to encrypt important and sensible information.

2.4 OpenAPI

The API used to manage the Learner Profile Repository is the LPR API. This OpenAPI is responsible for receiving and transmitting the learners profile data to the Leaner Profile Repository. The details of the functionalities behind the OpenAPI calls are listed in Figure 2 and described in Annex 2 OpenAPI LPR.

Figure 2: **Profile controller as seen in Swagger UI**

In short, the OpenAPI exposes services to:

- Retrieve all the leaners profiles from the MaTHiSiS database.
- Retrieve a learner profile attached to a particular user identifier.
- Update a specific profile.

2.5   Interface with the Front end

The Learner Profile Repository appears under the **User Manager** tab of the MaTHiSiS front end as shown in Figure 3. In the User Manager all the Learner Profiles created by MaTHiSiS users and stored in the Learning Profile Repository, can be browsed, viewed and edited.
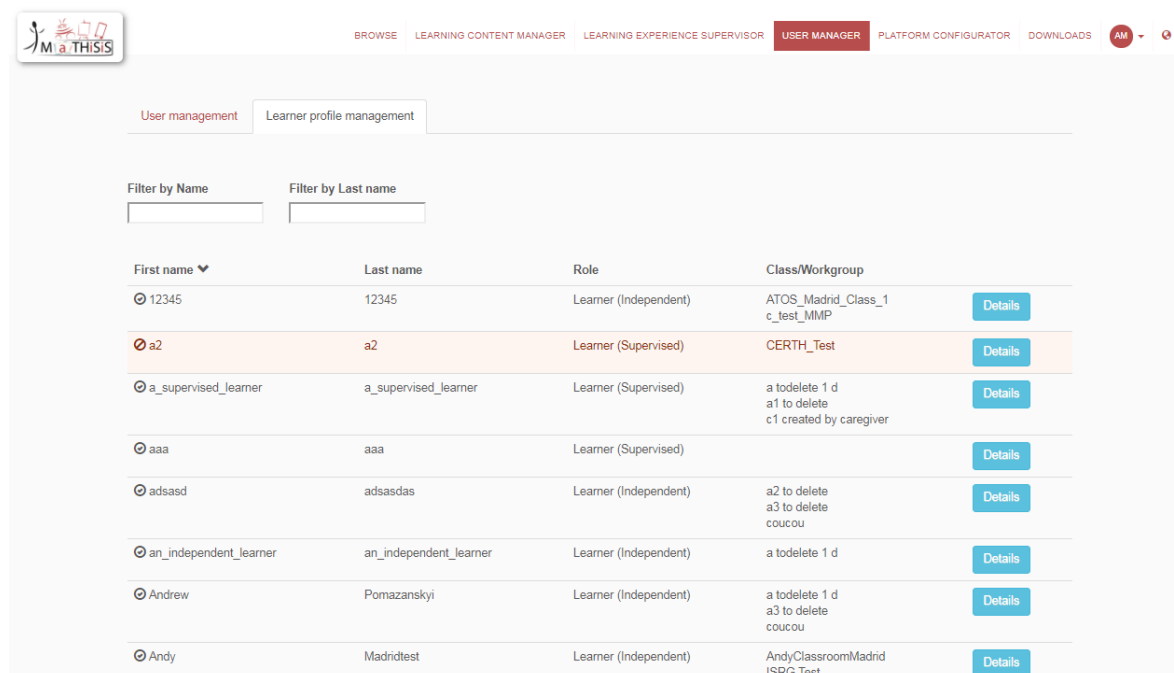

Figure 3: Learner profile management in the MaTHiSiS front end

The following set of details can be accessed by the user:

- *Personal information* including his first and last name
- *Accessibility* preferences
- Details regarding the *level of knowledge*
- *Learning style* options

