Co-funded by the Erasmus+ Programme of the European Union

SDI and EO Education and Training for North Africa

Project ref. number:
No. 610328-EPP-1 -2019-1-BE-EPPKA2-CBHE-JP

D1.5 - Specification of adapted curricula

Author(s)/Organisation(s)/Partner number:

Glenn Vancauwenberghe & Lisa Lacroix (KU Leuven)

Work Package / Task:

WP1 – Preparing the environment for curriculum design

T1.4 - Specification of project curriculum

Short Description:

This report discusses the adaptation of the SEED4NA project curriculum on Spatial Data Infrastructures (SDI) and Earth Observation (EO) to the local needs of partners and stakeholders in North Africa.

Keywords:

Curriculum design, Spatial Data Infrastructures (SDI), Earth Observation (EO)

Table of Contents

1. Introduction

1.1. The SEED4NA project

For many of the societal and environmental challenges that governments are facing, decision-makers strongly rely on spatial and earth observation data, to better target, monitor, and assess their actions and interventions. These data are now becoming more and more available, through the establishment of data infrastructures and platforms, which aim to improve the access to, sharing and use of data. The effective use of these data requires that professionals in the public, private and academic sector have the relevant knowledge and skills on spatial data infrastructures (SDI), earth observation (EO) and related technologies. This means that higher education institutions must have the knowledge and capacities to provide modern education to their students and offer professionals the right training programmes to raise the overall level of expertise in SDI & EO.

Initiatives to promote and coordinate the sharing of EO and spatial data are also emerging in the region of Northern Africa, at the local, national and regional level. Despite the growing availability and accessibility of data, there still are several barriers and challenges hindering the uptake and use of these data in policy making and implementation. Among these barriers and challenges is a lack of skills and knowledge on SDI and EO among practitioners, decision makers and other key stakeholders. Therefore, it is essential that academic institutions in the North African countries raise their capacities regarding SDI and EO.

The main objective of SEED4NA is to improve the quality of higher education in North Africa in the fields of SDI and EO, and to enhance its relevance for the labour market and society through the development of new and innovative SDI/EO curricula. The SEED4NA project aims to: 1) develop the required knowledge, skills and competencies on SDI & EO within partner universities; 2) help introducing modern SDI & EO courses in engineering and agriculture/forestry studies; 3) implement supporting relevant vocational training programmes; 4) help partner universities to support the development of SDI in their country and 5) promote a European approach to SDI & EO.

SEED4NA will result in the establishment of capable, well trained pools of experts within the involved North African academic institutions which will introduce a modern approach in academic and VET education on SDI & EO in their respective countries, thereby becoming promotors of SDI development and EO use.

1.2. Adaptation of the project curriculum on SDI and EO

WP1 of the SEED4NA project deals with the specification of a project curriculum on SDI and EO and the adaptation of this project curriculum to the needs of HEIs and stakeholders in North Africa. The work package has the following specific objectives:

- To analyse the present curricula with regard to GI and EO at HEI's in partner countries
- To analyse and collect existing learning material at HEI's at program countries;
- To identify SDI and EO stakeholders requirements regarding knowledge and skills requested by new and existing professionals;

- To design a curriculum on SDI and EO adapted to the needs of local HEIs and stakeholders

Task 1.4 deals with the specification and adaptation of the project curriculum in SDI and EO. This will be done based on the results of analyses of existing SDI/EO education in Europe and in North Africa, and an in-depth assessment of the skills requirements of SDI/EO stakeholders and practitioners in North Africa.

This deliverable 'Specification of adapted curricula' (D1.5) addresses the need to adapt the education curriculum on SDI and EO to the needs and interests of both HEIs and local stakeholders in the four partner countries (Algeria, Morocco, Egypt and Tunisia). It builds further on the project curriculum presented in the deliverable 'Specification of project curriculum in SDI and EO' (D1.4), in which the main components of an education curriculum on SDI and EO are introduced and presented. '

1.3. Structure of the document

The document is structured as follows. Chapter 2 provides an analysis of existing SDI/EO education at the partner universities involved in the SEED4NA project. Chapter 3 presents the main results and findings of the skills requirements analysis among stakeholders and practitioners in the four partner countries. Chapter 4 presents the planned curriculum projects at the different partner universities, i.e. the updated and new courses that will be implemented at the partner universities in Algeria, Egypt, Morocco and Tunisia. In this chapter, also the vocational education offer that will be prepared and implemented by the North African partners is discussed. Chapter 5 summarizes the key conclusions of each of the various chapters and related analyses, focusing mainly on the key topics that will be addressed in the various education and training activities of SEED4NA.

2. Assessment of existing SDI/EO education at the partner universities

In the first stage of the SEED4NA project, an overview and analysis was prepared of the existing curricula and courses on SDI/EO at the eight partner universities. Data were collected via an online questionnaire among the partner universities, of which the results and findings afterwards were discussed and validated within the project consortium. In this chapter, we briefly present and discuss these existing courses and their content.

2.1. Existing SDI/EO courses

In total 30 relevant existing courses were identified, offered by Alexandria University (3 courses), Fayoum University (5), Ibn Zohr University (2), the Hassan II Institute of Agronomy and Veterinary Medicine (9), Carthage University (2), University of Jendouba (3), the University of Oran 1 (2) and the University Of Science And Technology Houari Boumediene (5). An overview of these courses is provided in table X.

Partner institution	Course	Study level	Obligatory	Language
Alexandria Univ. (P6)	Geographical Information System	Bachelor study	Yes	English
	Application of GIS / Remote sensing in Environmental Indicators	Postgraduate study programme	No	English
	Introduction to Remote sensing	Postgraduate study programme	No	English
Fayoum Univ. (P7)	Geographical Information Systems I	Bachelor study	Yes	Arabic, English
	Geographical Information Systems II	Bachelor study	No	Arabic
	Remote sensing in Agriculture	Bachelor study	No	Arabic
	Mapping and Surveying	Postgraduate study programme	Yes	English
	Spatial web applications	Postgraduate study programme	Yes	English
Univ. Ibnou Zohr (P8)	Geographic Information System	Bachelor study	Yes	French

	Introduction to remote sensing	Bachelor study	Yes	French
Hassan II (IAV) (P9)	Spatial Database	Master study, Postgraduate study programme	Yes	French
	Modeling and GIS Spatial Analysis	Master study	Yes	French
	Introduction to GIS	Bachelor study	Yes	French
	Digital Terrain Modeling	Bachelor study	Yes	French
	3D Modeling	Master study	Yes	French
	Advanced Photogrammetry	Master study	Yes	French
	Geometrical Geodesy	Bachelor study	Yes	French
	GNSS Fundamentals	Master study	Yes	French
	Web Mapping	Master study	Yes	French
Carthage Univ. (P10)	Application of Earth Observation and Machine learning in Water monitoring and Mapping	Master study; Postgraduate study programme	Yes	French
	Water Resources Modeling	Master study	Yes	French
UN. of Jendouba (P11)	Hydrology and Climate Change	Master study	Yes	French
	GIS	Engineering programme	Yes	French
	Geostatistics	Engineering study	Yes	French
ORAN-1 (P13)	Big Data	Master study	Yes	French
	Geographical Information Systems	Master study	Yes	French
USTHB (P14)	GIS and Remote Sensing	Master study	Yes	French

	Spatial Oceanography	Master study Postgraduate study programme	Yes	French
	Remote sensing-Database-GIS	Master study	Yes	French
	Remote sensing	Master study	Yes	French
	GIS	Master study	Yes	French

Table 1 Relevant SDI/EO courses at the partner universities

It can be seen from this table that all partner universties already are offering courses in the domains of GI, SDI and EO. Most of these courses are offered in French, and only a few in English or Arabic. The courses included courses offered at Bachelor level, Master level, Engineering courses and Postgraduate courses. There are only a few optional courses, most of the identified courses are obligatory components of the programme.

2.2. Course content

Data were also collected on the content of the courses, which helps to better understand the key topics currently covered in each of these courses.

The core content of the three courses offered at Alexandria University is presented in table 2. The three courses offered are 'Geograpgical Information System, Application of GIS/Remote Sensing in Environmental Indicators and Introduction to Remote Sensing.

Partner institution	Course	Key topics
Alexandria Univ. (P6)	Geographical Information System	• Introduction and Overview of Geographic Information Systems • GIS and Maps, Map Projections and Coordinate Systems • Spatial Data Models • Data Sources, Data Input and Data Quality • Database Concepts • Spatial Analysis
	Application of GIS / Remote sensing in Environmental Indicators	• Advanced vector analysis • Model builder • Network analysis • Raster analysis building digital elevation model

		• Remote sensing sources • Finally change detection
	Introduction to Remote sensing	• History of remote sensing for earth Observation Remote Sensing Basics • Aerial Imagery – Visual • Interpretation • Remote Sensing Applications

Table 2 Key topics covered in SDI/EO courses at Alexandria University

At Fayoum University, five existing courses on SDI/EO were identified: Geographical Information Systems I, Geographical Information Systems II, Remote sensing in Agriculture, Mapping and Surveying and Spatial web applications. The content of these courses is summarized in table 3.

Partner institution	Course	Key topics
Fayoum Univ. (P7)	Geographical Information Systems I	• Relevant GIS technologies, evaluation of GIS technology • GIS applications, representation of geographic data, relationships of graphic and nongraphic data • Data: data types, data collection, census data, postcode- based data, data from surveys, customer lists, • Data from remote sensing, the data collection transformation, data input, vector digitizing, verification, attribute data input, raster data input, data input transformation. • Graphic data storage, data quality, planimetric features, topographic features, cadastral features, Parcel • Identification, area boundary features • Components of GIS: hardware software, configurations and data communications. • GIS design philosophy, GIS implementation methodologies, hypermedia and GIS, towards a socioeconomic GIS
	Geographical Information Systems II	• Introduction, definitions and applications Introduction to an open source program • Spatial data and their characteristics, enter maps and define coordinates

		• Maps and data visualization methods in GIS, surveying using Total station • Coordinate systems, mapping projection, surveying using GPS • Methods of data entry into GIS application to mapping software • GPS satellite positioning devices • DEM Topographic Simulation Models. Mid-term Practical Exam • Spatial Analytics 1 Introduction to the ARC GIS Program • Spatial Analytics 2 Entering maps and spatial analyzes • Geographic databases 1 spatial analyzes • Geographical databases 2 Establishing geographic databases • Basis of Simulation Models Introduction to a practical project • Practical project
	Remote sensing in Agriculture	• Introduction and Definitions - Theoretical Background • Types of satellites - the spatial accuracy - examples of applications for entering space images and adding coordinates • Electromagnetic energy and remote sensing - interaction with the atmosphere - active and passive RS remote sensing - electromagnetic spectrum Some optimization processes for space images
	Mapping and Surveying	• Introduction about maps and their types • Basics of mapping • Representing data in computers, • Projection and GPS systems and basics of using global positioning by satellite devices • Surveying and practical training in using Auto CAD program
	Spatial web applications	• Kinds of spatial web services, spatial web (users and clients), techniques and standards of distributing • Geographical data and maps through the internet, methods of making map services on the internet using GIS

		• Programming systems especially ArcGIS

Table 3 Key topics covered in SDI/EO courses at Fayoum University

Relevant courses on SDI/EO already offered at Ibn Zohr University are Geographic Information System and Introduction to remote sensing. The core topics covered in these courses is presented in table 4.

Partner institution	Course	Key topics
Univ. Ibnou Zohr (P8)	Geographic Information System	• Definition of GIS • Application of GIS • Definition of projections systems • Projections systems used in Morocco • Introduction to QGIS • Introductrion to ArcGIS
	Introduction to remote sensing	• Definition of remote sensing • Application of remote sensing • Active remote sensing • Passive remote sensing

Table 4 Key topics covered in SDI/EO courses at Ibn Zohr University

At the Hassan II Institute of Agronomy and Veterinary Medicine, the highest number of relevant courses of all partner universities was identified. There already are nine relevent courses, of which the core content is presented in table 5.

