Erasmus+

CALLME

Collaborative e-platform for innovation and educational enhancement in medical engineering - CALLME

NOVEL EDUCATIONAL METHODOLOGY (NEM)

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PROJECT GOAL

To form a knowledge triangle network that will enable interconnection between education, innovation, and business to enable knowledge transfer and sustainability of the developed platform, and to provide capabilities for constant upgrade of learning techniques by using **Novel Educational Methodology (NEM)** and **Science, technology, engineering, and mathematics (STEM)**.

INTRODUCTION TO PROJECT

Biomedical engineers are often responsible for the preservation and improvement of quality of life for ailing patients, so the work can be quite fulfilling. However, because of the complex and demanding nature of the work, interested individuals should possess certain character traits, **and complete their engineering education, before beginning to work in the field.**

INTRODUCTION TO PROJECT

INFORMED EDUCATED CONNECTED

Engineering and medical students and practitioners, must be constantly **informed** of newly developed methods in the specific fields of interests**, properly educated,** and **widely connected** in order to exchange knowledge. These goals define **three pillars** of the proper education and practice in the field of biomedical engineering; thus, they define the basis for the proper implementation of the CALLME project.

INTRODUCTION TO PROJECT

Just in time introduction to the novel methods applicable in personalized healthcare.

Proper **education and training** are essential for the successfully implementation of the novel methods.

Connection and collaboration between scientists, engineers, students and medical practitioners from clinics are very important in order to properly acquire required knowledge and to implement and develop new engineering methods and medical techniques.

INTRODUCTION TO PROJECT

The project outcome aims at thorough **improvement of the teaching process** of selected, branches/disciplines of medical and engineering sciences using **ICT and related technologies.**

The application of novel educational metodologies, augmented reality, simulation, 3D geometrical and mechanical/electrical/physical modeling, as well as e-learning, m-learning, distance and blended approaches, **will be in the focus and the backbone of the teaching methodology enhancements.**

INTRODUCTION TO PROJECT

Nowdays, two general approaches exist in designing web-based education systems with Open Online Courses (OOC): **adaptive education systems** and **intelligent tutoring systems** [Cem Tekin, eTutor: Online Learning for Personalized Education, 2014; M. Venu Gopalachari, Personalized Context Aware Assignment Recommendations in E-Learning System, 2016].

INTRODUCTION TO PROJECT

Main shortcomings of today's approaches in eLearning are: **missing or inadequate feedback from the students**, **system adaptation not focused on learning context**, and **course presentation** (learning material) limited to one teaching style. Beside stated advantages and disadvantages to eLearning methods, there are practical shortcomings which are important to address, like**: they are weekly adoptable to students with disabilities; they are not suitable for groups with different knowledge background and cognitive capabilities; they are poorly customizable to immersive business demands**, etc.

INTRODUCTION TO PROJECT

The important question is: “**How to create a sustainable learning system which will be tailored according to the requirements of the specific student (person), or domain of work (business) and education, but, which will also provide general and certified knowledge, and, work-based and lifelong learning**?”.

INTRODUCTION TO PROJECT

Learning system which will always provide contemporary content

Learning platform which will is able to adapt to the specific needs coming from educational institutions, companies, public institutions and organizations.

Work-based learning will enable students to learn by using different kind of courses developed by SMEs and enterprises, which can be performed online by using web platform, or by learning on company physical site.

INTRODUCTION TO PROJECT

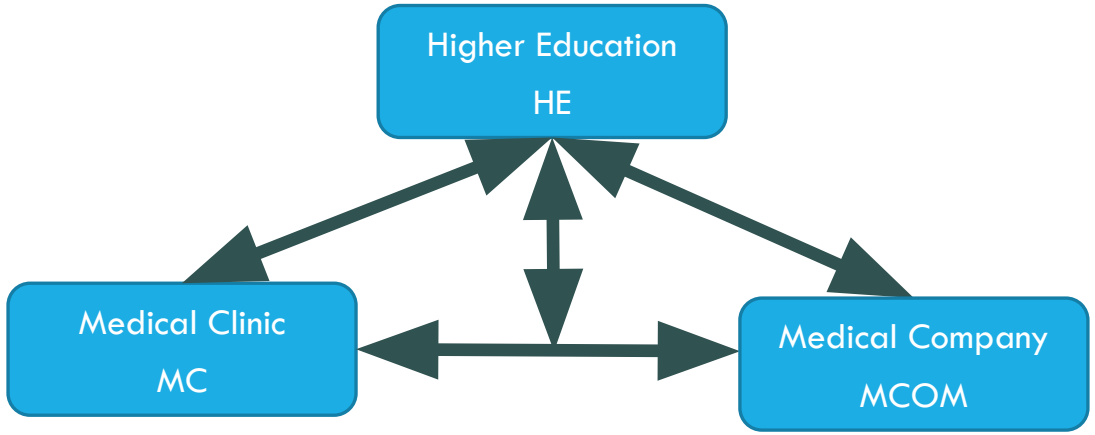
The main idea of this project is to upgrade and apply Novel Educational Methodology (NEM) initially developed by P1 (University of Nis), to open collaborative e-platform (E-COOL), thus, enabling creation and implementation of open personalized courses and courses with personalized content, for education, innovation, and business (knowledge triangle).

INTRODUCTION TO PROJECT

First Contribution

Network of biomedical engineering Centers

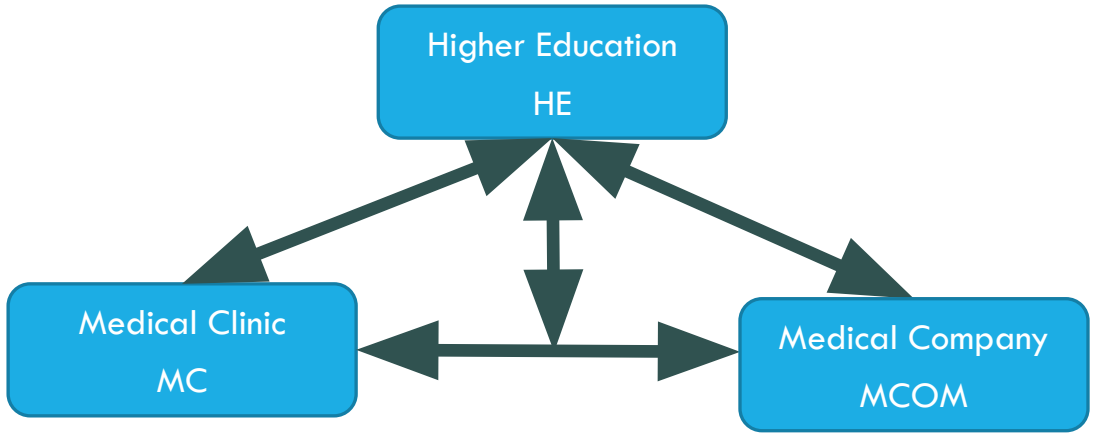
Connection and collaboration between scientists, engineers, students and medical practitioners from clinics are very important in order to properly acquire required knowledge and to implement and develop new engineering methods and medical techniques.



INTRODUCTION TO PROJECT

Second Contribution
Novel Educational Methodology

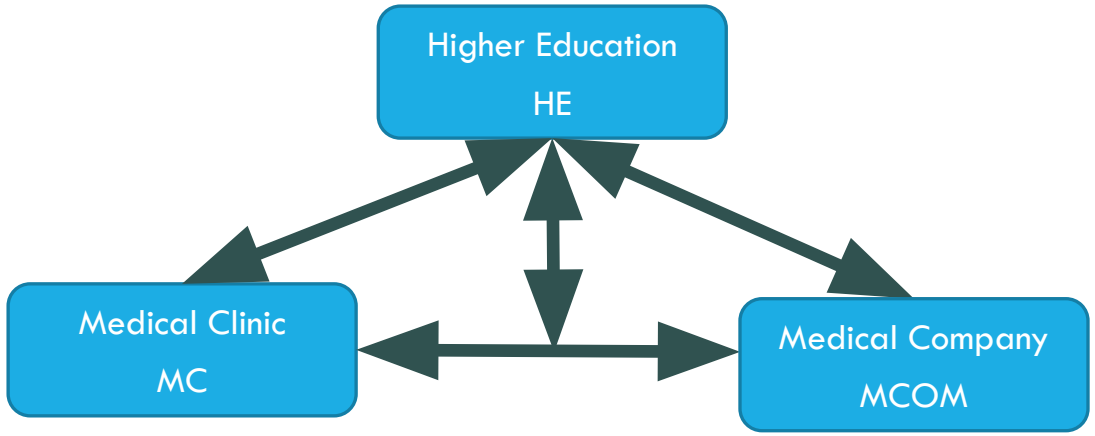
The new approach is to create flexible teaching materials in the form of courses oriented toward virtualization of biological, mechanical and other related systems, by using different learning methods and specifically **atomic learning**.



INTRODUCTION TO PROJECT

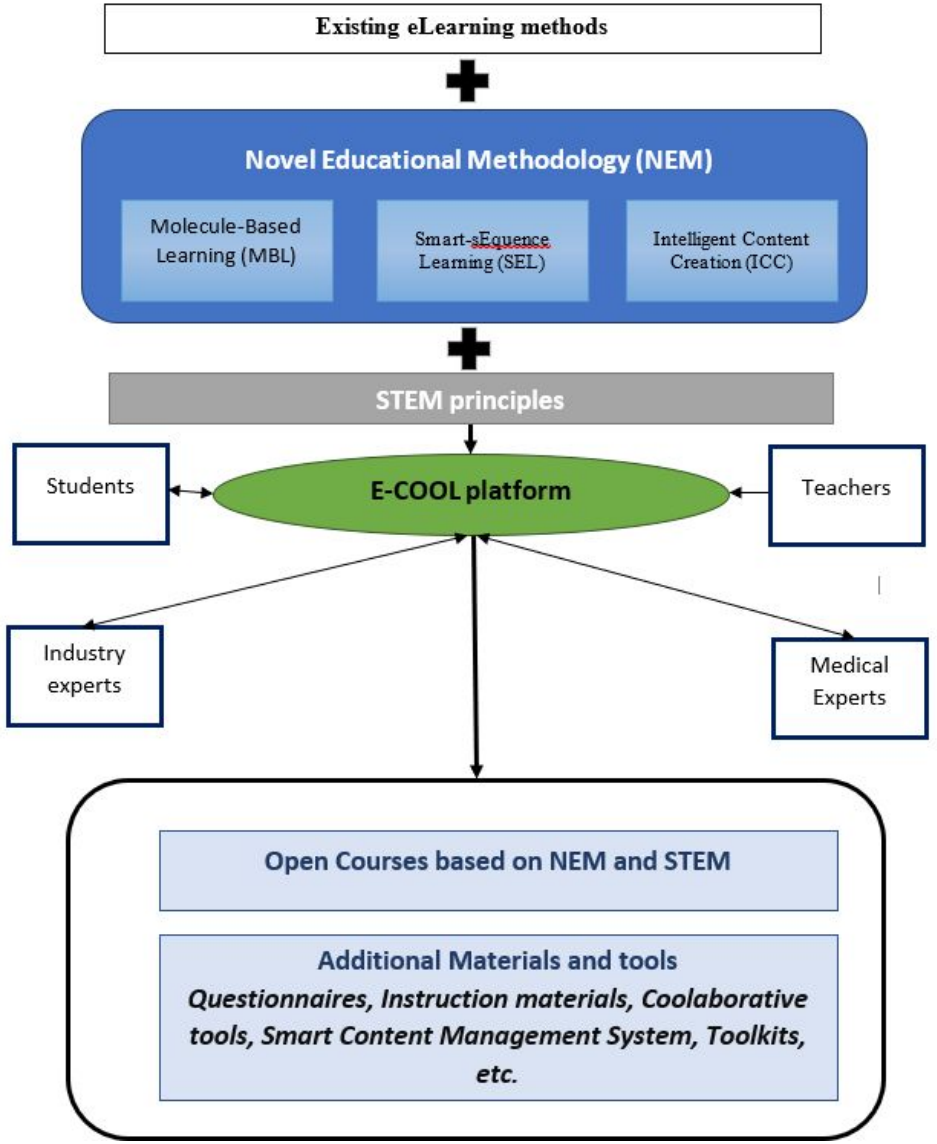
Third Contribution
Open E-platform for collaboration and knowledge exchange

The new approach is to create flexible teaching materials in the form of courses oriented toward virtualization of biological, mechanical and other related systems, by using different learning methods and specifically **atomic learning**.



INTRODUCTION TO NEM

NEM will enable creation or application of standard eLearning content (context-based learning, feedback-based learning, and adaptable learning) and **introduce new learning methods and approaches in both** universities and business educational processes, e.g., work-based learning, long-life learning, and long-term learning.



