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ICT solution “Register of training services for the Modern Business Services sector”

1. System description and purpose of the tool

1.1 Introduction

The purpose of this document is to describe the technical and functional description of an advanced ICT system, constituting a Service Registry for the Modern Business Services Sector (MBSS Training Registry), promoting the use of virtual and augmented reality (VR and AR) tools as effective and innovative training methods through the registration and publication of training offers, dedicated to institutions and companies involved in the organization of training and courses. The system is based on modern web technologies, combining an application front-end based on the React library with a back-end managed by CMS Strapi and an integrated LMS Chamilo module that handles educational content and communication. The project aims to create an easy-to-use, flexible and scalable tool that will be a central point for course organizers to publish and manage training offers, and for users to register and participate in those offers. The system also assumes that Employers will be able to submit requests for employees with specific competencies in the tool and communicate with training providers.

1.2 Overview of the technologies used to create the tool

The system is based on React, Strapi, Chamilo LMS technologies, and supports Open Badge 3.0-compliant microcredentials using a PostgreSQL database system. The key objective of the system is to provide functionality to support registration, management and promotion of training offers using modern technologies such as virtual and augmented reality (VR/AR), while taking into account the requirements of interoperability and digital skills validation.

The following technologies and resources are required to implement the project:

1. **As a front-end library, React** is one of the leading JavaScript libraries for building responsive and dynamic user interfaces tailored to different user roles such as training providers, employers, trainers and individual participants. React's modular architecture allows for easy management of components and their integration with the backend via a REST API.
2. **Strapi CMS. Strapi**, as a headless CMS, acts as a backend, offering flexibility in managing user, course and microcredentials data. By integrating with PostgreSQL, the system achieves high

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performance, reliability and the ability to store large amounts of data. **PostgreSQL** supports advanced data analysis, data encryption and replication mechanisms, which increases the security and scalability of the system.

3. **Chamilo LMS,** as an open source learning platform, has been integrated into the system to manage courses, monitor participants' progress and generate microcredentials. Thanks to Chamilo's API, data can be synchronized with the Strapi backend, making it possible, among other things, to automatically issue microcredentials compliant with the Open Badge 3.0 standard. These microcredentials, stored in JSON-LD format, ensure interoperability and compliance with the Verifiable Credentials Data Model and the European Learning Model.
4. **Integration with external APIs.** The system is to be prepared to integrate with various external data sources, providing flexibility and scalability.
5. **Data encryption and security protocols.** Support for HTTPS and JWT authentication guarantees the security of data transfer between the front-end, back-end and the Chamilo LMS.

References to the technical documentation used during the implementation of the system:

- **React:** https://react.dev
- **Strapi:** https://docs-v4.strapi.io/
- **Chamilo LMS:** https://docs.chamilo.org/
- **PostgreSQL:** https://www.postgresql.org/docs/
- **Open Badge 3.0:** https://www.imsglobal.org/spec/ob/v3p0/impl

1.3 Objectives of the tool

The main goal of the tool is to create a central registry of training offers, which will be a platform to enable:

- **Training providers:**
  - Creation and publication of offers that are available to end users (potential trainees).
  - Uniform login, which allows access to both the system itself and the content on the Chamilo LMS platform.
  - The ability to customize course topics to meet the needs of employers, increasing their market value and attractiveness to participants.
- **Employers:**

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  - Reporting in the tool the need for employees with specific competencies and communicating with training providers through tools such as chat, discussion forums, video conferencing.

- **Trainers:**
  - Access to elearning content creation tools.
  - Delivering online and hybrid classes including with the use of VR/AR technology.
  - Managing training groups.
  - Communicating with trainees through tools such as chat, discussion forums, video conferencing.
- **Trainees:**
  - Enrolling in training services.
  - Participating in on-site, hybrid, and remote classes using VR/AR technology.
  - Communicating with trainers through tools such as chat, discussion forums, and video conferencing.

1.3 Functional requirements of the system

The system performs several key functions:

- **Registration and login module.** Support for user accounts that will have access to various functions depending on their role (individual user, training provider, employer, trainer). Each individual user will be able to manage their profile, view offers and register for courses.
- **Chamilo LMS Integration.** Chamilo will provide access to training materials and allow users to work in a learning environment where they can interact with trainers, participate in quizzes and exercises.
- **Uniform login system.** Single logon allows users to use the features of the entire system and LMS platform without having to log in multiple times.
- **Offer management module.** Users with training provider permissions will be able to create, edit and delete training offers, which will be visible to other users. Offers must be approved by an administrator (Superadmin role) to ensure quality content.

Administration panel. Administrators will have access to a panel to manage users, assign roles, control content published in the system and monitor user activity.

1.4 Users of the system

The ICT system is designed to accommodate different types of users, who will be assigned different roles and rights:

1. **Individual user:** Can browse available training courses, register for them, rate courses and providers, and view their achievements in the form of microcredentials.
2. **Training provider:** An organization or company that can publish its training offers in the system, manage participants in its courses, and have access to statistics on the popularity of offers.
3. **Employer:** A user representing a company that has the ability to request specific competencies and establish partnerships with training providers for dedicated training.
4. **Trainer:** The person responsible for the implementation of training services who will have access to educational materials and the ability to communicate with participants through the LMS Chamilo module.
5. **Superadmin:** System administrator, responsible for managing users, controlling published content, monitoring activity and resolving any problems.

1.5 Scope of the project

The scope of the project includes full implementation and management of the system for a period of 12 months from the date of production launch. The system should be available to users in several languages (Polish, English, Italian, Greek) and support simultaneous sessions of up to 3,000 users. Hosting of the system will be provided by the project contractor until the end of the project, after which it will be handed over to the client.

1.6 Overview of the system's benefits

The system brings a number of benefits to all users:

- **Facilitating access to education and competence development.** With a central training registry, users gain easy access to a wide range of educational offers that are in line with market requirements.

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- **Standardization of training offers.** All offers are published according to uniform guidelines, which facilitates their comparison and ensures their high quality.
- **Effective communication.** Integration with Chamilo's LMS allows for the ongoing exchange of information between participants, trainers and organizers.
- **Ability to obtain microcredentials.** The system supports the generation of digital badges in the Open Badge 3.0 standard, compliant with the European Learning Model (ELM), which enables participants to present their achievements in a way that is understandable and recognized in the labor market.

1.7 Summary

The ICT system for the training offer registry offers a comprehensive solution that responds to the needs of the market, increases the accessibility of education and provides tools to support effective learning and professional development. Thanks to its well-thought-out architecture and diverse functionalities, the system is flexible, secure and scalable. The designed interface and unified login system provide a user-friendly environment, while integration with Chamilo LMS expands learning and development opportunities.

2. System architecture

2.1 Introduction to the system architecture

The architecture of the system that integrates the functions of training offer management, user management and remote learning (LMS) is built based on components that guarantee modularity, flexibility and scalability. The project is based on a three-layer architecture model: presentation layer (frontend), business logic (backend) and data layer (database and LMS). Each of these components works together via APIs, making it easy to integrate new features and external systems.

2.2 Presentation Layer - Frontend

The frontend of the system is created using the React library, which provides a dynamic and interactive experience for the user. React allows for the creation of reusable components, making code management and quick modifications easy.

1. **UI components:**

- **Registration and login panel.** Forms with client-side validation, allowing users to easily access their account.
- **Main interface.** Views showing training offers, user profiles, course details, and participation status.
- **Responsiveness and accessibility.** The system is designed according to Responsive Web Design (RWD) principles, adapting automatically to different screen resolutions. It complies with WCAG 2.2 at Level A and AA, ensuring accessibility for people with disabilities.

2. **Frontend functionalities:**

- **Interactions and dynamics.** The frontend responds to user actions, such as adding courses to favorites, signing up for courses and viewing offers.
- **Integration with Chamilo LMS.** With a unified login system (SSO), users can access educational resources without having to log in again.
- **Language support.** The system supports multiple interface languages (Polish, English, Italian and Greek). Each user can select a language at the time of registration, and the interface will automatically adapt to their settings.

2.3 Business logic layer - Backend (Strapi CMS)

The backend of the system is based on Strapi CMS, which allows managing content in the system and sharing data in the form of APIs. Strapi is a flexible content management tool that makes it easy to integrate with the frontend and provides the functionality needed to create complex applications.

1. **Strapi CMS Features:**

- **Content and user management.** Strapi allows to manage user profiles, publish training offers and control the permissions of individual roles (provider, trainer, individual user).
- **REST API.** Strapi offers a REST API that allows for easy data transfer between the frontend and backend. This makes the application more modular, and components can be easily replaced or scaled.
- **Authentication and security.** Strapi supports JSON Web Token (JWT) for secure authentication, and all transmitted data is encrypted with HTTPS.

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2. **Key backend modules:**
    - **Registration and Login Module.** Verifies user data, allows registration of new users and stores their profiles. Supports functionalities such as password reset, account lockout after a certain number of failed login attempts.
    - **Training offer management module.** Allows providers to add, edit, delete and publish training offers. These offers must be approved by the super admin.
    - **Statistics and analysis module.** Collects data on course popularity, user ratings and participation trends to help training providers tailor their offerings to market needs.
3. **Single sign-on system (SSO):**
    - Strapi integrates with the Chamilo LMS through the SSO mechanism, which allows users to automatically log into the LMS after logging into the main application. SSO uses OAuth or JWT, which provides secure session transfer between systems.

2.4 The data layer

The system's data layer is based on PostgreSQL, which is hosted on AWS (Amazon Web Services) to ensure performance, scalability and a high level of security. The choice of PostgreSQL allows for efficient management of user data, training offers, training materials and activity history in the system, while hosting on the AWS cloud offers flexibility and optimal resource management.

2.4.1 Database architecture

1. **PostgreSQL as an RDMS:** As a relational database management system, PostgreSQL allows for storing data in a structured manner, which is particularly useful for managing complex data, such as user profiles, permissions, training offers and user course enrollments. With JSON and JSONB support, PostgreSQL also allows semi-structured data to be stored, which increases the flexibility of the database.
2. **Hosted on AWS:** The system uses Amazon RDS (Relational Database Service) for PostgreSQL, which provides automation for database management, backups, software updates and performance monitoring. AWS RDS guarantees a high level of data availability through redundancy mechanisms, and also provides automatic backups for easy disaster recovery.
3. **Session management and user data storage:**

- **User table.** Contains detailed user profile data, such as user ID, email address, password (in encrypted form), role, and language preferences.
- **Roles and permissions table.** Defines permissions for specific roles, such as individual user, training provider, employer, trainer and superadmin, allowing granular control of access to system functions.
- **Session table.** Records users' active sessions, allowing you to monitor their activity and manage their sessions, including automatic logout after a period of inactivity.
- **Training offers table.** Stores data on training offers, such as title, description, course language, number of hours, price, qualification level (e.g., according to the European Qualifications Framework - EQF), and information on available microcredentials. By indexing fields such as language and course type, it is possible to quickly search for training offers based on user-specified criteria.

2.4.2 Security and data protection

AWS provides a number of mechanisms to protect data stored in the RDS:

- **Data encryption.** Database authorization keys are encrypted at rest using AWS Key Management Service (KMS), which protects data from unauthorized access. Traffic between the system and the database is encrypted using SSL, providing an additional layer of protection.
- **Access management.** Access to the database is controlled by AWS IAM (Identity and Access Management), and access to database resources is limited to designated system administrators and the Strapi backend.
- **Backups and restores.** Amazon RDS automatically backs up the database, allowing for disaster recovery. It is possible to configure the backup retention period and create custom backups at key points in the system lifecycle.

2.4.3 Database scalability and performance

AWS RDS allows for dynamic scaling of database resources to accommodate growing user numbers and workloads:

- **Automatic scaling.** In the event of increased traffic or an increase in database queries, Amazon RDS enables automatic scaling up of memory and CPU resources.

- **Replication and redundancy.** With replication mechanisms, the database can be configured in Multi-AZ (Multi-Availability Zone) mode, which guarantees high availability and protection against failures. Replication between zones ensures that data is available even if one zone fails.
- **Query optimization.** Regular monitoring and optimization of SQL queries keep performance high. AWS RDS offers performance monitoring tools such as CloudWatch to track metrics such as database response time and number of concurrent connections.

2.4.4 Data modeling and table structure

The database structure was designed with performance and scalability in mind:

1. **Users Table.** Contains key information about user profiles, roles, and contact information.
2. **Roles and Permissions Table.** Allows for flexible access management based on user roles, allowing individual permissions to be assigned to specific resources and functions.
3. **Training Offer Table.** The structure of the table includes fields such as title, description, language, requirements, number of hours, price, and designations for training provided using VR/AR technology.
4. **Employer Announcements Table.** Stores links to educational resources and information about their format and technical requirements, allowing quick access to materials on the LMS.

The database table has the following structure:

admin_permissions

Manages administrative privileges, defining specific access rights to system resources.

admin_permissions_role_links

Combines permissions with administrative roles, allowing specific permissions to be assigned to roles.

admin_roles

It lists administrative roles in the system and their details.

admin_users

Stores administrative user data, such as login credentials and IDs.

admin_users_roles_links

It connects administrative users with the roles they have.

components_organization_organizations

Represents organizations or institutions associated with the system, storing data such as name, address and contact information.

course_applications

Contains participant applications for courses, such as participant data, course, application status, etc.

course_applications_course_links

Connects applications (course applications) with the corresponding courses.

course_providers

Represents course providers or organizers, storing their data and details.

courses

Includes course information such as title, description, duration, price and other details.

courses_components

It stores course components, such as modules, lessons, and learning materials.

courses_course_provider_links

It connects courses with their providers (organizers).

courses_localizations_links

Manage course locations, such as the languages in which they are available.

files

Stores file data, e.g. names, file types, storage paths.

files_folder_links

Links files to the folders in which they are stored.

files_related_morphs

Supports relationships between files and different types of resources in the system (e.g., courses, users).

i18n_locale

Stores data on supported language locations in the system.

notifications

Includes notifications generated in the system, such as to users about events or activities.

notifications_localizations_links

It links notifications to their language locations.

notifications_recipient_links

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Connects notifications with their recipients.

participants

Represents the participants of the courses, storing their data.

participants_courses_links

Links participants to the courses they are enrolled in.

participants_user_links

Links participants to users in the system.

ratings

Stores ratings and reviews given by users.

ratings_course_links

Links ratings to the courses to which they apply.

ratings_course_provider_links

Links ratings to course providers.

ratings_uczestnik_links

Links ratings to the participants who gave them.

strapi_api_token_permissions

Manages permissions for API tokens in the Strapi system.

strapi_api_token_permissions_token_links

Links permissions to API tokens.

strapi_api_tokens

Stores API tokens, used for authorization and access to resources.

strapi_core_store_settings

Stores Strapi configuration settings.

strapi_database_schema

Contains the Strapi database schema.

strapi_migrations

Manages migrations of the Strapi database.

strapi_release_actions

Records the actions performed in system releases.

strapi_release_actions_release_links

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Links release actions to the corresponding releases.

strapi_releases

Represents versions of the Strapi system.

strapi_transfer_token_permissions

Manages permissions for transfer tokens.

strapi_transfer_token_permissions_token_links

Links permissions to transfer tokens.

strapi_transfer_tokens

Stores transfer tokens used to migrate or export data.

strapi_webhooks

Represents webhooks configurations, used for communication between systems.

trainers

Stores data about trainers (course instructors).

up_permissions

Manages user permissions.

up_permissions_role_links

Links permissions to user roles.

up_roles

Stores user roles in the system.

up_users

Contains the data of the system's users.

up_users_course_provider_links

Links users to course providers.

up_users_role_links

Links users to their roles in the system.

upload_folders

Manages the folders where files are stored.

upload_folders_parent_links

Supports hierarchical relationships between folders.