Partner institution	Course	Key topics
Hassan II (IAV) (P9)	Spatial Database	• Introduction to Spatial Databases • Spatial Database • Spatial data need a new data management paradigm, • Spatial file • System
	Modeling and GIS Spatial Analysis	• Spatial and Thematic Queries - Queries based on single or multiple layers of data operations based on vector data overlay - Operations based on image data overlay • Spatial Modeling - Cases of erosion - Desertification and forest fires

	Introduction to GIS	• Concepts of GIS - Definition of GIS, - History of GIS, - GIS Components - Raster and Vector • Spatial Data Acquisitions - Data sources - Corrections and georeferencing.
	Digital Terrain Modeling	• Digital terrain model introduction - Definitions - Notions - Concepts • Data sources and acquisition methods - Direct topographic surveys - Photogrammetric measurements - Digitization of maps - Satellite imagery - Airborne or satellite radars - Laser altimetry
	3D Modeling	• Fundamental concepts of 3D modeling - Definition - History - Evolution • Spatial Data Acquisitions - Data sources - Spatial data acquisition - Corrections and georeferencing
	Advanced Photogrammetry	• Automatic generation of digital terrain models principle - automatic correlation - zonal correlation - least squares correlation - correlation - based on contours - operators of interest • Automatic generation of digital orthophotos - Introduction - Principle - Image rectification - Image resampling
	Geometrical Geodesy	• History of geodesy • Methods in geodesy

		• Properties of the ellipsoid and of the geoid, and the relationships between the two surfaces • Insight into the relationships between astronomical and geodesic systems • Determination of the shape and the size of the earth • Cartesian and geodetic coordinate systems • Radii of curvature and the arc lengths on the ellipsoid • Methods of solving spherical triangles and coordinate transformations • Resolution of direct and inverse problems
	GNSS Fundamentals	• Overview and applications of GNSS systems • GNSS signals • Observation mode and source of errors in GNSS • Calibrating GPS receivers • Establishing a Geodetic Network by GPS. • Continuously Operating Reference Stations (CORS) • Field project
	Web Mapping	• Introduction to Web Mapping • Recall of Concepts of Web development • Programming Language for Web Mapping. • Standards of Geospatial data and services • Determination of the shape and the size of the earth • Architecture and publishing of a Web Map. • Libraries for Web Mapping • Trends in Web Mapping

Table 5 Key topics covered in SDI/EO courses at Hassan II Institute

At Carthage University, two courses on topics related to SDI/EO are already offered: Application of Earth Observation and Machine learning in Water monitoring and Mapping and Water Resources Modelling. The core content of both courses is summarized in table 6.

Partner institution	Course	Key topics

Carthage Univ. (P10)	Application of Earth Observation and Machine learning in Water monitoring and Mapping	• Introduction to EO. • Introduction to ML. • EO technologies and possible • ML approaches and possible uses • Integration of EO and ML for water management problems • Cases studies of EO and ML integration
	Water Resources Modeling	• Data preparation for water resource models (Hydrological and Groundwater Model) • Hydrological implementation, calibration and validation using SDI and EO data • Groundwater implementation, calibration and validation using SDI and EO data

Table 6 Key topics covered in SDI/EO courses at Carthage University

Table 7 shows the core content of the three existing courses on SDI/EO and related topics offered at the University of Jendouba: Hydrology and Climate Change, GIS and Geostatistics.

Partner institution	Course	Key topics
UN. of Jendouba (P11)	Hydrology and Climate Change	• Water resources under climate change, mainly in Mediterranean region • Hydrological alteration and climate change (at different scales) - vulnerability of hydrosystems • Average evolution of water resources considering climate change • Evolution of water resources as affected climatic extremes • Predictable impacts of climate change on water resources (temporal and spatial scales) • Application of hydrological models coupled to climate change scenarios (data collection, treatment, model • parametrisation and climate change impacts)
	GIS	• Fundamental Concepts in Geographic Information Science • Geospatial Data • Spatial Analysis

		• Application of GIS in watershed management.
	Geostatistics	• Exploratory analysis of spatial data. • Analysis of monitoring networks and de-clustering • Global and local estimations • Moving window statistics • Deterministic interpolations and cross-validation • Variography: exploratory variography and variogram modelling

Table 7 Key topics covered in SDI/EO courses at University of Jendouba

Two relevant courses on SDI/EO and related topics are already offered at the University of Oran 1: Big data and Geographical Information Systems. In table 8, the key topics covered in both courses are presented.

Partner institution	Course	Key topics
ORAN-1 (P13)	Big Data	• Introduction to Big data • Definition: the 4 dimensions of Big Data: Volume, Velocity, Variety, Veracity • Concepts and terminology • Business intelligence • Fundamental characteristics • Data type
	Geographical Information Systems	• Introduction to GIS and Planning and use of a GIS - Practical, didactical, formative-educative approach - Discovery of the software and manipulation of a geographic database • Functions of a GIS - Practical, didactical, formative-educative approach - exploitation of a geographic database

Table 8 Key topics covered in SDI/EO courses at the University of Oran 1

At the University Of Science And Technology Houari Boumediene, five relevant SDI/EO courses were identified, of which the key topics are summarized in table 9.

Partner institution	Course	Key topics
USTHB (P14)	GIS and Remote Sensing	• Concepts and definitions. - The components of GIS. - The 3 dimensions tool - information - organization. - GIS as a project. GIS as a decision support tool. - GIS and reality modeling. • Data processing and analysis - Consult data - Data processing - SQL queries - Spatial analysis - Data representation - Data import / export • Workshop - Case study, modeling (fires, degradation ...) - Simulation of rehabilitation scenarios
	Spatial Oceanography	• History of the RS • Solar Spectrum and Planck's Law • Visible RS (Different modes: Satellite, LIDAR) • Reflectance and Spectral Signature • Application Case of LANDSAT satellite • TLD IRT Inversely Planck's law • Measurement and calculation of TS (Land and Sea) • Different Spectral • Hyperspectral introduction
	Remote sensing-Database-GIS	• Remote sensing - Introduction - Physical basis in remote sensing - Vectors and Sensor - Data processing - Synthesis: creation of space maps • Geographic Information System • Introduction: Why this interest in GIS? • History and basic functions of GIS • How was GIS born • Main partners and basic functionalities

		• Aspects to consider before choosing the tool • Nature of the data (Raster and Vector) • Data structuring and their integration into GIS • Use of data in a GIS
	Remote sensing	• Fundamentals of remonte sensing • The physical bases • Interaction between matter and elecromagnetic radiation • Process of acquiring satellite image • Geometric corrections • Atmospheric corrections • Radiometric corrections • Calculate index (SAVI, NDVI, Gloss index…) • Post calssification
	GIS	• Fundamentals of GIS and Cartography • Projections, coordinate systems, scale and other core GIS concepts • Import, manipulation and visualization of raster and vector • Data base manipulation • Fragmentation • Outputs (Thematics maps and others) • Optional: Wildlife habitat and species distribution modelling

Table 9 Key topics covered in SDI/EO courses at USTHB

2.3. Conclusion

In this chapter, we provided an overview of courses related to SDI/EO already offered at the eight partner universities of SEED4NA. In total 30, relevant courses were identified, of which the core content was presented in this chapter. The majority of the relevant courses were courses dealing with GIS, Remote sensing or both. GIS courses are offered at seven of the partner universities, courses on remote sensing at four universities. There are no courses fully dedicated to the topic of SDI, only some courses dealing with web mapping and spatial web applications, which are topics most closely related to SDI. Important to notice also are the courses on SDI/EO in a particular field or application area, such as agriculture (Fayoum University), environment (Alexandria University), and hydrology (Carthage University and University of Jendouba). It is in the context of these courses that the SEED4NA curriculum will be introduced at the partner universities: some of these existing courses will be revised and updated, or the existing courses will be complemented with new courses on SDI/EO topics.

3. Skills needs assessment

In this chapter we look into the skills needs of the local stakeholders in North Africa. In the first stage of the project, an online survey was implemented aimed at identifying key skills and competencies needs within the four partner countries. In this chapter, we summarize the main results of this stakeholders skills needs assessment, also looking into the differences between the four partner countries.

3.1. Methodology

Key stakeholders, such as educational institutions, governmental institutions, business enterprises, professional associations in North African partner countries, were invited to participate in a survey on their GI/SDI/EO skills and competencies needs.

In total 148 persons responded to the questionnaire. Most answers were received from higher education organizations (46), followed by national-level public administration (34), research institutions (31) and Land surveying private companies (16). In the context of SDIs, 16% of respondents identify themselves as end-users and 14% as producers.

The aim of the questionnaire was to collect information on the importance of different GI/SDI/EO competencies. Based on the 11 Knowledge Areas (KAs) that are part of the GIS&T Body of Knowledge on geographic information science and technology, 77 different relevant competencies were identified, and respondents were asked to indicate the importance of each competency.

3.2. Key knowledge areas

In line with the Knowledge Areas identified in the GIS&T Body of Knowledge, the survey assessed the importance of elf different knowledge areas: Conceptual foundations, Geospatial data acquisition, Cartography and visualization, Data manipulation, Analytical methods, System Design Aspects, Data modelling, Image processing, Infrastructure & platforms, Society, Organizational and Institutional. Each of these knowledge areas covered several specific competencies, of which respondents were asked to assess the importance using a 1-5 scale (from not needed/important to very needed/important).

In table 11 the ranking of the knowledge areas is presented with regarded to the average importance of the underlying competencies. In general, there appeared to be most need for competencies related to the areas of conceptual foundations, geospatial data acquisition, analytical methods, and cartography and visualization. The least needed competencies refer to society, organizational and institutional, and infrastructure & platforms. The competencies of the remaining KAs that are image processing, system design aspects, as well as data modelling, are – on average -perceived as of medium significance.

Rank	Knowledge areas	Average	# competencies
1	Conceptual Foundations	3.775	3
2	Geospatial Data acquisition	3.670	10
3	Analytical Methods	3.656	7

4	Data manipulation	3.653	3
5	Cartography and visualization	3.652	8
6	Image processing	3.536	6
7	System Design Aspects	3.488	5
8	Data modelling	3.451	6
9	Society	3.436	6
10	Organizational and Institutional	3.372	5
11	Infrastructure & platforms	3.367	20

Table 10 Ranking of the knowledge areas

To better understand the local needs in the four partner countries, it's important to also look at the identified needs in each country, and identify relevant differences and similarities between the countries.

Figure 1 shows the relevance of the eleven knowledge areas as assessed by the stakeholders in Algeria. The figure shows for each knowledge area the percentage of respondents that assessed the competencies of the knowledge area as 'very necessary'. It can be seen from this figure that 82% percentage of the respondents indicated the competencies related to Conceptual foundations as very necessary, which makes this the most important knowledge area in Algeria. Other important knowledge areas are Geospatial data acquisition (76%), and Cartography and visualization (76%).

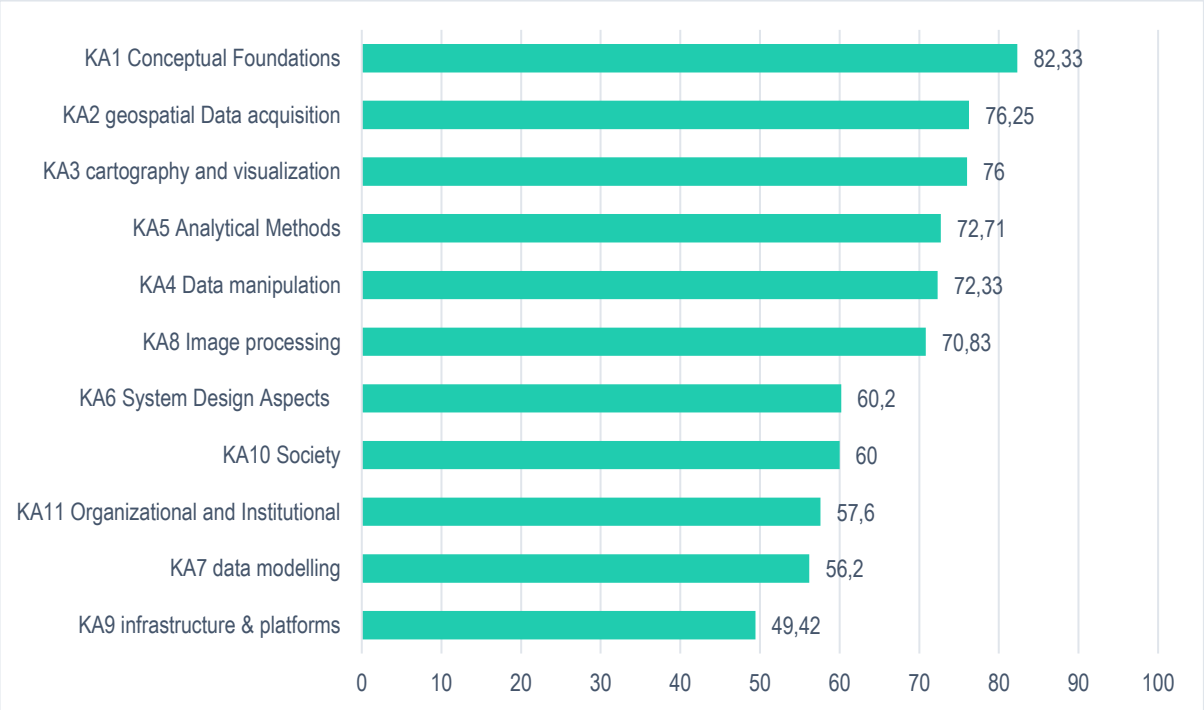

Figure 1 Importance of knowledge areas in Algeria

In Egypt, the knowledge area that generally is perceived as the most needed, is the area of 'Cartography and visualization'. Other important knowledge areas in this country, as can be seen from figure 12, are Conceptual Foundations and Image processing.