INTRODUCTION TO NEM

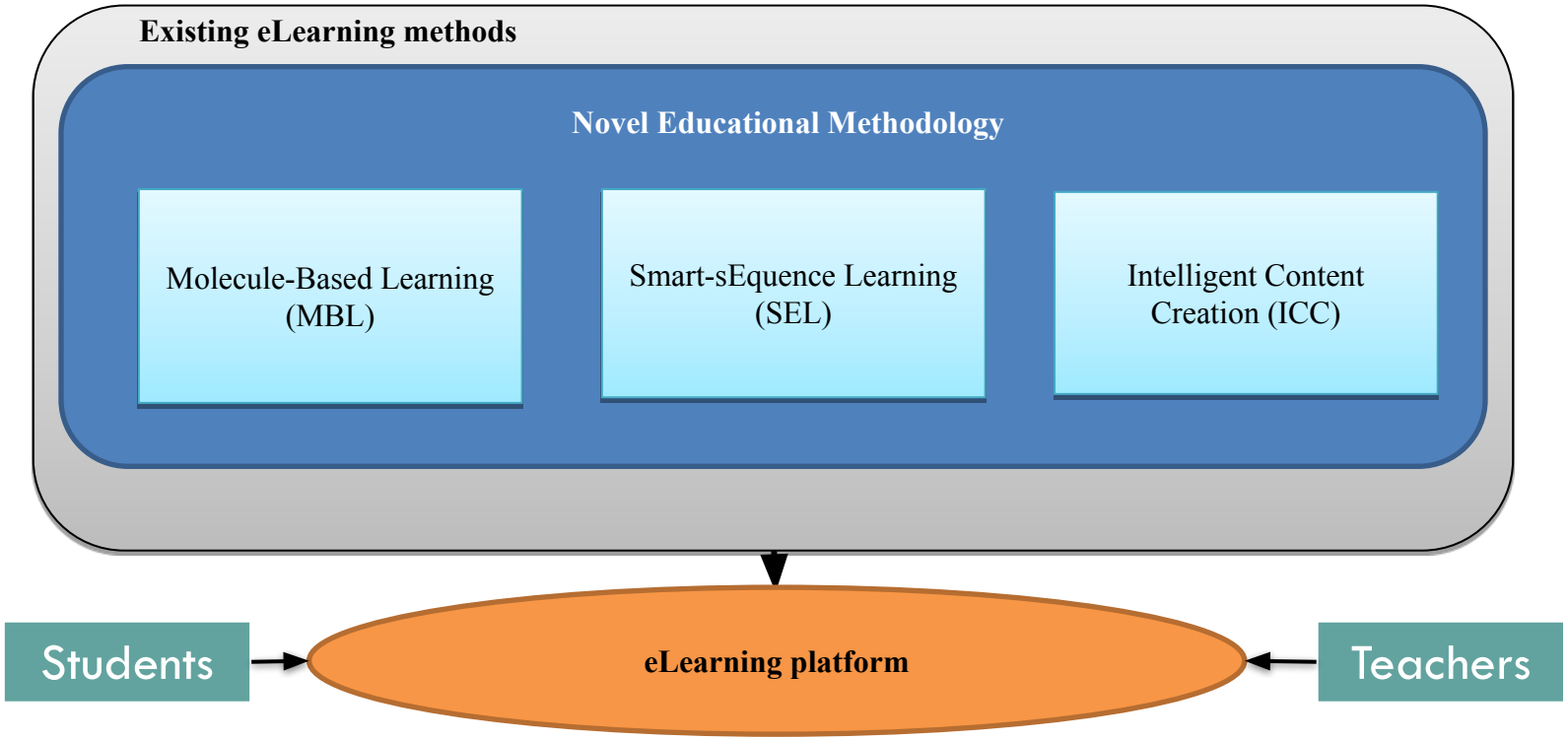
NEM is based on three main eLearning methodologies:

Molecule-Based Learning (MBL) - This technique is based on how learning content is presented to the learner. It introduces molecules of knowledge. It is based on nucleus eLearning technique (set of micro learning material)

Smart-sEquence Learning (SEL) - Sequence learning is known technique, and it presumes learning processes where basic elements of learning material are presented to the learner in defined order.

Intelligent Content Creation (ICC) - Learning material can be in a various forms, and most common forms are video material and text. This material is created during course creation and it is fixed

INTRODUCTION TO NEM



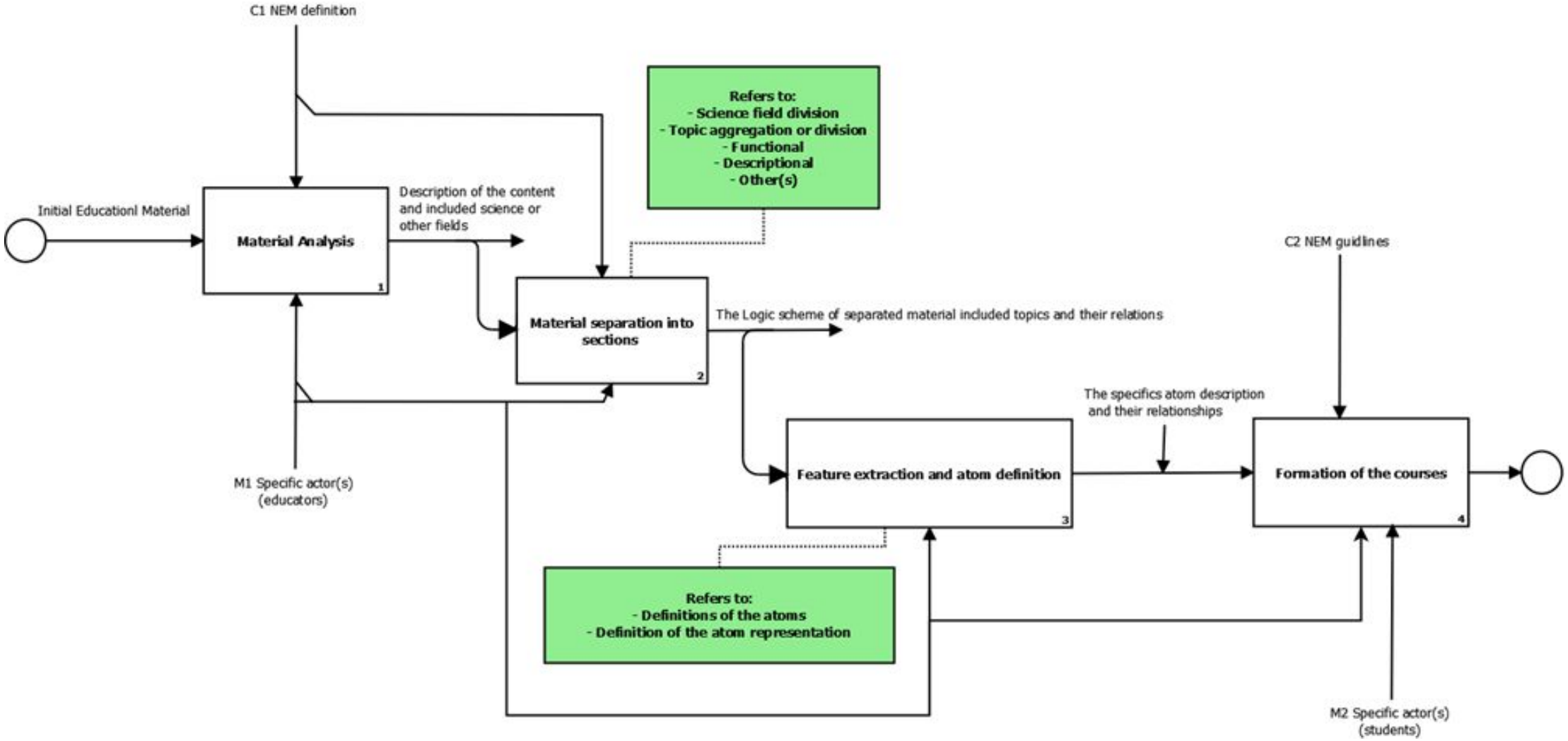
INTRODUCTION TO NEM

Molecule-Based Learning (MBL) - Improvement

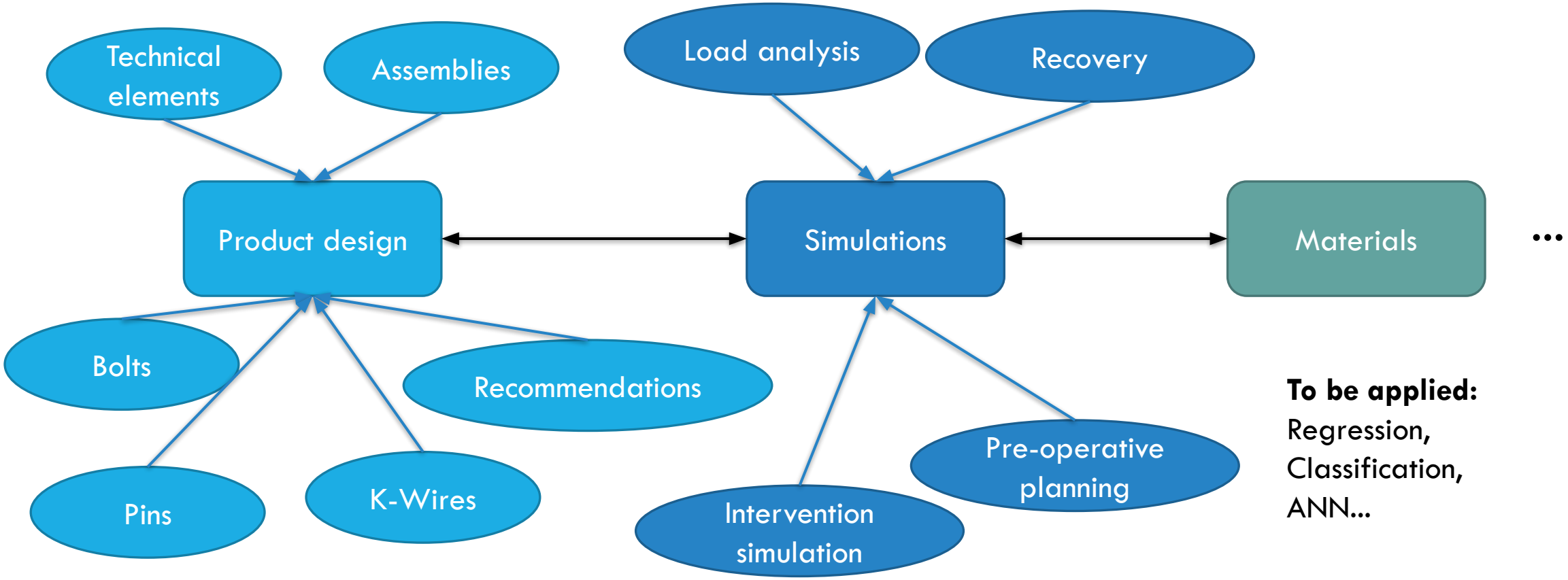
Knowledge Molecules contain one or more variants of the same nucleuses, i.e. they contain different variants of content explanations. One molecule can contain one or more nucleuses, and each of them can be applied individually, or combined.

To further upgrade this method, we substitute nucleuses with atoms, thus we add more layers (like electron levels) which can additionally explain content in the nucleus, and therefore we create atomic knowledge integrated into molecule (complex knowledge).

Learning processes can be adapted to the various target groups, like learners, learning subjects, learning domains, and goals.


C1 NEM definition
Refers to:
- Science field division
- Topic aggregation or division
- Functional
- Descriptional
- Other(s)
Initial Educationl Material
Material Analysis
1
Description of the content and included science or other fields
Material separation into sections
2
The Logic scheme of separated material included topics and their relations
C2 NEM guidlines
The specifics atom description and their relationships
Feature extraction and atom definition
3
Formation of the courses
4
M1 Specific actor(s) (educators)
Refers to:
- Definitions of the atoms
- Definition of the atom representation
M2 Specific actor(s) (students)

INTRODUCTION TO NEM – KNOWLEDGE ATOMS



To be applied:
Regression,
Classification,
ANN...

INTRODUCTION TO NEM – P1 AND PARTNERS

Partners

A. Formation of the atoms
B. Insertation of the atoms into the database
C. Creation of the atoms connections – Small Courses (Needed for later implementation)
D. Creation of the course defined by the WP3
E. Creation of the questenneries and surveys
F. Implementation of the selected course into the platform

P1

A. Creation of the classifications based on the smart connections defined in **D** by partners
B. Integration with other courses created by different partners
C. Implementation of SELL and ICC into the created knowledge base

INTRODUCTION TO NEM

Molecule-Based Learning (MBL) - Improvement

Knowledge Molecules contain one or more variants of the same nucleuses, i.e. they contain different variants of content explanations. One molecule can contain one or more nucleuses, and each of them can be applied individually, or combined.

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Learning processes can be adapted to the various target groups, like learners, learning subjects, learning domains, and goals.

INTRODUCTION TO NEM

Smart-sEquence Learning (SEL) - Improvement

In NEM complete learning material is created by combining molecules of knowledge and their content in a personalized sequence. Learning sequence can be created by aggregating molecule from different domains, thus creating new courses by using material already implemented in existing courses. New courses can be created automatically or semi automatically by using AI methods, and/or by manually choosing learning material.

INTRODUCTION TO NEM

Intelligent Content Creation (ICC) - Improvement

This material is created during course creation, and it is fixed. In NEM, even on a micro level, video material and text can be formed based on the personal preferences of a learner and a teacher. This is possible due to the application of the digital avatar for the teacher, and by using semantic interpretation of the learning material, i.e. by using ontologies, and Natural Language Processing (NLP) techniques.

COURSE DESCRIPTION

- A course is a complex object that is made up of a series of atoms (such as a machine assembly consists of machine elements), and the basic structure of the course.
- Atoms are made up of software and / or digital elements of different types.
- The main visuals are digital objects created in specific graphics software, and represented by 2D or 3D representation (e.g. gearbox, medical implant, patient's bone)
- Atoms may also be sound and some other representation of knowledge, such as an audio recording explaining the functioning of a implant system, and these elements support the main elements.