2.5.1   Personal information

The **personal information** of the learner is shown in Figure 4. The only editable field is the year of birth.
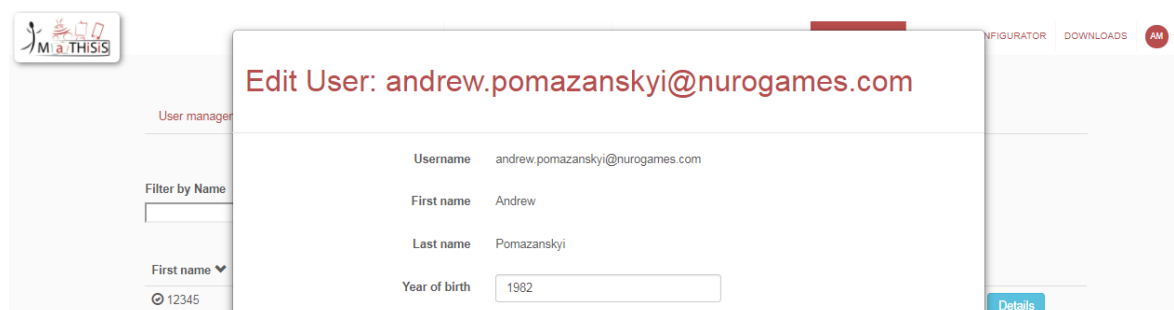
Figure 4: Personal information

2.5.2 Accessibility

Figures 5 and 6 show the **accessibility** preferences with relevant information about the *disabilities* that the learner may have. **Disabilities** describe the learner's special needs information and to facilitate the adaptation and personalization of the learning process:

Figure 5: Accessibility preferences (I)

Figure 6: Accessibility preferences (II)

The disabilities defined in MaTHiSiS are listed in the table below.