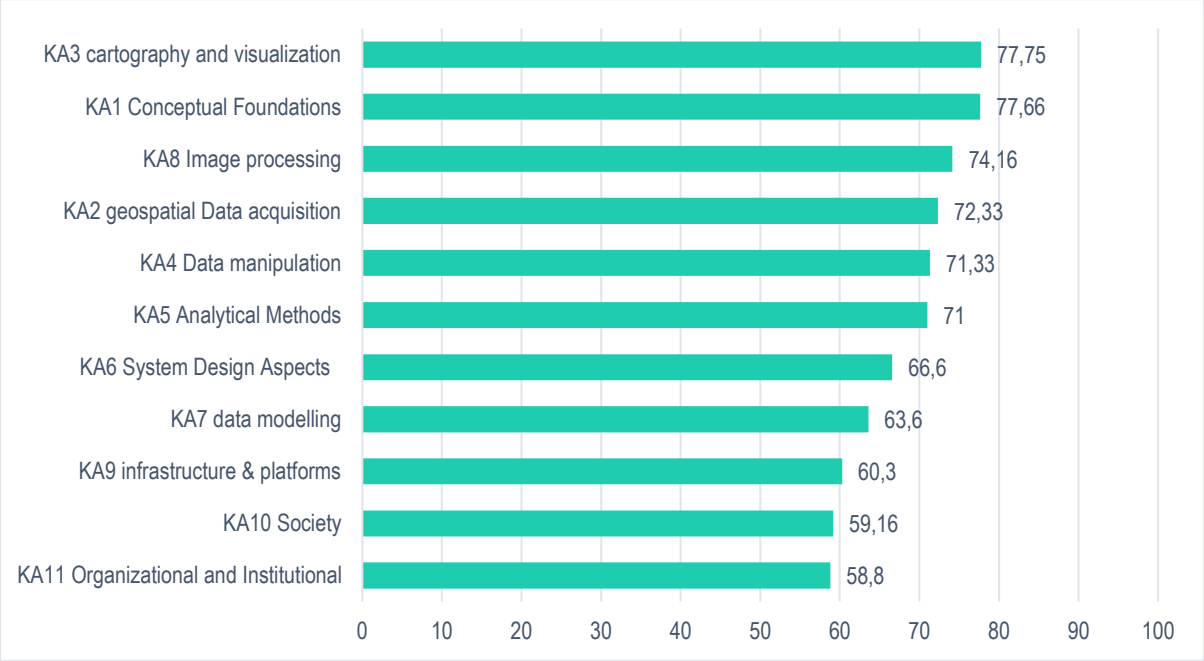

Figure 2 Importance of knowledge areas in Egypt

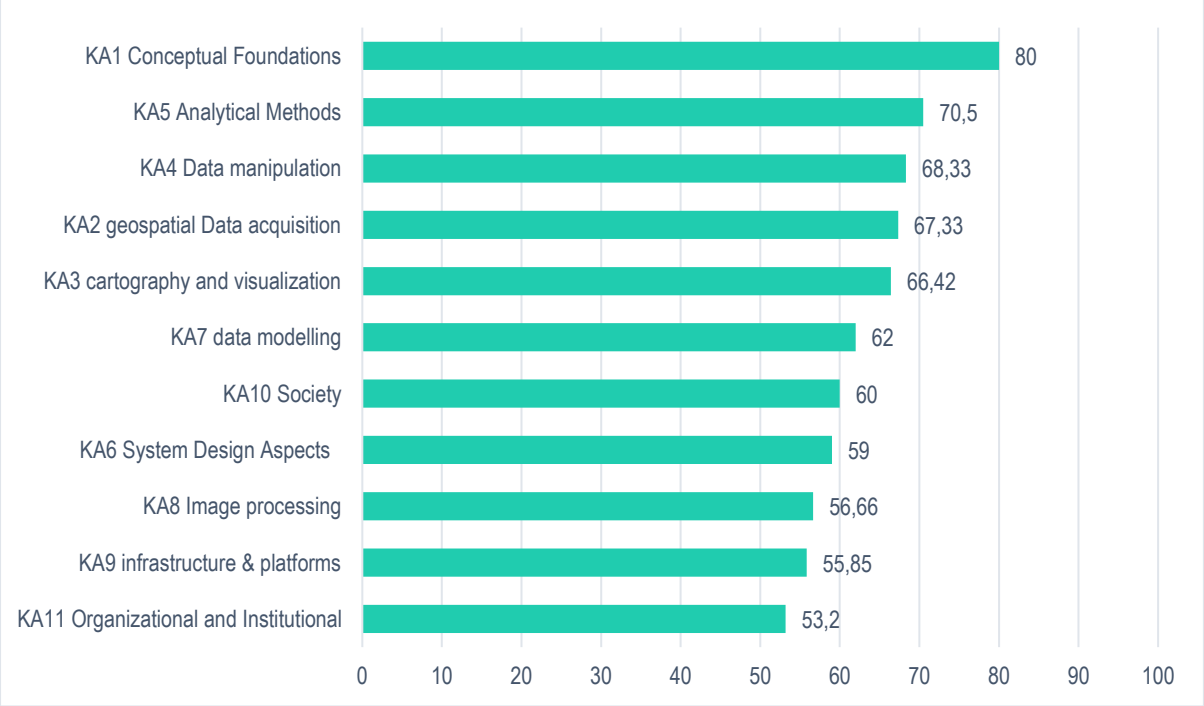

Figure 3 Importance of knowledge areas in Morocco

In Morocco, thearea of Conceptual foundations is considered to be the most needed by the local stakeholders. Analytical methods, Data Manipulation, Geospatial Data Acquisition and Cartography and visualization are the other knowledge areas in the top 5 of most needed knowledge areas, as perceived by the respondents.

Figure 4 shows the importance of the knowledge areas as evaluated by the Tunisian participants of the survey. Also in Tunisia, Conceptual foundations is considered to be the most needed or most important knowledge area, followed by Geospatial data acquistion, Data manipulation and Analytical methods.

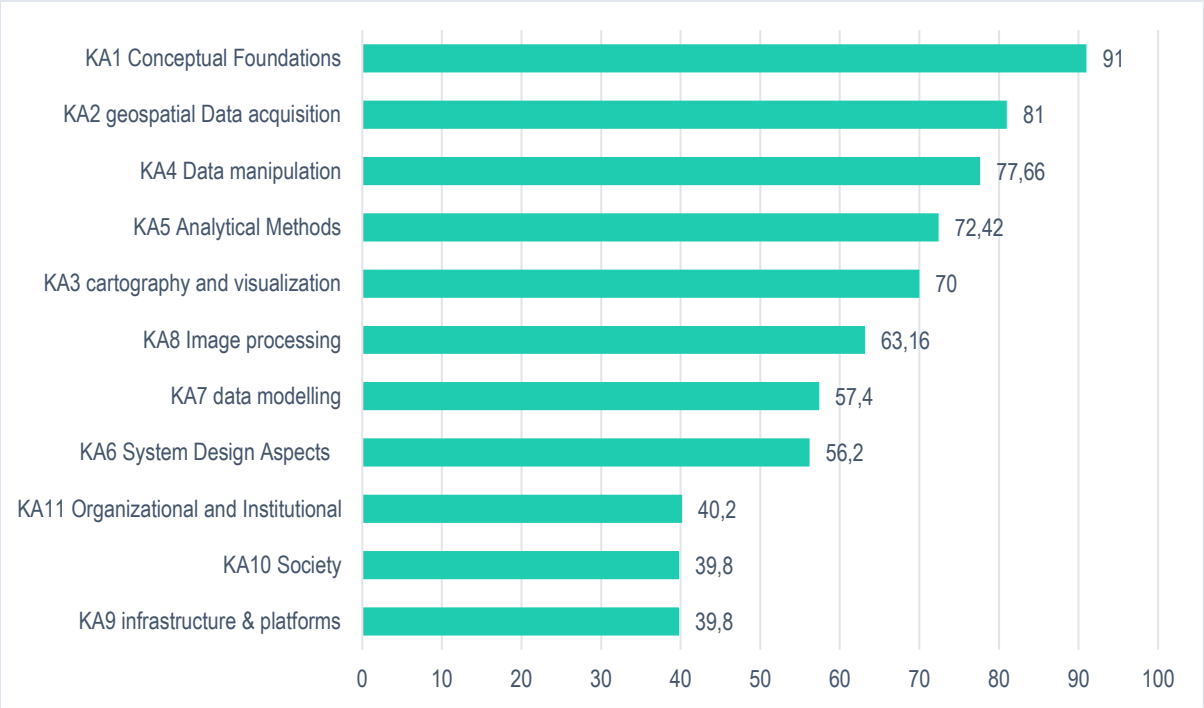

Figure 4 Importance of knowledge areas in Tunisia

In figure 5 we shows the assessment of each knowledge area for each of the four countries. The figure illustrates that there are some strong similarities between the four countries, in their assessment of the relevance and importance of each knowledge area. Conceptual foundations overall is considered among the most important areas, and the most important one in Algeria, Morocco and Tunisia. Also Geospatial data acquisition, Data Manipulation, Cartography and visualization and Analytical methods in all four countries are seen as important knowledge areas.

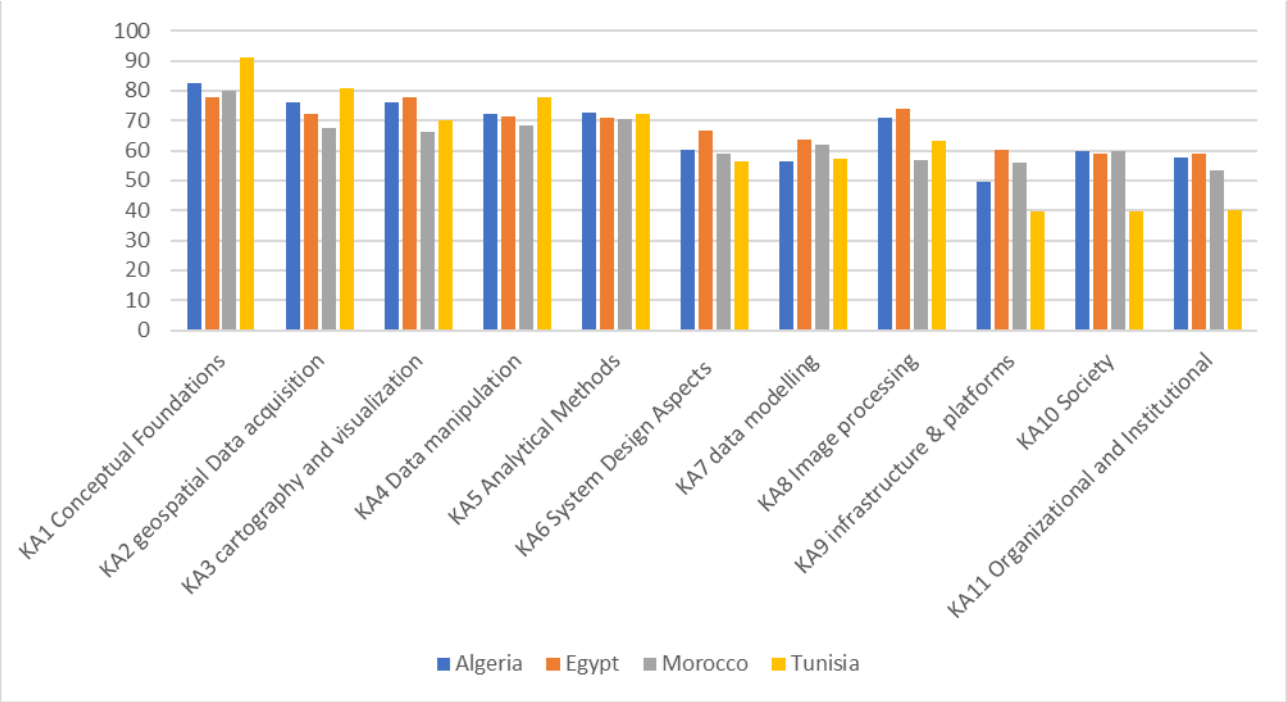

Figure 5 Importance of knowledge areas per country

3.3. Key competencies

While the assessment at the level of the knowledge areas shows the general importance of different areas in the field of GI/EO/SDI, the assessment of individual competencies shows more detailed information on the importance of specific competencies. In this section, we take a closer look at the competencies that were considered to be 'very necessary' by the respondents.