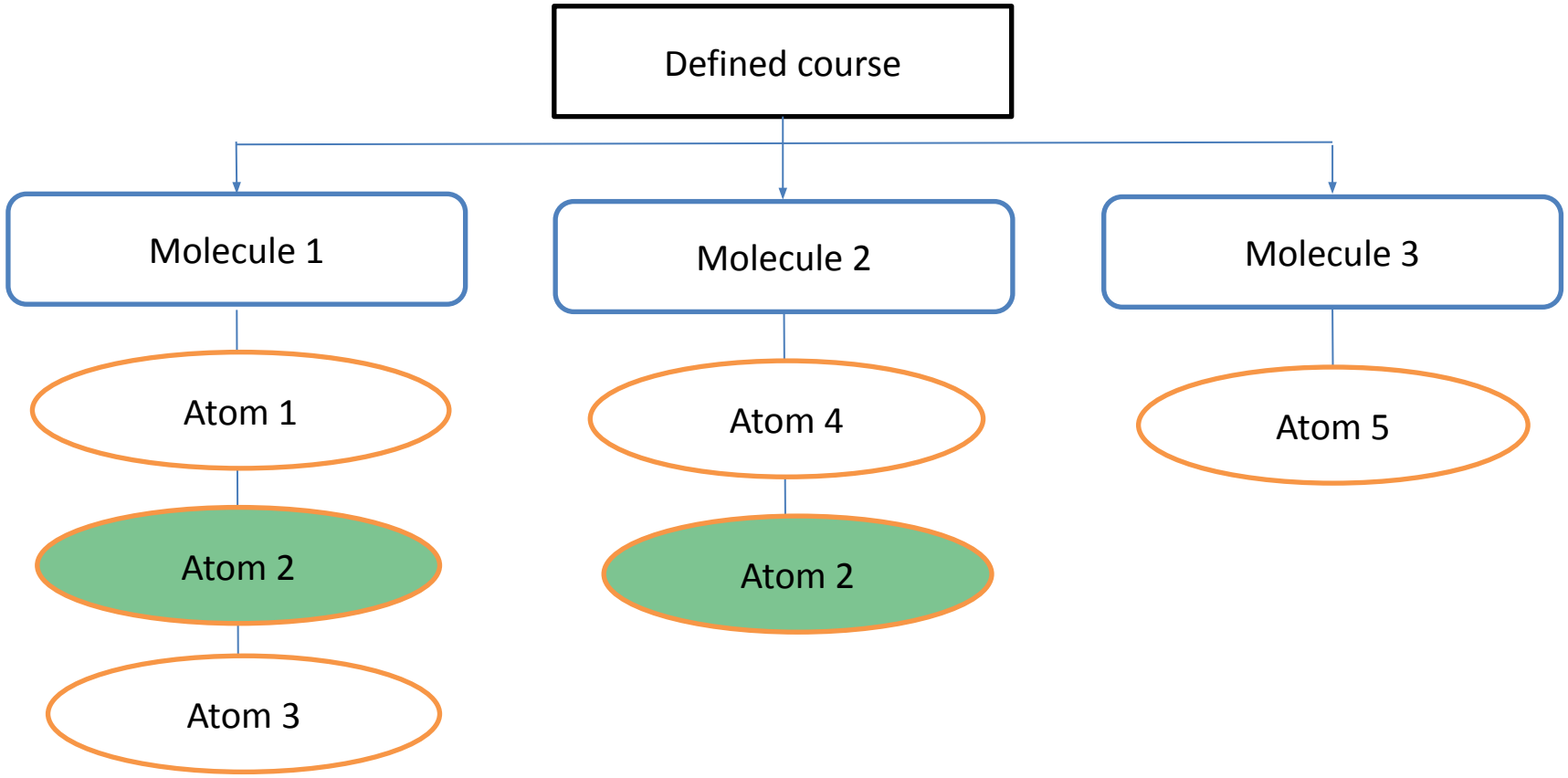
COURSE DESCRIPTION

- Atoms are assembled into moleculs and define certain rounded element. Possible examples:
  - An audio recording in which the author explains the breakthrough function and the 3D breakthrough model can define one entity.
  - VR application that simulates the orthopaedic surgical intervention, using appropriate hardware (e.g., Google cardboard)
  - A business system made up of multiple processes, i.e., multiple elements organized into groups.

COURSE DESCRIPTION

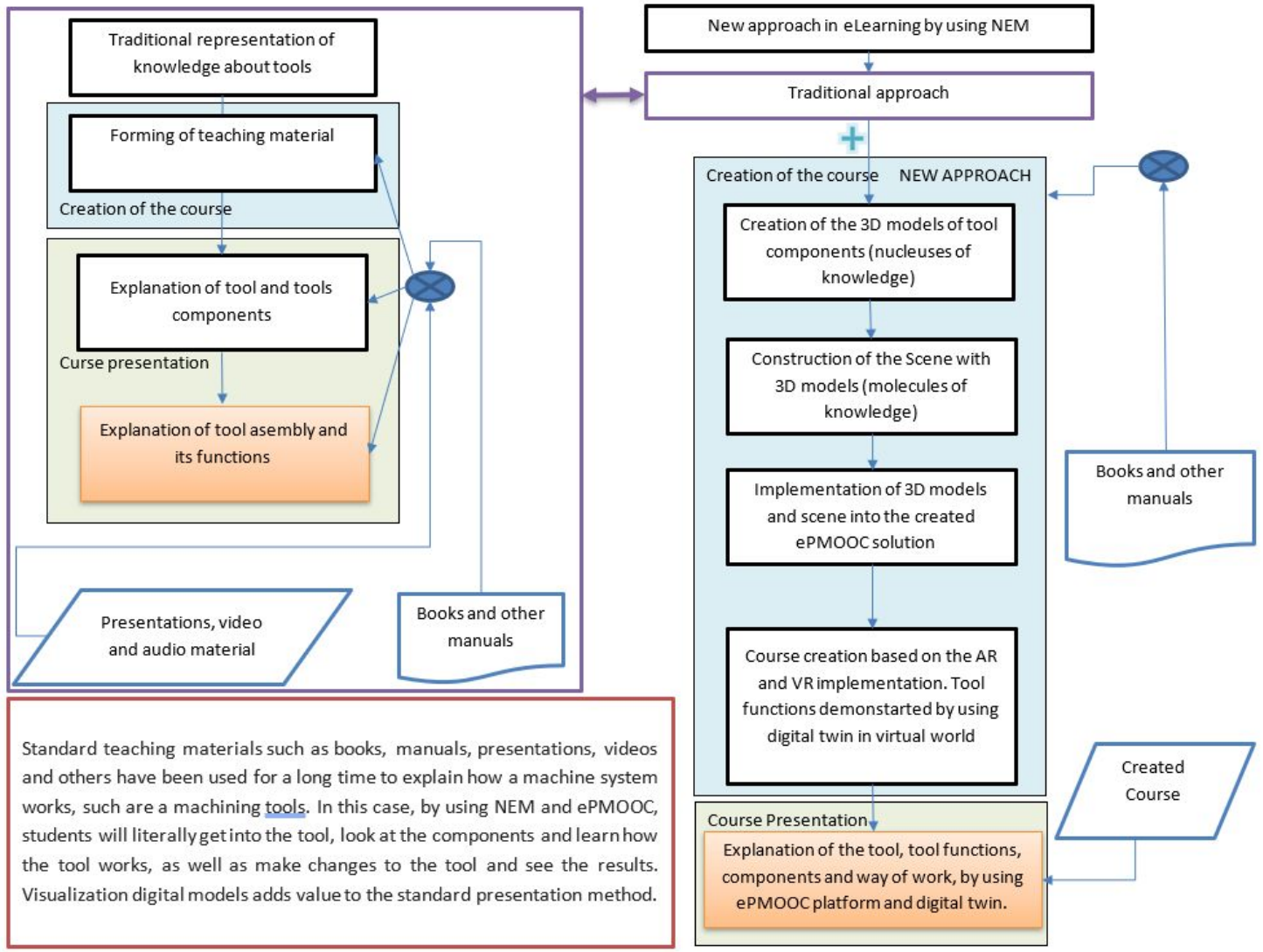
- Individual atoms can be combined into a set of several molecules which define the course, as presented.
- The flexibility of the course is reflected in the ability to combine different atoms, by selecting manually, or automatically based on the applied machine learning algorithms.
- E-COOL platform will enable creation of atoms, molecules and whole course content by implementing MBL, SEL, and ICC methodology

COURSE DESCRIPTION



COURSE EXAMPLE

Comparison of traditional VS. Novel educational Method supported Course in mechanical engineering



COURSE EXAMPLE

Traditional course for machine tools consists of images/drawings of the tools assemblies and tools components which are presented to the learner and explanation is provided. Educational experience, gained through teaching in last twenty years, shows that it is of great importance to provide some kind of visualization of the tools, tools components and tooling processes. The students must be informed, of each tool component, its function and possible application beyond current tools and assemblies.

COURSE EXAMPLE

One bolt which can be used for the fixation of the tool, can also be used for many other applications (in this tool, or completely different application), and its explanation and function demonstration is essential for the understanding of the whole tool assembly. This simple bolt is a basic element for the creation of atom explanation. Another element could be a nut, which usually goes with the bolt, but not always, which depends of the application. Nut can also be described by unique atom, but additional atoms can be added if there is a requirement.

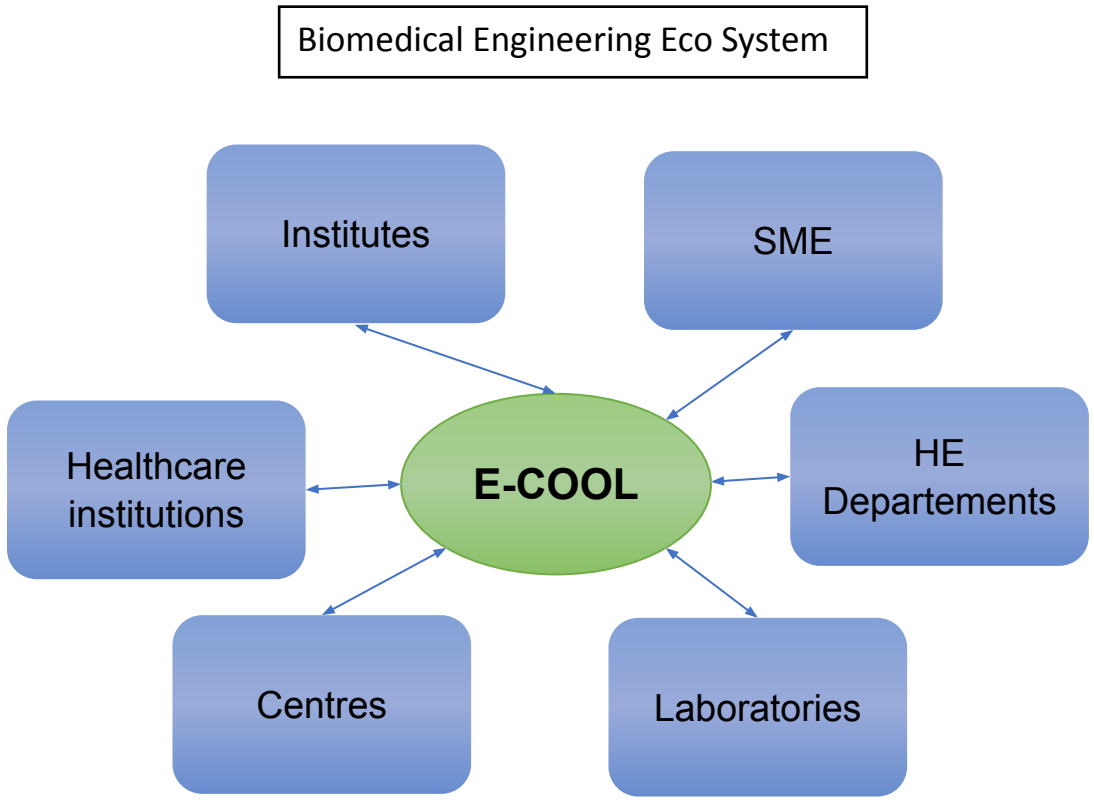
COURSE EXAMPLE

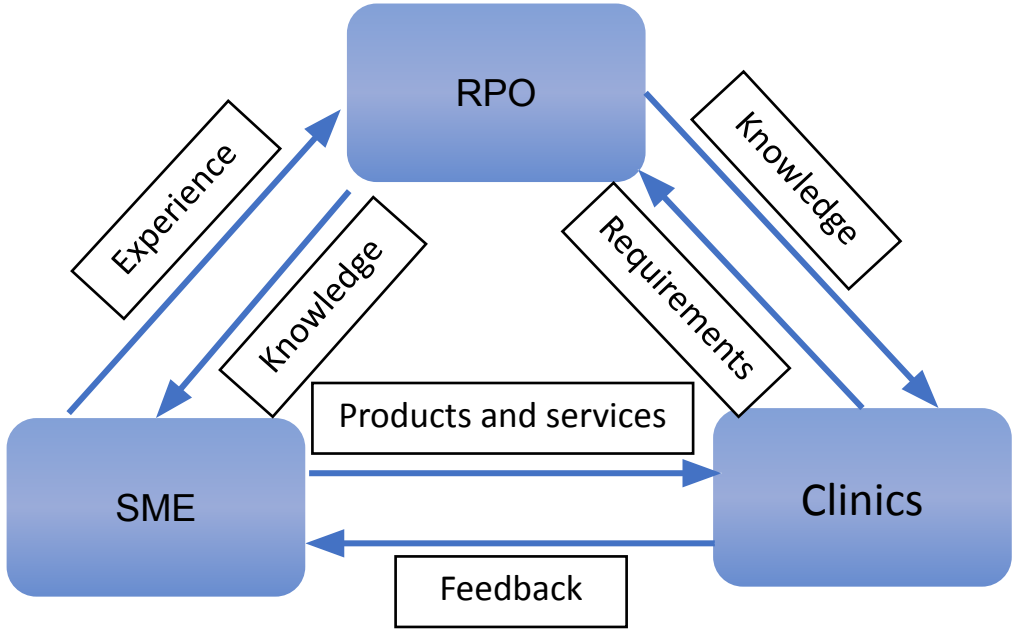
Author of the course can create 3D model of the bolt (first nucleus), add audio explanation (second nucleus), add textual explanation (third nucleus), and add everything which he finds appropriate, and form molecule of knowledge. The same can be done for nut, and any other element. After everything has been created, author can create VR or AR simulation and add all 3D models with attached audio explanation. In order to enable application of the created educational material, E-COOL platform can be used.