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```
admin_permissions
admin_permissions_role_links
admin_roles
admin_users
admin_users_roles_links
components_organization_organizations
course_applications
course_applications_course_links
course_providers
courses
courses_components
courses_course_provider_links
courses_localizations_links
files
files_folder_links
files_related_morphs
i18n_locale
notifications
notifications_localizations_links
notifications_recipient_links
participants
participants_courses_links
participants_user_links
ratings
ratings_course_links
ratings_course_provider_links
ratings_uczestnik_links
strapi_api_token_permissions
strapi_api_token_permissions_token_links
strapi_api_tokens
strapi_core_store_settings
strapi_database_schema
strapi_migrations
strapi_release_actions
strapi_release_actions_release_links
strapi_releases
strapi_transfer_token_permissions
strapi_transfer_token_permissions_token_
strapi_transfer_tokens
strapi_webhooks
trainers
up_permissions
up_permissions_role_links
up_roles
up_users
up_users_course_provider_links
up_users_role_links
upload_folders
upload_folders_parent_links
```

Figure 1 list of database tables

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2.4.5 Data layer optimization

Optimization of the data layer is a key aspect of the project, enabling efficient handling of large numbers of users and real-time query processing:

- **Indexing.** Key columns, such as user ID, course ID, and offer language, are indexed, allowing you to quickly search and filter data.
- **Caching and caching.** AWS RDS allows you to use Amazon ElastiCache as a cache, which allows you to temporarily store data in memory, reducing the number of direct queries to the database.

2.4.6 Summary

A data layer based on PostgreSQL hosted on AWS RDS provides a solid foundation for managing complex user data, courses and learning materials. With scalability, flexibility, and tools for monitoring and securing data, the system is prepared to handle large numbers of users in a secure and efficient manner.

2.5 System integration - APIs and external connections

The system is designed to be open to external integrations. This includes support for external APIs that enable:

- **Downloading data from other systems.** Ability to integrate with external data sources, such as job databases, which can be linked to the system to tailor training offers to market needs.
- **Providing public endpoints.** The system will provide endpoints that allow external applications to retrieve certain data sets.
- **Secure communication.** Authentication using JWT, and connections secured with HTTPS. The API is also monitored and limited to prevent overloading and ensure system stability.

2.6 Scalability and performance

1. Scalability of the system:
    - The system is designed to support up to 3,000 concurrent users. Modular architecture allows you to add new features and expand the infrastructure as the number of users grows.

2. Performance optimization:
    - The backend uses a cache to store temporary data, which minimizes the number of database queries.
    - Strapi and React are optimized for short loading times and dynamic rendering of elements, resulting in fast response times (2 seconds maximum for standard queries).

2.7 System security

System security is a priority throughout the design and implementation cycle:

- Authentication and authorization: JWT and OAuth guarantee secure user authentication and authorization for access to system resources.
- Data encryption: All traffic between the frontend and backend and between the backend and Chamilo's LMS uses HTTPS to ensure secure data transfer.
- Session management: The system manages user sessions, providing the option to automatically log out after a period of inactivity and allowing manual termination of the session from the user panel.

2.8 Summary

The system architecture is modular, scalable and secure. The use of Strapi CMS as a backend ensures efficiency and flexibility, while integration with Chamilo's LMS enables complex educational scenarios. The result is a structure that meets the needs of users, offering them comprehensive access to educational resources and an intuitive, secure and efficient interface.

3. Functional and non-functional requirements

Functional and non-functional requirements for an ICT system define the functions and characteristics that the system should meet in order to fully achieve its operational goals. Functional requirements refer to the specific activities and operations that the system enables users to perform, while non-functional requirements refer to operational qualities such as security, performance, scalability and regulatory compliance.

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3.1 Functional requirements

Functional requirements define what functions and services the system should provide to users. The following are the key functional requirements of the system, taking into account the various user roles and operations that will be carried out in the system.

1. **Registration and login module**:
    - **User registration:** Users can create new accounts by selecting from roles (individual user, training provider, employer, trainer).
    - **Login and authorization:** The system supports login via email or username and requires a strong password.
    - **Single Sign-On (SSO):** Once logged into the main system, users are automatically logged into the Chamilo LMS, eliminating the need for re-authorization.
2. **Managing user accounts and assigning roles:**
    - **Different user roles:** The system offers access to different functions and permissions depending on the role. Each role (individual user, provider, employer, trainer, superadmin) is assigned permissions, allowing access to relevant resources and operations.
    - **Administration Panel:** The superadmin manages users, can lock accounts, reset passwords, and grant and revoke permissions.
3. **Managing training offers**:
    - **Create, edit and publish offers:** Training providers can add, edit and publish offers, which are then approved by the superadmin.
    - **Offer analysis module:** The system tracks the popularity of offers, allows users to sign up for courses and rate courses. These results are analyzed to adjust the offerings to meet users' needs.
4. **Integration with LMS Chamilo**:
    - **Training module:** Integration with Chamilo's LMS provides access to learning resources, quizzes, tests and communication features.

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- **Access to course content:** The system allows users to access educational materials that are part of courses, such as videos, documents, exercises and quizzes.

5. **Analytics and reporting module**:
    - **User activity reports:** The system generates reports on user activity, number of enrollments, course ratings, and average engagement.
    - **Course effectiveness reports:** Superadmins and providers have access to course effectiveness reports such as completion rates, average ratings, and participant satisfaction levels.
6. **Management of educational materials:**
    - **Adding and editing educational resources:** Providers can add learning resources in a variety of formats (PDF, video, audio, interactive exercises) that are made available on Chamilo's LMS.
    - **Personalizing courses and managing participants:** Trainers have the ability to assign materials to specific user groups, manage progress and provide support to participants.
7. **Communication and social tools**:
    - **Chat, forum and teleconferencing:** Chamilo's LMS enables communication between participants and trainers. Forums and chat provide a place to exchange ideas, and teleconferencing enables real-time meetings.
    - **System notifications:** The system sends notifications of important events, such as deadline reminders and course updates.

3.2 Non-functional requirements

Non-functional requirements refer to the quality with which the system must perform its functions. They concern aspects such as performance, availability, security and scalability.

1. **Scalability**:
    - The system must support up to 3,000 concurrent users. The architecture based on Strapi CMS and PostgreSQL database (hosted on AWS) allows flexible scaling of resources depending on the load.

- The system allows new features to be added without disrupting existing modules, allowing the system to be expanded and updated in response to changing needs.

2. **Performance**:
   - **Response time:** Response time for standard queries should not exceed 2 seconds. Code optimization, caching and indexing in PostgreSQL database support fast data access.
   - **User interface optimization:** The frontend built in React enables fast rendering interactions, and the backend's query processing (Strapi CMS) and synchronization with Chamilo's LMS are optimized to minimize latency.
3. **Security**:
   - **Authorization and authentication:** The system uses JWT (JSON Web Token) for secure user authentication and OAuth for single sign-on (SSO) between the main system and the Chamilo LMS.
   - **Data encryption:** All data transmitted between the frontend, backend and LMS Chamilo is encrypted with HTTPS.