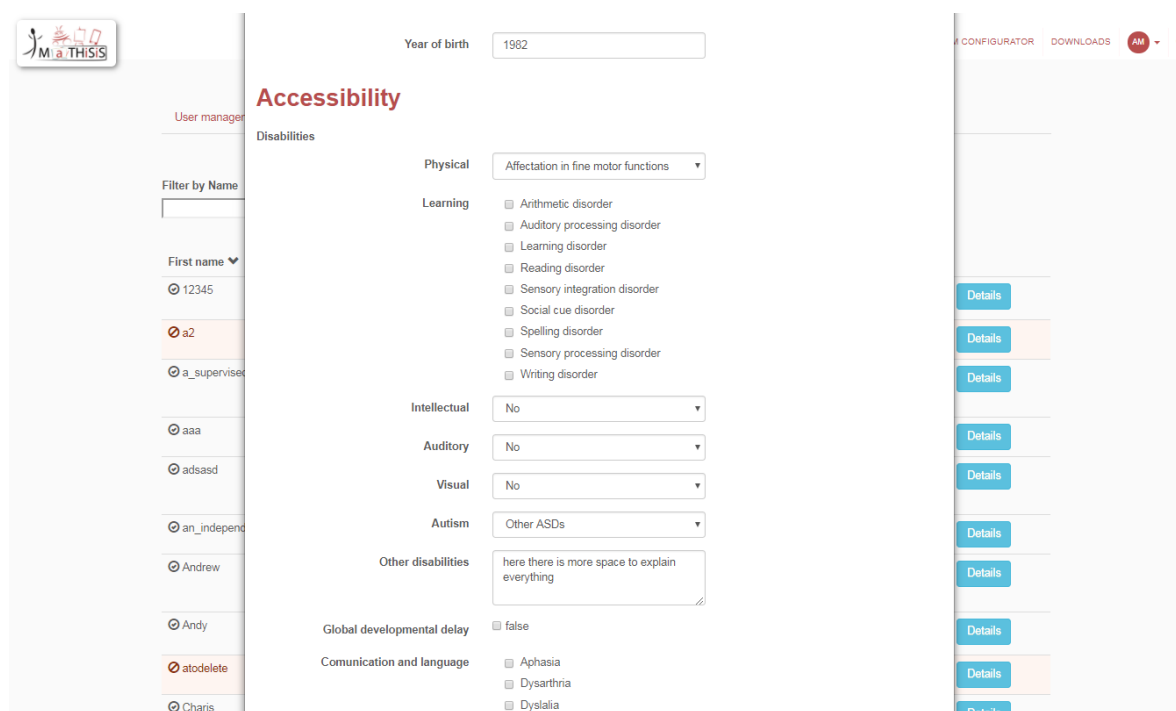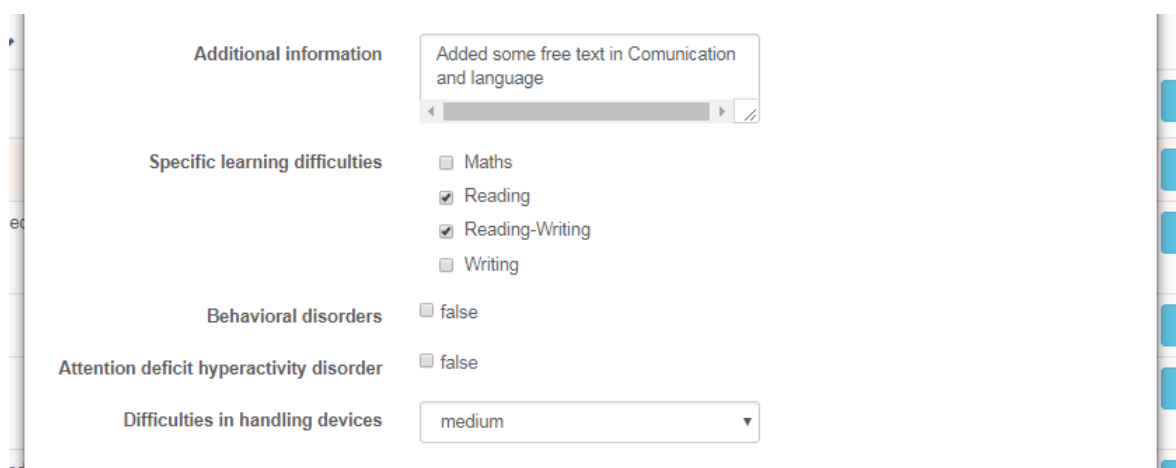| Disabilities	Description	In MaTHiSiS
Physical[2]	Limitation on a person's physical functioning, mobility, dexterity or stamina.	• No affectation in motor functions; • Affectation in fine motor functions; • Affectation in gross motor functions; • Motor skills delay (general developmental condition that affects motor coordination).
Learning	Number of conditions that might affect the acquisition, organization, retention, understanding or use of verbal or nonverbal information. Learning disabilities are due to genetic and/or neurological factors or injuries that alter brain functionality, in a way which affects one or more processes related to learning	• Arithmetic disorder • Auditory processing disorder • Learning disorder • Reading disorder • Sensory integration disorder • Social cue disorder • Spelling disorder • Sensory processing disorder • Writing disorder
Intelectual	Characterized by significantly impaired intellectual and adaptive functioning.	• No • Mild • Moderate • Severe
Auditory	Loss of hearing	• No • Mild hearing loss • Severe hearing loss • Total hearing loss
Visual	Decreased ability to see	• No • Visual impairment • Blindness
Autism	Range of conditions characterized by challenges with social skills, repetitive behaviors, speech and nonverbal communication, as well as	• No • Autism • High functioning autism • Other ASDs

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[2] http://www.disability.net/conditions.htm

Disabilities	Description	In MaTHiSiS
	by unique strengths and differences	
Other disabilities	Other disabilities the learner may have	Free text
Global development delay	Delay in the cognitive and physical development	• True • False
Communication and language	Individual's ability to comprehend, detect, or apply language and speech to engage in discourse effectively with other	• Aphasia • Dysarhria • Dyslalia • Dysphonia • Language delay • Selective mutism • Stuttering
Additional information		Free text
Specific learning difficulties	Difficulties in learning basic skills	• Maths • Reading • Reading-Writing • Writing
Behavioural disorders	Characteristics over a long duration, and to a marked degree that adversely affects the learners' educational performance	• True • False
Attention deficit hyperactivity disorder	Developmental condition of inattention and distractibility, with or without accompanying hyperactivity	• True • False
Difficulties in handling devices	Help teachers to choose the platform agent (tablet, robot, IWB, mobile device) that best suits the needs of a specific learner	• None • Low • Medium • Severe