E-COOL SMART CONTENT MANAGEMENT SYSTEM

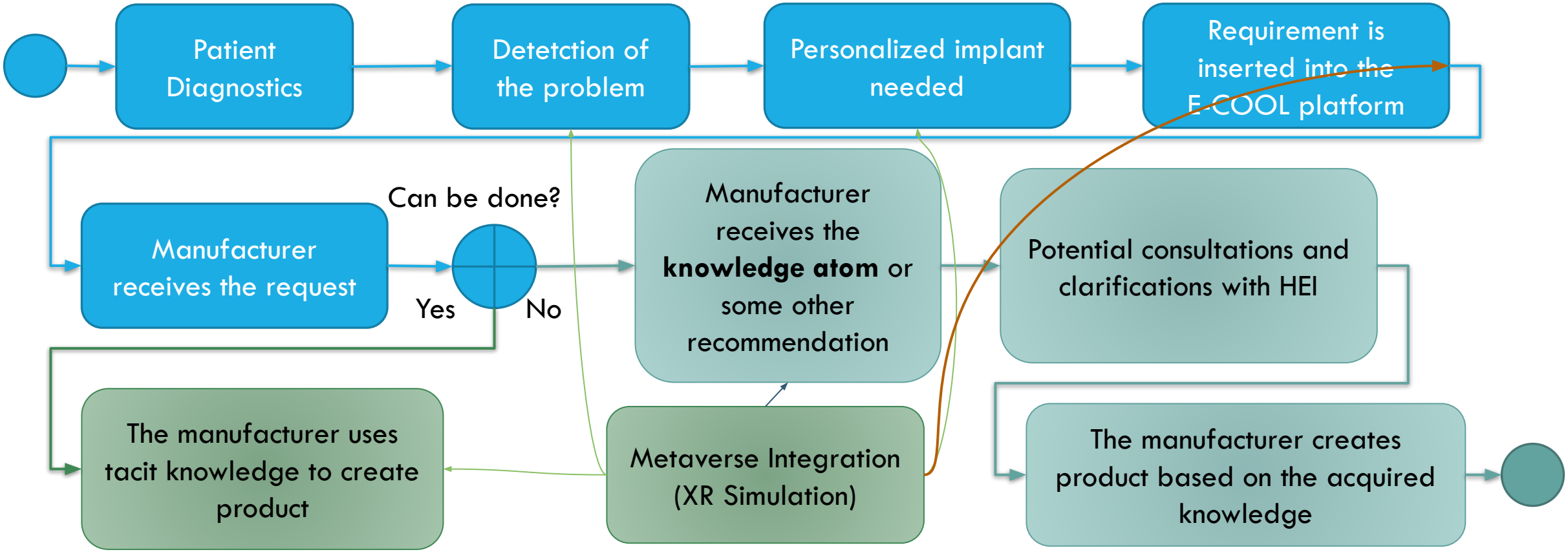
Important output will be open e-platform for collaboration and knowledge exchange, which will enable application of Novel Educational Methodology (NEM), **molecular network structure of knowledge triangle elements** (business, innovation, Higher Education), enhancement of existing Higher Education curriculums, creation of innovative patient-oriented products (hardware and software)

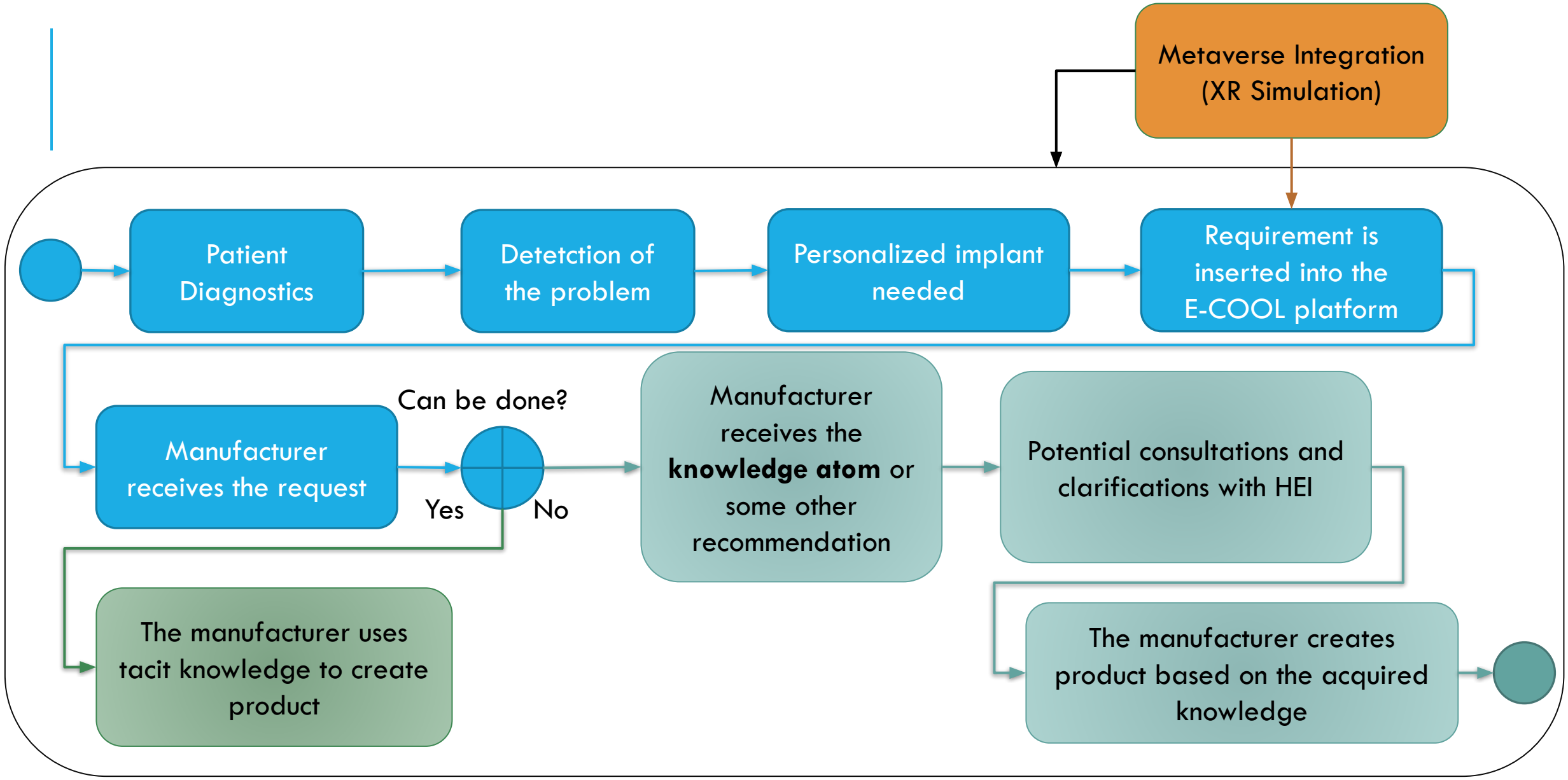
E-COOL SMART CONTENT MANAGEMENT SYSTEM



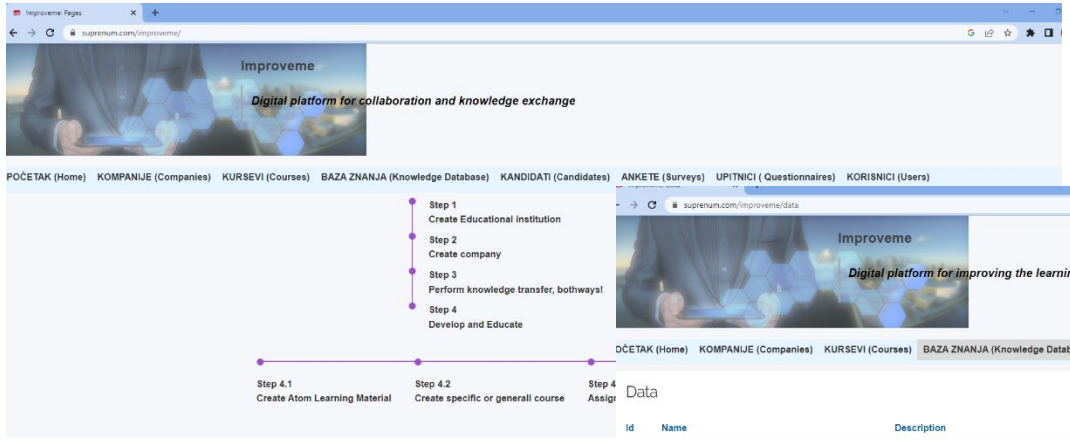


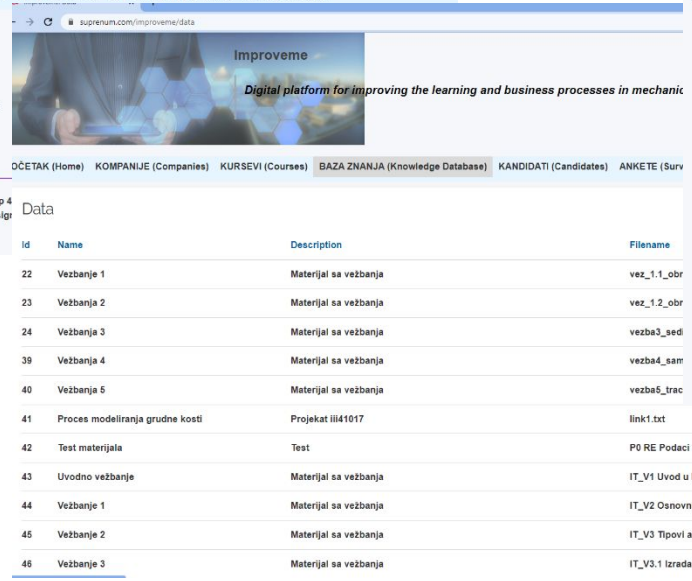
E-COOL SMART CONTENT MANAGEMENT SYSTEM – THE IDEA

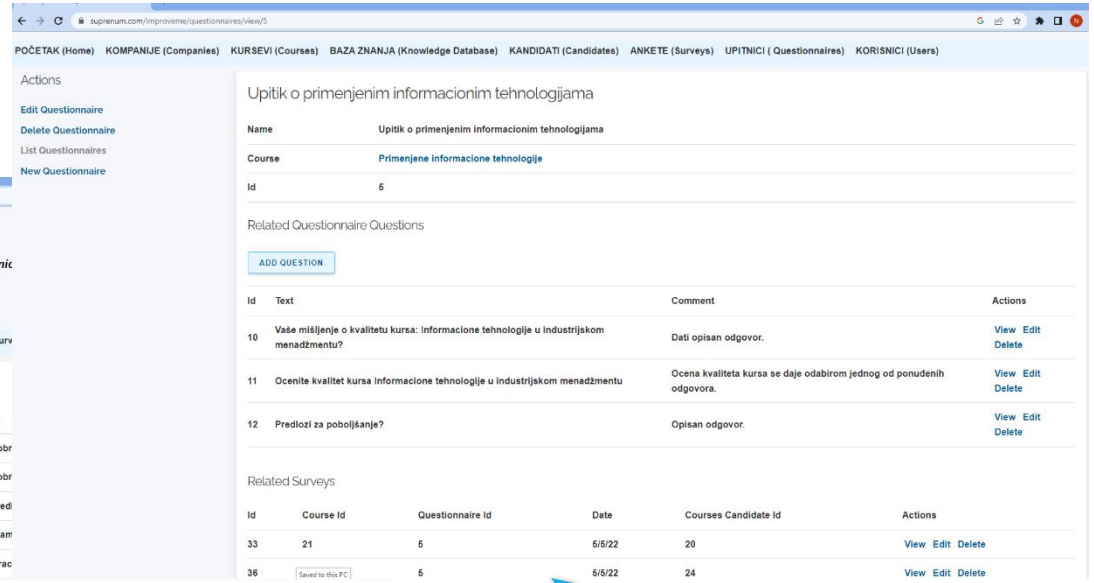



Metaverse Integration (XR Simulation)
Patient Diagnostics
Detetction of the problem
Personalized implant needed
Requirement is inserted into the E-COOL platform
Manufacturer receives the request
Can be done?
Yes
No
Manufacturer receives the knowledge atom or some other recommendation
Potential consultations and clarifications with HEI
The manufacturer uses tacit knowledge to create product
The manufacturer creates product based on the acquired knowledge

E-COOL PLATFORM – EARLY PROTOTYPE DEMONSTRATION







https.www.suprenum.com/improveme

Knowledge Database

Questionnaires

NETWORK IMPLEMENTATION

Network structure is composed of Centers for biomedical engineering, which are connected trough web portal implemented in Network. Each center can be interconnected, by direct connection between his components (field of science) and connected to network main node trough Smart Content Management System (SCMS) and E-COOL web portal.