   - **Application security:** The system locks user accounts after a certain number of failed login attempts to prevent brute force attacks. Permission segmentation mechanisms ensure that users only have access to the data they need.
4. **Availability and reliability**:
   - **System availability:** AWS RDS (Relational Database Service) ensures a high level of database availability through Multi-AZ (Multi-Availability Zone) replication. Maintaining system availability of 99.9% is a priority to enable continuous access to training resources.
   - **Backup and Restore:** AWS RDS automatically backs up the database, enabling fast disaster recovery. Backups are created according to a schedule, as well as on-demand at key moments, such as the introduction of new features.
5. **Compliance with WCAG (Web Content Accessibility Guidelines)**:

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- The system is WCAG Level A and AA compliant, ensuring accessibility for users with various disabilities. Each frontend component is designed with accessibility principles in mind, such as appropriate color contrast, button labels and keyboard support.
- Responsive design adapts automatically to screen resolutions, making the system comfortable to use on both computers and mobile devices.

6. **Flexibility and adaptability**:
   - The system is designed with future expansions in mind. Modular architecture allows integration of new technologies or modules without redesigning the entire application.
   - The ability to customize roles and permissions and edit the user interface gives you the flexibility to tailor the system to your organization's specific needs.
7. **Regulatory compliance:**
   - **RODO (GDPR):** The system ensures compliance with the RODO through data protection mechanisms such as anonymization, the ability to delete data on demand, and a privacy policy. Users are able to view and manage the personal data that is stored in the system.
   - **Compliance with educational regulations:** The system incorporates European Learning Model (ELM) standards and supports the generation of microcredentials that comply with European regulations, which increases their credibility and recognition in the labor market.
8. **Event monitoring and logging**:
   - The system logs key user operations and events, such as login attempts, course enrollments, course completions, and account updates. This allows the superadmin to monitor user activity and perform audits as needed.
   - **Alert system**: If suspicious activity is detected, such as multiple login attempts from different IP addresses, the system automatically sends an alert to the administrator, allowing appropriate action to be taken.

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3.3 Summary

The functional and non-functional requirements of an ICT system reflect the needs of the organization, users and regulations that must be met. The system is designed not only to perform specific functions, but also to operate with the high quality, security and accessibility that are crucial to the educational environment.

4. Functional modules

The ICT system is offering a central registry of training services consists of several key functional modules that allow users to perform their tasks and interact with the platform according to their roles. Each module is designed to meet the specific requirements of users such as training providers, employers, participants, trainers and system administrators (superadmins). The modules integrate with each other and with the Chamilo LMS, creating a cohesive ecosystem to support remote learning, bid management and collaboration between users.

4.1 Access to the system from the Guest role

Access from the guest level (without registration and login) gives the opportunity to search and browse training offers placed in the system. It is also possible to view information about Partners and sign up for newsletters.

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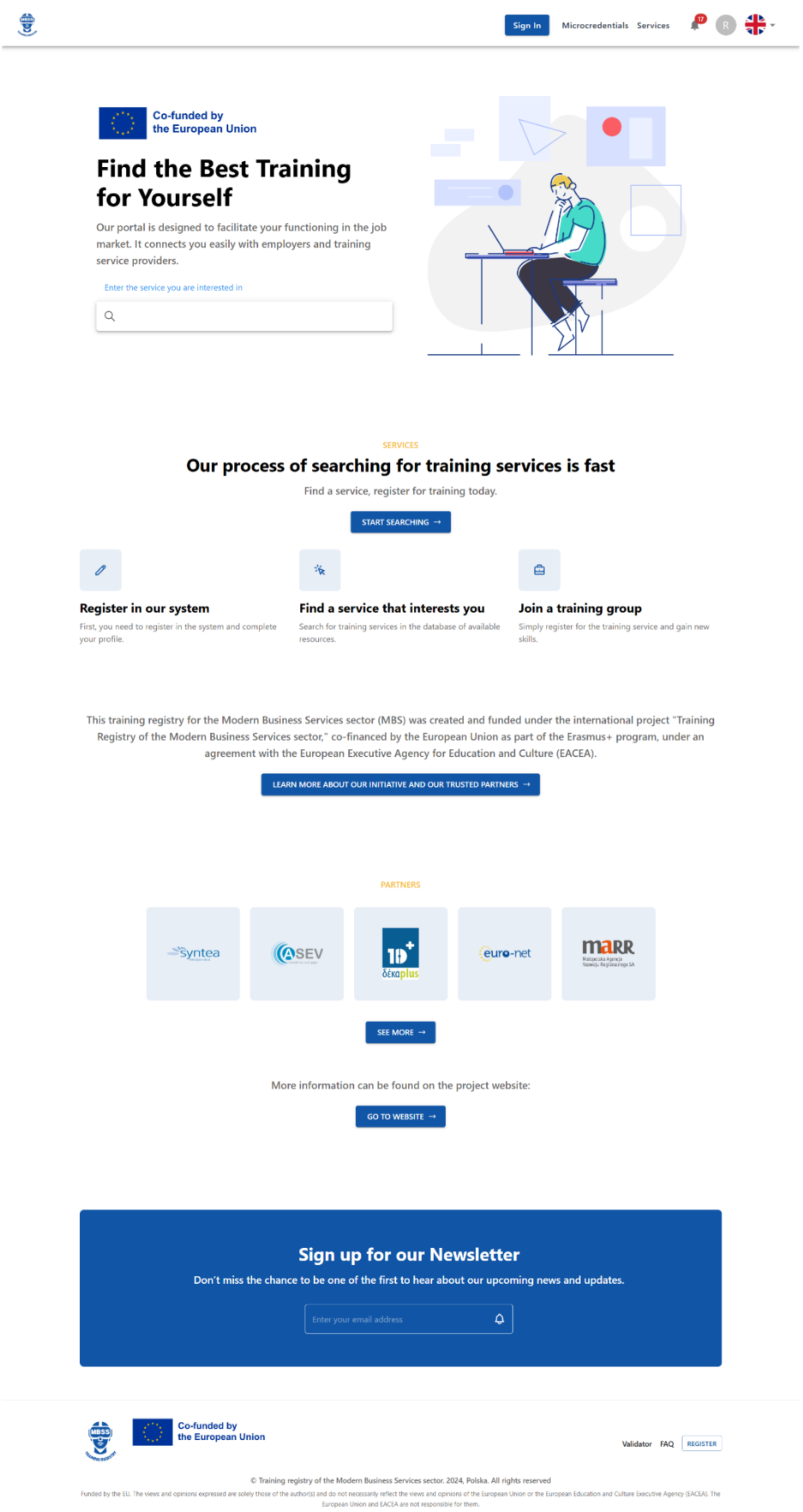

Figure 2 View of the home page

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4.2 Registration and login module

The registration and login module provides authorization and management of user accounts. It is designed with a focus on security and convenience, allowing each user to create an account, select a role, and access features appropriate to that role.

1. **User registration**:
    - Users can select a role (individual user, training provider, employer, trainer) during registration.
    - The registration form includes field validation, such as checking the uniqueness of the email address and the correctness of personal information.
    - Requiring strong passwords (a minimum of 12 characters, including numbers, letters and special characters) increases account security.

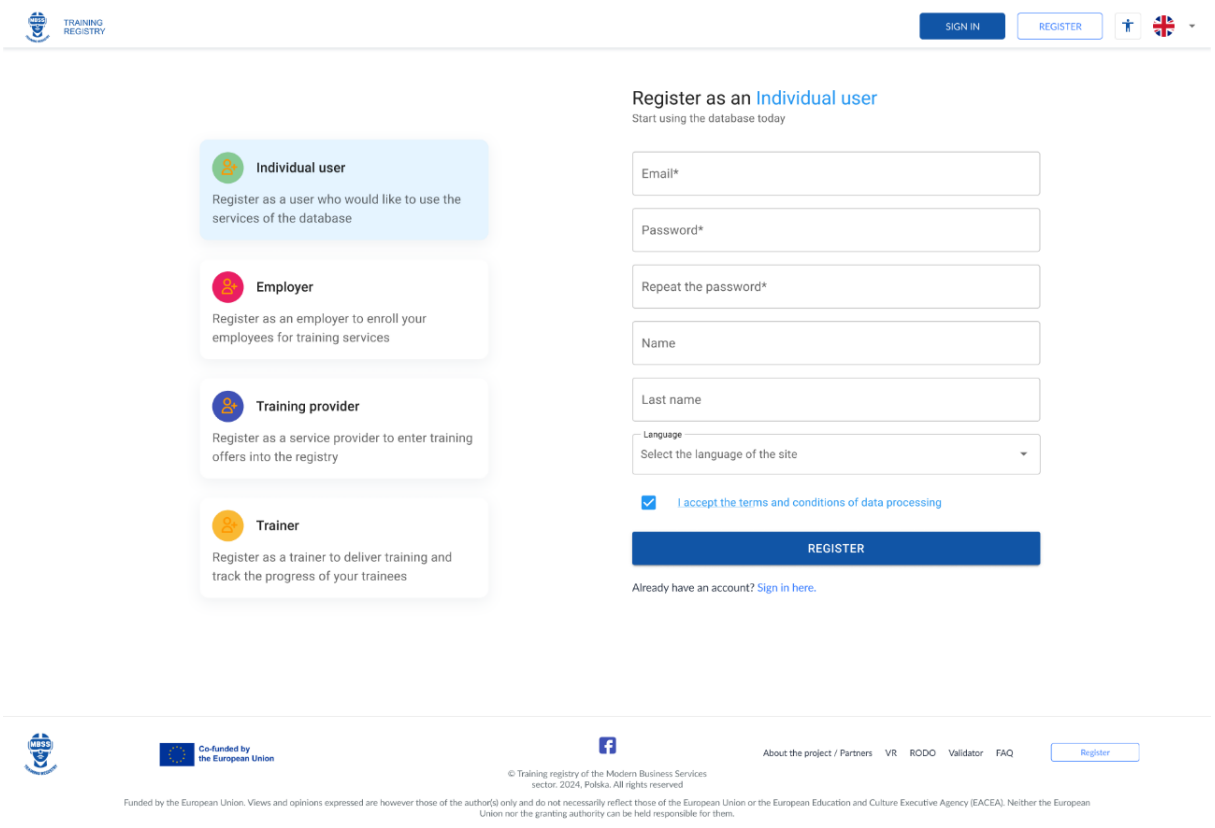

Figure 3 View of the registration form using the Individual user as an example

2. Confirmation of registration is sent to the registrant's email address and requires confirmation by clicking the appropriate link.

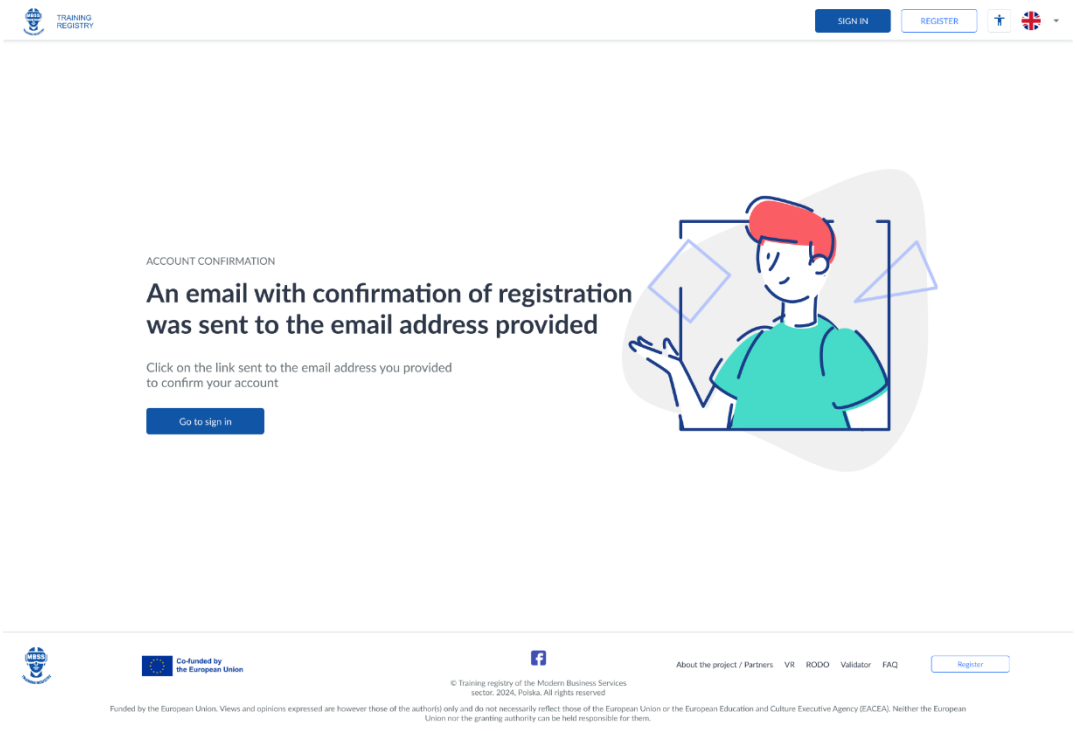

Figure 4 View after submitting the registration form

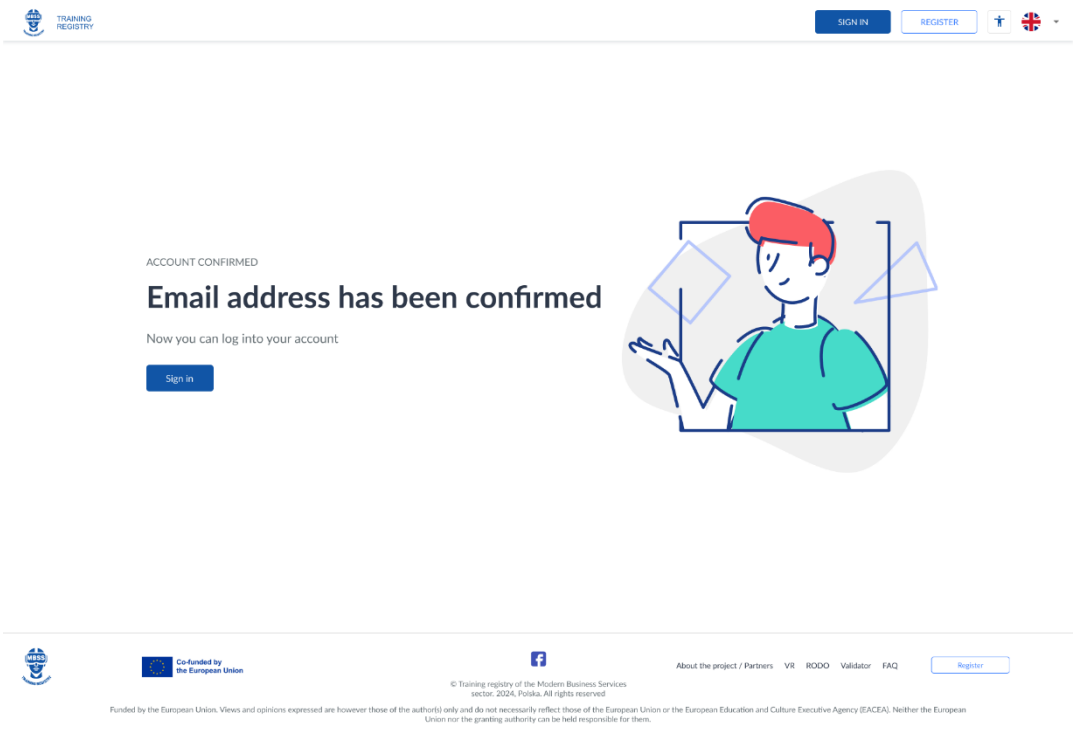

Figure 5 Account confirmation notification

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3. A system has been implemented in the system that allows password reminders to be sent to a designated email address.

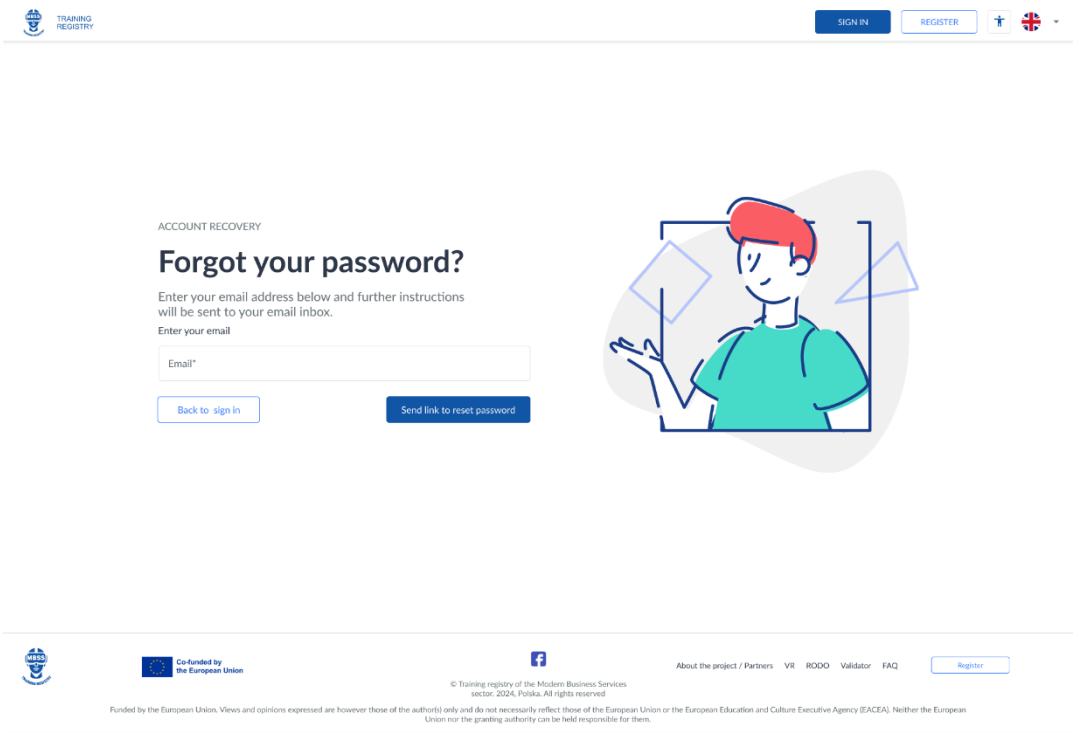

Figure 6 Login password reminder view

4. **Login and SSO (Single Sign-On):**
    - The login module supports both login via email address.
    - A user logging into the main application automatically accesses Chamilo's LMS through SSO integration, eliminating the need for multiple logins.
    - Secure authentication via JWT (JSON Web Token) and forced login via HTTPS ensure fully secure data transmission.
5. **Session management and security:**
    - The system manages user sessions, allowing automatic logout after a specified period of inactivity.
    - In case of multiple failed login attempts, the system locks the account for a specified period of time to prevent brute force attacks.

- The superadmin can monitor active sessions and manually terminate sessions to oversee security and user activity.

4.3 Main functionalities of the main module of the registry in the role of the Trainee

Correctly logging in displays the registry, while also providing the opportunity to sign up for training courses. The system has implemented advanced enabling filtering by various criteria.

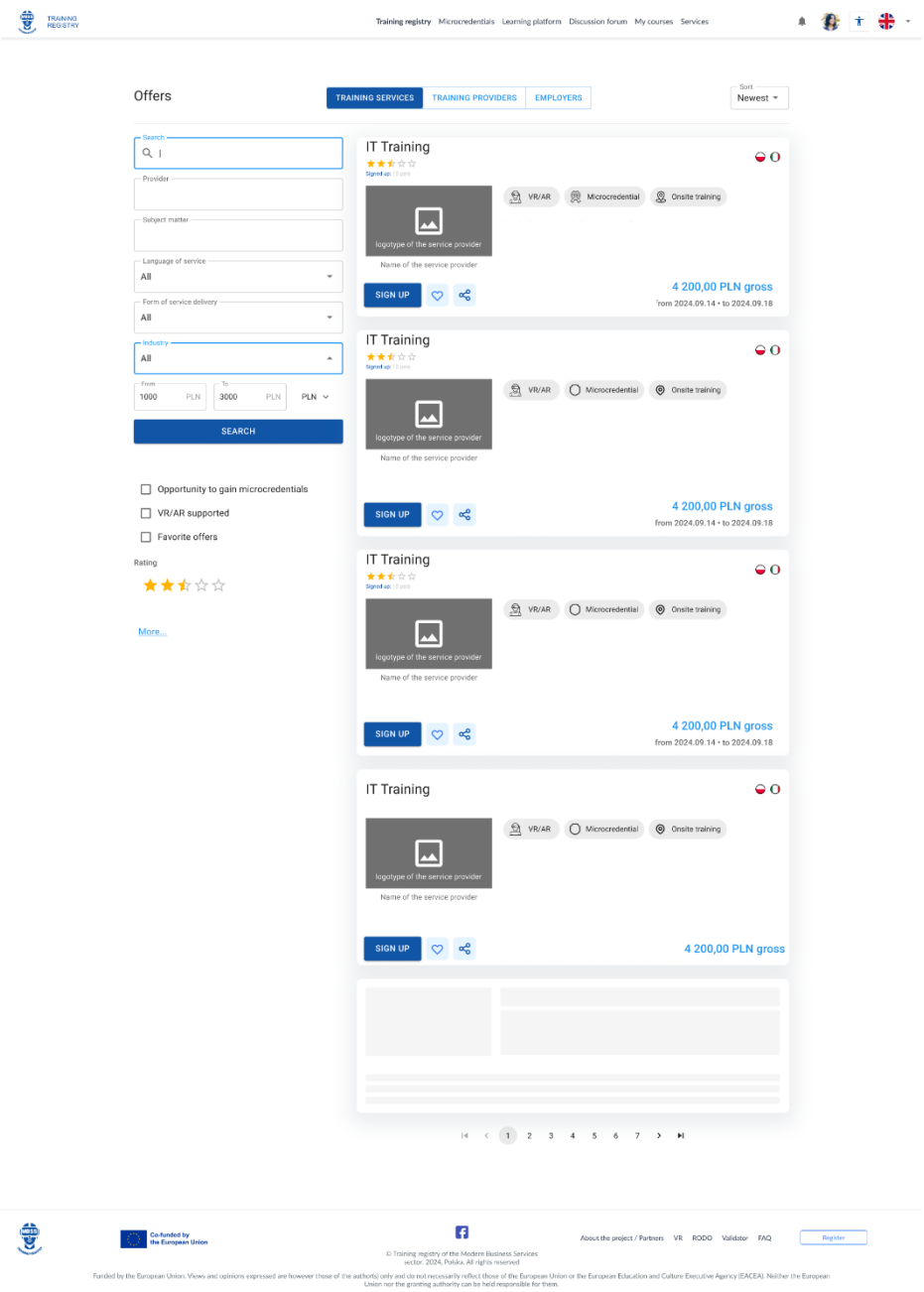

Figure 7 View of the list of training registry services from the participant's perspective

To sign up for training, go to the training details views.

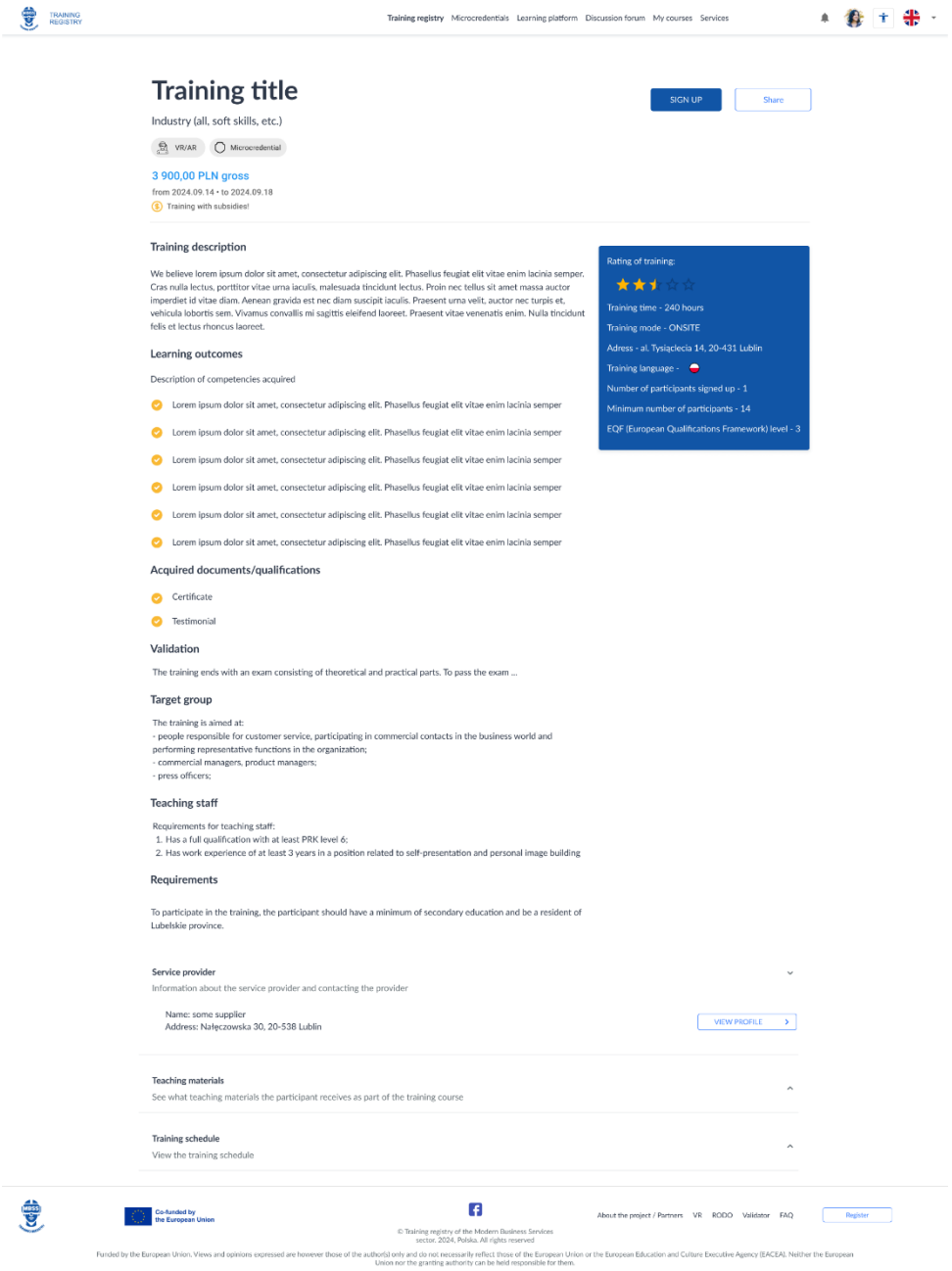

Figure 8 View of detailed description of training

After signing up for the service, you will receive a message that the service administrator must approve the request.

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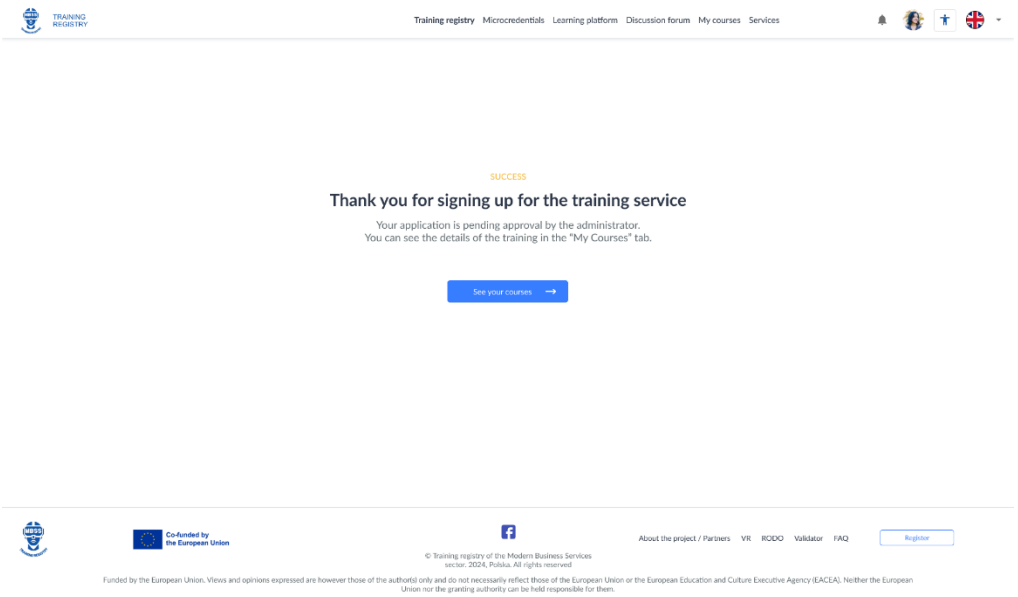

Figure 9 Message after signing up for a training service

Completed training courses that the user has enrolled in are visible from the **My Training** tab.

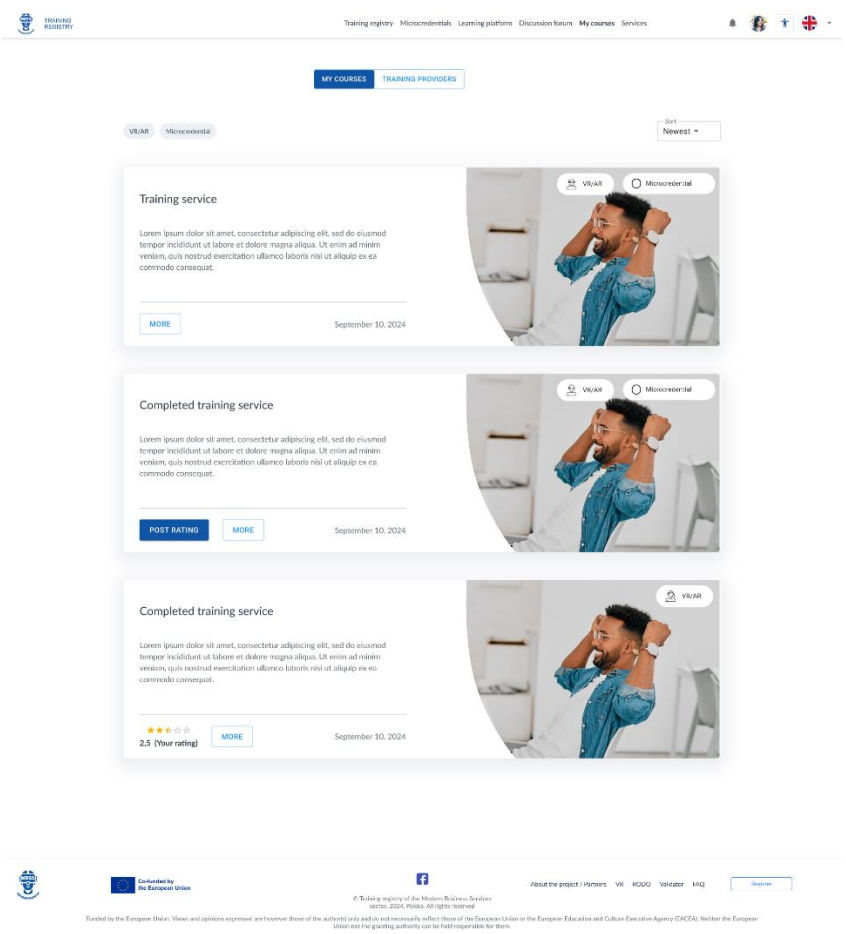

Figure 10 View of the list of completed training services

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Each participant has the opportunity to evaluate the training after completion.

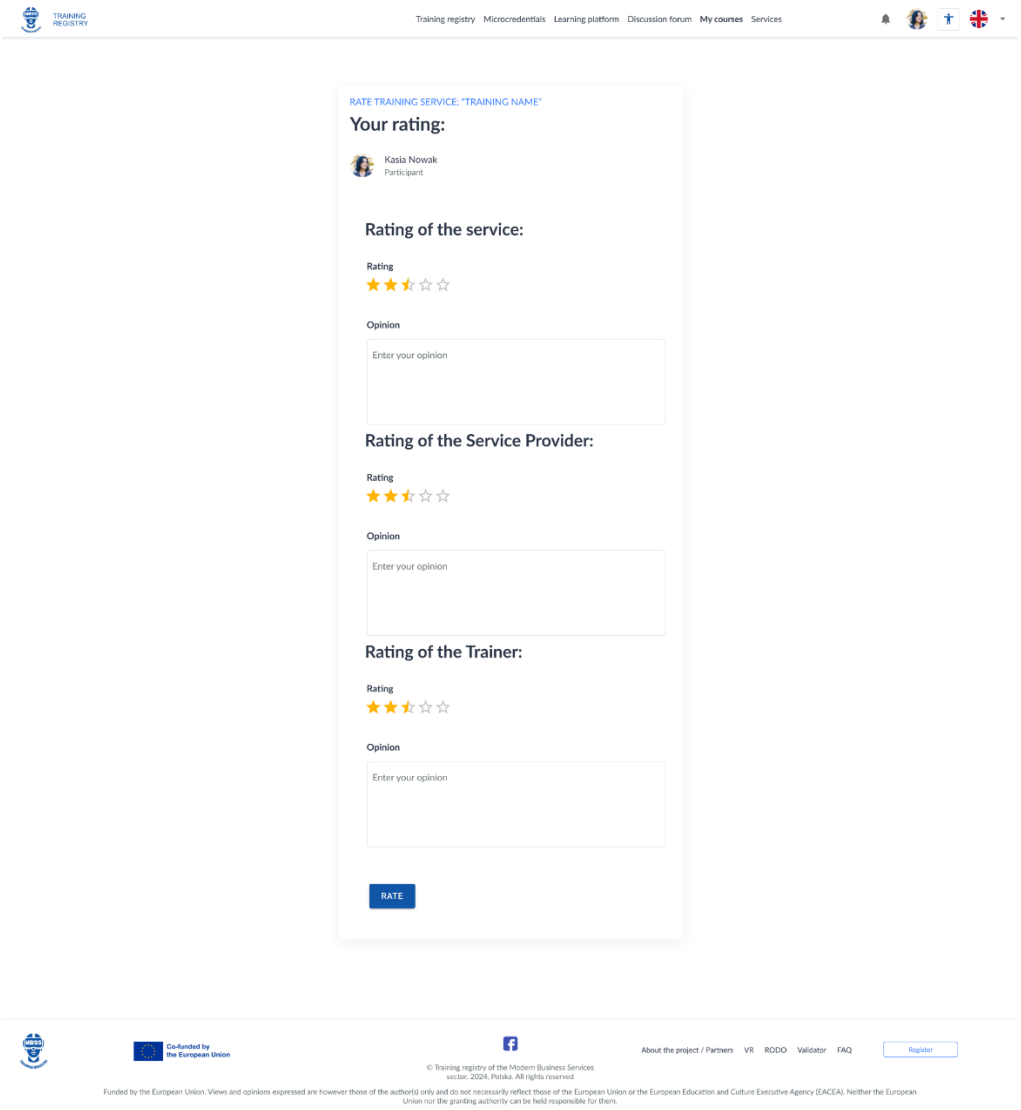

Figure 11 Service and staff evaluation view

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The rating given along with the ratings given by other participants can be seen in the view below.

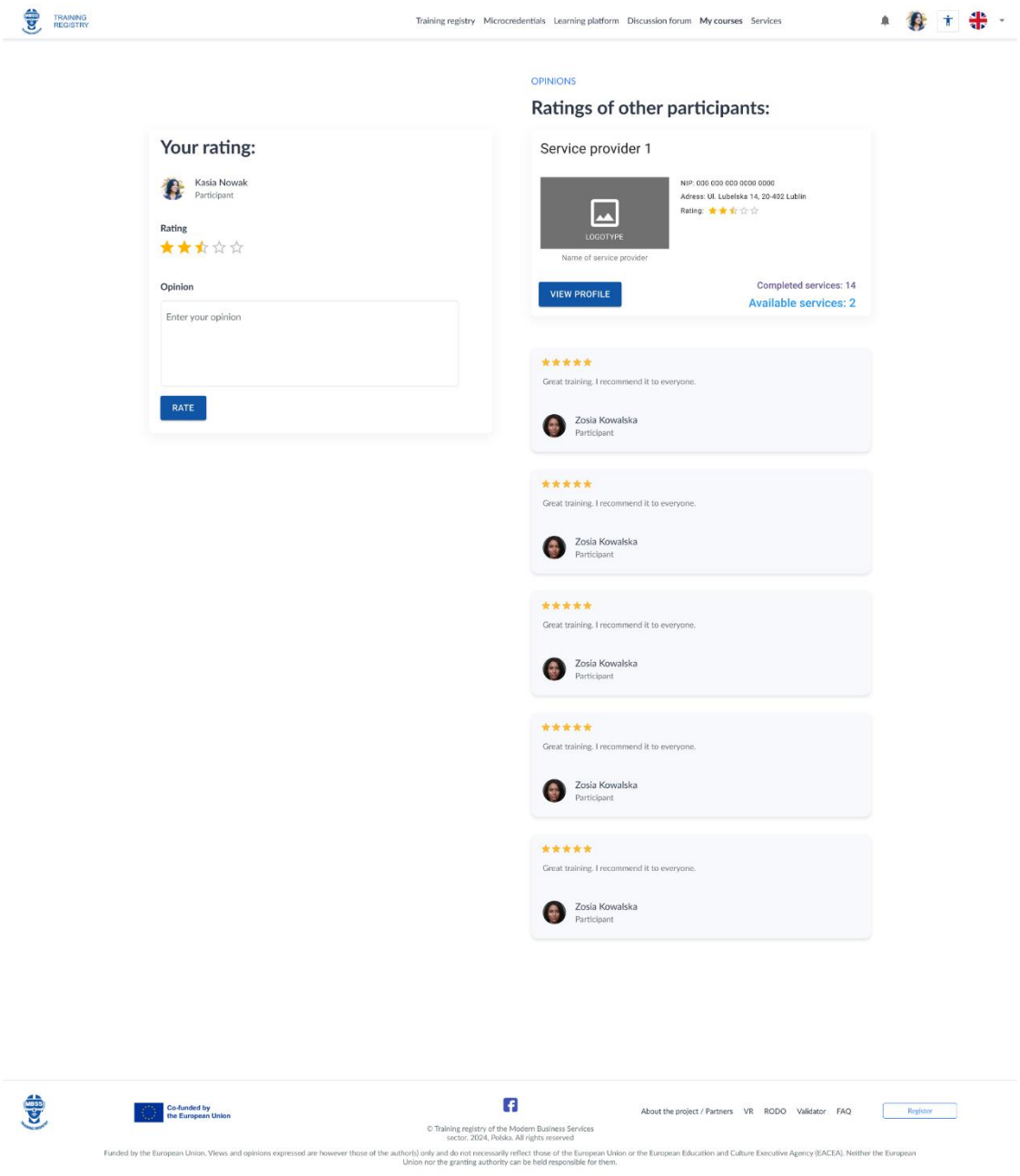

Figure 12 View of training evaluations, including other participants

Some training courses end with validation and issuance of microcredentials. The microcredentials earned by the participant can be seen in the following view.

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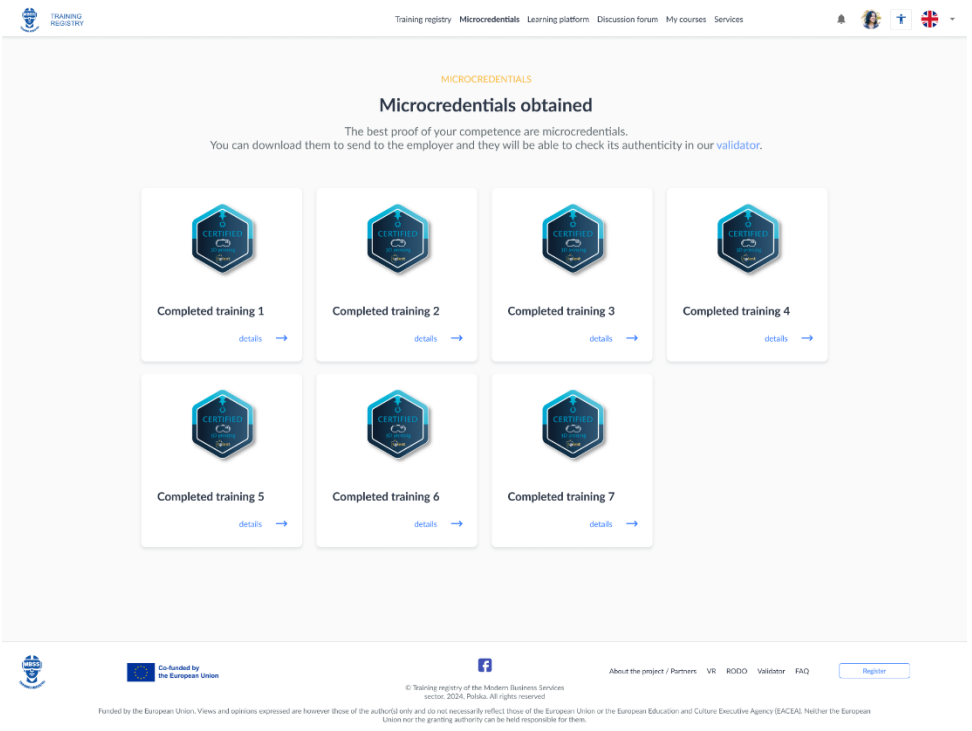

Figure 13 Summary view of microcredentials acquired

A detailed view of the microcredentials including, at a minimum, the name of the entity, date of issuance, subject area or learning outcomes is illustrated below.

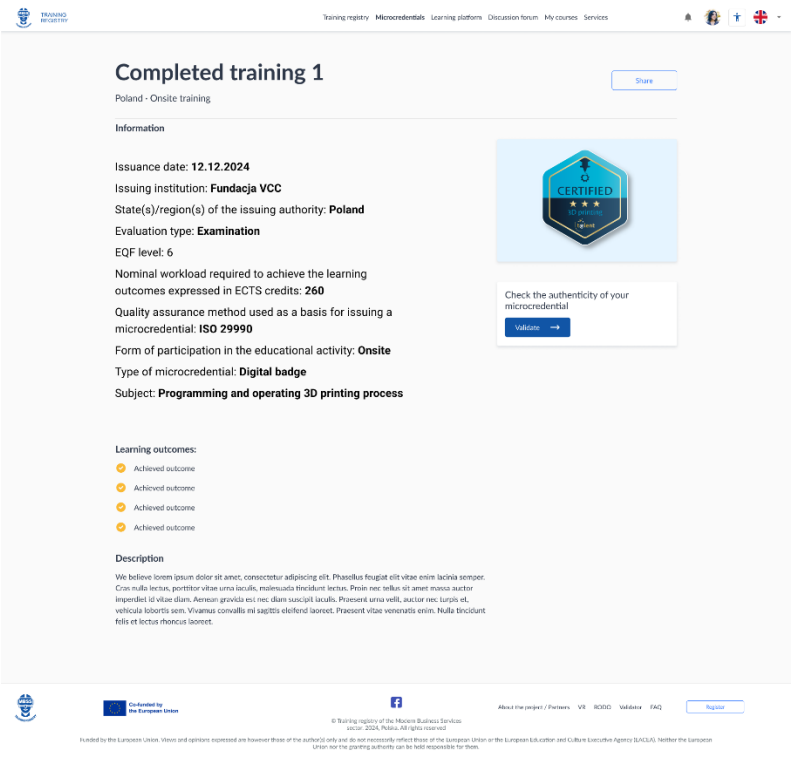

Figure 14 Detailed view of the microcertificate

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Each microcredential can be downloaded as a .png image file. The validator provided on the service checks the authenticity of a given microcredential.

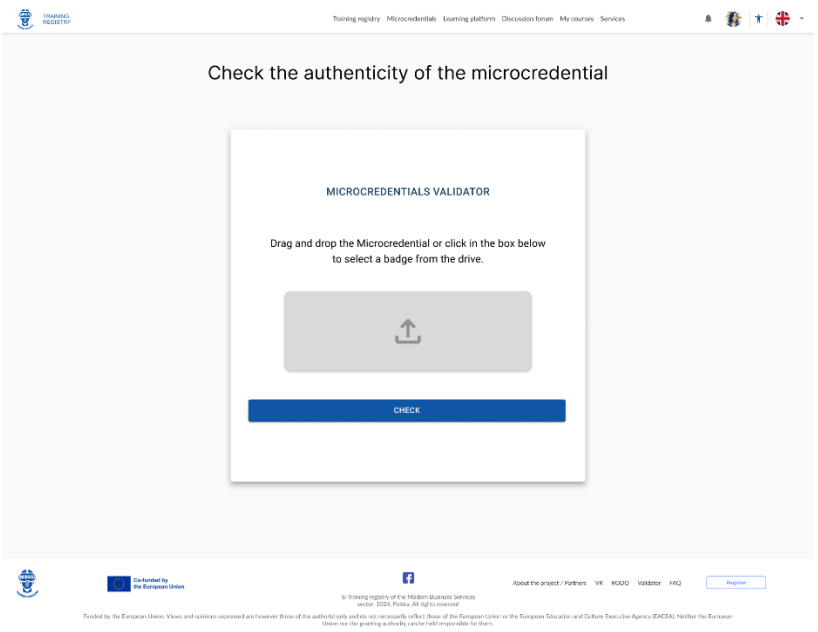

Figure 15 Microcredentials validator

One view indicates how a participant can use the VR module. It includes instructions along with the requirements for the VR application, as well as the login information needed to use the application with the goggles.

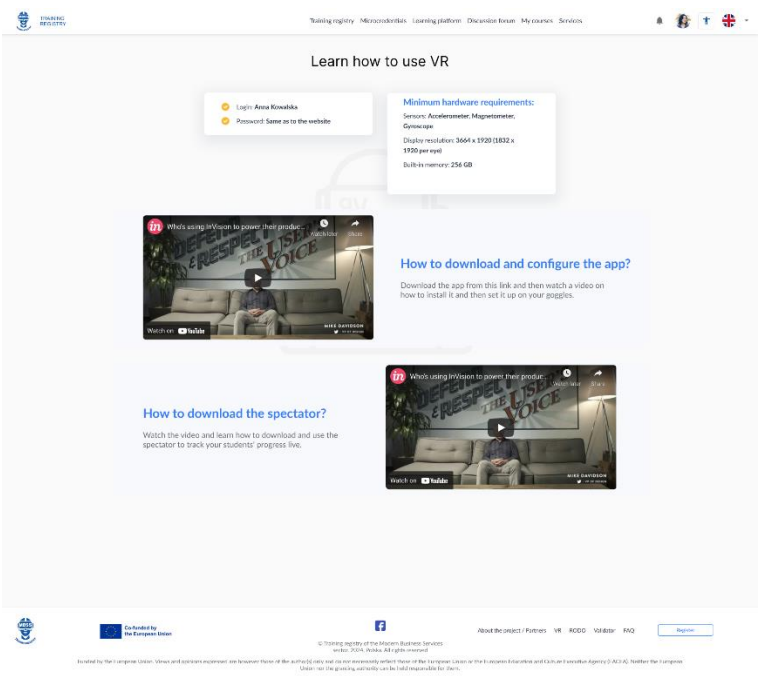

Figure 16 View of the VR training support tab

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4.4 The main functionalities of the main module of the register in the role of the Trainer