According to the respondents the following twenty competencies were considered to be the most needed:

1. Understanding the concepts of data management (89,20%)
2. Understanding spatial data, e.g. georeferencing systems, map projections, topology, coordinate systems and geoinformatics (87,5 %)
3. Preparing data for map production (e.g., classification, generalization, map projection) (85,75)
4. Analyzing spatial data and use spatial statistics (85%)
5. Using different imagery types (satellite, aerial, spectral, LIDAR, ...) (84%)
6. Understanding the concepts of Earth Observation (80%)
7. Field data acquisition (e.g., select sample size, spatial sample types, sample intervals, field data technologies and GPS/GNSS (79,5%)
8. Understanding the concepts of data sharing and interoperability (79,1%)
9. Designing maps, graphic presentation techniques and visual variables (e.g., symbology, typography, colour schemes) (75,7%)

10. Transforming data representations (e.g., data model conversion, format conversion, coordinate transformations) (75%)
11. Being familiar with different EO imagery sources (e.g. LandSAT, Sentinel, SPOT, …) (74,25%)
12. Managing and versioning spatial databases (73,5%)
13. Having practical experience of working with specific GI software (73,5%)
14. Using and producing maps (e.g., map reproduction, color separation, digital cartography, photogrammetry) (73%)
15. Applying different Vector data analysis (73,5%)
16. Applying image classification and judge classification accuracy (72,5%)
17. Choosing adequate graphic representations (e.g., thematic mapping such as Choropleth and Proportional Symbols maps, web mapping and visualization of temporal, geospatial data) (71,7%)
18. Designing databases (e.g., Modeling tools, conceptual/logical/physical models) (72,7%)
19. Applying image interpretation and feature extraction (71,5%)
20. Performing different Raster data analysis (71%)

Again, it is important to look into the competencies needs for each of the specific countries. We limit our analysis to the ten competencies that are considered to be most needed in each country. In figure 6 we show the ten most needed competencies according to the respondents from Algeria. Among these key competencies are 'understanding geospatial data', 'preparing data for map production', 'analysing spatial data and using spatial statistics', 'using different imagery types' and 'field data acquisition'.

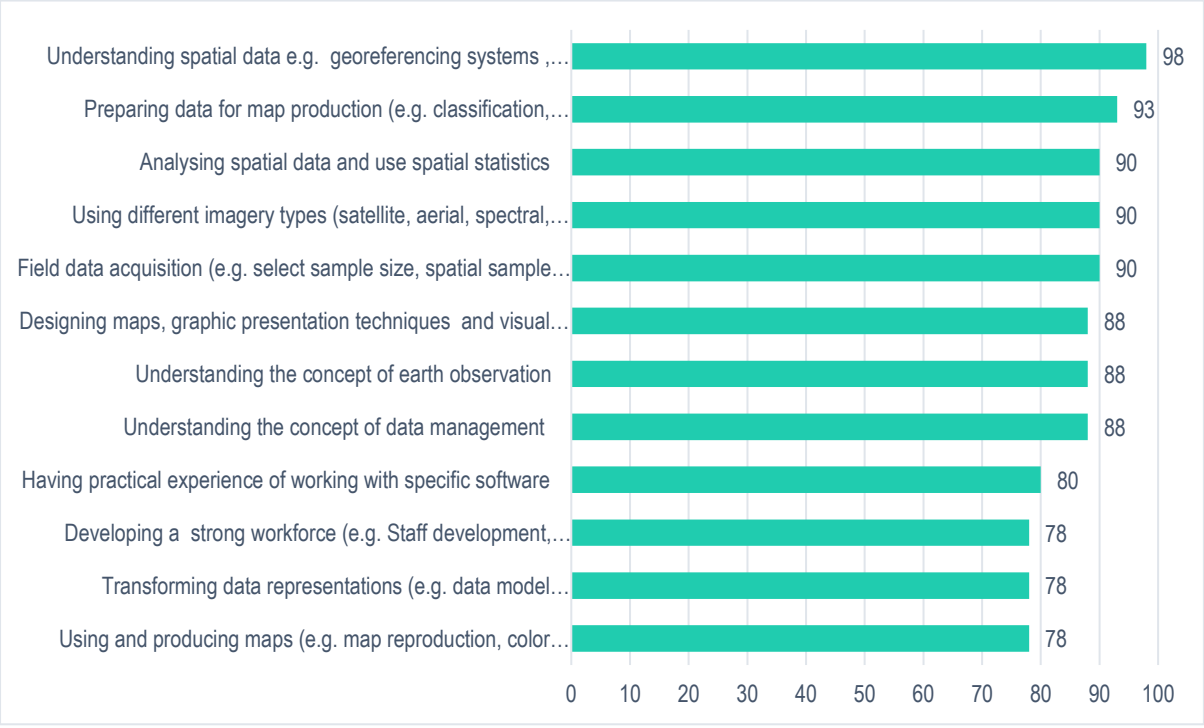

Figure 6 Most needed competencies in Algeria

The preparation of data for map productions and the analysis of spatial data and use of spatial statistics also are seen as important competencies by the respondents from Egypt. Other important competencies according to these respondents are 'applying image classification and judge classification accuracy', 'choosing adequate graphic representation' and 'understanding the concepts of data sharing and interoperability'.

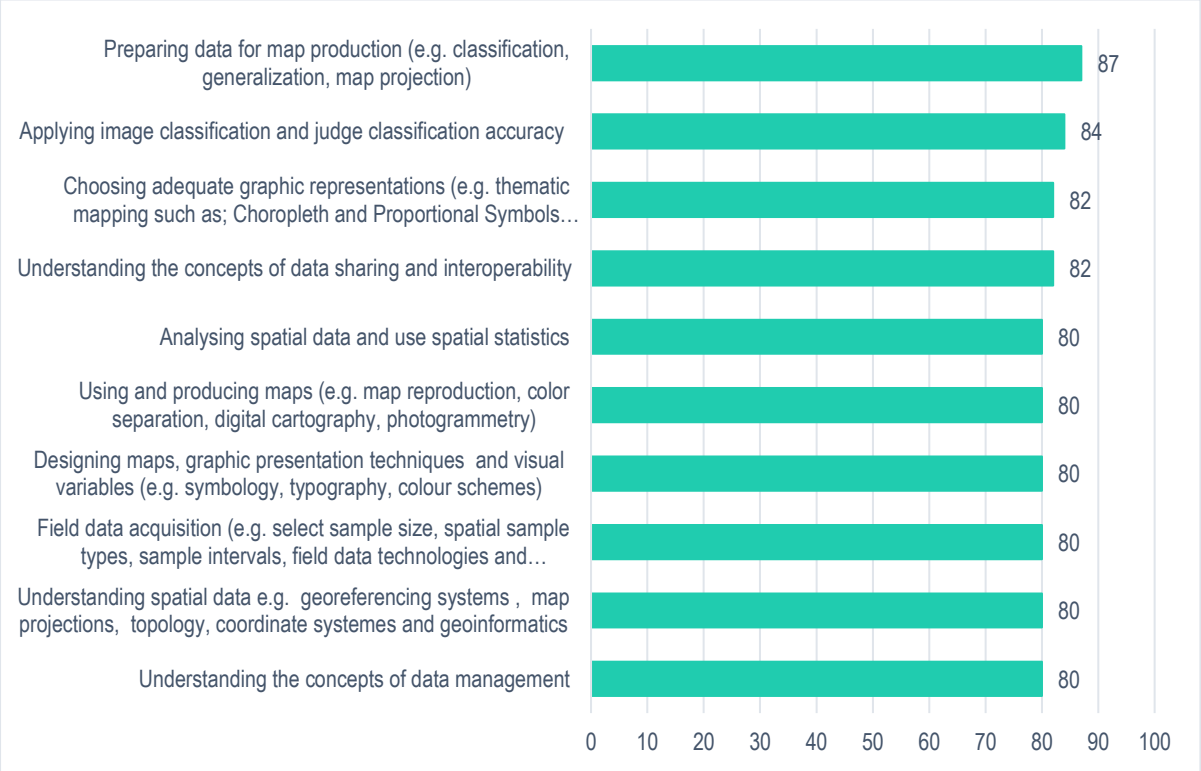

Figure 7 Most needed competencies in Egypt

According to the respondents from Morocco, the most needed competencies in their country is 'understanding the concepts of data management'. Also in other countries, this is seen as an important competency, but not the most important one. Similar to Egypt, also in Morocco 'understanding the concepts of data sharing and interoperability' is seen as an important competencies. Also other key competencies are similar as the ones proposed in the other countries: 'understanding spatial data', 'analysing spatial data and using spatial statistics' and 'preparing data for map production'.

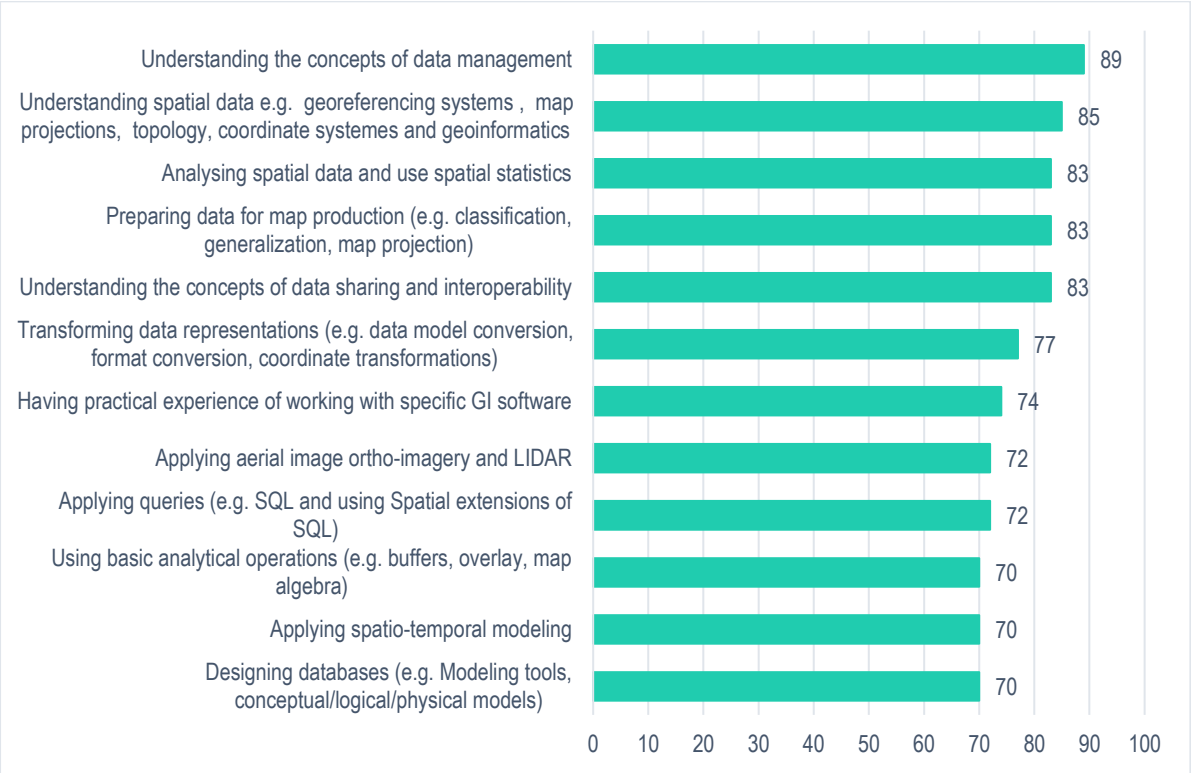

Figure 8 Most needed competencies in Morocco

The most needed competencies according to the respondents in Tunisia are presented in figure 9. The use of different imagery types and understanding the concepts of data management are seen as the most important competencies in Tunisia. Also 'managing and versioning spatial databases' and 'understanding the concepts of earth observation' are considered as important competencies.

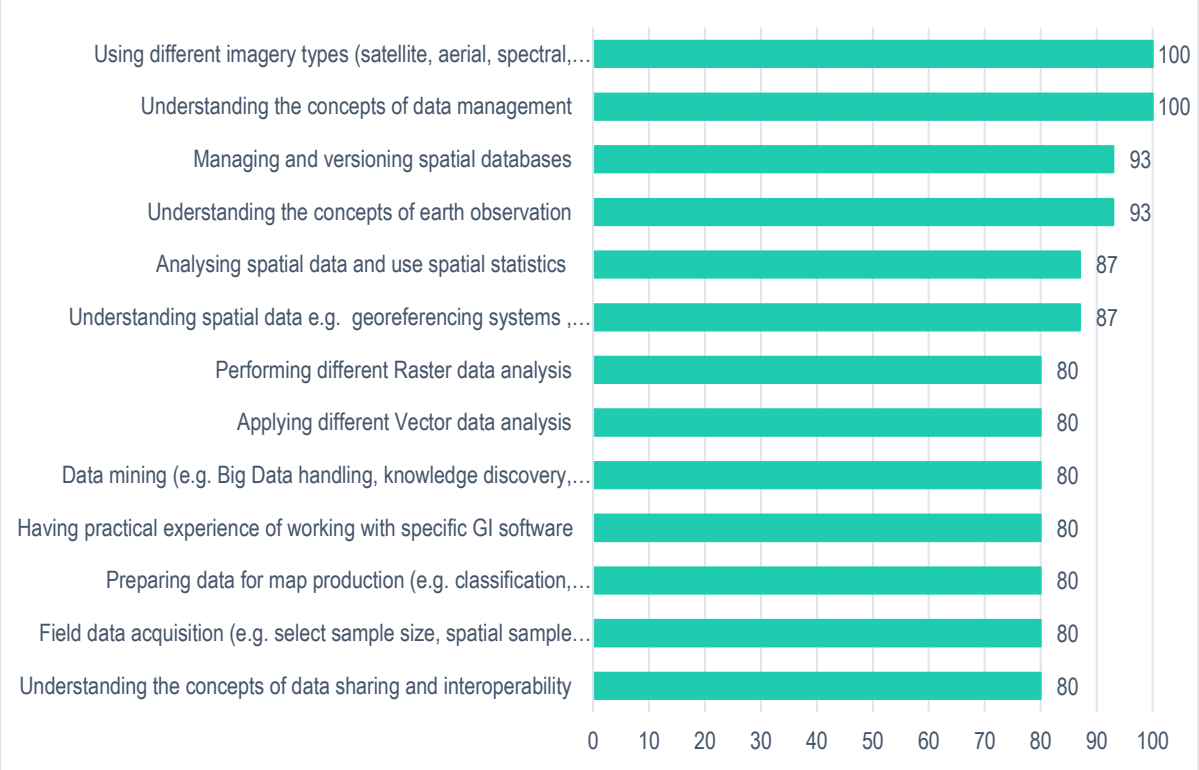

Figure 9 Most needed competencies in Tunisia

3.4. Conclusion

In this chapter we presented and discussed the main results of the skills and competencies assessment by the local stakeholders in the four partner countries. The SEED4NA projects implemented a survey among professionals and stakeholders in the geospatial domain in North Africa to identify the most needed knowledge areas and competencies in the region, and in the four partner countries (Algeria, Morocco, Egypt and Tunisia) in particular.