Each network center is defined as Molecule

NETWORK IMPLEMENTATION

Network molecule contains more atoms of the different scientific fields.

One network center can have more medical atoms (orthopedic, surgery, neurosurgery) and more engineering atoms (materials engineering, IoT, mechanical engineering, etc.).

By combining Individual atoms, adequate team can be created, which can address medical problem of individual patient, i.e. perform personalized healthcare.

The individual atoms cover individual science field and they are composed of core (basic medicine or engineering) and levels (HE professors on one level, company engineers on second level, medical practitioners on third level, etc.).

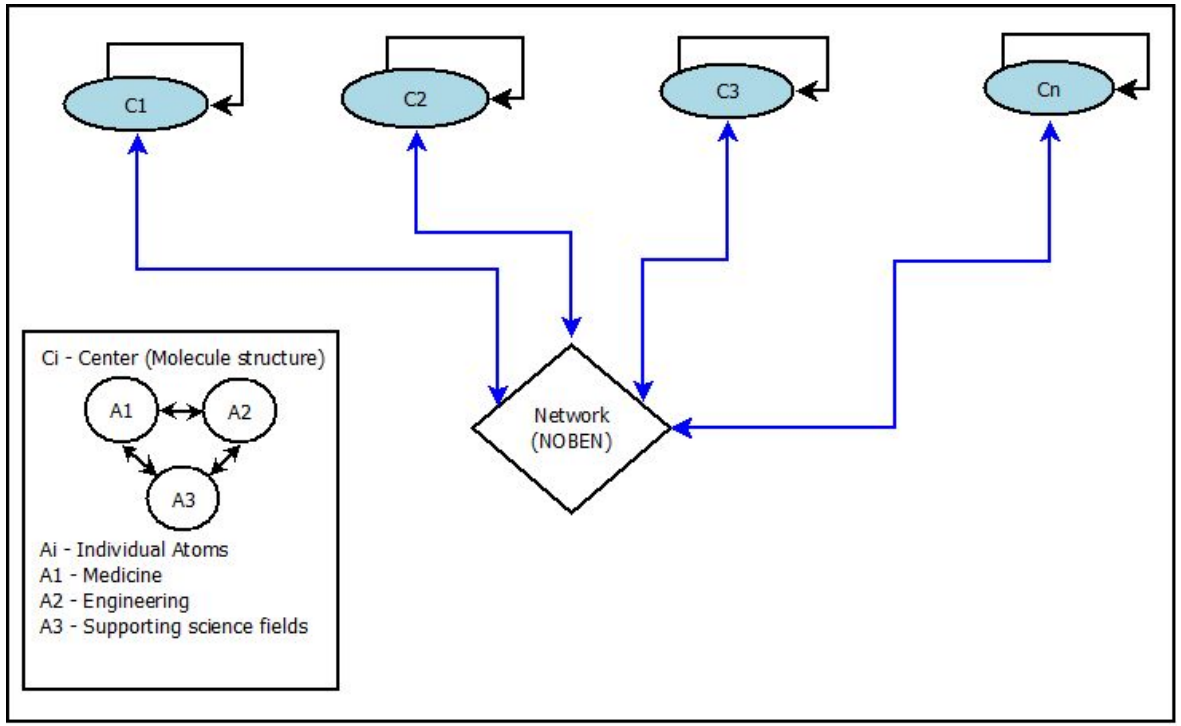
NETWORK IMPLEMENTATION

These levels are defined in digital world, and they are defined in Centre's database.

If there is a requirement for specific entities, they can be contacted trough the web portal (E-COOL).

Levels are not static, yet, they are dynamic, therefore, people can be changed according to the requirements.

The data about each Center, i.e. each atom (core and levels) is stored in custom database which will be developed during project implementation and integrated into SCMS.



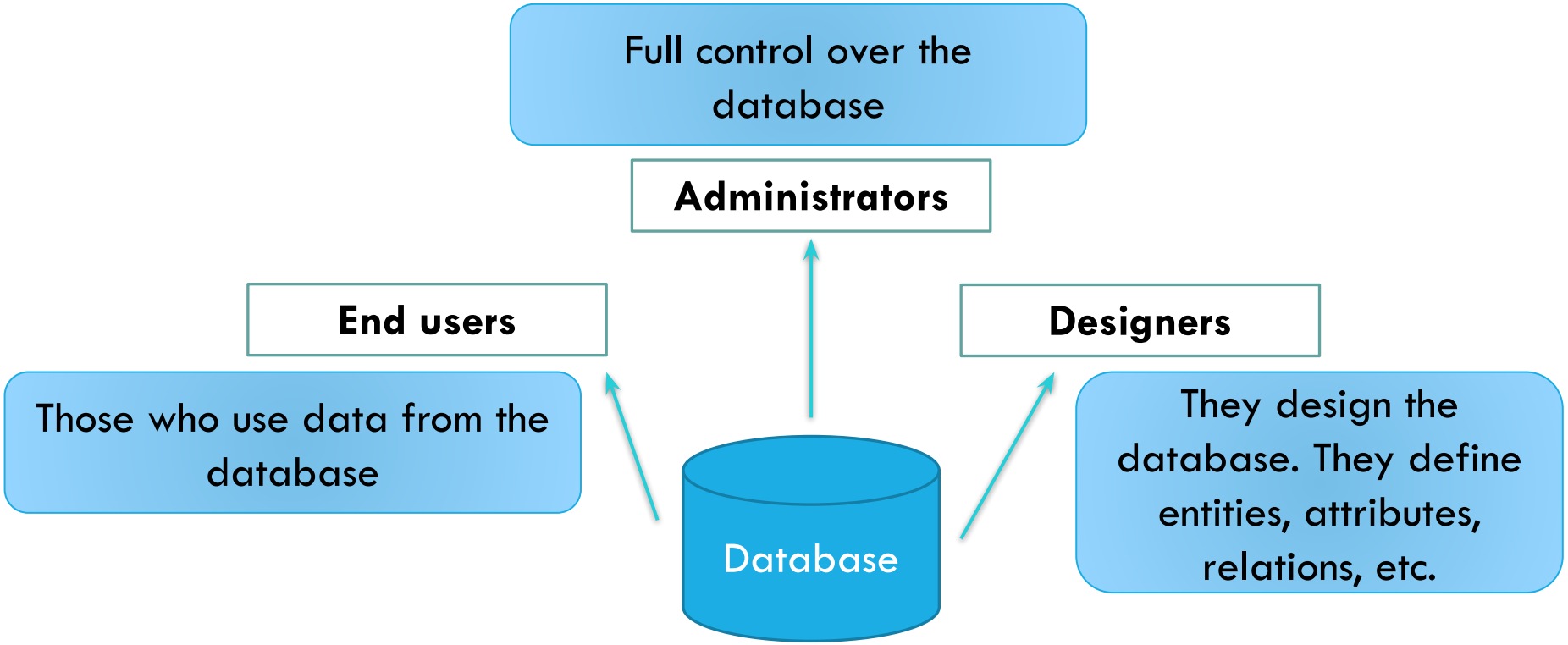
CHARACTERISTICS OF DATABASES

- A database is a collection of data that can be processed to form adequate information
- A database management system (**DataBase Management System - DBMS**) is a system that enables data storage for creating and manipulating information.
- DBMS is oriented as a description of the real and abstract world (a student, a monitor, a window in the Windows operating system, events)
- The DBMS enables the creation of tables based on the entities and the relationships between them
- The DBMS enables less redundancy, i.e., data is normalized. This means that there is no repetition of data.

CHARACTERISTICS OF DATABASES

- **Query language** - DBMS contains a certain language that can be used to get data and perform other operations with the database.
- ACID properties - **Atomicity, Consistency, Isolation, and Durability** - These properties allow database sustainability in a multi-user system.
- **Multi-user operation** - Data remains valid during parallel access by multiple users. Users are not aware of actions that are carried out in the background.
- **Multiple Views** – DBMS allows multiple views to be created depending on which user is accessing the database. Also, access to certain data may be restricted.

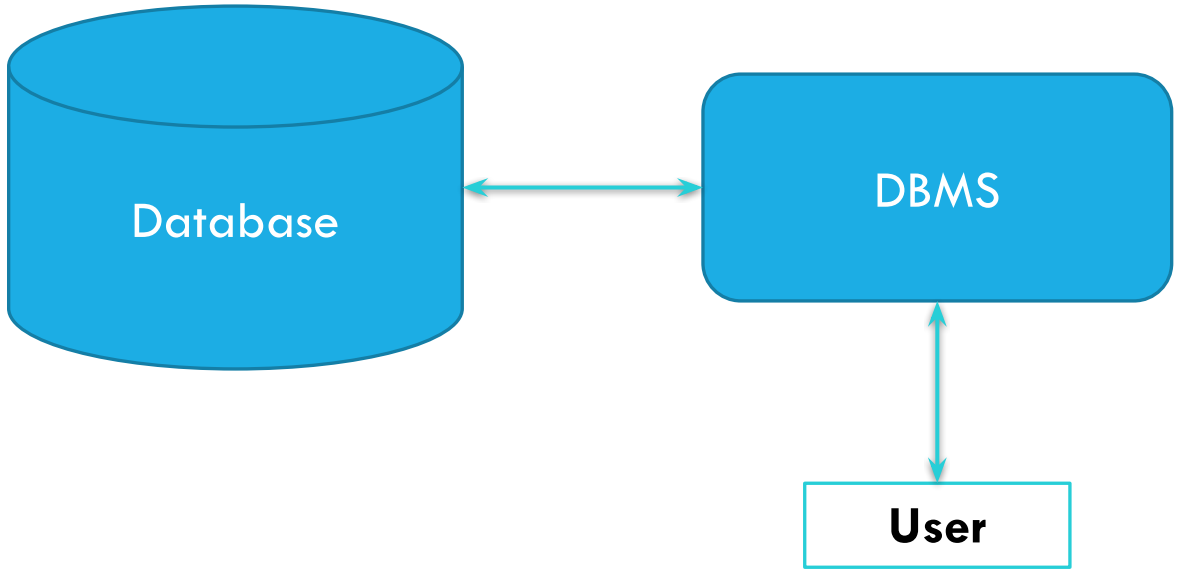
DATABASE USERS



DATABASE ARCHITECTURE

1-tier architecture

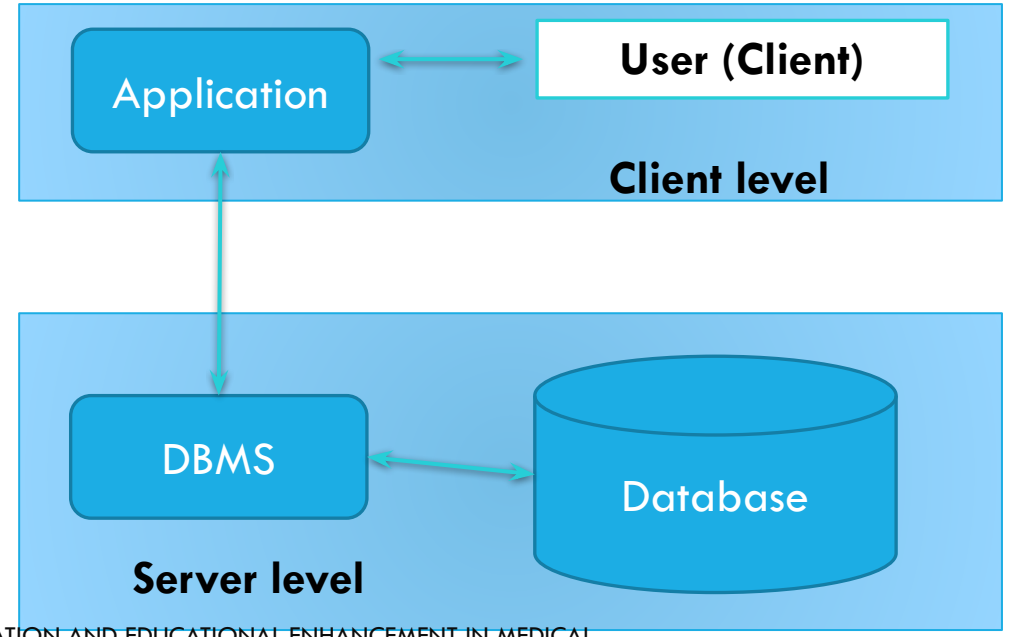
- DBMS is the only entity that communicates with data. The user works directly with the DBMS.



DATABASE ARCHITECTURE

2-tier architecture

- Client level – An application that communicates with the DBMS through the appropriate software (driver) and is located on the client side
- Server Tier - Database and DBMS.