The trainer registers in a similar way to a participant. The trainer can view all the content available to the participant, but from the trainer's role it is not possible to sign up for training as a participant.

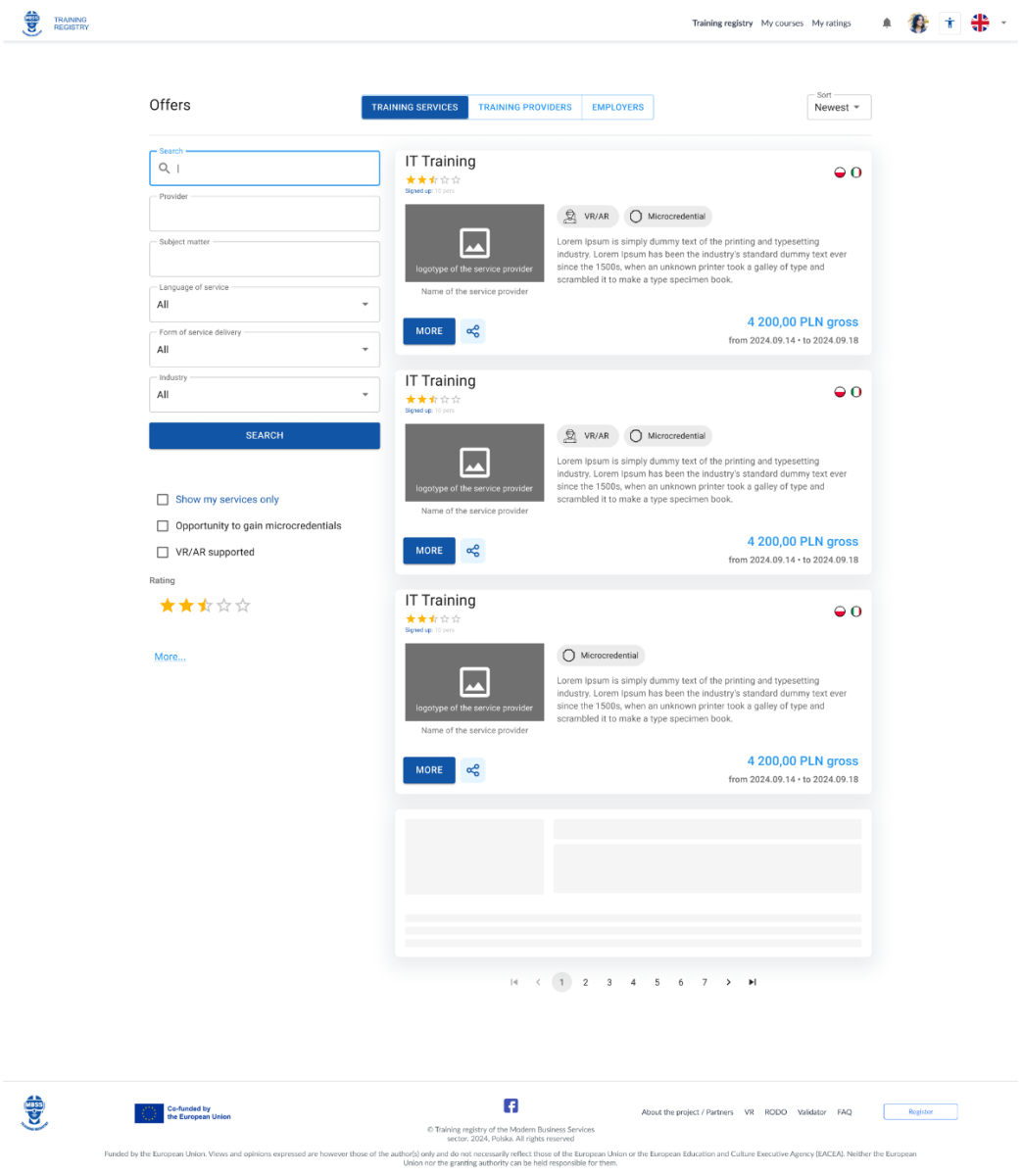

Figure 17 Register view from the trainer's account

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Instead, the user can join as a trainer for a particular training service provider (confirm participation as a trainer), as long as the provider has designated a trainer for the service.

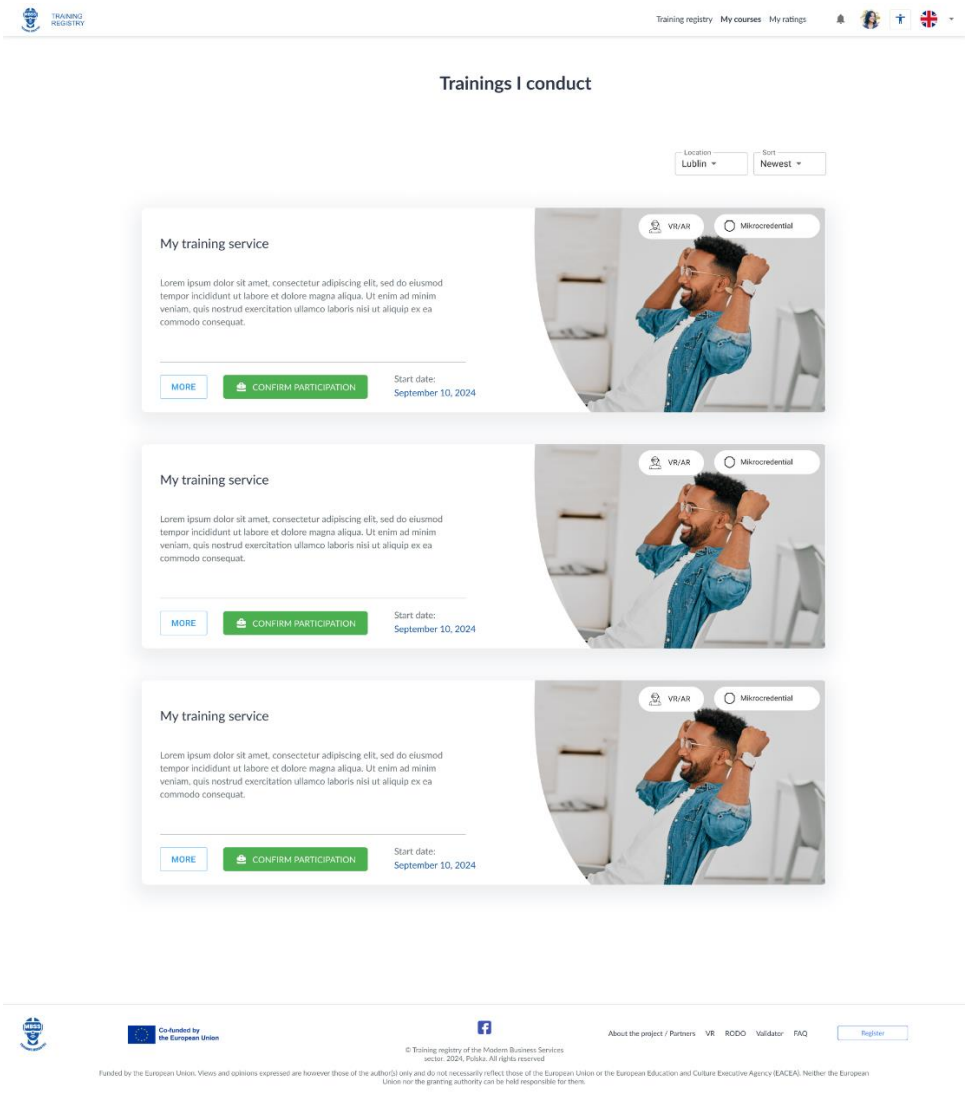

Figure 18 View of training service enrollment

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The trainer has the ability to edit his or her profile and to view completed trainings along with information on the number of trainings. The trainer also has an available view of training evaluations by participants.

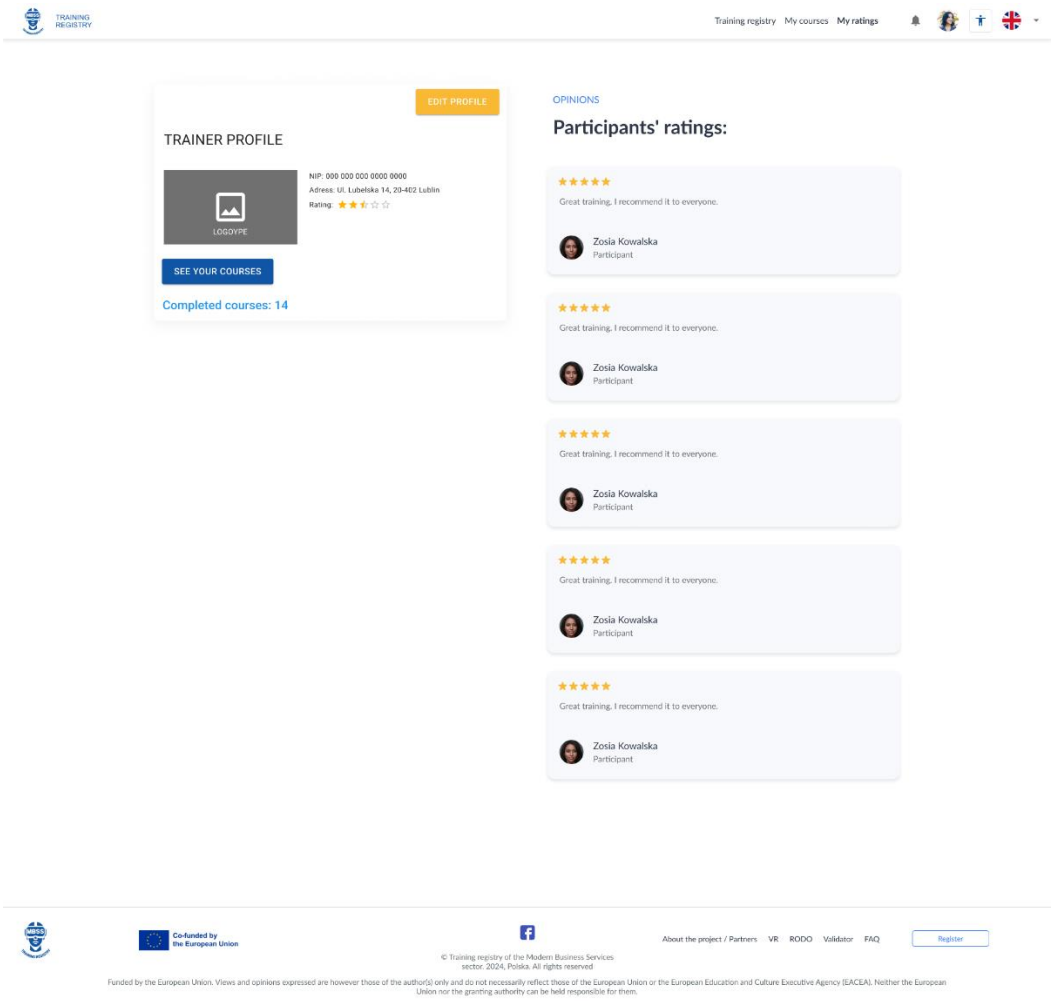

Figure 19 Trainer Profile

4.5 Main functionalities of the main module of the registry in the role of Training Provider

Similar to other roles in the system, the Training Provider has the ability to view all offers entered in the registry. He also has tabs available for providers and employers registered in the system.

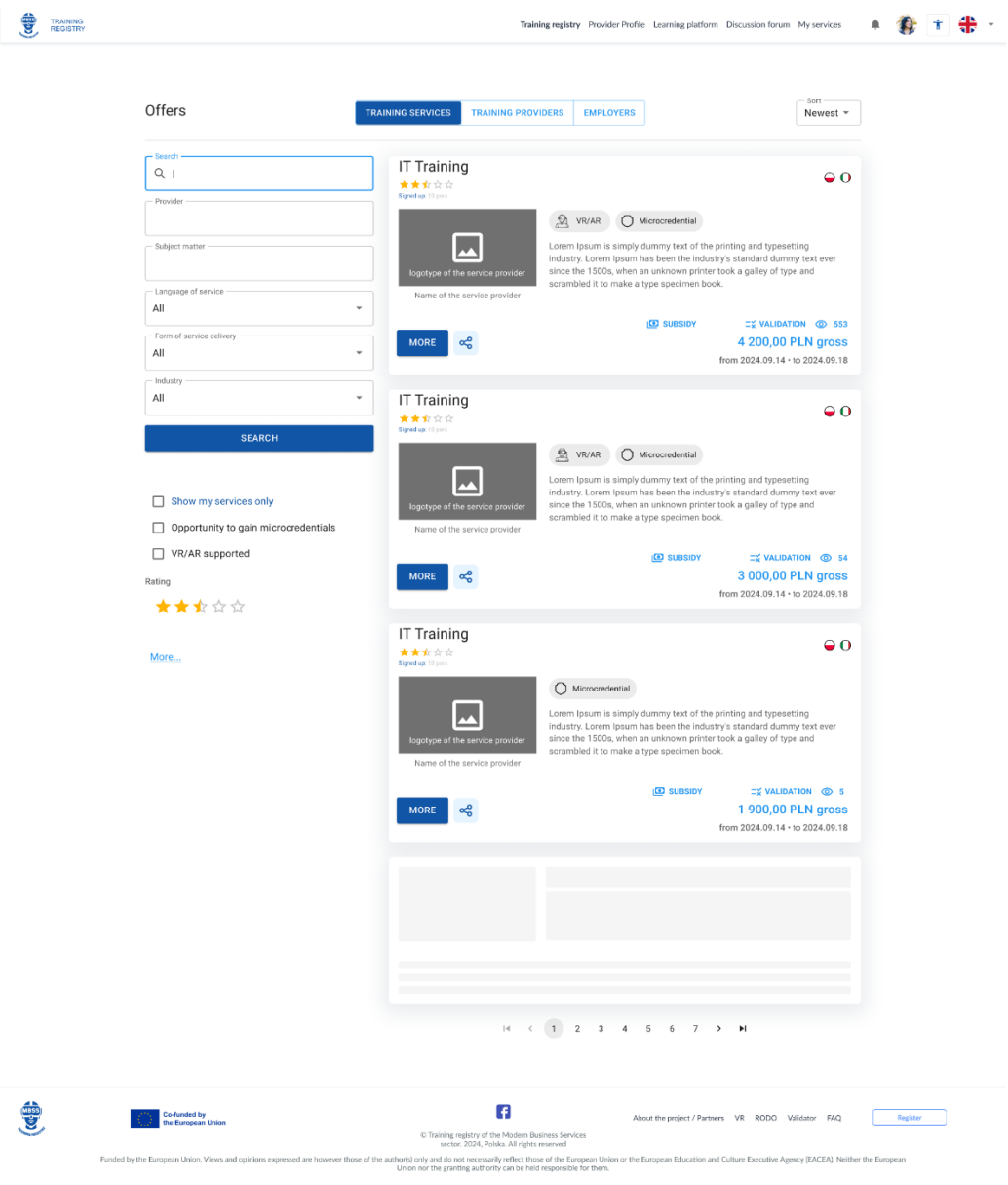

Figure 20 View of the training services register from the training provider level

The training offers management module is crucial for training providers, allowing them to publish offers and manage course content. The module supports different course formats, such as onsite, remote, hybrid and blended learning training, so that offers can be tailored to market and user needs.

1. **Creation and publication of training offers**:
    - Providers can create new training offers using a form that includes detailed fields such as title, description, industry, course language, number of hours, training mode (onsite, online, hybrid), price, and the possibility of obtaining microcredentials.

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- Each offer must be approved by the superadmin before publication, ensuring high quality content and compliance with regulations.
- Ability to choose the language of the training and add educational materials for participants, which are available on the LMS Chamilo.

The training service provider through the **My Services** tab can add a new service or withdraw an existing one (no later than 1 day before the scheduled date of service).

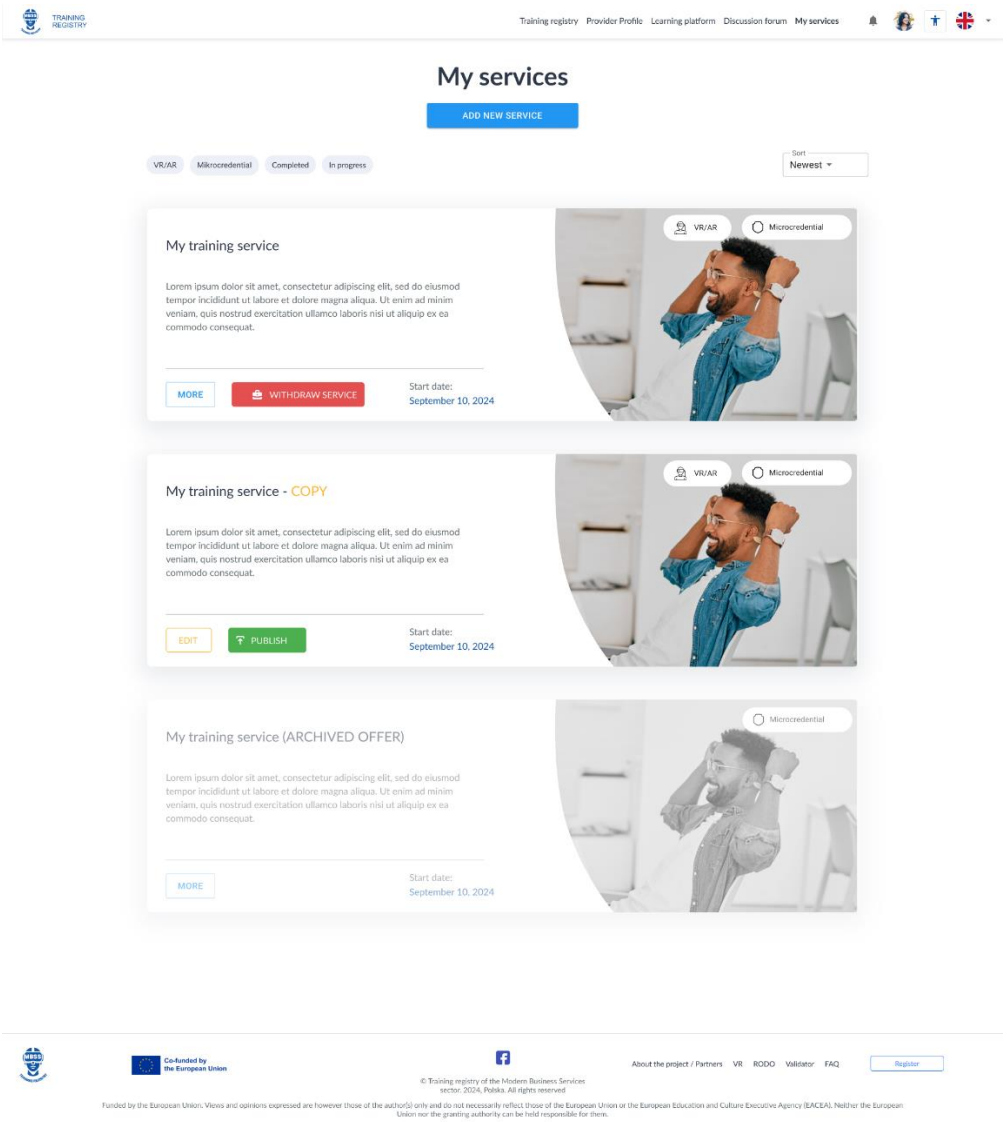

Figure 21 View of the My Services tab

The service provider enters the data of the planned training service according to the form below.

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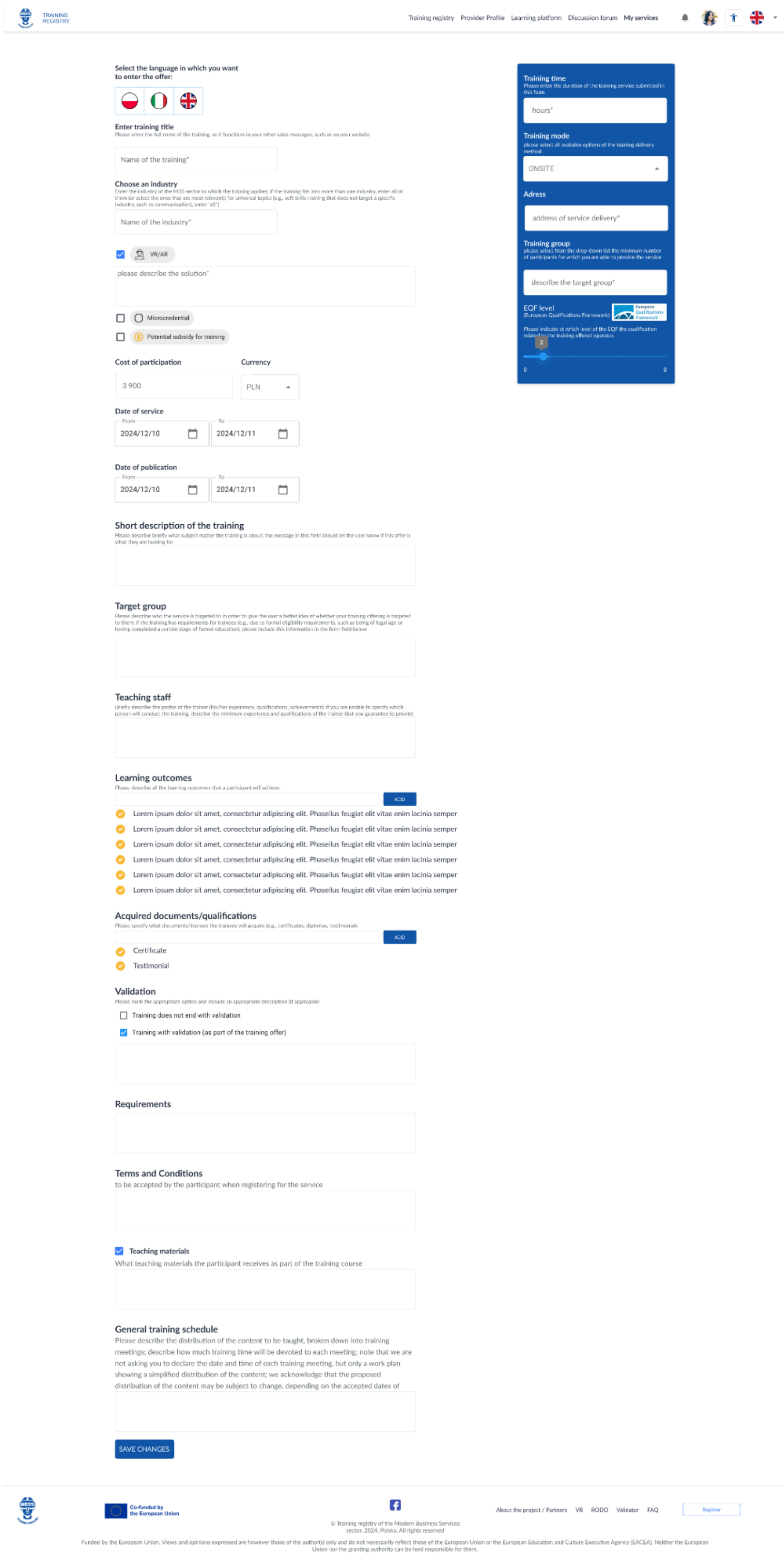

Figure 22 Form for adding a training service

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From the Service Provider Profile, the provider has the ability to view the training offers he has added, as well as a view of training analytics (services delivered or number of people trained). It also accepts other organization administrators who will be able to manage the Provider Profile. The ratings that training participants have given are also visible.

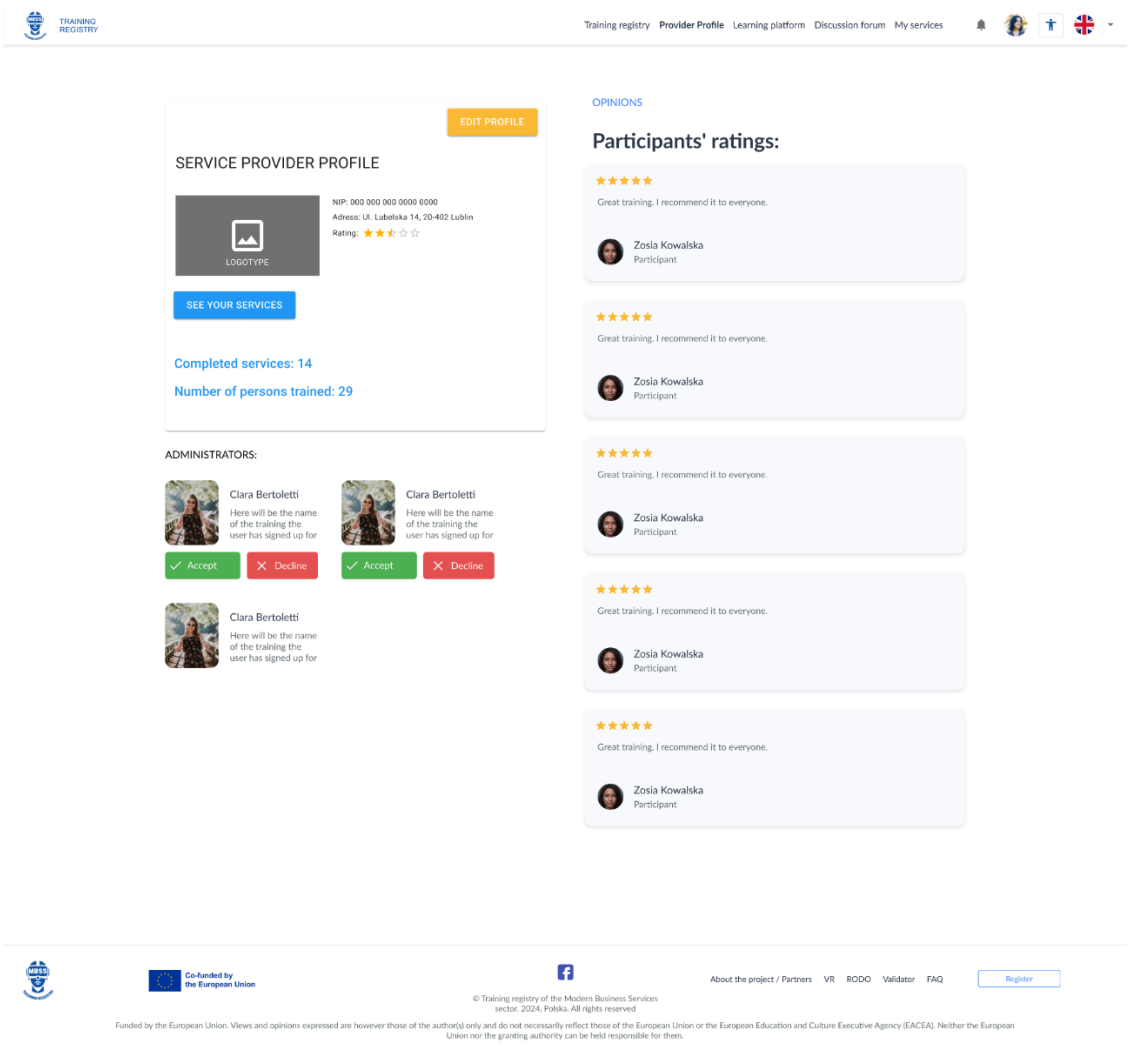

Figure 23 Profile view of a Training Provider

4.6 Main functionalities of the main module of the register in the role of the Employer

The employer in the main register module has the ability to add competency demand offers and monitor the process of attaching employees to training offers. The Training Services view looks the same as for the Service Provider.

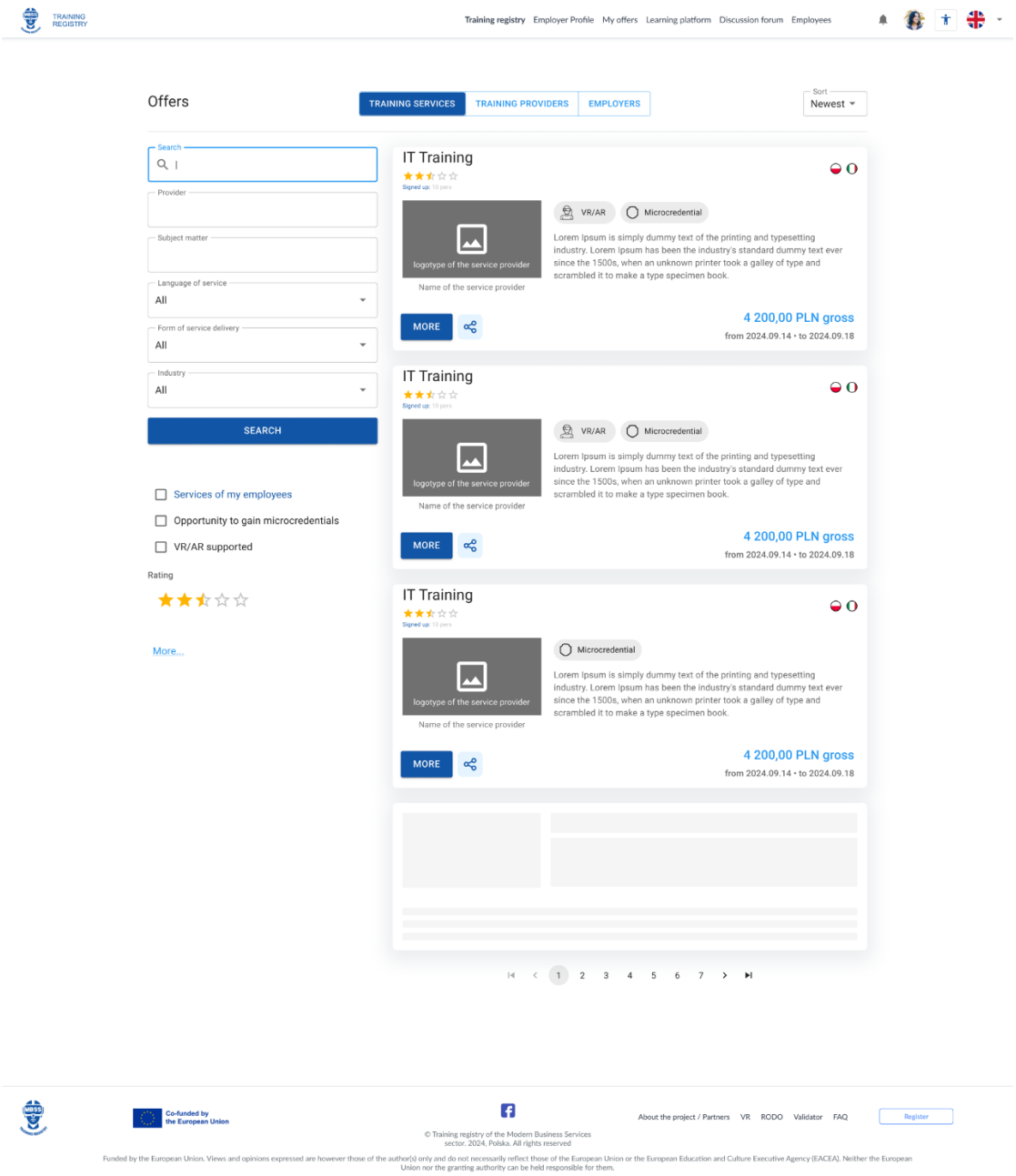

Figure 24 View of the register from the Employer level

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However, if a participant has joined the training by indicating an employer with an account in the system, his/her Employer can see that the person has enrolled in the training.

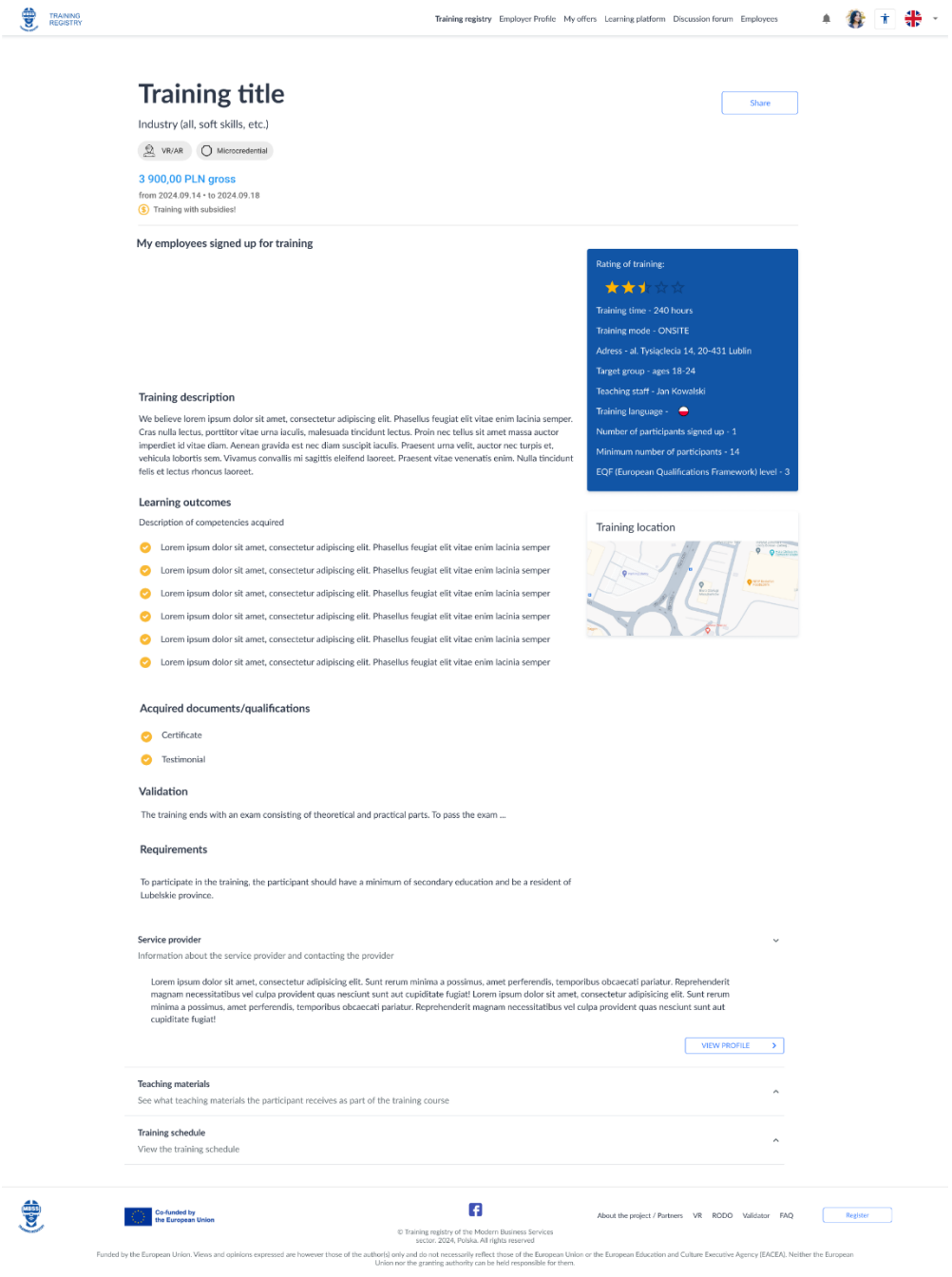

Figure 25 View of training from the Employer level

An employer can add postings in the system of two types. The first type is to seek training for employees:

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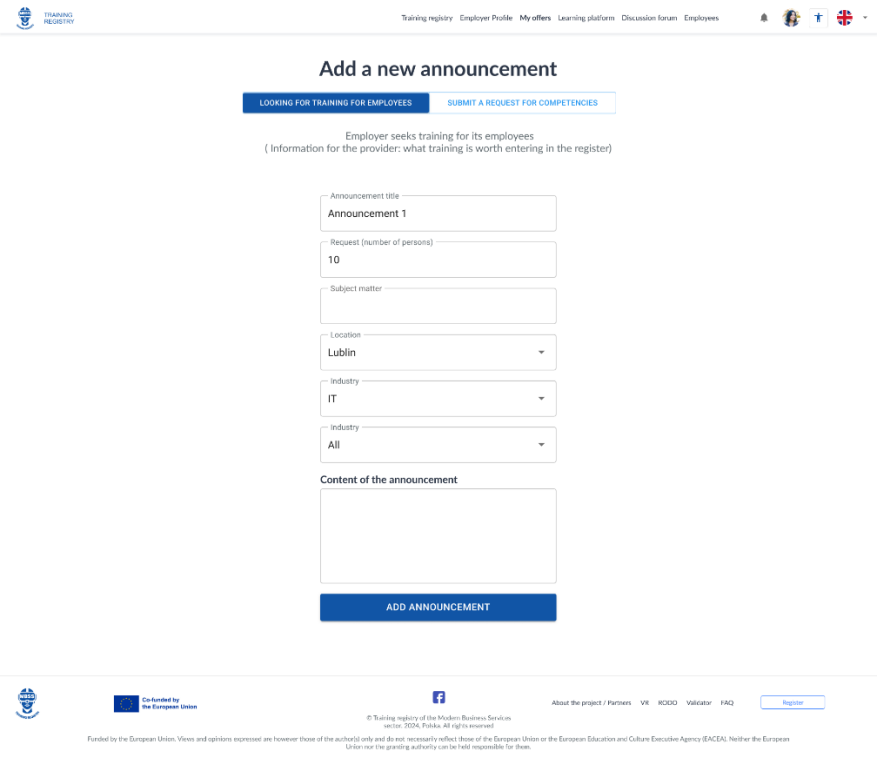

Figure 26 View of adding training for employees

The second type is a request for competence:

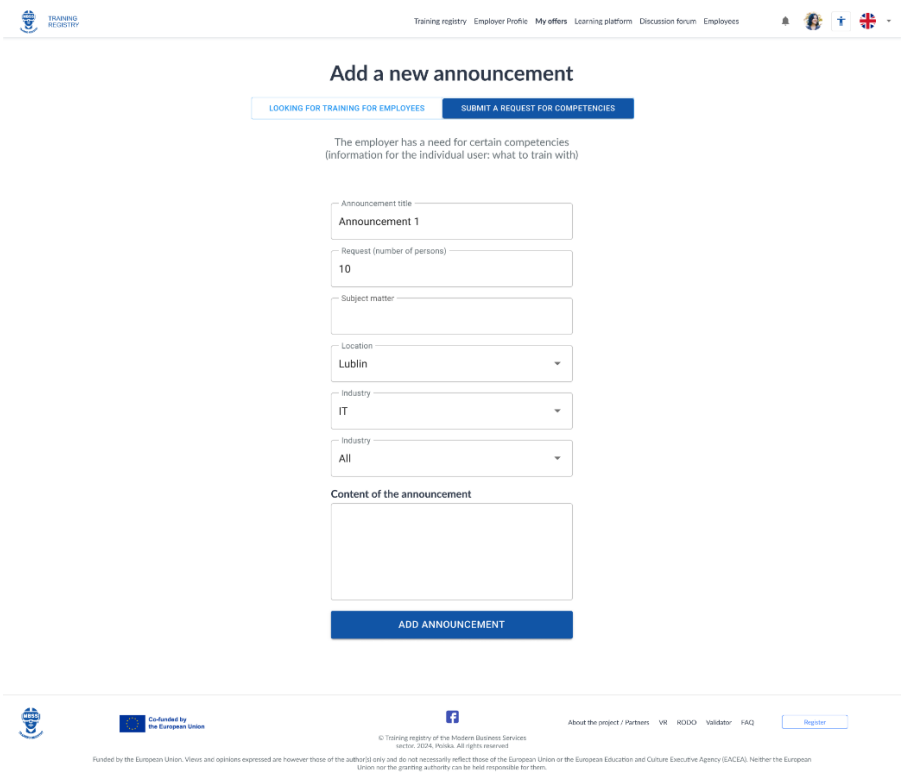

Figure 27 Adding a competency requirement request

Analogous to the supplier profile, the employer can designate administrators to manage the organization's account. He can also see the services he has used as well as evaluations and analytics on the training his employees have received.

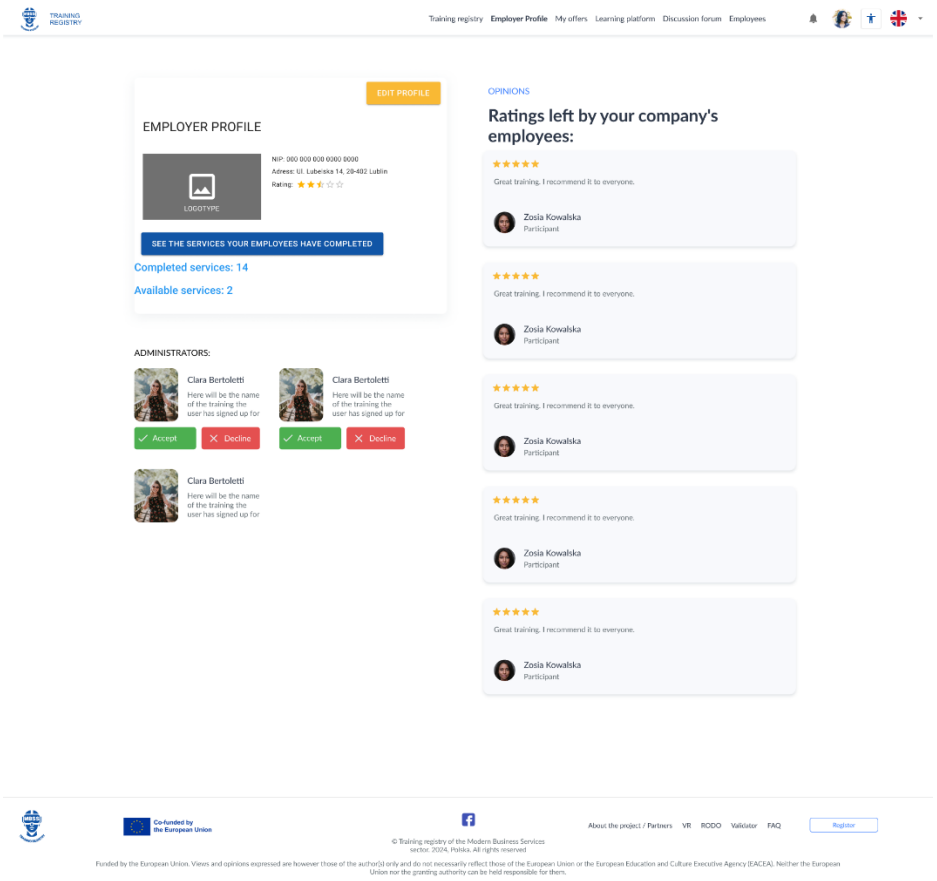

Figure 28 Employer Profile View

4.7 Training module (LMS Chamilo)

The ICT solution is integrated with Chamilo's LMS version 1.11.29. Chamilo is an open source learning management system (LMS) designed to facilitate effective online education. The platform offers a comprehensive set of tools and features that support both teachers and students in creating, managing and participating in digital courses. Chamilo is distinguished by its intuitive user experience, wide range of capabilities and customizability. The ICT solution integrates the platform with the training module, linking it together in a way that is unnoticeable from the trainee's point of view.

4.7.1. Key features of the LMS

1. Course management

- **Course creation** (Trainers can easily create courses, organizing content to meet specific learning objectives).
- **Course accessibility** (Chamilo allows full control over course access - Trainers can decide who has access to learning materials and under what conditions).

2. Content management

- **Supports a variety of formats** (The platform allows users to upload and publish documents in many formats, such as HTML, PDF, PowerPoint, Word, Excel, multimedia files (MP3, OGG, AVI), as well as OpenOffice and LibreOffice documents. This makes Chamilo flexible and compatible with different user needs).
- **Learning Paths** (The function for creating learning paths allows teachers to organize content in a logical sequence, guiding students through the steps of a course).

3. Evaluation and progress monitoring

- **Tests and quizzes** (Chamilo offers tools to create a variety of tests, such as multiple choice, true/false, and open-ended questions. The system automatically grades the results and can generate feedback for students).
- **Homework and projects** (Trainers can assign assignments, set due dates, and provide detailed feedback).

4. Communication and cooperation

- **Discussion forums** (Chamilo includes forum modules that promote interaction between students and teachers, creating an environment that fosters collaboration and the exchange of ideas).
- **Chats and messaging** (The platform has real-time communication features that promote direct contact between users).

5. Monitoring and reporting

- **Tracking learner progress** (Chamilo provides detailed information on learner engagement and achievement, helping trainers adjust teaching methods on an ongoing basis).
- **Advanced reports** (The system generates reports summarizing students' performance, allowing analysis of course effectiveness and decision-making for course modifications).

6. User management

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- **Roles and permissions** (Chamilo supports various user roles (administrators, trainers, participants) that can be flexibly customized to meet the needs of educational institutions).

7. Multimedia integration

- **Media support** (The platform allows for the integration of multimedia content, such as video, audio files or interactive elements, which enriches the learning experience).

8. Compliance with standards

- **SCORM** (Chamilo is compliant with the SCORM 1.2 standard, allowing for easy import and export of educational materials).

9. Adaptation and expansion

- **Open source** (With open source code, users can customize the system to suit their individual needs).
- **Extensions and plug-ins** (Chamilo supports add-on modules, allowing users to add new features and integrate with external applications).

10. Accessibility and usability

- **Friendly interface** (Chamilo features intuitive navigation and clear icons, making the platform easy to use for both trainers and participants).
- **Multi-language support** (The platform supports multiple languages, making it suitable for users from different regions of the world).

The training module provides users with access to educational content, quizzes, exercises and communication functions. Integration with Chamilo's LMS enables full implementation of the course curriculum and management of learning activities.

4.7.2 Implementation of communication functionalities on the platform for all roles (views using the Training Provider and Employer roles as examples) - chat

Interactive communication tools:

The system allows communication between trainers and participants via chat, forum, and teleconferencing, which fosters interaction and supports the learning process. A built-in messaging system allows notifications and reminders to be sent about upcoming tasks or deadlines, which motivates participants to complete the course. Trainers can respond to participants' questions in real time, allowing them to respond quickly to difficulties that arise.