Table 2: MaTHiSiS Disabilities

2.5.3 Level of knowledge

The figure below illustrates the **Level of knowledge.**

Figure 7: Level of Knowledge

The level of knowledge is composed by "curricular level" and "competencies":

- The **curricular level** is the educational stage of the learner: preschool 1-2, primary 1-6, secondary 1-6, further education, other, college, master, PhD.
- **Competencies** are the knowledge and skills of the learners that will be used for the personalization of the learning experience in MaTHiSiS. MaTHiSiS uses the key competences, necessary for personal fulfilment, active citizenship, social cohesion and employability in a knowledge society, identified by the European Reference Framework of Key Competences for Learning:
  - *1. Mother tongue*: ability to express and interpret concepts, thoughts, feelings, facts and opinions in both oral and written form (listening, speaking, reading and writing), and to interact linguistically in an appropriate and creative way in a full range of societal and cultural contexts; in education and training, work, home and leisure.
  - *2. Foreign languages*: ability to understand, express and interpret concepts, thoughts, feelings, facts and opinions in both oral and written form (listening, speaking, reading and writing) in an appropriate range of societal and cultural contexts (in education and training, work, home and leisure) according to one's wants or needs.
  - *3. Mathematical competence and basic competences in science and technology*: Mathematical competence is ability to develop and apply mathematical thinking in order to solve a range of problems in everyday situations while the competence in science and technology refers to the ability and willingness to use the body of knowledge and methodology employed to explain the natural world, in order to identify questions and to draw evidence-based conclusions.
  - *4. Digital competence* involves the confident and critical use of Information Society Technology (IST) for work, leisure and communication.

- o *5. Learning to learn* is the ability to pursue and persist in learning, to organise one's own learning, including through effective management of time and information, both individually and in groups.
- o *6. Social and civic competence* includes personal, interpersonal and intercultural competence and cover all forms of behaviour that equip individuals to participate in an effective and constructive way in social and working life, and particularly in increasingly diverse societies, and to resolve conflict where necessary
- o *7. Sense of initiative and entrepreneurship* refers to an individual's ability to turn ideas into action. It includes creativity, innovation and risk-taking, as well as the ability to plan and manage projects in order to achieve objectives.

These key competences consist of knowledge, skills and attitudes and contribute to personal fulfilment, social inclusion and active citizenship and employability.

2.5.4 Learning styles

The term "*learning styles*" speaks to the understanding that every student learns differently. The learning style refers to the preferential way in which the learner absorbs, processes, comprehends and retains information. Figure 8 shows the different styles considered in MaTHiSiS which are based on the Felder-Silverman theory.
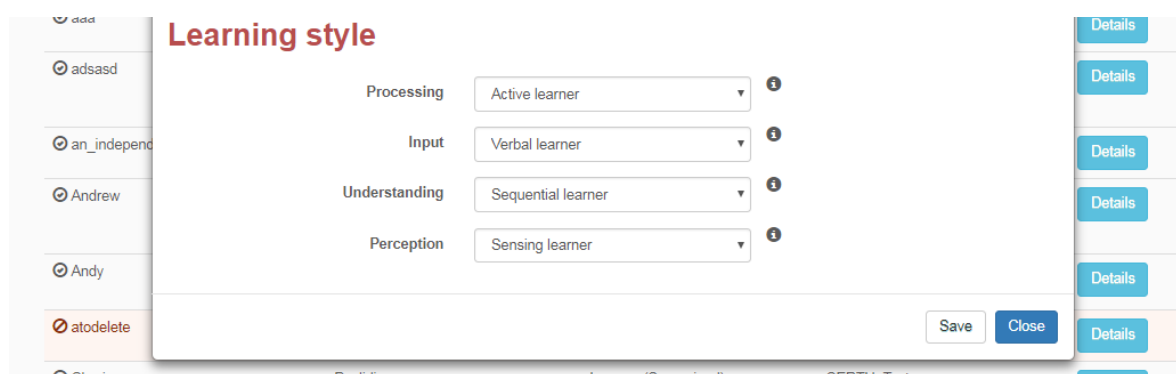
Figure 8: Learning style