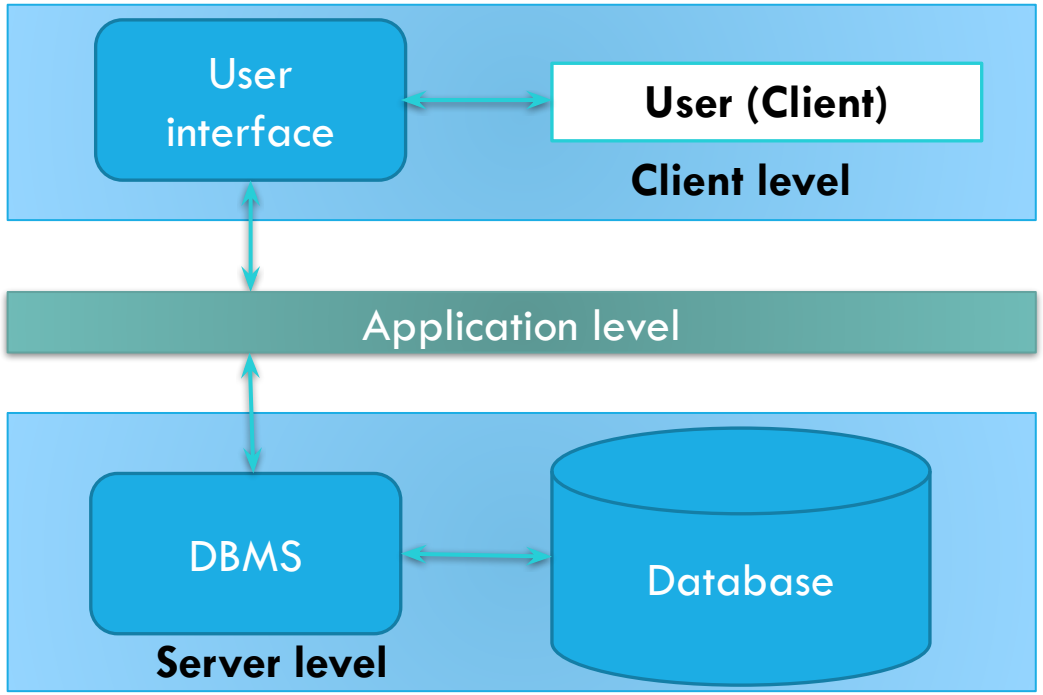


DATABASE ARCHITECTURE

3-tier architecture – the most common architecture

- **Client level** – The user interface that communicates with the DBMS through the application level
- **Application layer** –

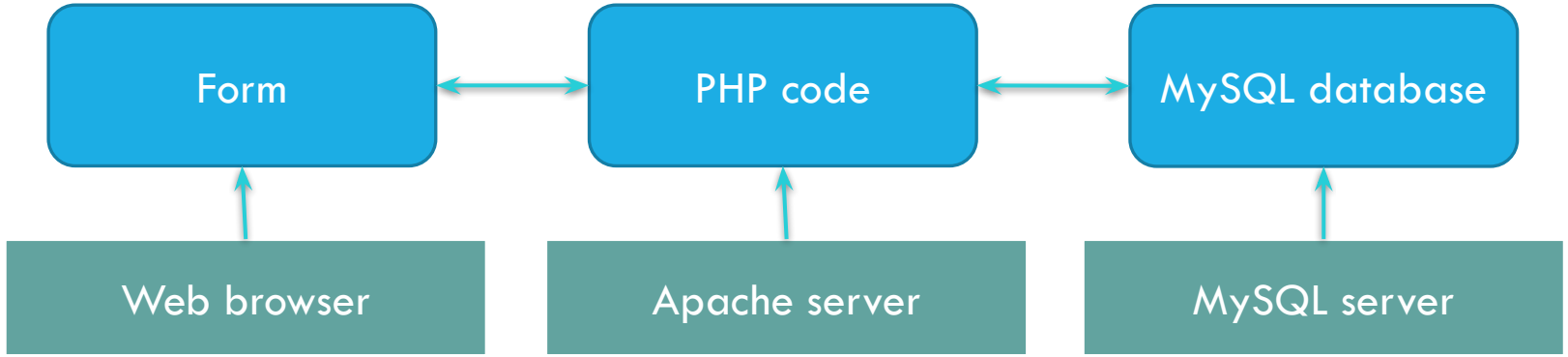
  It contains the driver and business logic
- **Server Tier** - Database and DBMS.



DATABASE ARCHITECTURE

Three-tier architecture (3-tier) – Example

- Web application
- Client level - User registration form
- Application level - Code on the server side that processes data and places it in the database, and, if necessary, returns data
- Database level – MySQL database



DATABASE MODEL

- The database model defines the logical design of the database
- Defines relationships between data in the database
- The database model is the first level of abstraction of data and the connections between them
- Historically, there have been three models:

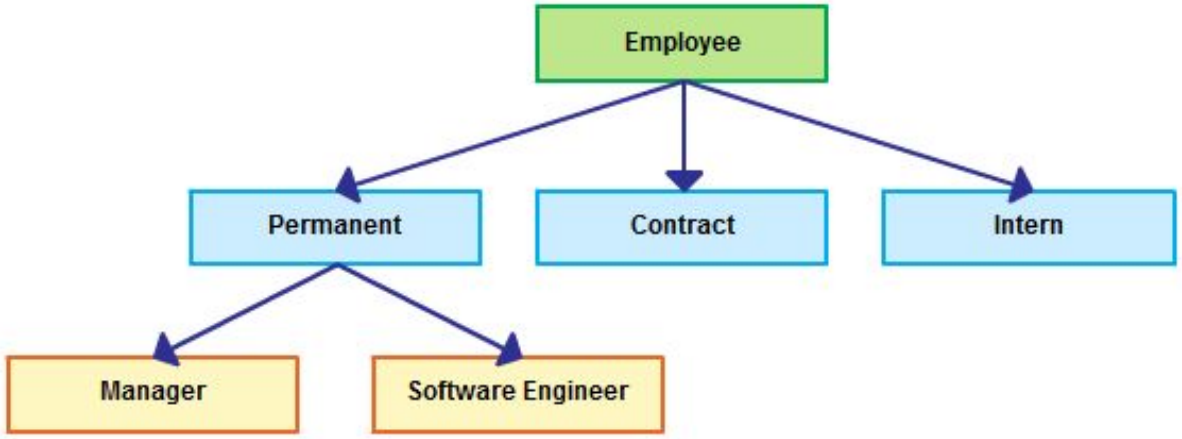
Hierarchical model

Network model

Relational model

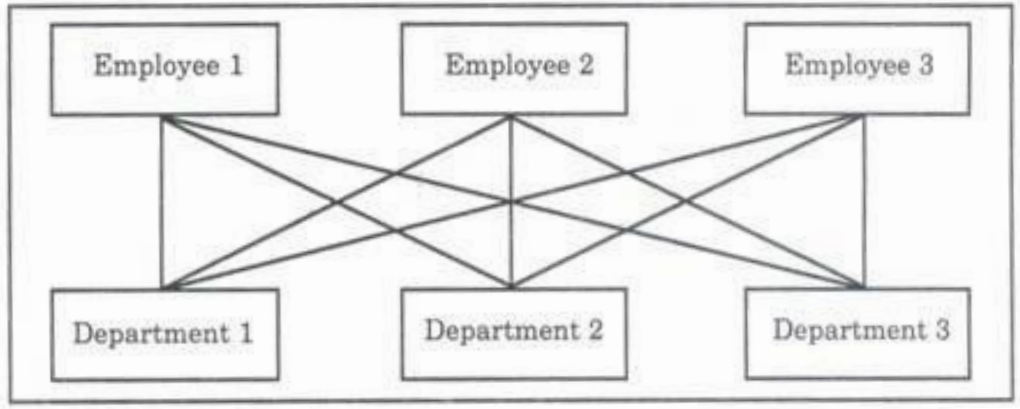
HIERARCHICAL MODEL (IBM, 1960)

- In the hierarchical model, each entity can have multiple children but only one parent. **Tree structure.**
- At the top of the hierarchy, there is only one element **- root.**
- Data are stored as records **and** are connected by **links**.
- The entity **type** defines which fields the record contains



NETWORK MODEL (1971)

- In a network data model, entities are organized in terms of a graph
- An entity can have multiple parents and multiple children
- The hierarchical model has been expanded - e.g. one employee can belong to several departments (it is not possible to describe with a hierarchical model)
- Replaced with the relational model



ENTITY-RELATIONSHIP (ER) MODEL

ER is currently the best model for the conceptual base design

The ER model is based on:

- Entities and their attributes (entity student with attributes: name, gender, ID number...)
- Relations between entities. Relations depict a logical connection between tables and can be:
  - One-to-one - 1:1
  - One to more – 1: ∞
  - More to one - ∞ : 1
  - More to More - ∞ : ∞

OUR MODEL FOR STORING DATA

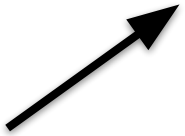
ENTITY/MODEL EXAMPLE

ID	Name	Surname	Index number
1	Dragan	Petrovic	1000
2	Milan	Markovic	1001
3	Dejan	Milanović	1002

The main features of the model are:

- Data is stored in tables called relations
- Relations can be normalized.
- In normalized relations, values are **atomic values**.
- Each row contains a unique value.
- Each column contains values from a certain area (domain)

LIKE ATOMIC KNOWLEDGE



FIRST NORMAL FORM – 1NF

1NF – 1st Normal Form

A base is in first normal form if it satisfies the following values:

- Contains an atomic value - **A value that cannot be divided.**
- No repeating groups of data - **The table contains no similar columns.**

- Example of a non-normalized entity - **Product table**

ID	The color	The price
1	red, green	200
2	yellow	400
3	yellow, blue	300
4	Red	190

The Color column contains values that are not atomic - they can be split

FIRST NORMAL FORM – 1NF

Solution to the problem:

The table can be represented by two tables

ID	The color	The price
1	red, green	200
2	yellow	400
3	yellow, blue	300
4	Red	190

ID	The price
1	200
2	400
3	300
4	190

ID	The color
1	Red
1	green
2	yellow
3	yellow
3	blue
4	Red

SECOND NORMAL FORM – 2NF

2NF – 2nd Normal Form

A base is in second normal form if it satisfies the following values:

- It is in the first normal form
- All non-key attributes are completely dependent on the primary key
- Example of a non-normalized entity - **Purchase_details table**

Client ID	Store ID	Location
1	1	Niš
2	1	Niš
1	2	White City
3	3	Novi Sad

- A primary key consists of two columns (two attributes). However, the location is only defined by the StoreID attribute

SECOND NORMAL FORM – 2NF

Solution to the problem: The table can be represented by two tables

- A table containing a unique primary key (only one column) is always in 2NF

Client ID	Store ID
1	1
2	1
1	2
3	3

Store ID	Location
1	Niš
2	White City
3	Novi Sad

THIRD NORMAL FORM – 3NF

3NF – 3rd Normal Form

A base is in third normal form if the following holds:

- It is in another normal form
- There is no transitive functional dependency - If B depends on A and C depends on B, then there is a dependency between A and C via B
- An example of a table in which there is a transitive functional dependency

IDBooks	GenrID	Type Genre	The price
1	1	Science	10
2	2	Sports	15
3	1	Science	20
4	3	Travels	12
5	2	Sports	17

THIRD NORMAL FORM – 3NF

Solution to the problem:

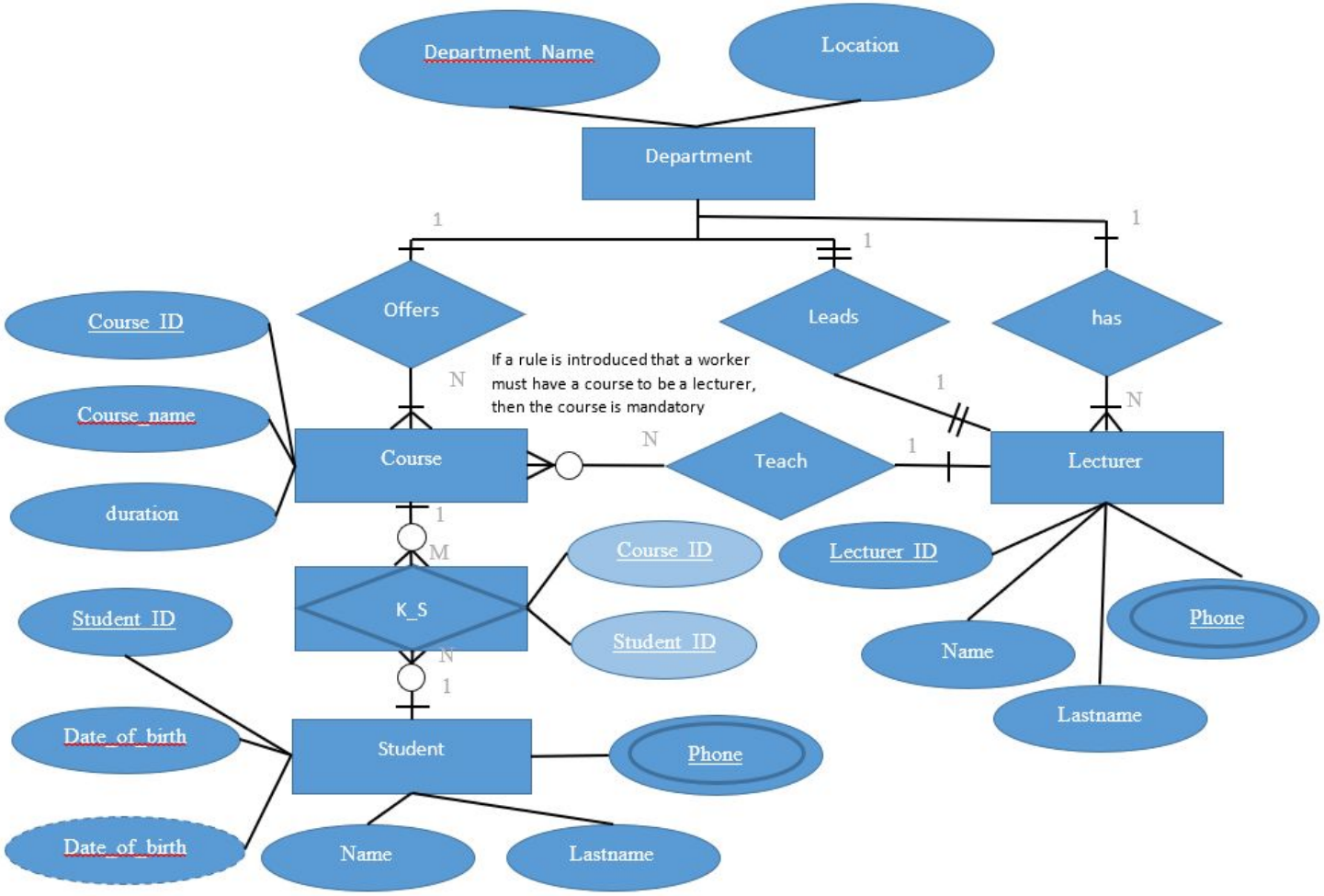
The table can be represented by two tables