Important to notice is that the survey didn't only focus on skills and competencies related to SDI and EO, but focused on wider GI Science & Technology skills. This resulted into a wider understanding of skills and competencies needed in the geospatial domain, including also more general GI & GIS skills. However, some of the identified skills and competencies that were considered as important by the professionals and stakeholders, are outside the – original - scope of the SEED4NA project. But even in this case, the identification of these skills and competencies inspires and helps us – and especially the partner universities – to improve the relevance of the offered curricula and courses.

When looking at the skills and competencies related to the domains of SDI and EO, several important topics were identified: data sharing and interoperability, data transformation, spatial data management & databases, earth observation, the use of different imagery types and different EO imagery sources. In this way, the results and findings of the stakeholders needs' assessment provided important input to the identification of topics to be covered in the SEED4NA curriculum implemented at the partner universities.

4. Curriculum projects at partner universities

Based on the proposal for a SEED4NA curriculum on SDI and EO and on the stakeholders' needs identified through the survey, the teachers and teaching experts involved in GI/SDI/EO education at the partner universities identified a set of new subjects they want to cover in their academic education, through revised and/or new courses, and in vocational training courses offered directly to the professionals and other stakeholders. In this chapter we look into the subjects identified by the local experts.

4.1. SEED4NA curriculum on SDI and EO

A proposal for a SEED4NA curriculum on SDI and EO was made in deliverable D1.4 on 'Specification of project curriculum'. The proposed curriculum consisted of five main building blocks, which are also shown in figure 1:

I. GI, SDI and EO for geospatial solutions
II. Spatial Data Infrastructures
III. Earth Observation
IV. Applications of SDI and EO
V. Emerging technologies

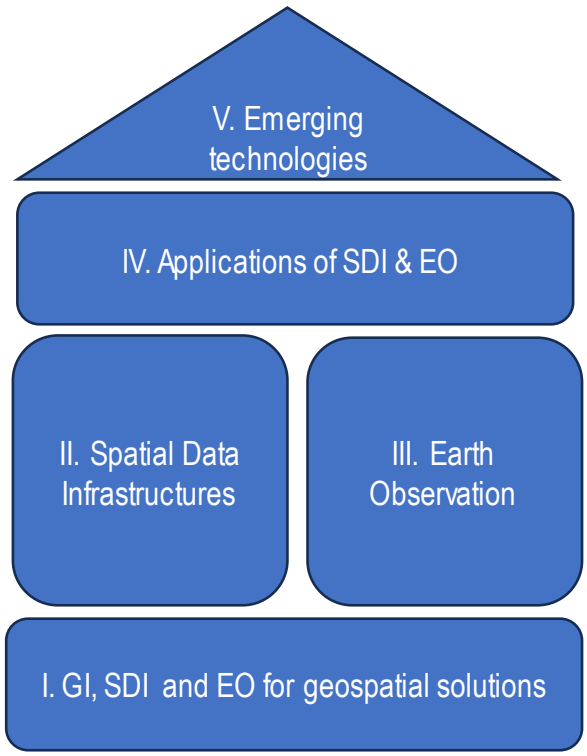

Figure 10 Building blocks of the SEED4NA curriculum on SDI and EO

For each of these building blocks, a set of core topics were identified, which could serve as main components or modules in education on these building blocks. In table 11 we show the main topics included in the proposed SEED4NA curriculum on SDI/EO.

Building block	Topics/components
I. GI, SDI and EO for geospatial solutions	- Foundations of GI, SDI & EO - Data acquisition - Databases & data management - GI Programming - Data analysis - Geovisualization - Geo-information products & services - Data quality
II. Spatial Data Infrastructures	- Spatial Data Infrastructures: components & practices - Standards and interoperability - Spatial data modelling - SDI Services - Organisational and institutional aspects of SDIs
III. Earth Observation	- Principles of remote sensing - Satellites, sensors & imagery - Image processing and analysis - EO platforms
IV. Applications of SDI and EO	- SDI and EO applications - Natural Resources Management - Water Management - Spatial Planning - Land Administration - Natural Hazards and Disaster Risk Reduction - Cities & local government
V. Emerging technologies	- Artificial Intelligence - Big data - 3D & Digital Twins

Table 11 Components of the SEED4NA curriculum on SDI & EO

4.2. Updated courses

In this section, we look into the subjects of the courses to be updated, i.e. courses that the SEED4NA partner organisations want to modify by introducing new subjects and/or new teaching practices.

Alexandria University (Egypt) wants to update one course, i.e. the already existing course on 'Introduction to RS and EO4. In table 12 we show the main topics to be covered through this course revision.

Course	Key Topics
Introduction to RS and EO (BSc)	• Exploration, interpretation and analysis of remote sensing imageries • Basics of electromagnetic energy and its interactions with atmosphere and different surfaces • Types of sensors and platforms • Processing of remotely sensed data and applications related to urban areas, such as monitoring urban growth using change detection • Land cover classification and LST retrieval for mapping urban heat island.

Table 12 Courses to be updated at Alexandria University

Fayoum University (Egypt) proposed the revision of two courses, in which the main want to include the more practical use of GI software.

Course	Key Topics
GIS (BSc - Faculty of Agriculture)	• Practical use of GI software
GIS (BSc - Faculty of Computers and Information)	• Practical use of GI software

Table 13 Courses to be updated at Fayoum University

Courses to be updated at Ibn Zohr University (Morocco) include the BSc course on GIS and the Bsc course on Remote Sensing. The topics to be further addressed in both courses are proposed in table 14.

Course	Key Topics
GIS (BSc)	• GIS, introduction, concept • Design and Setup of Geographic Information Systems
Remote Sensing (BSc)	• Imagery data • Imagery collection • Imagery modeling

Table 14 Courses to be updated at Ibn Zohr University

The Hassan II Institute of Agronomy and Veterinary Medicine (Morocco) identified two courses that could benefit from a significant update, the course on 'Spatial Data Management' and the course on advanced 'Photogrammetry'. The content of these updates is shown in table 15.

Course	Key Topics
Spatial Data Management (BSc)	• Spatial Big Datasets • Approaches for Spatial Big Data Management • Approaches for Spatial Big Data Computing • Approaches for Spatial Big Data Visualization
Advanced Photogrammetry (BSc)	• 3D modeling using numerical images and points cloud • Drone image processing • Combining Lasergrammetry and Photogrammetry • Synchronization and calibration of GNSS and IMU for aerial image georeferencing

Table 15 Courses to be updated at Hassan II

At Carthage University (Tunisia), a proposal was made for one course to be updated, i.e. the course on 'Decision support systems for optimal water management'. The topics to be covered through this update are shown in table 16.

Course	Key Topics
Decision support systems (DSS) for the optimal water management: Use of EO, ICT and IoT (MSc/PhD)	• IWRM principals, • Concept of DSS, • Water management optimization: Conceptual model and problem formulation. • Data requirement for optimal water management, • Wireless and real time Monitoring systems: ICT and IoT. • Use of Earth observation data for the optimal water management • International Case study

Table 16 Course to be updated at Carthage University

At the University of Jendouba (Tunisia), two courses were selected to be updated. However, the precise content to be modified or added will be defined at a later stage.

Course	Key Topics
Hydrology and Climate Change (MSc)	TBD
Geostatistics (Eng.)	TBD

Table 17 Courses to be updated at University of Jendouba

At the University of Oran 1 (Algeria), two courses will be updated as part of the SEED4NA curriculum projects: one course on 'Spatial Big Data' and one on GIS. The topics that will be covered through this update are shown in table 18.

Course	Key Topics
Spatial Big Data (MSc Networks and Distributed Systems)	• Data storage • Data processing, • Data analysis • Processing of huge spatial data sets in the context of spatial data infrastructure using a number of existing GIS extensions for Hadoop Big Data platform • GIS, DBMS, Data Analytics • Spatial big data and the power of open source software's to deal with spatial data science problems
GIS (MSc Marine Bio-Geosciences)	• Geographic information systems (GIS) and remote sensing image processing (TIT), to the study and management of a targeted area from a biological perspective.

Table 18 Courses to be updated at the University of Oran 1

At University Of Science And Technology Houari Boumediene (Algeria) a long lists of potential courses to be updated was drafted, including the (new) subjects to be covered. These courses – of which still a selection will be made at a later stage – are presented in table 19.

Course	Key Topics
GIS and Remote Sensing (MSc Biodiversity and Vegetable Ecology)	• Fundamentals of remote sensing • The physical bases • Interaction between matter and elecromagnetic radiation • Process of acquiring satellite image • Geometric corrections (creation of routines must be reinforced) • Atmospheric corrections (need to be reinforced), Radiometric corrections • Calculate index (SAVI, NDVI, Gloss index…) • Post calcification
GIS and Remote Sensing (MSc Protection of Ecosystems)	• Fundamentals of GIS and Cartography • Projections, coordinate systems, scale and other core GIS concepts • Import, manipulation and visualization of raster and vector • Data base manipulation • Fragmentation • Outputs (Thematic maps and others) • Optional: Wildlife habitat and species distribution modelling

Topography and Automatic Cartography (MSc Urban Development)	• Topography (leveling) -Urban mapping • Use of software for the realization of thematic maps, delivering a clear and effective message; - AutoCAD: initiation to Computer Aided Design • Understanding Spatial data, Managing spatial data, Analysing spatial data
Automatic Cartography (MSc Climat and Risks)	• From data analysis to the production of relevant images on geographic space. • The components of a cartographic communication system. • Geographic information: basic concepts, digitization, databases, data structures, software. • CartAO workflow and Geographic Information Systems (GIS) • Organization and preparation of geographic information in Quantum GIS • Easy visualization of geographic data with Quantum GIS • Automatic mapping
Remote Sensing Applied to Climatology (MSc Climate and Risks)	• Remote sensing data sources • Physical interpretation of data • Images processing and interpretation
Remote Sensing (MSc Applied Geomorphology)	• Image analysis • Remote sensing • Spectral analysis (visible and infrared) • Radar imagery • Geometric correction of images • Improvement of images Principal Component Analysis • Multispectral classification. • Applications to rocks and geological formations: samples and satellite images. • Understanding EO Basics, Aerial Photography, Multispectral scanner, active sensor, preprocessing of remote sensing, image interpretation, derive
Remote Sensing (MSc Tectonics and Geo Computing)	• Image analysis • Remote sensing • Spectral analysis (visible and infrared) • Radar imagery • Geometric correction of images, Improvement of images Principal Component Analysis, Multispectral classification. • Applications to rocks and geological formations: samples and satellite images. • Understanding EO Basics, Aerial Photography, Multispectral scanner, active sensor, preprocessing of remote sensing, image interpretation, derive

GIS (MSc Tectonics and Geo Computing)	• The different types of projections • Components of geographic information • Data representation models • Major GIS functions • Data quality in the GIS • Treatment tools • Modeling and Analysing spatial data • Analysing requirement
Remote Sensing and Regional models (MSc Tectonics and Geo Computing)	• Aerial photography and photogrammetry • Introduction to remote sensing • The physical bases of remote sensing • Geospatial information technology: Understanding , Using and assessing SDI, setting up and maintaining SDI. Managing metadata
GIS and Remote Sensing (MSc Mineral Resources and Environment)	• The physical basis of remote sensing and image acquisition • Principle's sensor and image format • Earth observation satellites and their optical and radar instruments • The main types of images available, Creation of indexes and image ratios • Image classification (supervised and unsupervised) • Modeling and analysing spatial data, analysing requirement
Geomatics, GIS and Remote Sensing I (MSc Marine Geosciences and Coastal Engineering)	• Introduction to GIS, The data in a GIS, The structure of data in GIS • Data sources and integration techniques • GIS products and the concept of quality: • Principles of error management • Modeling and analysing spatial data, analysing requirement
Geomatics, GIS and Remote Sensing II (MSc Marine Geosciences and Coastal Engineering)	• The different applications • Maps, Database management, Notions of spatial analysis • Use and handling of MAPINFO and / or ARCGIS software • Understanding EO Basics, Aerial Photography, Multispectral scanner, active sensor, preprocessing of remote sensing, image interpretation, derive

Table 19 Courses to be updated at USTHB

4.3. New courses

In addition to the courses to be revised or updated, the partner universities also identified some (potential) new courses to be developed and introduced in the context of SEED4NA.