The following table provides details on the MaTHiSiS learning styles:

Learning Style	Description	In MaTHiSiS
Processing	Indicates how the learner prefers to process the information actively through engagement in physical activity or discussion, or reflectively through introspection.	• *Active Learners* learn by doing something with information. They prefer to process information by talking about it and trying it out. They prefer to work in groups; • *Reflective learners* think about the information before doing anything with it. They prefer to work alone, rather than in groups.

Learning Style	Description	In MaTHiSiS
Input	Indicates sensory channel through which external information is most effectively perceived by the learner: visual pictures, diagrams, graphs, demonstrations, or auditory words, sounds and tactile input.	• *Visual learners* are better able to remember images they have seen (charts, graphs, pictures). • *Verbal learners* are better able to remember written or spoken words.
Understanding	Shows how the learner progresses towards understanding: sequentially in continual steps, or in fits and starts	• *Sequential learners* prefer learning linearly, with logical steps. • *Global learners* prefer a holistic approach and seem to learn almost randomly by fitting pieces together into a big picture.
Perception	Type of information the learner prefers to receive: sensory (external) such as sights, sounds, physical sensations; or intuitive (internal) such as possibilities, insights, hunches	• *Sensing learners* are detail-oriented and practical with a preference for concrete facts and real world applications. • *Intuitive learners* have a creative disposition and are drawn *to the theoretical and abstract*.

Table 3: MaTHiSiS Learning styles

3. Conclusion

This document describes the Learner Profile repository which is a cloud-based infrastructure that stores information relating to individual learners who are engaged in the learning environment.

The Learner Profile Repository is central to the approach taken in MaTHiSiS as will allow the platform to personalize the learning experience taking into account the learners' needs.

In addition, this document gives details on the implementation of this concept in the second release of the MaTHiSiS platform. The implementation has evolved during the first two years of project, based on the feedback of end users gathered the during Driver and Assisted Pilot phases but also on the additional insight concerning concrete uses in classes or during professional training with real people involved in education and learning during the two Pilots phases. For the third phase of the pilots ("real life") the learner profile repository will record the history of changes to allow the user to see the changes in the level of knowledge of a learner. Also, the level of knowledge will be customizable for the industrial training learners.

4. References

[1] ATOS (eds) D3.7 Learner's Profile Repository
[2] UM (eds) D6.2 The MaTHiSiS Learning Graph Engine, 2017
[3] Felder-Silverman learning style resources available at http://www4.ncsu.edu/unity/lockers/users/f/felder/public/Learning_Styles.html. Retrieved October 2016.