Direct 1:1 communication in the form of chat between users

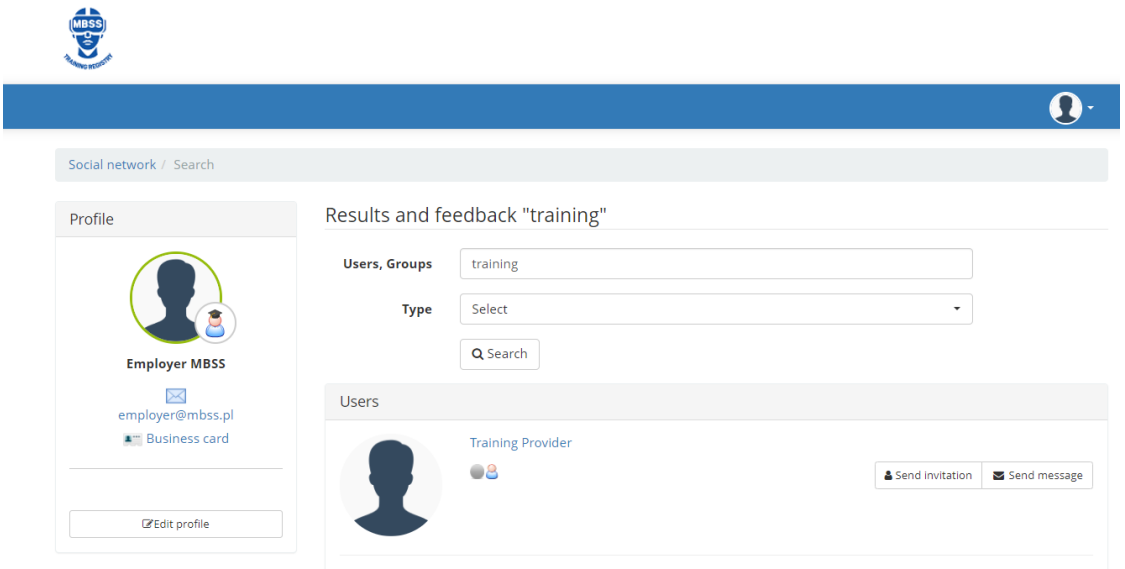

Figure 29 In the profile view, search for and invite another user (using the Employer role as an example)

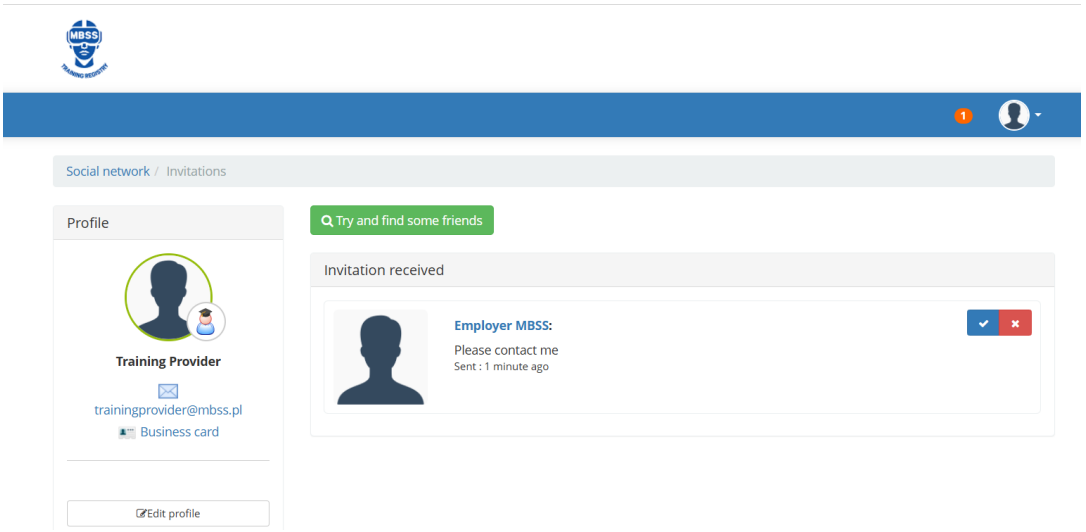

Figure 30 Confirmation of an invitation by another user

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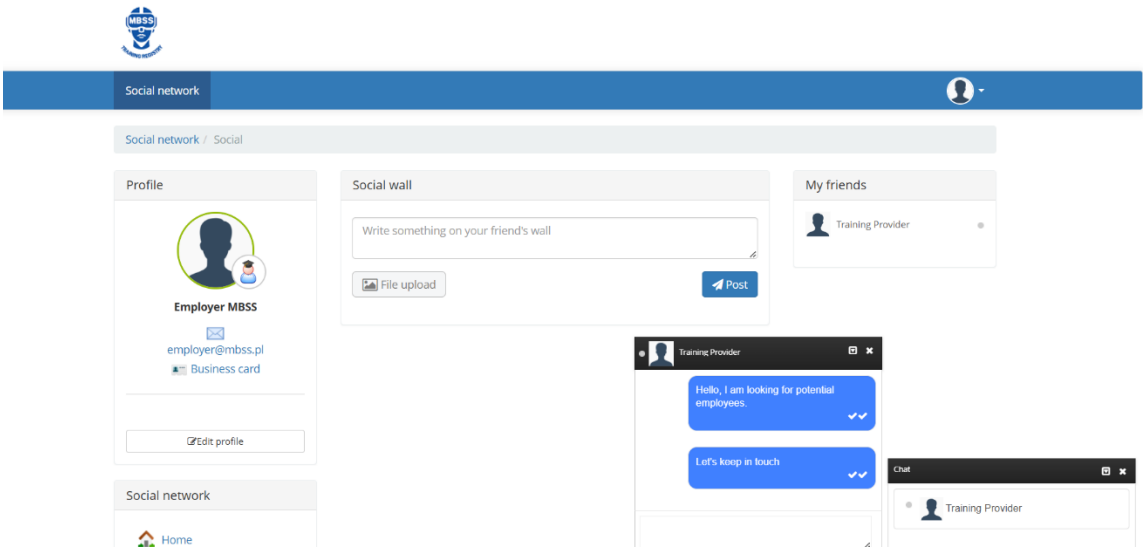

Figure 31 Example of communication between users (Employer and Training Provider)

4.7.3 Implementation of communication functionalities on the platform for all roles (views on the example of the roles Training Provider and Employer) - discussion forum

Communication functionalities (chat, forum, teleconferencing), with individually assigned access for users)

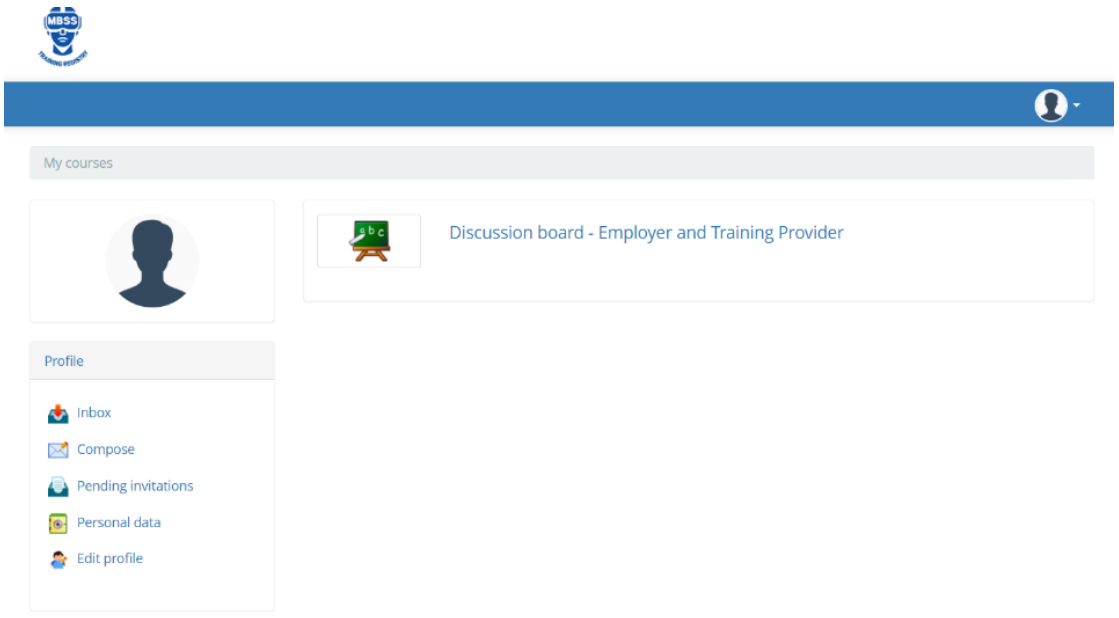

Figure 32 Entering the course view (communication functionalities

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Direct communication between users through a discussion forum

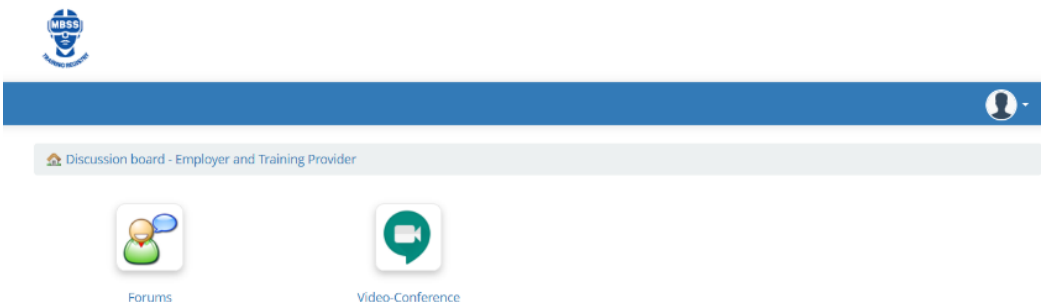

Figure 33 Action: selecting the forum tool from the course view by Training Provider or Employer

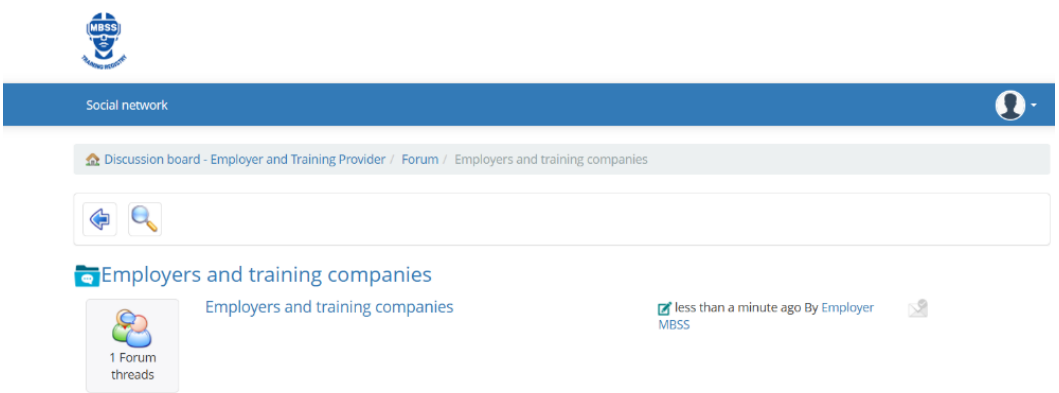

Figure 34 Switching to the view of the discussion forum category (e.g. Employers and training companies) and forum (Company is looking for employees).

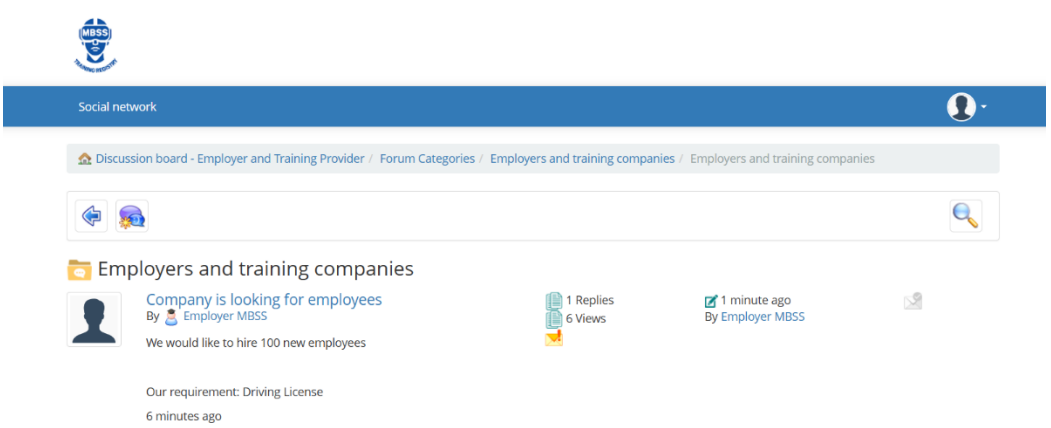

Figure 35 Switching to the detailed view of the forum - view of the threads

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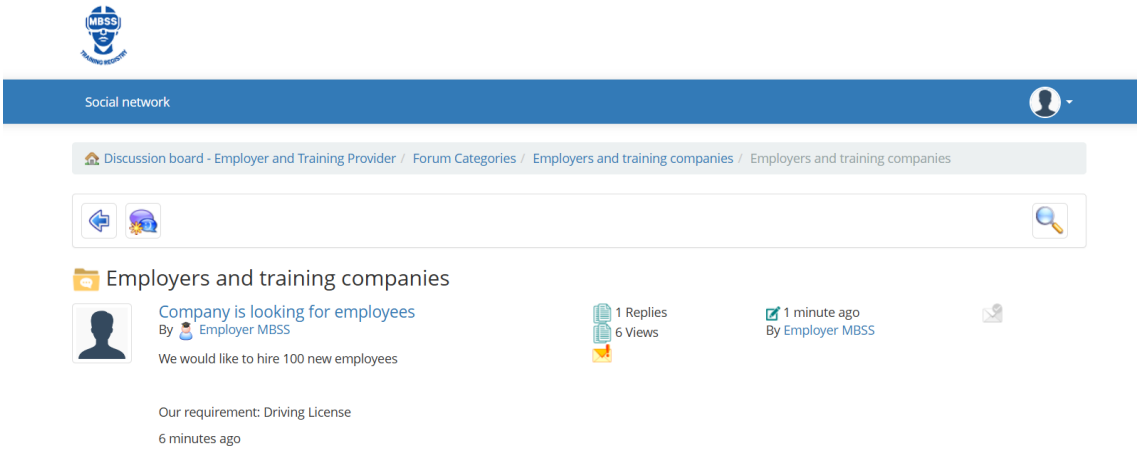

Figure 36 Switching to the detailed view of the forum - view of the threads

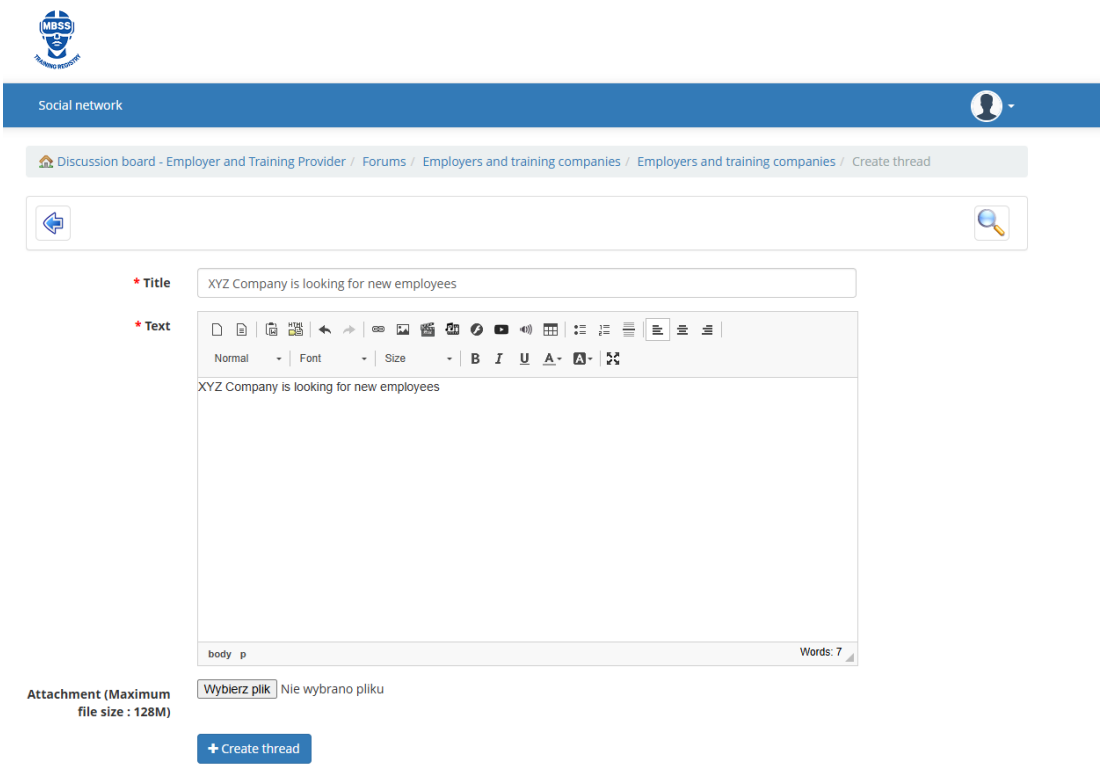

Figure 37 Moving to the detailed view of the forum - Creating a new thread (Employer)

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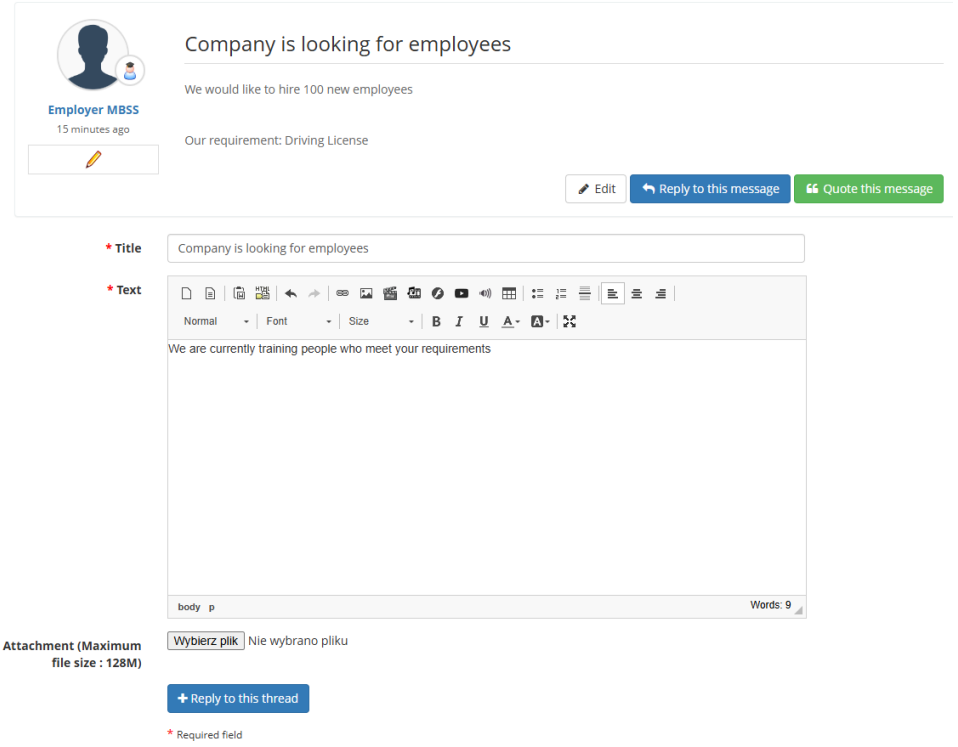

Figure 38 Moving to the detailed view of the forum - Replying in a thread (Training Service Provider)

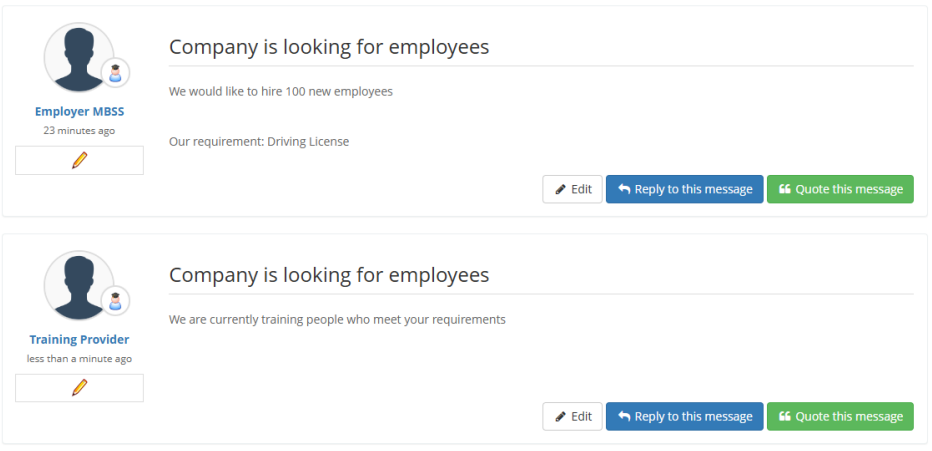

Figure 39 Moving to the detailed view of the forum - View of the thread after adding a reply (Service Provider)

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4.7.4 Implementation of communication functionalities on the platform for all roles (views using the Training Provider and Employer roles as examples) - video conferencing

Direct communication between users via video conference

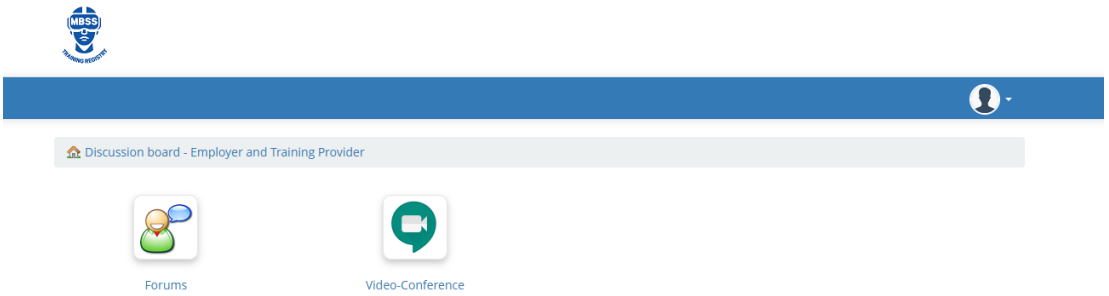

Figure 40 Moving to the video conferencing tab from the main course view

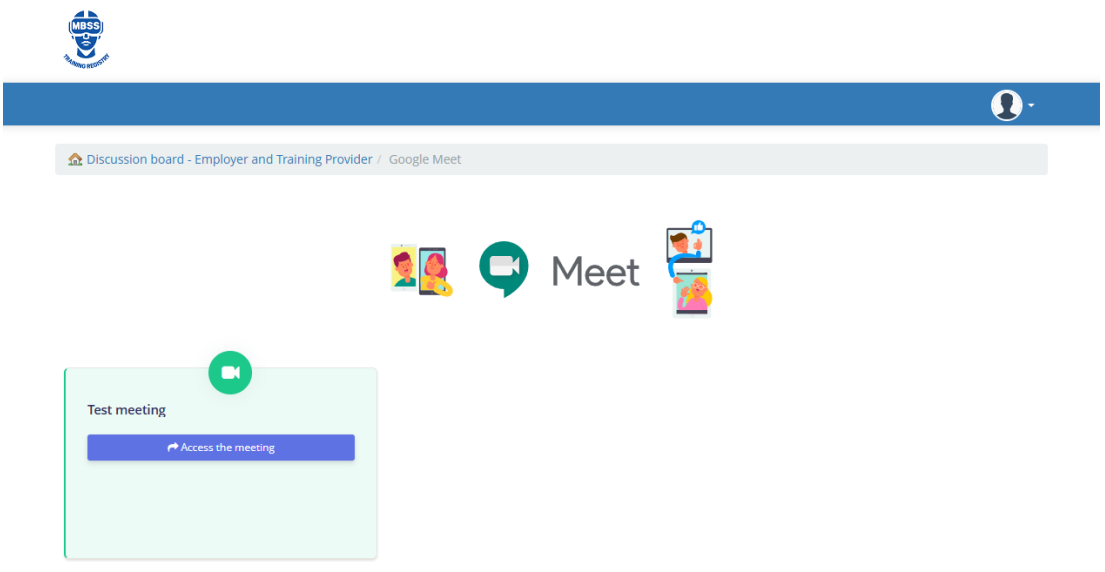

Figure 41 Starting a meeting by clicking a button (Google Meet platform)

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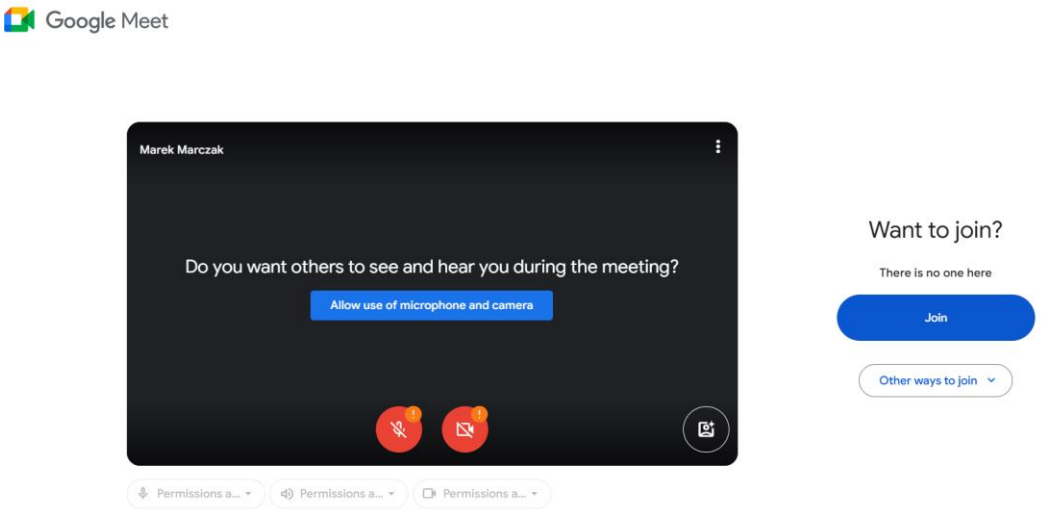

Figure 42 Starting a meeting by clicking a button (Google Meet platform)

4.7.5 Implementation of posting educational materials on the platform by the Trainer for trainees

1. Management of educational content and materials:

Providers have the ability to add educational content such as presentations, audio recordings, videos, tests, PDF documents and interactive exercises. Educational materials can be made available to participants directly through Chamilo's LMS or embedded as external resources. The system also allows providers to update course materials at any time. Updated content is automatically synchronized with user accounts.

2. Creation and organization of courses:

Providers can create courses that include a variety of content: presentations, documents, videos, interactive exercises and quizzes. Courses can be divided into thematic modules that are accessed in a specific order, allowing participants to complete the course in stages. Trainers can grant individual access to materials or group participants to customize content for specific groups.

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Posting of text and multimedia materials on the LMS platform by the trainer

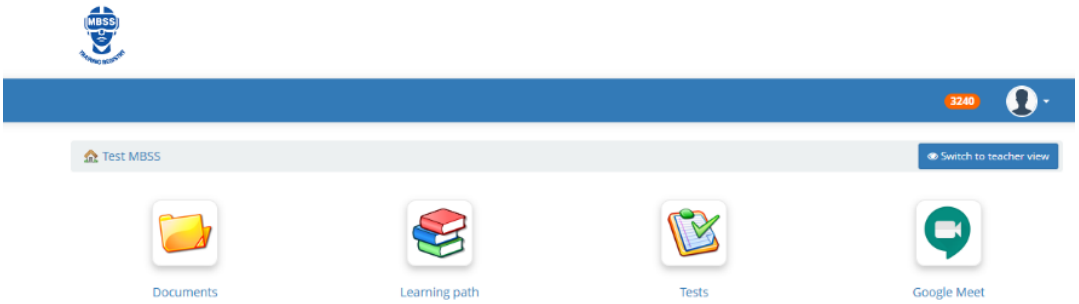

Figure 43 Entering the course detail view

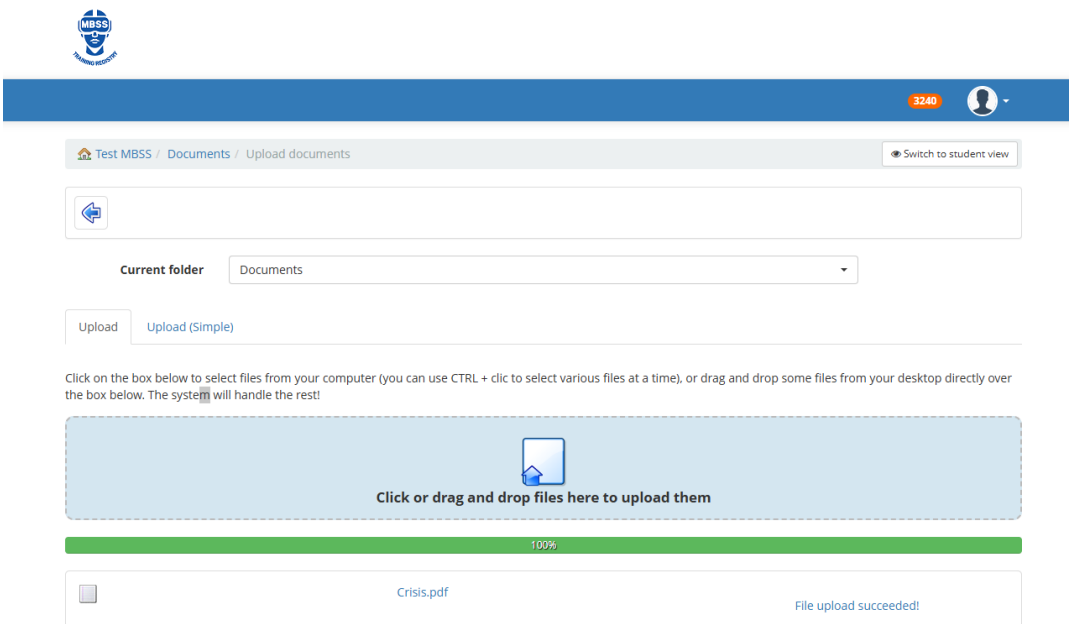

Figure 44 Transferring files

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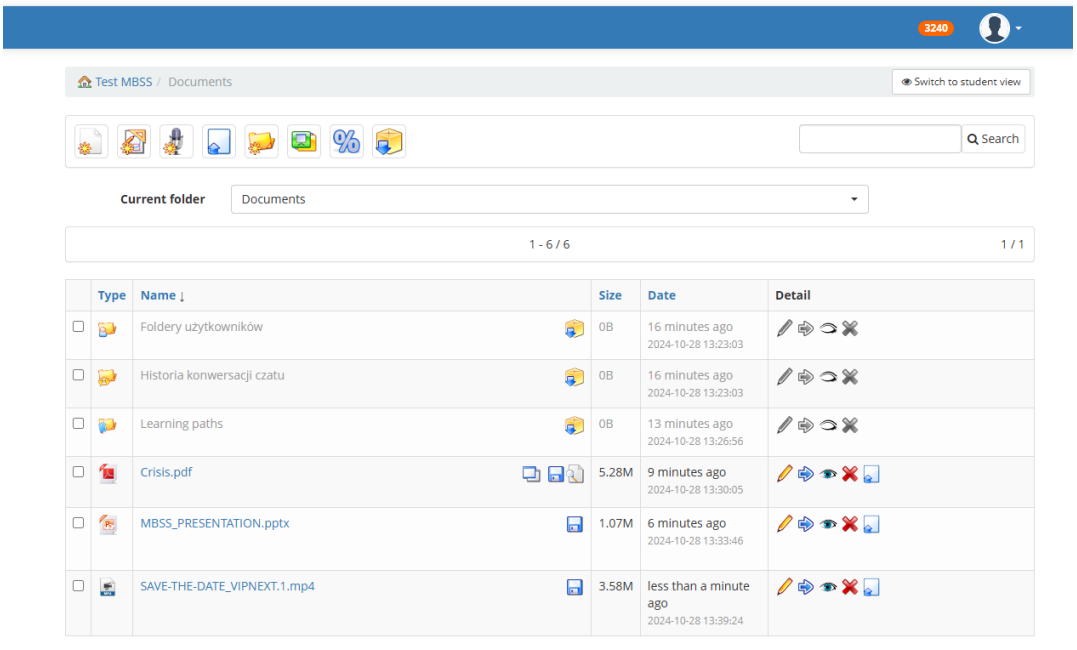

Figure 45 Posting files of various types: text, graphics and multimedia

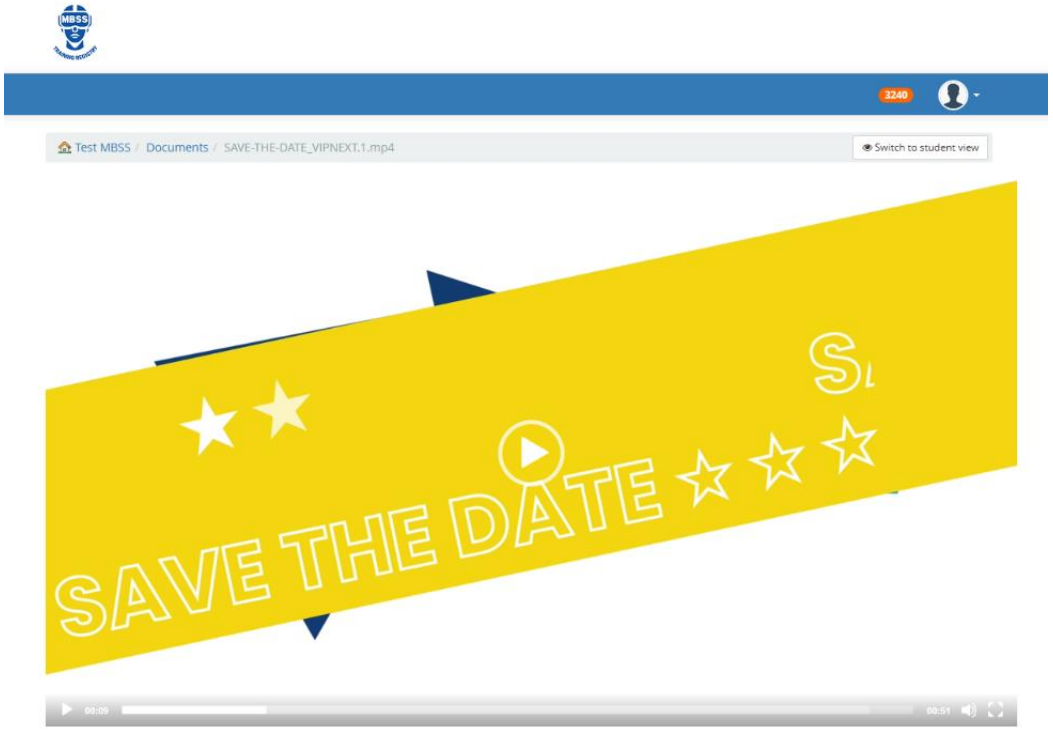

Figure 46 File playback (multimedia)

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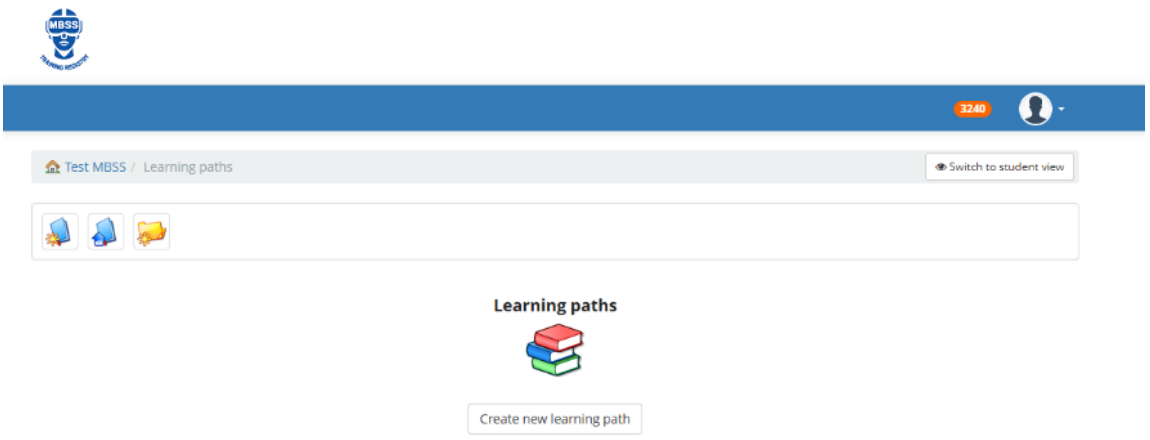

Figure 47 posting learning paths and SCORM files (exercises)

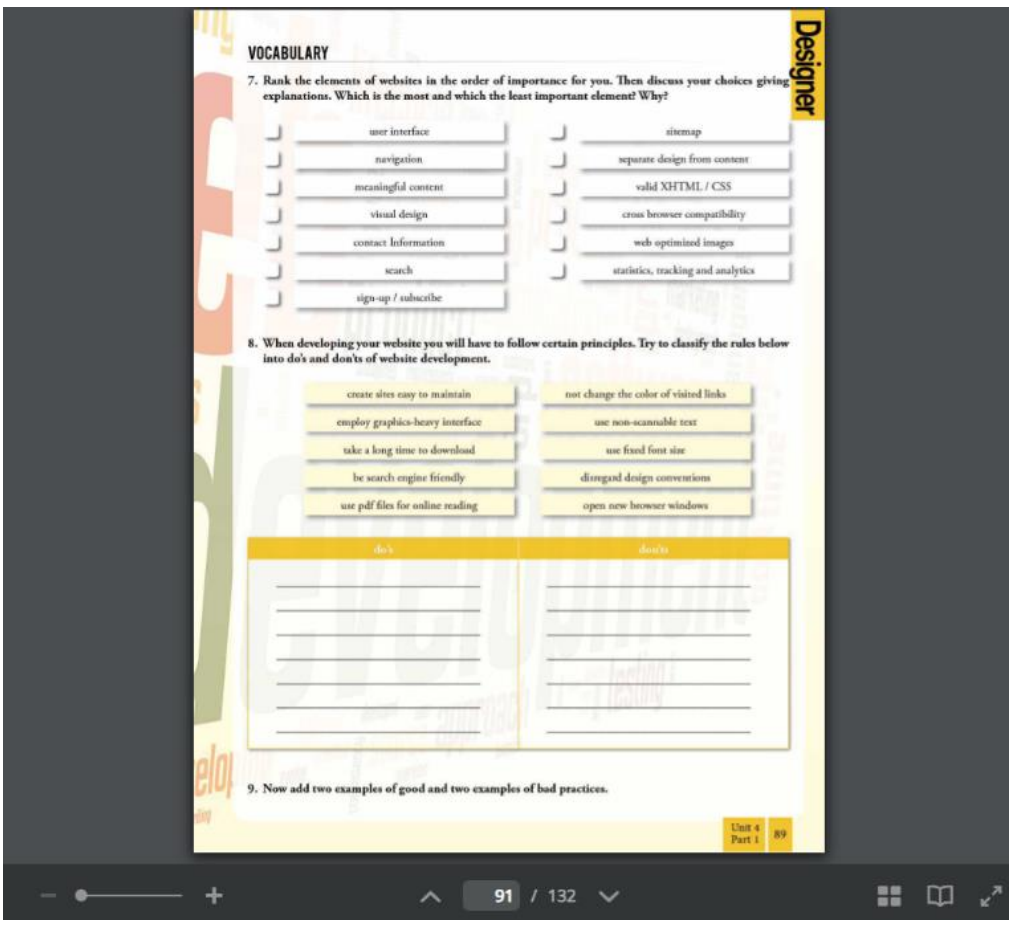

Figure 48 display of materials in SCORM format (trainee)

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Publishing tests on the LMS platform by the trainer

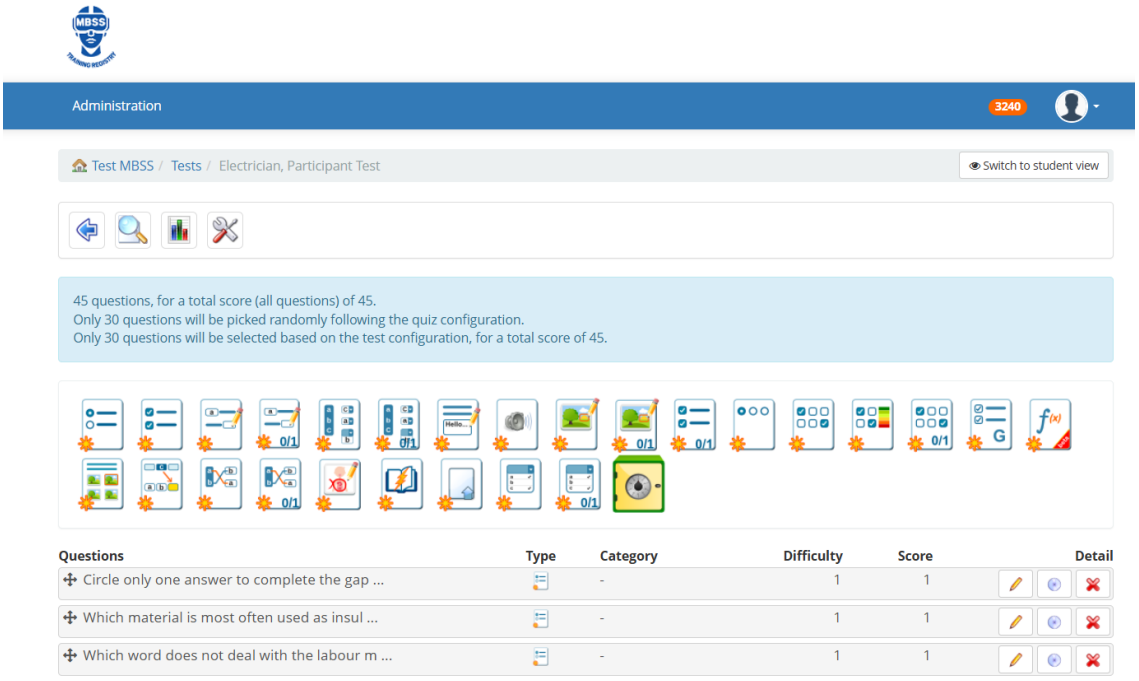

Figure 49 Test editing view (trainer)

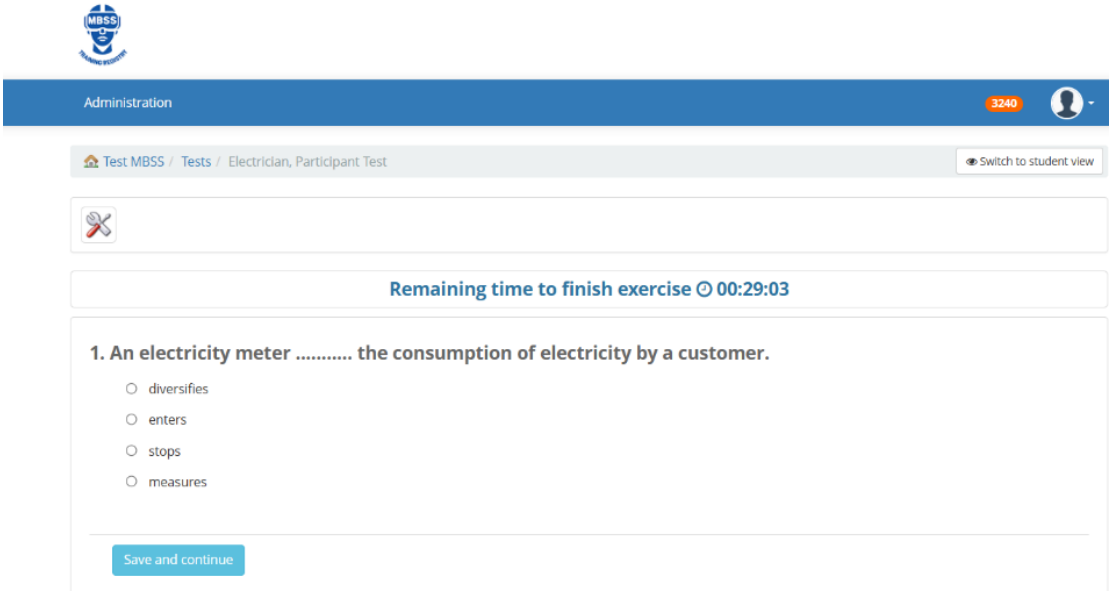

Figure 50 View of the test (trainee)

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4.7.6 Monitoring of participants' progress by the trainer

Tracking user progress - Trainer

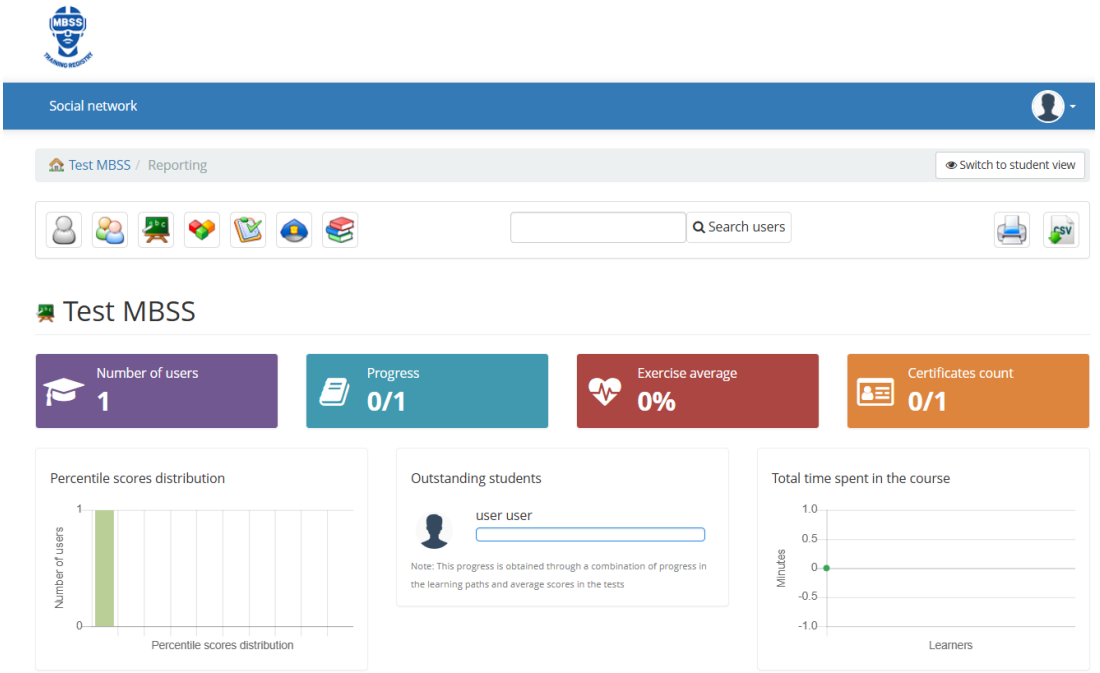

Figure 51 summaries of user activities in the course

Tracking one's own progress - participant

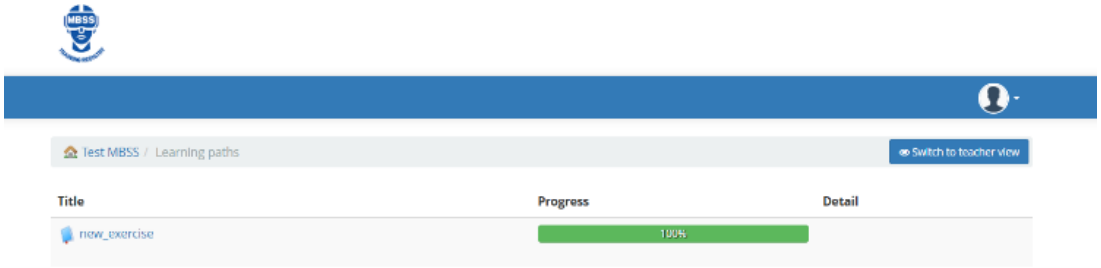

Figure 52 monitoring progress in the learning pathway

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4.7.7 Providing support to trainees through a chat module

Interaction with trainees, including answering questions (chat)

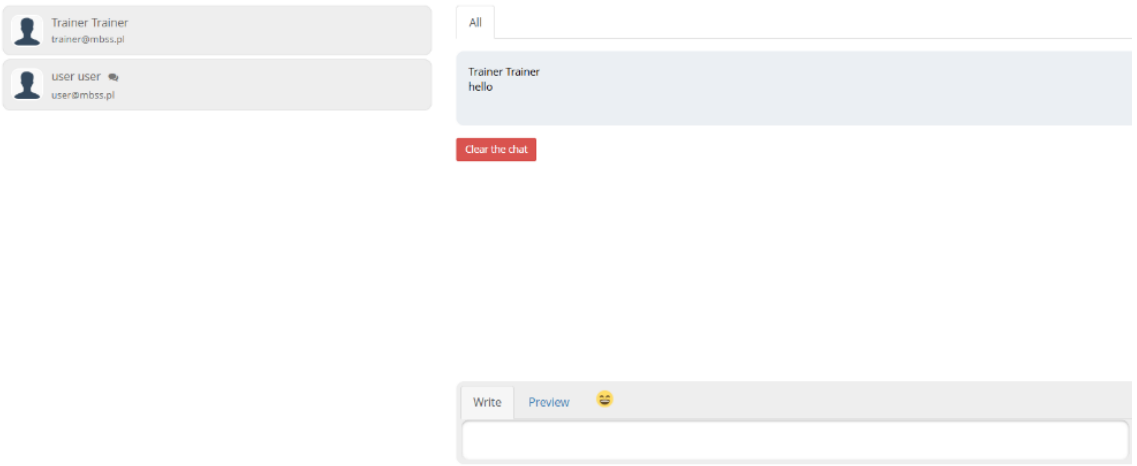

Figure 53 Summary of user activities in the course

4.8 Administration Panel (AP)

The administration panel is a tool for the super admin available in Strapi CMS, allowing to supervise all system functions, manage users and their roles, as well as monitor content and ensure security.

Superadmin has the ability to manage users and their roles, including adding, editing and deleting accounts, as well as assigning appropriate roles. The administration panel allows blocking users and granting them permissions to selected functions or sections of the system. In addition, the superadmin has access to the users' activity log, which allows him to track their activities and resolve any problems. In terms of moderation and content management, the superadmin can approve or reject training offers, monitor content added by suppliers, and moderate forum and chat posts, ensuring a friendly environment for users. The system also provides the ability to manage files and educational materials, allowing control over published resources. Superadmin has full access to security settings, such as SSO configuration, authentication settings and user session management. The administration panel also allows configuration of system settings, such as registration parameters, email settings and storage regulations.

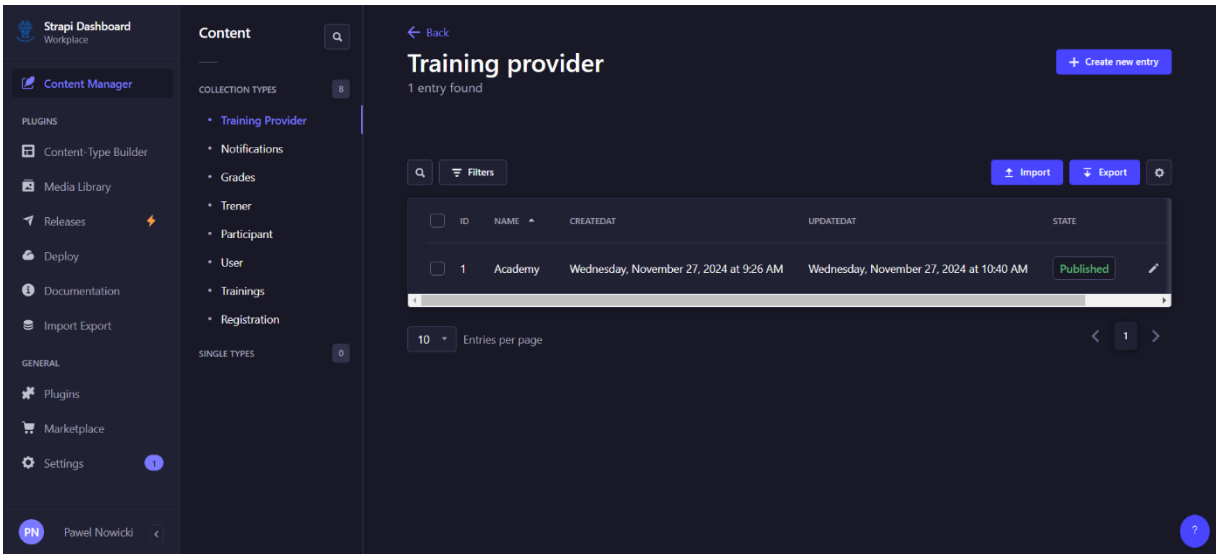

Figure 54 View of the edit panel for training providers

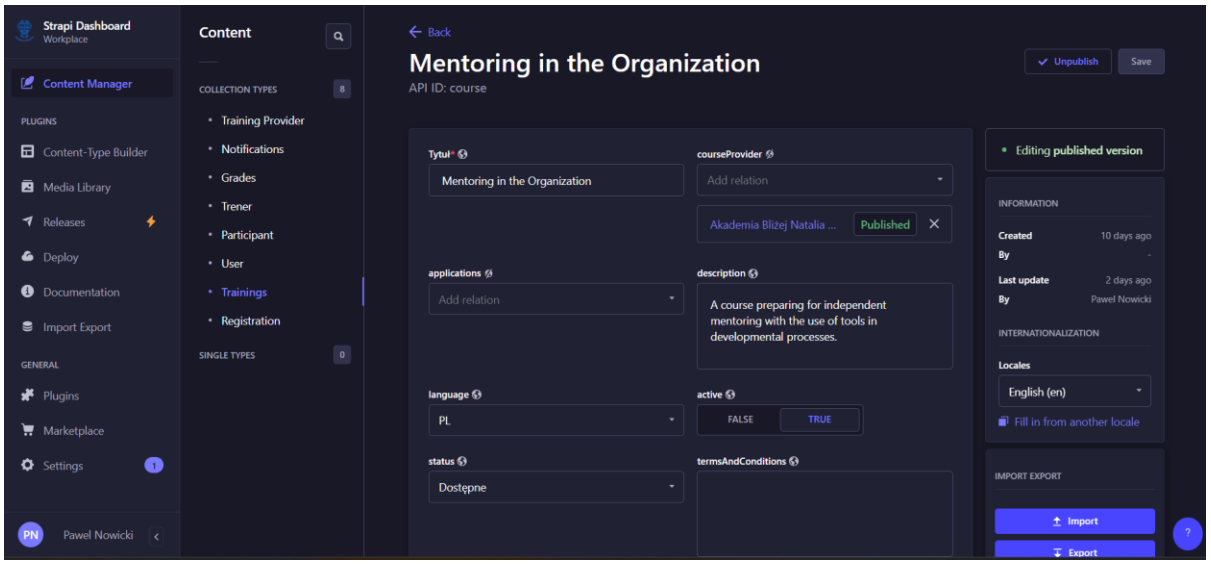

Figure 55 View of editing training modules

4.9 Analytics and reporting module

The analytics and reporting module enables the creation of reports, supporting decision-making and platform improvement. User reports provide information on the number of active users, the number of course enrollments, the average number of logins per user, and the most frequently viewed offers. They also include data on course evaluations, average satisfaction levels and the effectiveness of individual trainers. In the course and content reports area, the superadmin and trainers have insight

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into the effectiveness of the courses by analyzing participants' completion rates, the average number of quizzes completed successfully, and user engagement. In addition, the analysis of training content supports providers in customizing materials to meet the needs of participants, resulting in more attractive courses. The system's functional modules have been designed with different user groups in mind, providing them with access to dedicated tools to support task completion. Thanks to the integration with the Chamilo LMS, users can take advantage of advanced educational functions, allowing the platform to fully exploit its potential as both an educational tool and a competence management system.

4.10 Summary

The system's functional modules have been designed with different user groups in mind, each of which has access to dedicated functions and tools to support task completion. Thanks to the integration with the LMS Chamilo, users have access to advanced educational tools, which enables the platform to fully exploit its potential as an educational and competence management tool.

5. API integration

API integration plays a key role in the system's architecture, enabling the exchange of data between major components such as the frontend, Strapi CMS backend, and Chamilo LMS. The API (Application Programming Interface) provides flexibility and modularity, enabling easy integration of new functionality and integration with external systems such as learning platforms, analytics tools, or mobile applications.

5.1 API integration goals