At Alexandria University (Egypt) five potential new courses were identified, of which the key topics to be covered are presented in table 20.

Course	Key Topics
Spatial Modelling and Applications for SDI (MSc)	• Spatial problems that emerged in cities • The language of spatial analysis and related terminologies, • Data exploration. • Vector and raster analysis, • Spatial statistics, • Geo-statistics, • Spatial modelling • Multi-criteria decision making, land suitability analysis/site selection, impact assessment
Web GIS (MSc)	• GIS as an information system that is used on a standalone computer. • Cartographic rules for monitors. • Techniques for the transmission of spatial data over the Internet. • Creating GIS services on the Internet using various software systems, and custom coding of markup languages and scripting languages.
Geoportals for SDI (MSc)	• Role of geoportals • Public access points to Spatial Data Infrastructures (SDI) • Promoting public participation and involvement through geoportals, • Identification roles and potential contributions and techniques of SDI development and organization of metadata.
Applications of GIS and RS (MSc)	• How remote sensing systems provide geospatial information that is relevant, accurate, timely, accessible, available in an appropriate format, and cost-effective.
Database Management Systems for SDI (MSc)	• Industry-standard software and datasets easily available for analysis and representation of spatial phenomena. • ESRI's geodatabase structure • SQL Server

Table 20 Proposals for new courses to be introduced at AU

Also Ibn Zohr University (Morocco) identified five potenial new courses to be prepared and implemented at their university.

Course	Key Topics
SDI (BSc)	• SDI introduction • SDI standards • SDI applications
Cartography and visualization, Platforms, sensors	• Access to data and visualization • Access to imagery and treatment

and digital imagery (BSc)	
Geospatial data, image processing and analysis (BSc)	• GIS and RS applied to geology and geosciences
Web services and introduction to programming (MSc)	• Introduction to web mapping and web application
Spatial modelling and artificial intelligence and data mining (MSc)	• Applied to mining, geology, geosciences and natural resources

Table 21 Proposals for new courses to be introduced at Ibn Zohn University

Table 22 shows the two proposals for new courses at the Hassan II Institute of Agronomy and Veterinary Medicine (Morocco).

Course	Key Topics
Geospatial technologies for Smart Cities (MSc)	• Geospatial Data for Smart Cities • Approaches of Data Management in Smart Cities • Smart applications for Smart Cities
Location Based Services and Internet of Things (MSc)	• Introduction to Location Based Services • Introduction to Internet of Things • Labs and projects

Table 22 Proposals for new courses to be introduced at Hassan II

Carthage University (Tunisia) proposed two new courses to be prepared and implemented on SDI/EO and related topics. These two courses and the core topics are shown in table 23.

Course	Key Topics
Machine Learning for water resources and uses characterization (MSc)	• Machine learning principals • Data requirement's for ML implementation, • Stram flow modellin/prediction using ML approach, • Aquifers piezometry characterization using ML approach, • Water demand modellig/prediction using ML approach, • Water supply modelling/prediction using ML approach

EO data use for agriculture and environmental management (MSc/PhD)	• Earth observation principals, • EO Data processing automation • EO data sources, • Surface water resources characterization using EO • Irrigation water requirements evaluation using EO • Drought and Land degradation evaluation using EO • Environmental assessment using EO data

Table 23 Proposals for new courses to be introduced at Carthage University

A new course on 'Application of GIS & Machine Learning in Water Mapping' is proposed to be introduced at the University of Jendouba (Tunisia).

Course	Key Topics
Application of GIS & Machine Learning in water Mapping (PhD)	• Geospatial Data for Smart Cities • Approaches of Data Management in Smart Cities • Smart applications for Smart Cities

Table 24 Proposals for new courses to be introduced at University of Jendouabe

At University of Oran 1 (Algeria) proposals for two new courses were made: one on Remote Sensing, another one on Machine Learning to Satellite Imagery.

Course	Key Topics
Remote Sensing (MSc Networks and Distributed Systems)	• Remote sensing, characteristics of remote sensors, • Remote sensing applications in academic disciplines and professional industries. • Image acquisition and data collection techniques in the electromagnetic spectrum • Dataset manipulations.
Machine Learning to Satellite Imagery (PhD)	• Classifying, analyzing and acquiring information, and building knowledge on massive satellite data • Concepts and techniques used to determine the physical and biological properties of diverse objects through measures taken at large distance. • Visual analysis of the pixel and its neighborhood.

Table 25 Proposals for new courses to be introduced at University Oran 1

At the **University Of Science And Technology Houari Boumediene (Algeria)** also a long list of potential new courses was prepared, of which some will be selected at a later stage. In Table 26, the proposed new courses and their content is presented.

Course	Key Topics
Photogrammetry I (MSc Geodesy and Cartography)	• Camera and sonsors architecture • Coordinate systems and transformations • Aquisition process • Image rectification • Bundle block adjustment • Relative orientation and stereo • 3D modeling
Photogrammetry II (MSc Geodesy and Cartography)	• Camera and sonsors architecture • Coordinate systems and transformations • Aquisition process • Image rectification • Bundle block adjustment • Relative orientation and stereo • 3D modeling
Numerical Cartography I (MSc Geodesy and Cartography)	• Spatial data acquisition methods, • Georeferencing and coordinates sytemes • Cartographic visual expression • Raster and vector data • Digital Terrain Models • Geographic Information System (GIS) • DataBase: structure, queries and SQL • Web mapping
Numerical Cartography II (MSc Geodesy and Cartography)	• Spatial data acquisition methods, • Georeferencing and coordinates sytemes • Cartographic visual expression • Raster and vector data • Digital Terrain Models • Geographic Information System (GIS) • DataBase: structure, queries and SQL • Web mapping

Table 26 Proposals for new courses to be introduced at USTHB

4.4. Vocational training courses

The results and findings of the stakeholders' needs assessment also served as input to the definition of a vocational training programme offered by the partner universities, and the selected of topics to be covered by such a program. In a later stage of the SEED4NA projects, the partner universities will developed and offer several vocational training courses on SDI/EO and related topics.

Alexandria University (Egypt) identified four key topics for potential vocational training to be offered by the university: 'EO for urban growth surveillance', 'GIS for local authority', 'Land information systems' and 'SDI for Urban Management'. **Fayoum University (Egypt)** mainly identified an opportunity in designing, preparing and offering more general GIS courses to professionals, in which also aspects of SDI and EO could be covered.

In Morocco, it was especially the **Hassan II Institute of Agronomy and Veterinary Medicine** that identified several potential VET courses to be prepared: 'Advanced remote sensing image analysis', 'AI for GIS', 'Managing AI for GIS Projects', 'Point cloud 3D modelling' and 'UAV for spatial data acquisition'.

Also **Carthage University (Tunisia)** mainly identified an interest in more general GIS courses, both on the basics but also more advanced GIS. The other Tunisian HEI, the **University of Jendouba,** proposed a VET course on 'Application of EO, ICT & IoT in water management'.

The **University of Oran 1 (Algeria)** identified potential VET courses in different domains and on different topics. 'Global Navigation Satellite Systems', 'GI/EO Technologies for Precision Agriculture', 'Introduction to GIS and SDI' and 'Spatial Decision Support Systems'. Potential VET courses to be developed by the **University Of Science And Technology Houari Boumediene (Algeria)** all were dealing with earth observation and remote sensing. Proposals for VET courses included: 'Remote Sensing Basics', 'SAR Imagery & Applications', 'Machine Learning applied to Remote Sensing' and 'Image processing using different tools'.

4.5. Conclusion

In this chapter, we provided an overview of the key topics that will be covered in the revised and new academic courses and the VET courses by the partner universities in SEED4NA. Inspired by the SEED4NA curriculum on SDI and EO and driven by the locals needs, the partner universities identified several topics to be covered in the curriculum projects at their university.

Taking into consideration the curriculum projects of the individual partners, three main observations can be made:

1. None of the partners will fully developed and implement the entire SEED4NA curriculum. The curriculum is designed in such a way that partners can easily select particular building blocks or components to integrate into their own education.
2. Each of the identified components will be covered by at least one partner. These partners will further develop these components – i.e. design the courses and develop the teaching activities and materials – in the context of their own education, inspired and supported by the SEED4NA curriculum. The priority remains the modernisation and improvement of the partner universities' courses.
3. Some subjects proposed by certain partners at this stage are not included in the curriculum, as they are not fully within the scope of SEED4NA, and its focus on SDI and EO.

5. Specification of the SEED4NA curriculum on SDI/EO

In this chapter, we further specify the SEED4NA curriculum on SDI/EO, by identifying those components of the proposed curriculum that are most relevant to the individual curriculum projects of the SEED4NA partner organisations. This activity is supported by the EO4GEO Curriculum Design Tool, which enables the creation of educational offers, by relying on the Body of Knowledge for the EO*GI domain. In this chapter we first introduce this Tool and afterwards discuss the key components of the curriculum.

5.1. The EO4GEO Curriculum Design Tool

The EO4GEO Curriculum Design Tool (CDT) allows users to create, edit and find educational offers in the field of Earth Observation and Geographic Information. The CD Tool is supported by the EO4GEO Body of Knowledge, an ontology for the EO*GI domain, which describes the Geographic Information and Earth Observation domain by defining the underpinning inter-related concepts (theories, methods, technologies, etc.) that should be covered in education and training curricula. In the CD Tool, educational offers benefit from the EO4GEO BoK, by re-using descriptions of related BoK concepts and link specific EO/GI BoK concepts and skills.

The CD Tool is a modular tool, which supports the creation of educational offers at different levels of granularity, from an entire study program to a single lecture or lesson. This allows its use by a broad range of educational offers by various providers, ranging from academia programs to high school curricula or VET trainings. The CD Tool also allows re-use of educational offers, by duplicating or promoting existing offers and adapting them to the user's needs.

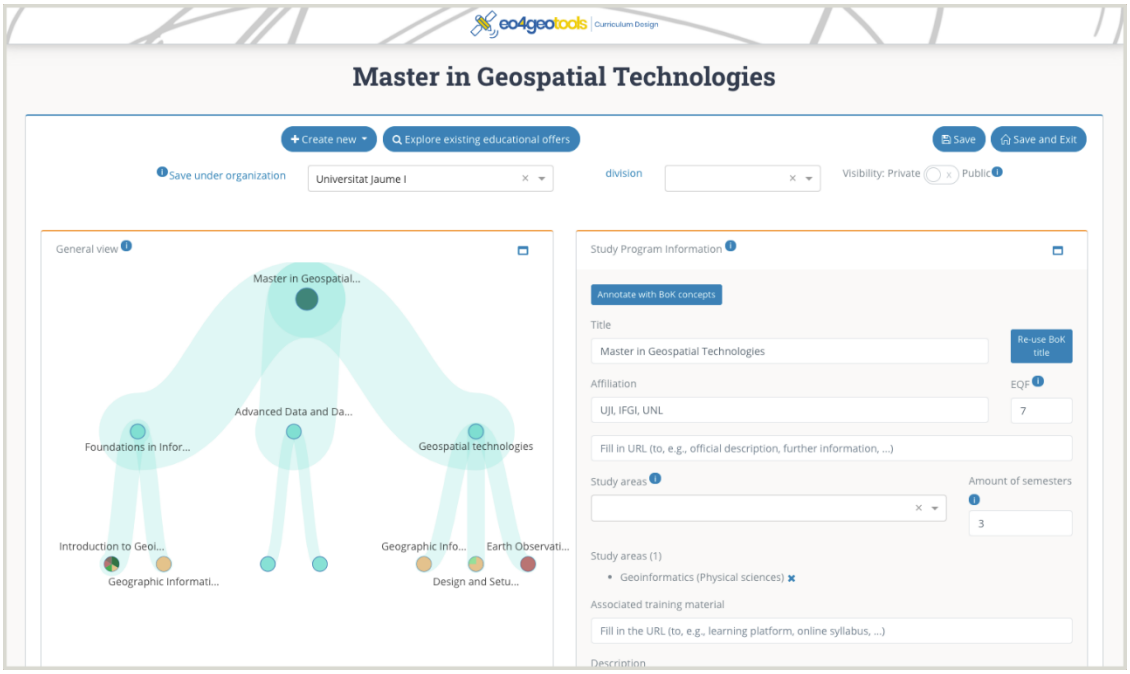

Figure 11 EO4GEO Curriculum Design Tool

The Curriculum Design Tool is displayed in figure 11. The figure shows – as an example - the Master in Geospatial Technologies as designed and described in the CD Tool, consisting of different modules and courses.

We used the CD tool to design the SEED4NA curriculum on SDI/EO, and further adapt it to the needs and interests of the local stakeholders and experts in the four countries (and at the eight partner universities). In figure 12, the five main modules of the curriculum are shown, which constitute the core structure of the curriculum.