5. Annex 1: LPR JSON

Learner Profile in JSON format. Some of the content has been removed in order to improve readability.

```json
{
  "firstname": "",
  "lastname": "",
  "user_name": "",
  "user_pswd": "",
  "is_active": "True",
  "role": "",
  "access_rights": ["writing, editing"],
  "last_activity": {
    "lg_location_url": "www.url.com",
    "pa_used": "IWB"
  },
  "learner_profile": {
    "age": "",
    "accesibility": {
      "disabilities": {
        "physical": {
          "options": [
            "no_affectation_in_motor_functions",
            "affectation_in_fine_motor_functions",
            "affectation_in_gross_motor_functions",
            "motor_skills_delay"],
        },
        "learning": {
          "arithmetic_disorder": false,
          "writing_disorder": false,
          "reading_disorder": false,
          "spelling_disorder": false,
          "auditory_processing_disorder": false,
          "visual_processing_disorder": false,
          "sensory_integration_disorder": false,
          "learning_disorder": false,
          "social_cue_disorder": false
        },
        "intellectual": {
          "options": [
            "no",
            "mild",
            "moderate",
            "severe"],
        }, "auditory": {
          "options": [
            "no",
            "mild_hearing_loss",
            "severe_hearing_loss",
            "total_hearing_loss"],
        },"visual": {
          "options": [
            "no",
            "visual_impairment",
            "blindness"],
        },"autism_spectrum_disorder": {
          "options": [
            "no",
            "autism",
            "high_functioning_autism",
            "other_asds"],
        },
        "other_disabilities": "",
        "global_developmental_delay": false,
        "communication_and_language": {
          "aphasia": false,
          "selective_mutism": false,
          "dysarthria": false,
          "stuttering": false,
          "language_delay": false,
          "dyslalia": false,
          "dysphonia": false
```

```
    },
    "additional_info": "",
    "specific_learning_difficulties": {
      "reading": false,
      "writing": false,
      "maths": false,
      "reading-writing": false
    },
    "behavioral_disorders": false,
    "attention_deficit_hyperactivity_disorder": false,
    "difficulties_in_handling_devices": {
      "options": [
        "none",
        "low",
        "medium",
        "severe"],
    }
  },
  "performance": {
    "curricular_level": {
      "options": [
        "curricular_level_3",
        "curricular_level_4",
        "curricular_level_5",
        "curricular_level_6",
        "curricular_level_7",
        "curricular_level_8",
        "curricular_level_9",
        "curricular_level_10",
        "curricular_level_11",
        "curricular_level_12",
        "curricular_level_13",
        "curricular_level_14",
        "curricular_level_15",
        "curricular_level_16",
        "curricular_level_17",
        "curricular_level_18",
        "college",
        "master",
        "phd"],
    },
  },
  "learning_style": {
    "learner_processing": {
      "options": [
        "active_learner",
        "reflective_learner"],
    },
    "learner_input": {
      "options": [
        "visual_learner",
        "verbal_learner"],
    },
    "learner_understanding": {
      "options": [
        "sequential_learner",
        "global_learner"],
    },
    "learner_perception": {
      "options": [
        "sensing_learner",
        "intuitive_learner"],
    }
  },
  }
}
```

6. Annex 2: OpenAPI LPR

This section contains the complete list of calls managed by the LPR API with descriptions of their functionality.

Method	GET lpr/profiles		
Description	Get a list of all the Profiles in the system		

Responses	If Success, return "LearnerProfile list" data model
	
	200 application/json
	
	`[{"_id":{"$oid":"3836b7485cfb41e7cb71078"},`
	`   {"learner_profile": {…}}`
	`},{…},`
	`{…}]`		

	If Error, return an error response JSON
	
	400 application/json
	
	`{ "errors": [{`
	`    "description": "Error. Couldn't find any profile",`
	`    "location": "body",`
	`    "name": "password"`
	`  }],`
	`  "status": false}`		

Parameters	Name	Location	Data Type
	X-User-Path	body	string
	X-User-Token	body	string

Table 4: GET lpr/profiles

Method	GET lpr/profiles/{id_user}
Description	Gets a Learner Profile by using the user identifier

Responses	If Success, return the LearnerProfile data model
	
	200 application/json
	
	`{"_id":{"$oid":"3836b7485cfb41e7cb71078"},`
	`   {"learner_profile": {…}}`
	`}`

If Error, return an error response JSON
400 application/json
{ "errors": [{
"description": "Error. Couldn't find the specified profile",
"location": "body",
"name": "password"
}],
"status": false}

Parameters	Name	Location	Data Type
	X-User-Path	body	string
	X-User-Token	body	string

Table 5: GET lpr/profiles/{id_user}

Method	**PUT lpr/profiles/{id_user}**
Description	Updates the profile found by its user id
Responses	If Success, return Success feedback
	200 application/json
	{"access":true,
	"message":"Profile updated successfully",
	"permissions":{
	"collection":"users",
	"method":"PUT",
	"statusCode":"200"
	}
	If Error, return an error response JSON
	400 application/json
	{"access":false,
	"statusCode":"400",
	"message":"There is no such Profile"}

Parameters	Name	Location	Data Type
	X-User-Path	body	string
	X-User-Token	body	string
	user_id	header	string
	learner_profile	body	schema: LearnerProfile{}

Table 6: PUT lpr/profiles/{id_user}