IDBooks	GenrID	Type Genre	The price
1	1	Science	10
2	2	Sports	15
3	1	Science	20
4	3	Travels	12
5	2	Sports	17

IDBooks	GenrID	The price
1	1	10
2	2	15
3	1	20
4	3	12
5	2	17

GenrID	Type Genre
1	Science
2	Sports
3	Travels

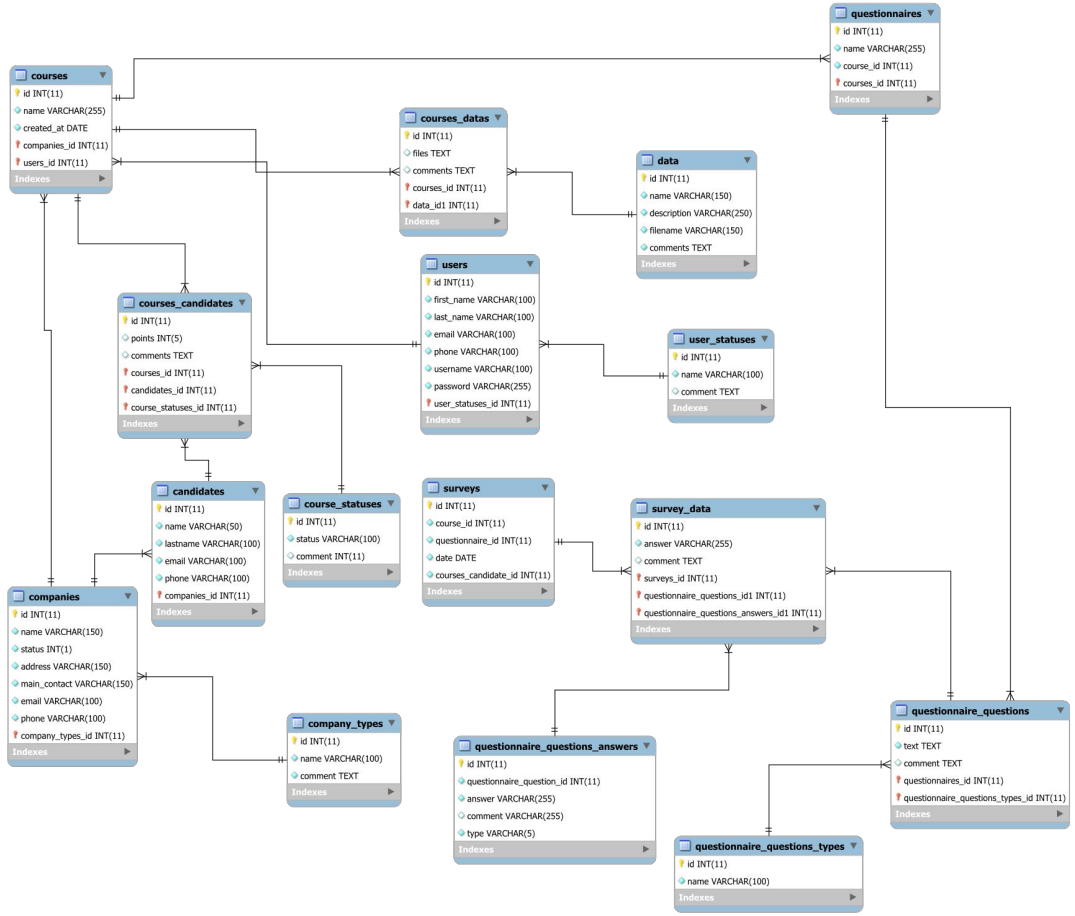
DATABASE MODEL EXAMPLE



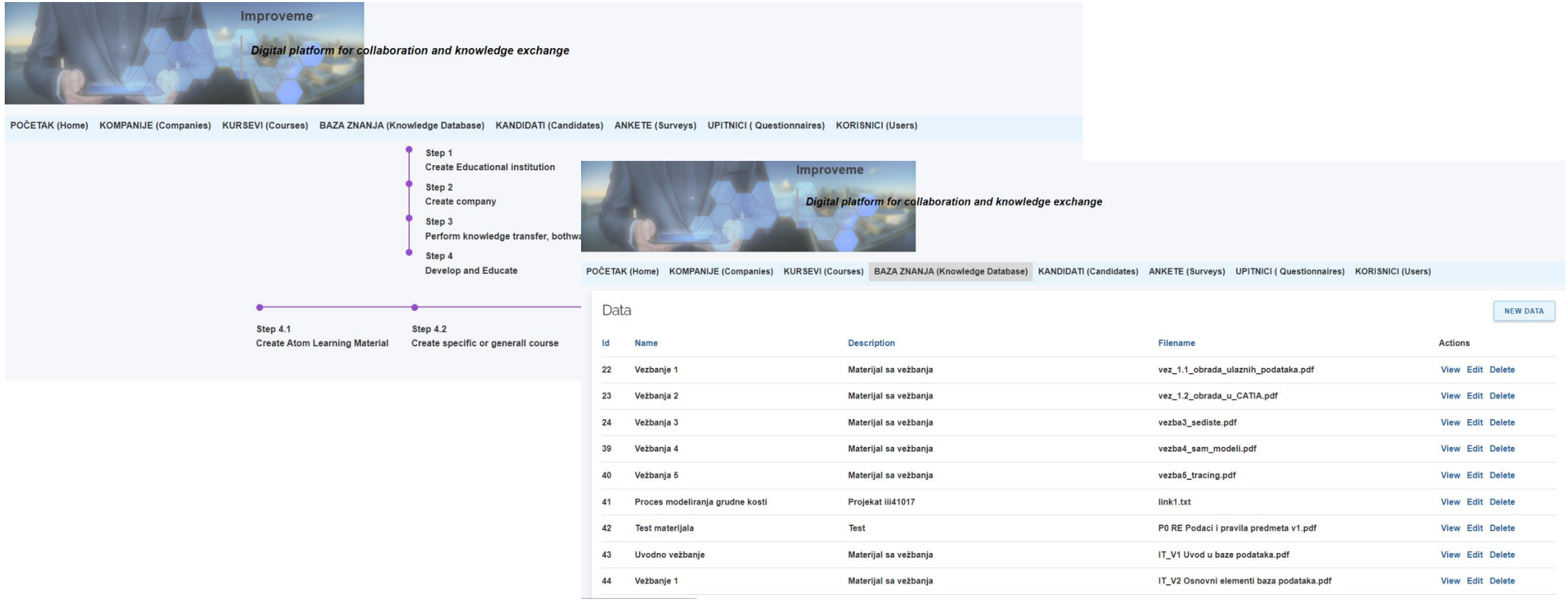
DATABASE APPLICATION IN NEM – DATABASE STRUCTURE – DATA MODEL

Main tables:

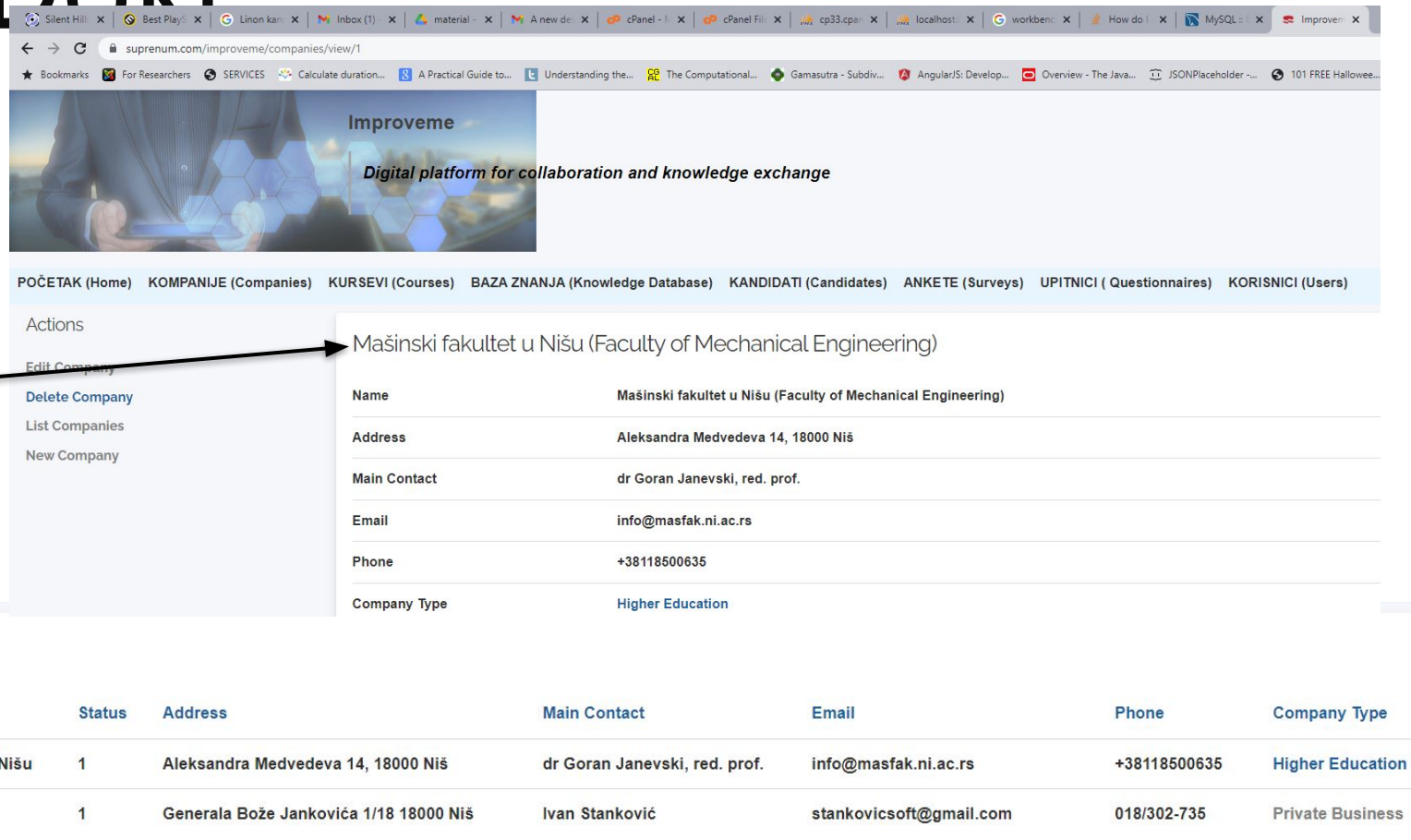
- **Users** – Users of the system
- **Companies** – Business, Innovation, and HEI
- **Candidates** – For taking courses
- **Courses** – Courses based on data
- **Questionnaires** – User defined questennaries
- **Surveys** – User-defined surveys
- **Data – Atoms of knowledge**