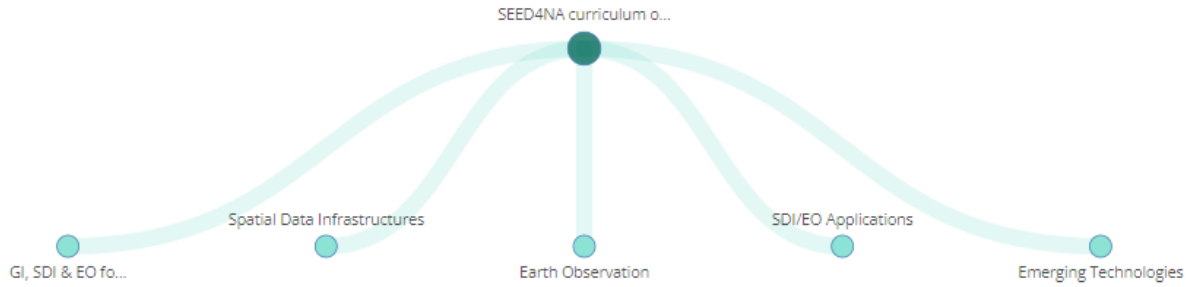

Figure 12 Five modules of the SEED4NA curriculum

5.2. GI, SDI & EO for geospatial solutions

Taking into consideration the needs and interests of the local stakeholders and universities in the four partner countries, the first building block of the SEED4NA curriculum still consists of a general introduction on GI, SDI & EO for geospatial solutions.

Some modifications were made to the underlying components of this building block, as the most relevant components were selected. These include:

- A general introduction on the **'Foundations of GI, SDI and EO'** in which these core concepts are introduced, as well as the relationships between them. This component could be central in the various proposed courses on GIS (*e.g. at Fayoum University, Ibn Zohr University, University of Oran 1 & University Of Science And Technology Houari Boumediene*) as well as in the proposed courses on GIS and Remote Sensing (at *University Of Science And Technology Houari Boumediene)* and on GIS and SDI *(at University of Oran 1).*
- A component on '**Spatial Data Management',** which deals with different aspects of an various approaches and tools for the management of geospatial data. This could support the revision of such courses at *Hassan II Institute of Agronomy and Veterinary Medicine* and the design of a course on Database Management Systems for SDI at *Alexandria University*.
- A component on '**Applications of GI and EO'**, which focuses on applications of GI and EO, and the acquisition, management and use of EO data and geospatial data for different

purposes in different sectors. This course supports the preparation of a new course on 'Applications of GI and RS' at Alexandria University.

- A component on '**Spatial Data Acquisition'**, which deals with different ways of data acquisition (remote sensing, UAV, field data) and different data sources, but also processes of data corrections and georeferencing. This course will support the development of courses on 'GIS and Remote Sensing' & 'Numerical Cartography' (*University Of Science And Technology Houari Boumediene)* and on 'UAV for spatial data acquisition' *(Hassan II Institute of Agronomy and Veterinary Medicine).*

In figure 13, the four components of the building block on 'GI, SDI & EO for Geospatial Solutions' are shown, and positioned within the overall SEED4NA curriculum.

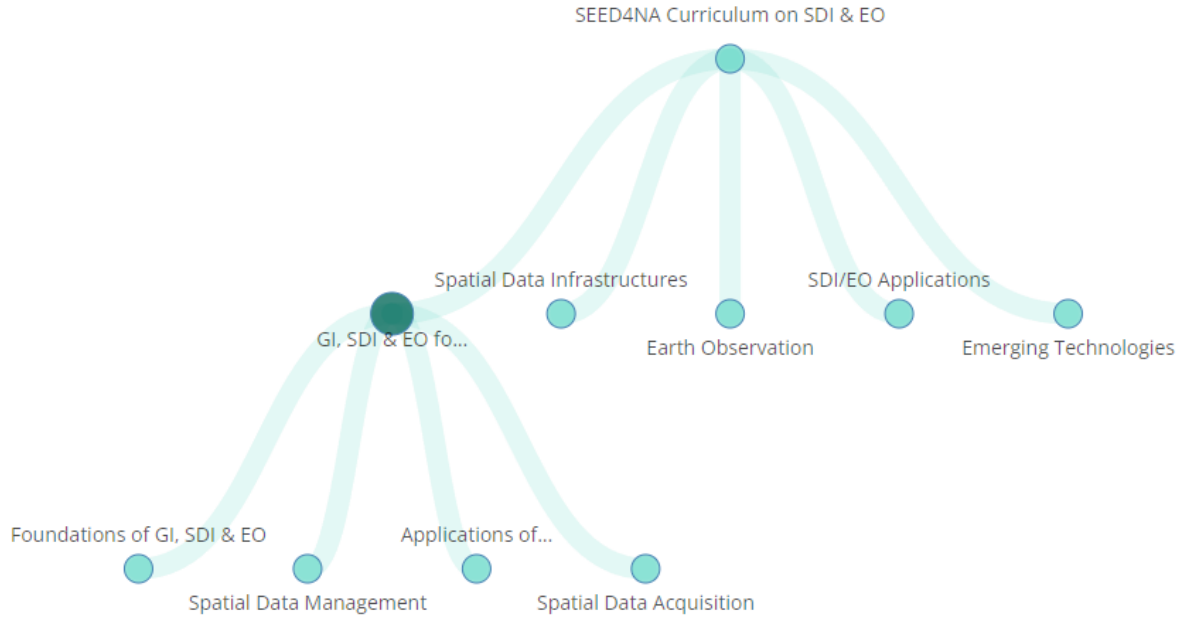

Figure 13 Module on GI, SDI & EO for Geospatial Solutions

5.3. Spatial Data Infrastructures

The second building block of the SEED4NA curriculum fully deals with Spatial Data Infrastructures and the various components of these infrastructures. Based on the needs and interests of the local stakeholders, it was decided to add a new course on 'Geoportals' but not cover the 'Organisational and Institutional aspects of SDIs'. As a result, the building block on 'Spatial Data Infrastructures' still consists of five components.

- An **Introduction to SDI,** in which the different components of SDIs are introduced and explained, and examples of SDIs in different parts of the world are shown. This component could support the design and development of the course on SDI at *Ibn Zohr University* and the vocational training on GIS and SDI at *University of Oran 1*.

- A component on '**Standards and Interoperability'**, which focuses on different types of interoperability (technical, semantic, legal, organisational) and the importance of standards (OGC, ISO, national standards) in the establishment of SDIs. This course could provide the basis for the design and development of the course on SDI at *Ibn Zohr University* and the vocational training on GIS and SDI at *University of Oran 1*.
- A component on '**Spatial data modelling'**, which deals with spatial data models, but also the harmonization, transformation and validations of geospatial data. This course could support the preparation of a new course on 'Spatial modelling and artificial intelligence and data mining' at *Ibn Zohr University* and the new course on 'Spatial Modelling and Applications for SDI' at *Alexandria University*.
- A component on **'Web-based GI'**, which focuses on methods and techniques for sharing but also managing GI over the internet. This course will support the preparation of a new course on 'Web GIS' at *Alexandria University* and the new course on 'Web services and introduction to programming' at *Ibn Zohr University.*
- Finally, a new component on '**Geoportals for SDI'** was included in the curriculum, to support the preparation of such a course on Geoportals at *Alexandria University*. The course would look at geoportals as main access points of SDIs, and related aspects such as metadata, catalogues and discovery services. Also new ways of discovering and accessing geospatial data will be covered.

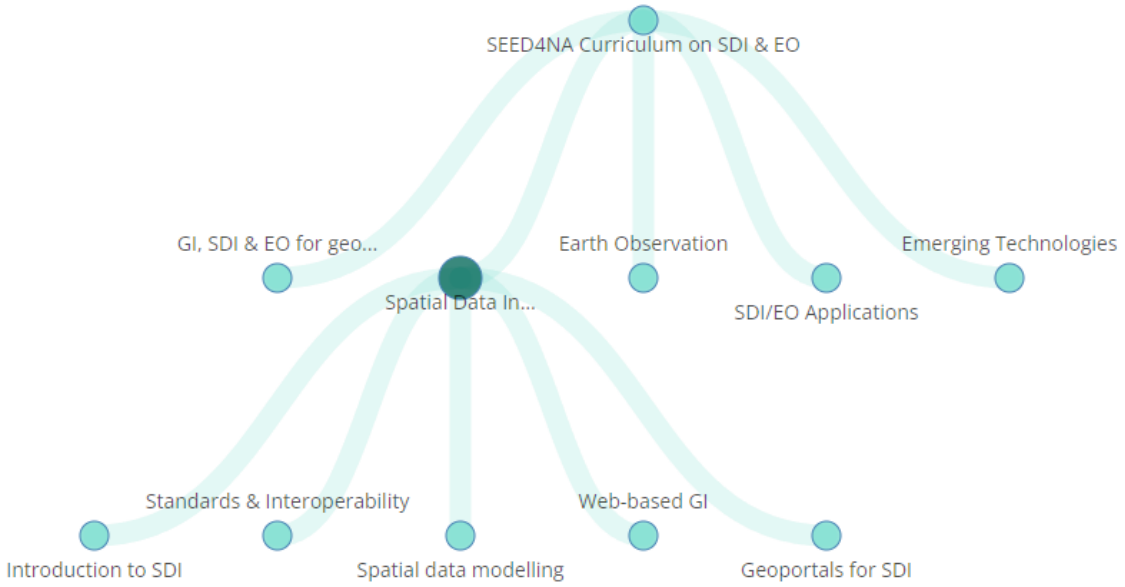

Figure 14 Module on Spatial Data Infrastructures

Figure 14 shows the different components of the building block (or program module) on Spatial Data Infrastructures, and how they fit in the overall curriculum.

5.4. Earth Observation

The third building block of the curriculum fully focuses on 'Earth Observation'. The content of this building block was reduced to three main components:

- '**Introduction to RS and EO':** explains to key principles and fundamentals of RS & EO
- **'Satellites, sensors & imagery':** looks into the different types of sensors, satellites and different imagery types (and how to access them).
- **'Image processing and analysis':** focuses on the processing and analysis of imagery.

These three topics are relevant to many of the – updated / new – courses proposed by partner universities of SEED4NA, such as *University of Oran 1*, the *University Of Science And Technology Houari Boumediene*, *Ibn Zohr University*, and *Alexandria University.*

Figure 15 shows the proposed structure of the building block on Earth Observation, and how they are positioned within the SEED4NA curriculum on SDI and EO. When covering these components in education, courses could be structured around these three components or around more basic/introductory and more advanced courses. In many of the proposals for courses by the partner universities, it can be seen that an approach of basic courses versus advanced courses is followed.

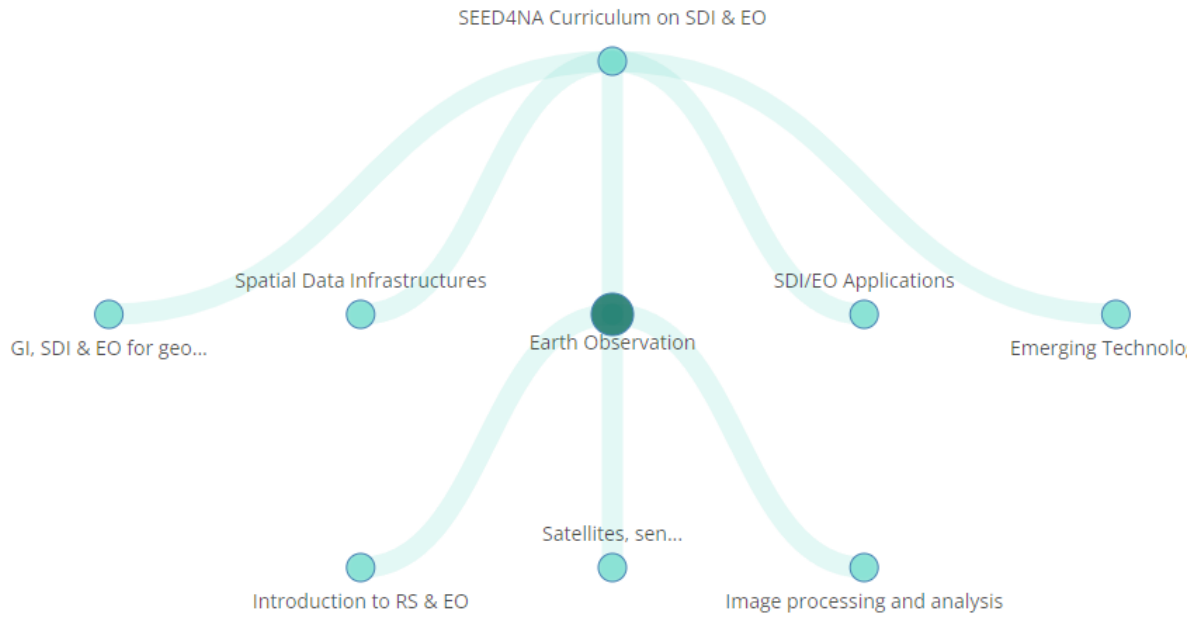

Figure 15 Module on Earth Observation

5.5. SDI/EO Applications

In the proposals for revised and new courses made by the SEED4NA partner universities, there are many courses on the use of GI/SDI/EO in specific fields. In the proposal for a SEED4NA curriculum we already included a building block on SDI/EO Applications. Based on the course proposals by the partner universities we selected the most relevant domains. These include:

- **Urban Planning**: in support of the VET courses on 'EO for urban growth surveillance' and on 'SDI for Urban Management' at *Alexandria University*;
- **Smart Cities**: in support of the new course on 'Geospatial technologies for Smart Cities' at *Alexandria University;*
- **Water Management**: in support of the new courses on 'Application of GIS & Machine Learning in water Mapping' (*University of Jendouba)*, and on 'Machine Learning for water resources and uses characterization' (*Carthage University)* and the revised courses on 'Hydrology and Climate Change' (*University of Jendouba)* and on 'Decision support systems for optimal water management' at (*Cartaghe University)*;
- **Agriculture**: in support of the VET course on 'GI/EO Technologies for Precision Agriculture' at *University of Oran 1* and the new course on 'EO data use for agriculture and environmental management' at *Carthage University*;
- **Environmental Management**: in support of the new course on 'EO data use for agriculture and environmental management' at *Carthage University*;
- **Land Management**: in support of the VET course on 'Land information systems' at *Alexandria University*.