The API integration is designed to:

1. **Enable unified access to data:** Provide access to resources in a way that is secure, flexible and consistent with functional and non-functional requirements.
2. **Facilitate communication between components:** An API connects the frontend to the backend and LMS, ensuring seamless system operation and real-time data synchronization.
3. **Support for external integration:** Provide public and private API endpoints that enable the system to integrate with external applications, such as analytics systems, CRM or other learning platforms.

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5.2 API structure

The system provides various types of APIs, which include:

1. **REST API:** The main method of communication between the frontend and backend. REST API is used to transfer data such as user registration, login, viewing offers, managing training materials, etc. REST API is lightweight, flexible and adapted to the requirements of modern web applications.
2. **Authentication API:** the authentication module works on the principle of JWT (JSON Web Token), which provides secure login and authorization for user access to various resources.
3. **SSO Integration:** The SSO integration API between the main application and Chamilo's LMS allows users to log in automatically, eliminating the need for re-authorization.

5.3 Backend API (Strapi CMS)

Strapi CMS acts as a backend for the application and manages user data, training offers and other resources. Strapi CMS provides the following key API endpoints:

1. **Selected Strapi endpoints**

1. /api/course

- **Opis:** Endpoint for Course Management (Course).
- **Actions:**
    - GET /api/course - Get a list of all courses.
    - GET /api/course/:id - Get the details of the selected course.
    - POST /api/course - Add a new course.
    - PUT /api/course/:id - Update the course information.
    - DELETE /api/course/:id - Delete the course.

2. /api/course-application

- **Opis:** Endpoint for managing course applications (Course Application).
- **Actions:**

- GET /api/course-application - Get the list of applications.
- GET /api/course-application/:id - Get the details of a specific application.
- POST /api/course-application - Add a new course application.
- PUT /api/course-application/:id - Update the application.
- DELETE /api/course-application/:id - Delete a submission.

3. /api/course-provider

- **Opis:** Endpoint for Course Provider Management (Course Provider).
- **Actions:**
  - GET /api/course-provider - Get the list of course providers.
  - GET /api/course-provider/:id - Get the details of a provider.
  - POST /api/course-provider - Add a new course provider.
  - PUT /api/course-provider/:id - Update the provider information.
  - DELETE /api/course-provider/:id - Delete a provider.

4. /api/notification

- **Opis:** Endpoint to manage notifications (Notification).
- **Actions:**
  - GET /api/notification - Get all notifications.
  - POST /api/notification - Send a new notification.
  - DELETE /api/notification/:id - Delete a notification.

5. /api/participant

- **Opis:** Endpoint for participant management (Participant).
- **Actions:**
  - GET /api/participant - Get the list of participants.
  - GET /api/participant/:id - Get the details of a participant.

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- POST /api/participant - Add a new participant.
- PUT /api/participant/:id - Update the participant's details.
- DELETE /api/participant/:id - Delete a participant.

6. /api/rating

- **Opis:** Endpoint for managing course evaluations (Rating).
- **Actions:**
  - GET /api/rating - Get a list of ratings.
  - POST /api/rating - Add a course rating.
  - DELETE /api/rating/:id - Delete a rating.

7. /api/trener

- **Opis:** Endpoint for Trainer Management (Trainer).
- **Actions:**
  - GET /api/trainer - Download the list of trainers.
  - GET /api/trainer/:id - Get the details of a trainer.
  - POST /api/trainer - Add a new trainer.
  - PUT /api/trainer/:id - Update the details of a trainer.
  - DELETE /api/trainer/:id - Delete a trainer.

8. /api/plugin/content-type-builder

- **Opis:** Endpoint for managing content types in the system (Content Types Builder).
- **Actions:**
  - GET /api/plugin/content-type-builder - Get content type configurations.
  - POST /api /plugin/content-type-builder - Add a new content type.

9. /api/plugin/email

- **Opis:** Endpoint to handle email dispatch (Email).

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- **Actions:**
    - POST /api /plugin/email - Send an email message.

10. /api/plugin/i18n

- **Opis:** Endpoint for handling multilingualism (Internationalization).
- **Actions:**
    - GET /api/plugin/i18n - Get the list of available languages.
    - POST /api/plugin/i18n - Add a new language.

11. /api/plugin/import-export-entries

- **Opis:** Endpoint for importing and exporting data (Import Export Entries).
- **Actions:**
    - POST /api/plugin/import-export-entries/import - Importuj dane.
    - POST /api/plugin/import-export-entries/export - Eksportuj dane.

12. /api/plugin/upload

- **Opis:** Endpoint for Upload management.
- **Actions:**
    - POST /api/plugin/upload - Upload a new file.
    - GET /api/plugin/upload - Get a list of uploaded files.
    - DELETE /api/plugin/upload/:id - Delete a file.

13. /plugin/users-permissions

- **Opis:** Endpoint for managing users and permissions (Users Permissions).
- **Actions:**
    - GET /plugin/users-permissions - Get a list of users.
    - POST /plugin/users-permissions - Add a new user.
    - PUT /plugin/users-permissions/:id - Update user information.

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- DELETE /plugin/users-permissions/:id - Delete a user.

5.4 API LMS Chamilo

Integration with Chamilo's LMS is via a REST API and an SSO mechanism that allows users to automatically log in to the LMS. Key endpoints include:

1. **User synchronization endpoints**:
    - **POST /lms/users/sync:** Endpoint enables synchronization of user data between the main application and LMS Chamilo. Each newly registered user automatically gets an account in LMS Chamilo.
    - **PATCH /lms/users/update:** This endpoint allows user data to be updated, e.g. in case of password changes or profile data updates.
2. **Endpoints of courses and educational materials**:
    - **GET /lms/courses:** Provides a list of courses available in Chamilo's LMS. This provides users with a complete view of current educational offers.
    - **POST /lms/courses/resources:** Endpoint allows users to add learning resources to existing courses in LMS Chamilo.
    - **GET /lms/courses/progress:** Provides data on the progress of course participants, which is useful for monitoring their activity.
3. **Endpoints of communication tools**:
    - **POST /lms/courses/chat:** Allows users to use the chat feature within the course.
    - **POST /lms/courses/forum:** Allows users to create posts and make comments within the course's forum to encourage interaction between participants.

5.5 API integration security

The system's API is designed with security in mind. Each endpoint requires an appropriate level of authorization, and access to resources is controlled by authentication and authorization mechanisms such as:

1. **JWT (JSON Web Token):** Each user, upon logging in, receives a JWT token, which is required to use secure API endpoints. The JWT token is stored on the client side and sent in HTTP headers with each request.
2. **HTTPS:** All communication between the frontend, backend and LMS Chamilo is encrypted with HTTPS to protect data from interception.
3. **Access control and role segmentation:** Each endpoint is secured based on user role, so that only authorized users have access to certain functions.

5.6 Scalability and API optimization

The system's API is optimized for performance, and the architecture allows for scaling according to growing workloads. Among the key solutions are:

1. **Caching:** Selected API endpoints use caching, which minimizes the number of database queries. The cache is stored in Amazon ElastiCache, allowing quick access to frequently used data.
2. **Query Limiting:** The API has limits set on the number of queries from a single source in a certain period of time to prevent system overload.
3. **Pagination, filtering and sorting:** Most endpoints, such as user or course lists, offer pagination, filtering and sorting functions for results, allowing for efficient processing of large data sets.

5.7 Summary

API integration enables seamless communication between the frontend, backend and Chamilo's LMS, ensuring smooth system operation and access to educational resources. With proper security, scalability and optimization, the system's API is prepared to handle large numbers of users in a secure and efficient manner, and is ready for future expansions.

6. Compatibility with ELM and microcredentials

The ICT system is designed to support the European Learning Model (ELM) and microcredentials standards, which allow users to document their achievements and skills in a way that is recognized in the labor market. Microcredentials are digital badges awarded for completing courses or obtaining competencies that can be displayed on resumes, on professional portals such as LinkedIn, and as proof of course completion.