PROTOTYPE APPLICATION FOR KNOWLEDGE COLLECTION



PROTOTYPE APPLICATION FOR KNOWLEDGE COLLECTION – THE PROCEDURE



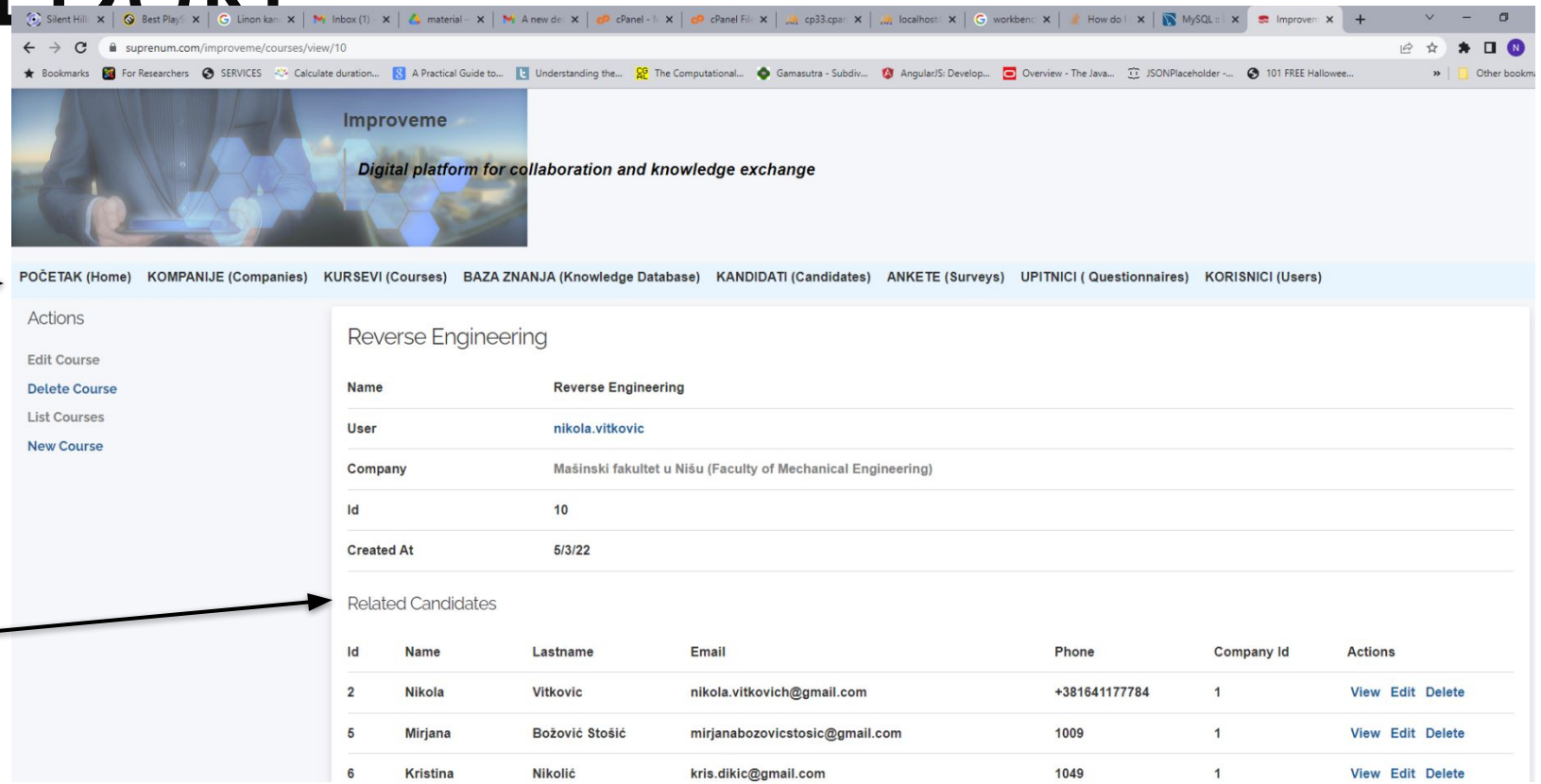
HEI

COMPANY

PROTOTYPE APPLICATION FOR KNOWLEDGE COLLECTION – THE PROCEDURE

COURSE

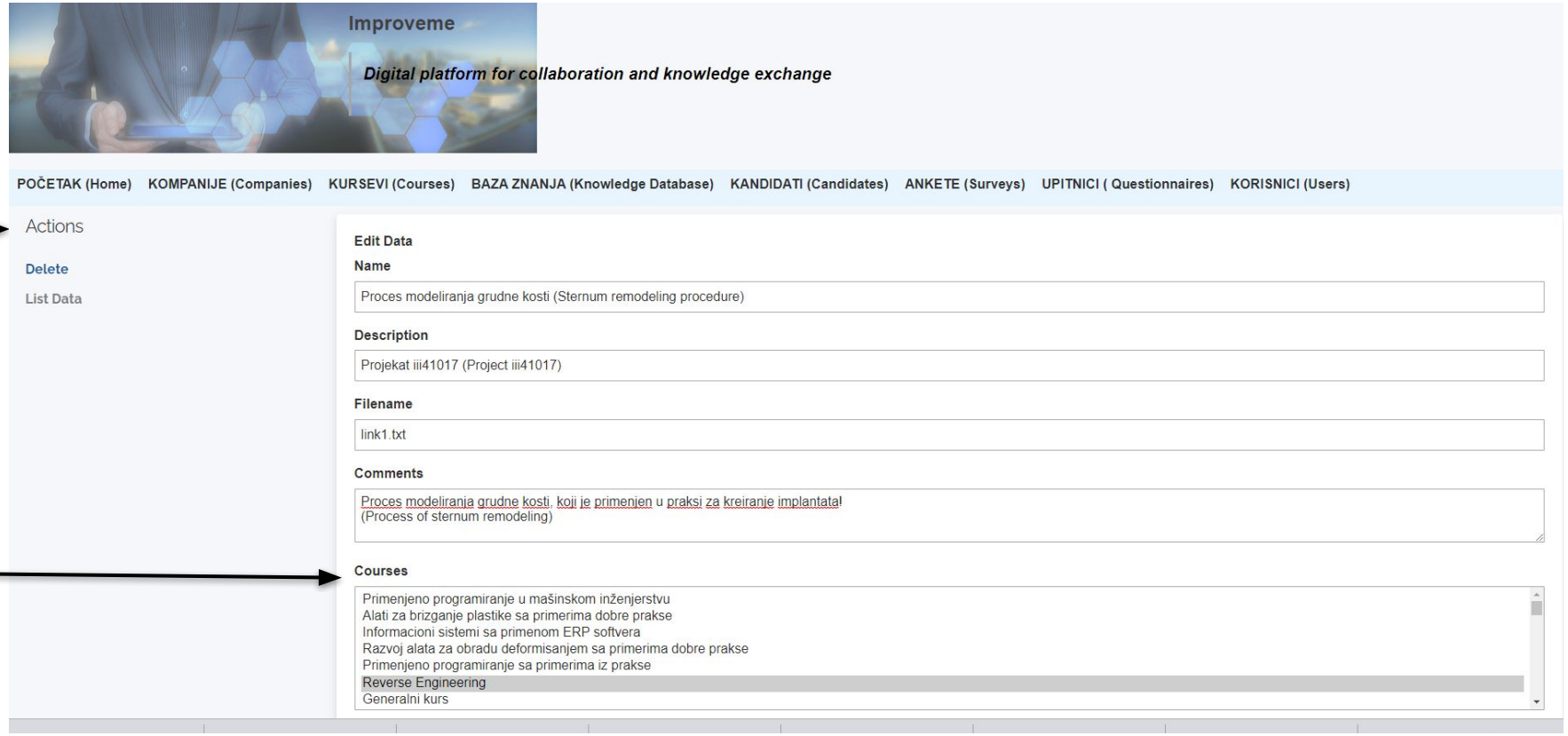
CANDIDATES



PROTOTYPE APPLICATION FOR KNOWLEDGE COLLECTION – THE PROCEDURE

DATA

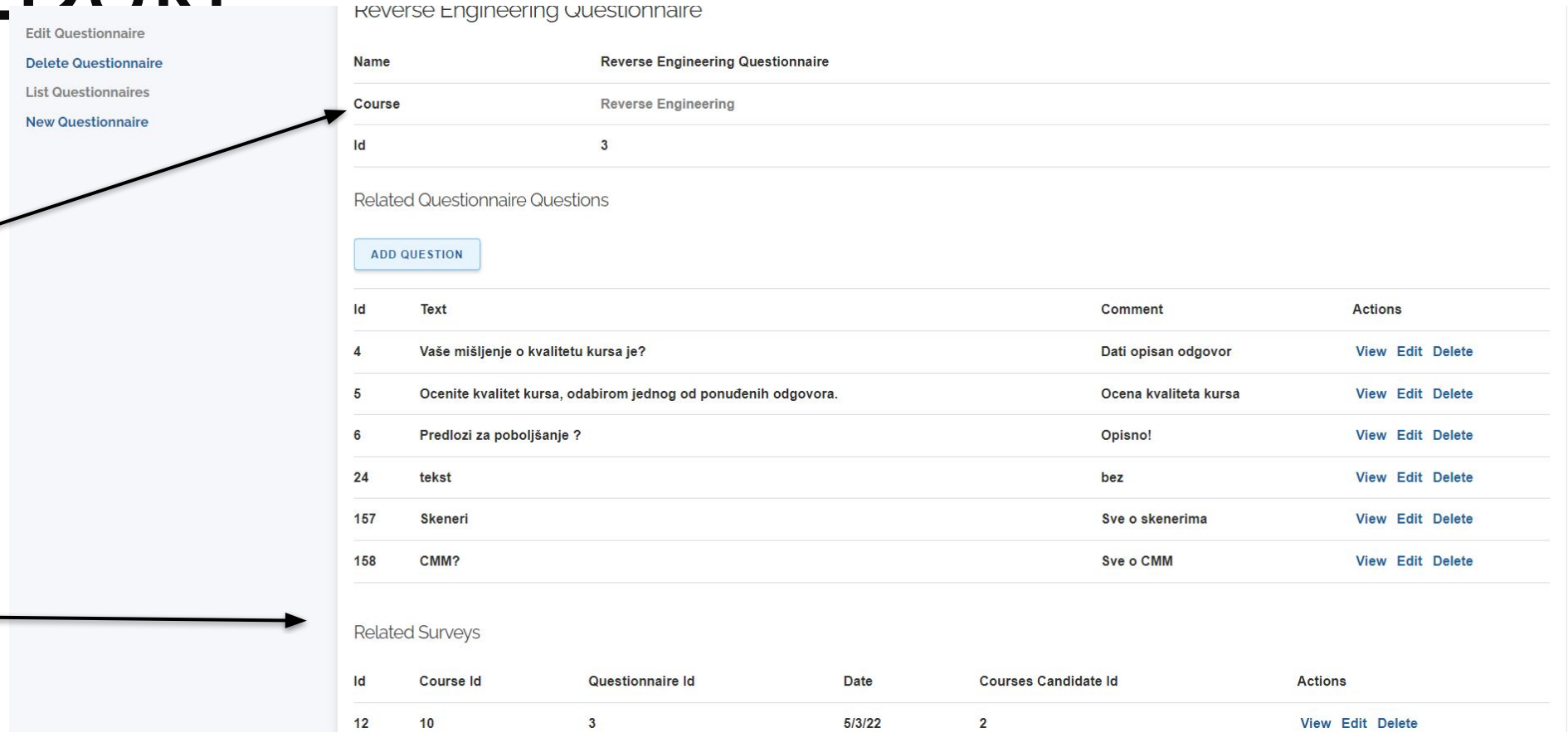
COURSES



PROTOTYPE APPLICATION FOR KNOWLEDGE COLLECTION – THE PROCEDURE

Curse Questionnaire

Survey for questionnaire



Edit Questionnaire
Delete Questionnaire
List Questionnaires
New Questionnaire

Reverse Engineering Questionnaire

Name	Reverse Engineering Questionnaire
Course	Reverse Engineering
Id	3

Related Questionnaire Questions

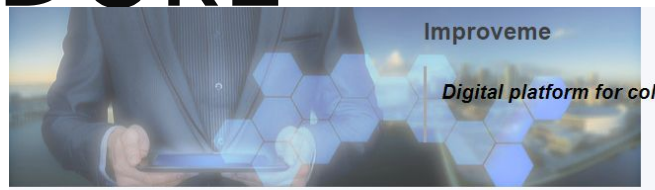
ADD QUESTION

Id	Text	Comment	Actions
4	Vaše mišljenje o kvalitetu kursa je?	Dati opisan odgovor	View Edit Delete
5	Ocenite kvalitet kursa, odabirom jednog od ponuđenih odgovora.	Ocena kvaliteta kursa	View Edit Delete
6	Predlozi za poboljšanje ?	Opisno!	View Edit Delete
24	tekst	bez	View Edit Delete
157	Skeneri	Sve o skenerima	View Edit Delete
158	CMM?	Sve o CMM	View Edit Delete

Related Surveys

Id	Course Id	Questionnaire Id	Date	Courses Candidate Id	Actions
12	10	3	5/3/22	2	View Edit Delete

PROTOTYPE APPLICATION FOR KNOWLEDGE COLLECTION – THE PROCEDURE



Digital platform for collaboration and knowledge exchange

POČETAK (Home) KOMPANIJE (Companies) KURSEVI (Courses) BAZA ZNANJA (Knowledge Database) KANDIDATI (Candidates) ANKETE (Surveys) UPITNICI (Questionnaires) KORISNICI (Users)

Actions

Edit Survey
Delete Survey
List Surveys
New Survey

Course	Reverse Engineering
Questionnaire	Reverse Engineering Questionnaire
Id	12
Courses Candidate	Nikola Vitkovic (nikola.vitkovich@gmail.com)
Date	5/3/22

Related Survey Data

Id	Survey Id	Questionnaire Questions Id	Questionnaire Questions Answers	Actions
59	12	Vaše mišljenje o kvalitetu kursa je?	Dobar je!	Delete
60	12	Ocenite kvalitet kursa, odabirom jednog od ponudenih odgovora.	Odličan	Delete
61	12	Predlozi za poboljšanje ?	više primera	Delete

Curse Survey/Questionnaire

Survey for questionnaire