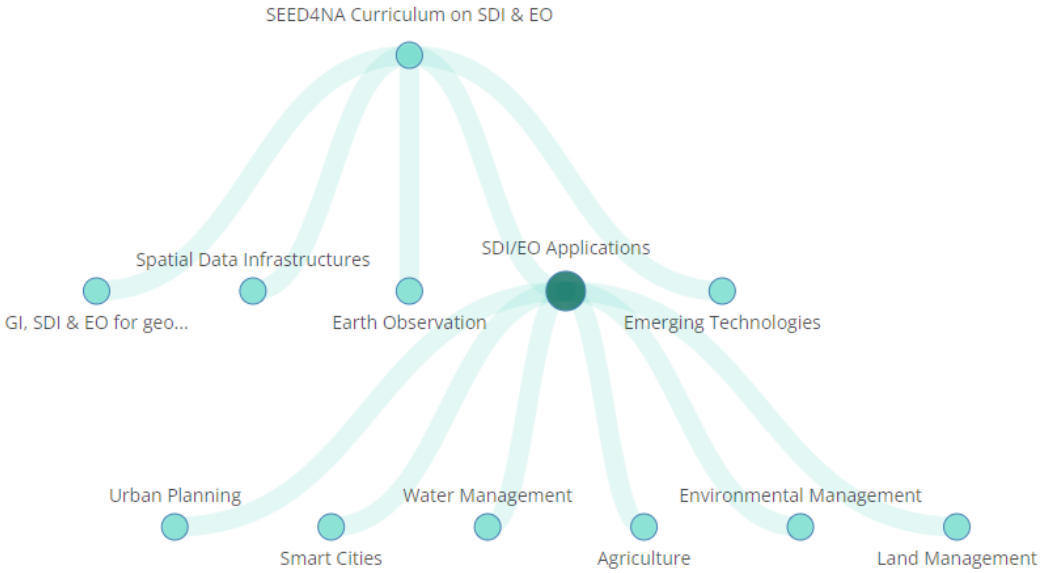

Figure 16 Module on SDI/EO Applications

The components of the building block (or module) on SDI/EO Applications are shown in figure 17, which also shows the position of these components within the overall curriculum. Important in these components is to especially look into the importance and added value of SDI and EO to each of these fields of applications.

5.6. Emerging Technologies

The SEED4NA curriculum also included a building block on Emerging Technologies, in which originally three technological developments were central: Artificial Intelligence, Big Data and 3D and Digital Twins. Taking into consideration the expressed interests of the local stakeholders, there was little interest in the topic of '3D and Digital Twins', and thus no need to include this in the SEED4NA curriculum. Two partners expressed an interest to develop education on another emerging technology, the Internet of Things.

As a result, the building block on Emerging Technologies now covers three main components:

- **Artificial Intelligence**: relevant for VET courses on 'AI for GIS' and on 'Managing AI for GIS Projects' at the *Hassan II Institute of Agronomy and Veterinary* and the new course on 'Spatial modelling and artificial intelligence and data mining' at *Ibn Zohr University.*
- **Big data**: relevant for revised courses on 'Big data' at *University of Oran 1* and on 'Spatial Data Management' at *Hassan II Institute of Agronomy and Veterinary Medicine*.
- **Internet of Things (IoT):** relevant for the revised courses on 'Decision support systems (DSS) for the optimal water management' at *University of Jendouba* and the new course on 'Location Based Services and Internet of Things' at the *Hassan II Institute of Agronomy and Veterinary.*

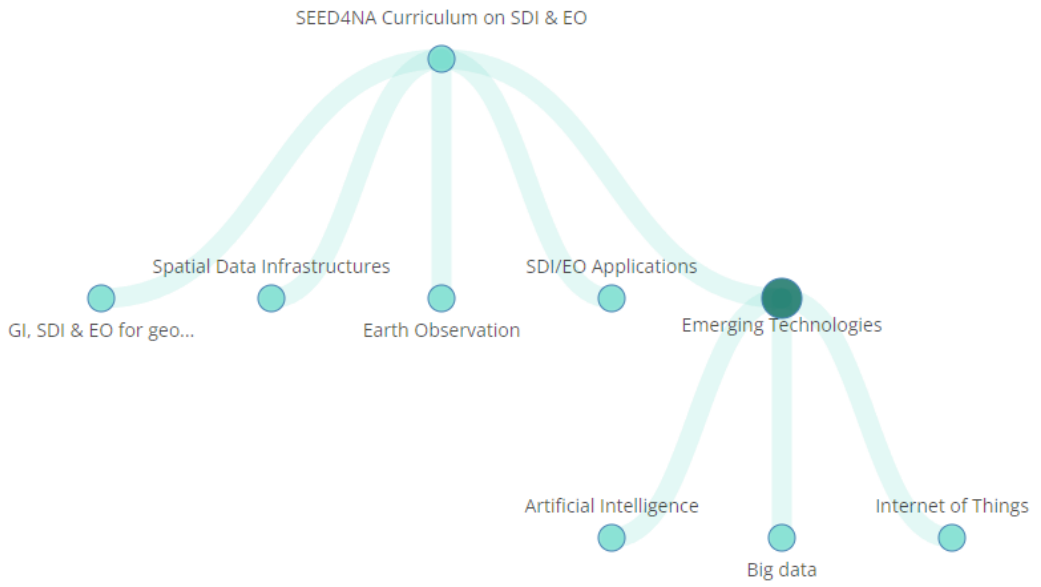

Figure 17 Module on Emerging Technologies

5.7. Specifying the SEED4NA curriculum

The creation of the SEED4NA curriculum via de EO4GEO CD Tool also provided interesting possibilities for further specifying the curriculum. The CD Tool provided three main benefits to the creation of the SEED4NA curriculum:

1. **The exploration and inclusion of elements from already existing curricula**: the CD Tool allows to explore existing educational offers, i.e. existing modules, courses and lectures on particular topics. In this way, also the content, structure and/or learning objectives of existing courses easily could be explored and, if relevant, added to the new curriculum. In figure 18 an example is shown of how existing courses on SDI easily could be discovered, and elements of them could be integrated into the SEED4NA curriculum.

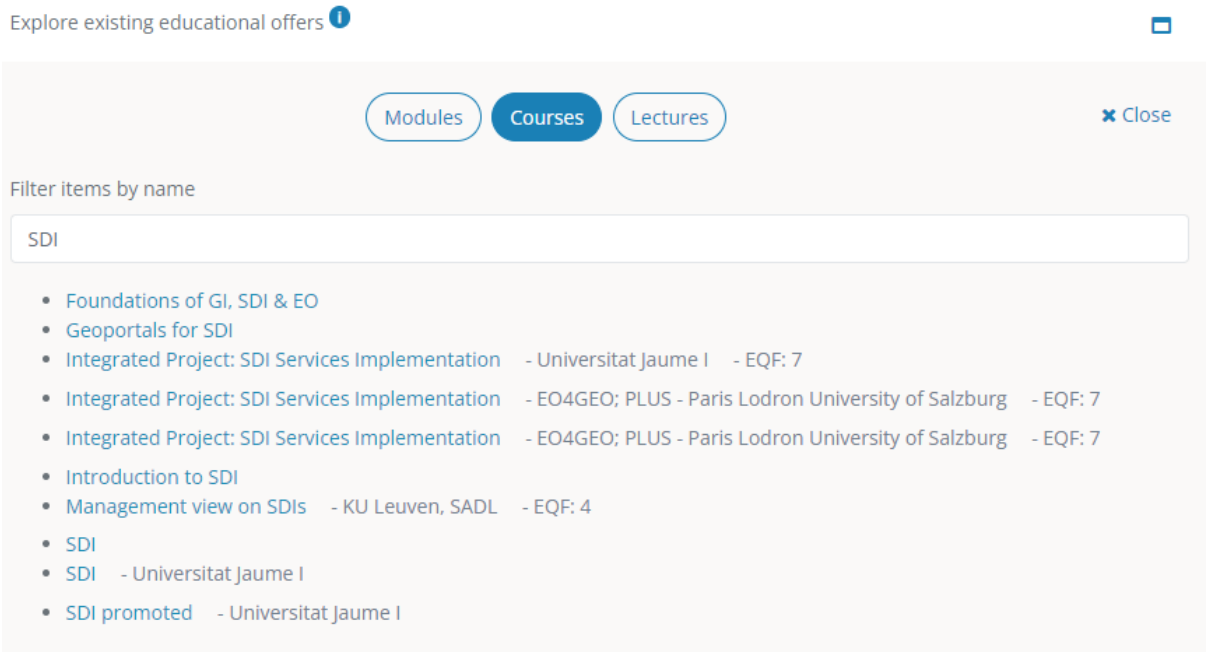

Figure 18 Exploring the existing educational offer for SEED4NA

2. **The annotation of curriculum components with BoK concepts**: the CD Tool allows annotate the content of curricula with concepts of the Body of Knowledge on EO*GI. Annotation means that concepts of the BoK are assigned or linked to a component of the curriculum. This allows to easily integrate relevant content related to this concept. Figure 19 shows how learning outcomes related to 'Web-GIS' easily could be integrated into the SEED4NA curriculum by annotated the component 'Web-based GIS' with the BoK concept of Web-GIS.

Figure 19 Re-use of BoK learning outcomes by annotating the SEED4NA curriculum

3. **Adding new content to the CD Tool**: the CD Tool also allowed to add new content to the curriculum, such as new learning objectives. For the SEED4NA curriculum this made it possible to also add learning objectives from existing courses, provided by the European partners or by other partner universities. Eventually, these learning outcomes could also be integrated directly into the Body of Knowledge on EO*GI, allowing a broader reuse of them, also in other EO4GEO tools.

6. Conclusion

The aim of this report was to further adapt and specify the SEED4NA curriculum on SDI and EO to the needs and interests of the local stakeholders in the four SEED4NA partner countries (Algeria, Morocco, Egypt and Tunisia). In this report, we presented and discussed the approach and results of this specification process, which consisted of four main steps:

1. **An investigation of existing courses on GI/SDI/EO at the eight partner universities in North Africa.** This is the context in which the SEED4NA curriculum projects will take place. Some of these courses will be revised, other already cover some of the core topics of the curriculum. At several partner universities, new courses will be added to the already existing offer, to cover topics currently not covered.
2. **An assessment of the knowledge and skills needs of the local stakeholders:** the results of the SEED4NA questionnaire on GI/EO/SDI knowledge and skills needs of stakeholders in the four countries were further investigated, also looking at key differences between the four countries. In this way, more specific needs at country level could be identified.
3. **An inventory of the proposals for curriculum projects at the partner universities**: the results and findings of the needs assessment and the proposal for the SEED4NA curriculum were used to propose curriculum projects at the partner universities, i.e. courses to be revised, new courses to be introduced and VET courses to be prepared.
4. **Modification of the SEED4NA curriculum on SDI and EO:** based on the proposed courses and their content, several modifications were made to the SEED4NA curriculum. The five – original – building blocks were retained, but important changes were be made in the underlying components.

While some of the original components were removed, since there was no clear need for skills and education about them among the local stakeholders, we also added some new components. Among these are new components on 'Geoportals for SDI' and 'Internet of Things', and the adaptation of the components dealing with SDI/EO Applications to the fields of interests of the local partners.

Designing the SEEDNA curriculum in the EO4GEO Curriculum Design tool provided a lot of opportunities to enrich the content, by referring to and adding components of existing educational offers. The work on the curriculum will continue, as the partner universities in the four North African countries will further develop those components of the curriculum that are related to their curriculum projects. The SEED4NA curriculum will serve as the foundation of these development projects, which will improve the relevance and quality of education on SDI and EO in North Africa.