6.1 European Learning Model (ELM)

The European Learning Model (ELM) is an initiative to standardize the system for validating skills and qualifications in Europe so that they are internationally recognized. Through compliance with the ELM, the system:

1. **Enables validation of skills:** Offers course providers and employers the ability to create ELM-compliant courses, meaning that each course can be assigned to a specific level of professional qualification in the European Qualifications Framework (EQF).

2. **Ensures recognition and transparency of qualifications:** With ELM-compliant standardization, the certificates and micro-credentials awarded to users upon course completion are easier to recognize and evaluate by employers and institutions across Europe.

3. **Supports integration with other educational systems:** The ELM standard enables integration with learning management systems (LMS) and, in the future, potentially with professional qualification databases, which contributes to an easier flow of information about users' achievements.

6.2 Definition of microcredentials

Microcredentials are digital badges awarded to users for achievements, skills or qualifications acquired through participation in courses. Microcredentials contain detailed information such as a description of the skill, prerequisites, date of award, and information about the awarding organization. With microcredentials, users can:

1. **Showcase achievements on professional platforms:** Microcredentials can be easily added to a professional profile on sites such as LinkedIn or attached to a resume.

2. **Document and monitor competence development:** The system stores a history of microcredentials earned, allowing users to track their progress and provide evidence of skills gained.

3. **Obtain EQF-compliant certifications:** Each Microcredential is assigned to the appropriate level of the European Qualifications Framework, allowing users to obtain internationally recognized digital badges.

6.3 Implementation of the Open Badge 3.0 standard

The Open Badge 3.0 standard is a modern solution for digitally documenting educational and professional achievements in the form of microcredentials. Thanks to its implementation, the ICT system gains the ability to generate, manage and share digital badges compliant with the global standard, which increases their recognition and interoperability in educational environments and the labor market.

6.3.1 Key features of Open Badge 3.0

1. **Interoperability**:
    - Badges generated with the Open Badge 3.0 standard are compatible with other systems and platforms that support the standard. This allows users to easily transfer their achievements between educational systems, professional platforms and digital portfolios.
2. **Data structure**:
    - Badges are represented in JSON-LD (Linked Data) format, which allows the badge data to be semantically linked to other sources, enabling the creation of more extensive information networks.
3. **Expandability**:
    - Open Badge 3.0 allows custom fields to be added to badges, such as detailed descriptions of competencies, test scores or organizer data, which can be tailored to the specific needs of the system.
4. **Security and verification**:
    - Badges contain a digital signature that allows recipients to verify their authenticity and integrity. Each badge is associated with a unique identifier and source, eliminating the possibility of forgery.

6.3.2 Stages of implementation of the Open Badge 3.0 standard in the system

1. Badge structure design

Microcredentials data:

Title: Name of the Microcredential.

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Description: A brief description of the achievement or skill.

Date of issue: Date when the credential was granted.

Period of validity (if applicable): Information on the validity period of the Microcredential.

Issuer data:

Name of the organization: Full name of the institution that issued the microcredential.

Contact information: Email address or link to the issuer's website.

Unique issuer identifier: A code to uniquely identify the organization.

Recipient data:

Name: Data of the person who received the microcredential.

Unique identifier: (optional, according to RODO rules) e.g. ID number in the issuer's system.

Requirements and verification process:

Criteria: What the recipient had to do to earn the microcredential (e.g., completing a course, passing an exam).

Technical information:

Unique microcredential identifier (URI): A link to a digital version of the credential, allowing it to be verified online.

Data format: JSON-LD compliant with the Verifiable Credentials Data Model.

Links to qualification frameworks:

Level in the EQF (European Qualifications Framework): If applicable, indication of level (e.g. EQF 4).

ECTS (European Credit Transfer and Accumulation System): The number of credit points assigned for achievement (optional).

Security and verification:

Digital Signature: A cryptographic mechanism to ensure the authenticity of a credential.

Validator: A link or online tool to verify a microcredential.

3. Badge storage

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- **Database**:
    - Information about each badge generated is stored in a PostgreSQL database for later editing, export and synchronization with user profiles.
    - Data such as badge award time, related courses and EQF level are indexed, allowing for quick searching and filtering.

4. Export and external integration

- **Support for digital wallets**:
    - Users can export their badges to popular educational portfolios, such as Mozilla Backpack, Open Badge Passport or other applications that support the Open Badge 3.0 standard.
    - The system generates a link to the badge that can be shared on professional platforms (e.g., LinkedIn) or in online resumes.
- **API integration**:
    - The system provides an endpoint API that allows external applications, such as LMS systems, to access and verify badge data.
    - Example of an API for badge retrieval:
        - **GET /api/badges/**
        - Returns badge details in JSON-LD format, including information about the criteria, organizer, and related qualifications.

5. Verification of authenticity

- **Digital signature**:
    - Each badge is digitally signed using the course organizer's private key. Verification of the signature is done using a public key, allowing recipients (e.g., employers) to confirm the authenticity of the badge.
- **Verification portal**:
    - The system provides a website where employers or other interested parties can enter the badge ID and verify its authenticity and details.

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Benefits of Open Badge 3.0 implementation

1. **Increase recognition of achievements**:
    - Users can present their badges on international educational and professional platforms, increasing their value in the job market.
2. **Easy verification and transparency**:
    - A digital signature and unique badge identifier ensure the reliability and integrity of the information.
3. **Flexibility and forward-looking adaptation**:
    - With the ability to extend data in JSON-LD format, the system can easily adapt to new requirements and integrate with new platforms.
4. **Support for competence development**:
    - With Open Badge 3.0-compliant microcredentials, users can systematically document their achievements and plan their professional development.

6.4 The process of granting microcredentials

The process of granting microcredentials in the system is automated and includes the following steps:

1. **Defining the requirements**:
    - Course providers, in accordance with ELM guidelines, define course requirements for earning a microcredential. Requirements may include achieving a certain score, completing a knowledge test, passing a practical exercise, or participating in a certain number of training hours.
    - Each course may have different levels of microcredentials assigned to it, making it possible to earn basic or advanced badges depending on the level of the course.
2. **Course implementation and scoring**:
    - The system tracks users' progress on the course, monitoring their activity and performance on quizzes and assignments.

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- Participants earn points based on their engagement, test scores, and completion of individual modules, which influences the awarding of microcredentials.
- Upon completion of the course with a score that meets the established requirements, the system awards a microcredential to the user.

3. **Granting and storage of microcredential**:
   - After completing the course and meeting the required criteria, the user receives microcredentials in the form of digital badges.
   - Each microcredential is saved in the user's account and is available in the achievement history, where details of earned badges can be viewed.
   - The system automatically generates badges that comply with the Open Badges standard, making them easy to store and export to external professional and educational applications.

6.5 Microcredentials security features

1. **Encryption and data integrity**:
   - All microcredentials are stored on secure servers and encrypted with HTTPS to ensure their protection from unauthorized access.
   - Each microcredential is assigned to an individual user ID, eliminating the risk of impersonation.
2. **Digital signature and authenticity**:
   - Microcredentials are generated with the course provider's digital signature to ensure their authenticity. Employers and other institutions can verify that the badge came from a trusted source.
   - The system stores a history of microcredentials awarded, so it is possible to see when a badge was awarded and by whom.
3. **Data privacy in compliance with RODO**:

- The system is compliant with RODO (GDPR), and user data stored in the system is protected in accordance with applicable regulations. Users have the right to inspect their data, as well as the ability to delete it upon request.

6.6 Verification of microcredentials

The system allows employers and educational organizations to easily verify the authenticity of microcredentials:

1. **Verification code and unique identifier:** Each microcredential has a unique verification code that can be checked in the system to verify its authenticity and details.
2. **Insight into the qualification description and EQF level:** Employers can check the details of the microcredential, including the description of the skills acquired, prerequisites, and assignment to the EQF level, making it easier to assess the candidate's qualifications.

6.7 Summary

Compliant with the European Learning Model and microcredentials standards, the system offers users a modern tool for documenting their educational achievements. With digital badges that can be easily exported to professional and educational platforms, users can effectively showcase their skills and qualifications in the labor market.

7. Deployment and hosting

The implementation and hosting of the ICT system is a key stage of the project, which provides a stable environment for the operation of all components, such as the frontend, backend, LMS Chamilo and PostgreSQL database. The system is designed to be deployed on the AWS cloud platform, which allows flexible resource scaling, load management and data security.

7.1 Deployment process

The implementation process includes preparation, configuration and testing of each component of the system. The entire process is divided into several stages:

1. **Preliminary stage - configuration of the environment**:
    - **Preparation of cloud infrastructure:** Set up a basic cloud infrastructure on AWS, including development, test and production environments. Each of these environments is isolated from the others so that updates can be tested securely.

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- **Setting up a PostgreSQL database on Amazon RDS:** Running a PostgreSQL instance on Amazon RDS with multi-AZ replication, ensuring high availability and secure data storage.
- **Creating code repositories:** Create code repositories in a version control system such as Github, enabling application version management and team collaboration on system development.

2. **Application configuration stage**:
   - **Installing the Strapi CMS backend:** Installation of Strapi CMS on an application server or on a container, allowing for flexible content management on the system. Configuration includes JWT authentication, API endpoint configuration and PostgreSQL database access.
   - **Frontend (React) installation:** Launching the frontend application in a production environment, with configuration tailored for integration with the Strapi backend and LMS Chamilo.
   - **Integration with LMS Chamilo:** Configure LMS Chamilo on a dedicated server or AWS instance, including SSO (Single Sign-On) integration and data synchronization with the main PostgreSQL database.
3. **Testing and validation stage**:
   - **Unit and integration tests:** Conduct unit tests for each component to ensure that all functions are working properly. Integration tests include checking the communication between the frontend, backend, database and Chamilo LMS.
   - **Load and performance testing:** Testing the system for performance to make sure it can handle up to 3,000 concurrent users without performance degradation.
   - **Security testing:** Verifying system security, including JWT authentication, HTTPS encryption and protection against brute force attacks.
4. **The production version implementation stage**:
   - **Migration to production environment:** Once testing is complete, migration of all components to the production environment is performed. The database is replicated from the test version to the production version.

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- **Monitoring and support:** Monitoring is set up in Amazon CloudWatch to track system performance, monitor traffic and detect any problems in real time.

7.2 AWS cloud hosting

The AWS (Amazon Web Services) platform offers comprehensive hosting and system management solutions that provide a high level of security, flexibility and reliability.

1. **Backend and database hosting**:
    - **Amazon RDS for PostgreSQL:** The database is hosted on Amazon RDS with Multi-AZ replication, which guarantees high availability and protection of data from failures.
    - **Strapi CMS backend hosting:** The backend is deployed on an EC2 server or in Docker containers managed by Amazon ECS (Elastic Container Service), allowing automatic scaling and easy management of the application environment.
2. **Frontend and Chamilo LMS hosting**:
    - **Amazon S3 and CloudFront:** The static files of the frontend (React) are stored on Amazon S3, which allows for fast loading of resources using a CDN (CloudFront). This solution provides optimal performance and minimizes loading times for users worldwide.
    - **Amazon EC2 or Elastic Beanstalk for LMS Chamilo:** LMS Chamilo is hosted on EC2 or Elastic Beanstalk, which provides flexibility in resource management and automatic scaling in case of increased traffic.
3. **Flexibility and scalability**:
    - **Auto Scaling:** AWS Auto Scaling monitors server load and automatically adds or removes resources as needed. This is especially important during busy periods.
    - **Load Balancer:** AWS Elastic Load Balancer balances the load between server instances for even traffic distribution and optimal system performance..

7.3 Security and access management

1. **Data encryption**:

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- **Encryption:** Data is stored in Amazon RDS and secured with a KMS authorization key, and communication between the frontend, backend and database is secured with HTTPS.
- **JWT tokens:** Users are authenticated with JWT tokens, which are generated at login and encrypted to ensure the security of the user session.

2. **Access control and IAM**:
   - **AWS IAM (Identity and Access Management):** Access to resources is controlled by IAM, which allows users to be assigned precise permissions. Each system administrator and application component has access only to specific resources, according to security policies.
   - **VPC (Virtual Private Cloud):** The entire system runs in an isolated VPC environment, which provides an additional layer of protection against external access.

7.4 Data backups and restoration

1. **Automatic backups**:
   - **Amazon RDS:** Automatically backs up the database every day and the ability to set up so-called snapshots, which store full copies of data. AWS RDS also allows recovery of data from a specific point in time.
   - **AWS S3:** All static frontend files and learning resources stored on Chamilo's LMS are backed up to Amazon S3, allowing for quick recovery when needed.
2. **Data restoration strategy**:
   - **Recovery procedures:** In the event of a system failure or security breach, the recovery procedure includes restoring from the latest RDS snapshots and resources on Amazon S3. The recovery plan is regularly tested to ensure its effectiveness.

7.5 Maintenance and updates

1. **Application and component updates**:
   - **Regular updates to Strapi CMS and React:** Backend and frontend updates are performed in a test environment before deployment to production to prevent bugs and ensure compatibility with new features.

- **LMS Chamilo updates:** The technical team monitors LMS Chamilo updates and installs them on schedule to ensure access to the latest features and security fixes.

2. **Error management and support**:
    - **Error monitoring:** The system automatically logs errors in CloudWatch so that problems can be detected and fixed quickly.
    - **Technical support:** AWS offers technical support that provides access to experts in case of problems with the cloud infrastructure.

7.6 Summary

By deploying the system on the AWS platform, the ICT system achieves a high level of scalability, security and reliability. The cloud architecture enables flexible resource management, automatic scaling and data encryption, ensuring that the system meets both functional and non-functional requirements.