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MODELS AND METHODS FOR PROVIDING PERSONALISED SERVICES IN E-LEARNING

AUTHOR'S ABSTRACT

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Title: **MODELS AND METHODS FOR PROVIDING PERSONALISED SERVICES IN E-LEARNING**

Introduction

Modern e-learning is fundamentally changing the way knowledge is created, organised, delivered and acquired. The development of digital technologies, the increasing dynamism of the professional environment and the need for lifelong learning necessitate a transition from standardised to more flexible and adaptive models of learning. In this context, the personalisation of the learning process is becoming increasingly important, as learners differ in their prior level of preparation, professional experience, needs and pace of learning.

Traditional e-learning systems often provide the same content to all learners, without taking sufficient account of their individual characteristics and specific gaps in knowledge, skills and competences. This limits the effectiveness of training and hinders the creation of appropriate training programmes tailored to the actual needs of the individual learner. It is precisely for this reason that contemporary research and technological solutions are increasingly focusing on competence-based and personalised learning, in which the content and learning pathway are adapted to the learner's individual profile.

A particularly important role in this process is played by the analysis of training needs, the development of a competency profile, and the ability to structure, parameterise and deliver training content according to specific requirements and gaps. The development of learning management systems, competence management systems, authoring tools and artificial intelligence-based solutions creates new opportunities for building more intelligent, adaptive and effective learning environments.

This doctoral thesis aims to investigate the possibilities for developing a model, methods and software tools for analysing training needs, creating individual competence profiles and delivering personalised training programmes. Based on an analytical review of existing theoretical frameworks, models, systems and technologies, conceptual and applied solutions have been developed, as well as a platform architecture to support the implementation of personalised learning in a digital environment.

Aim and objectives of the thesis

The objective of the thesis has been formulated on the basis of the analytical review:

To propose a model, methods and software tools for analysing training needs, creating individual competence profiles and delivering personalised training programmes.

To this end, the following objectives are defined:

1. To develop a method for personalising the training programme according to the trainee's individual competence profile
2. To develop a model for creating individual competence profiles and personalised training programmes.
3. To develop a model for creating e-learning courses using generative artificial intelligence and integrating closed expert systems with content from OpenAI,
4. Develop a model for a comprehensive infrastructure for the creation and management of personalised competency profiles
5. To develop an architecture and prototype of a platform for creating a personalised training programme based on the trainee's competency profile

Structure of the thesis

The thesis is structured into four chapters: introduction, conclusion, scientific and applied contributions, directions for future research, and bibliography.

The first chapter provides an analytical review of the theoretical and applied framework related to the thesis's problem area. It examines key concepts, approaches and technological solutions in the field of e-learning, competence profiles, training needs analysis, the digitisation of learning processes, learning objects, competence management and assessment systems, knowledge management systems and the personalisation of training programmes. On this basis, the need to develop a model, methods and software tools for analysing training needs, creating individual competence profiles and delivering personalised training programmes is justified. At the end of the chapter, the main conclusions, the aim and the objectives of the thesis are formulated.

The second chapter develops the models and methods necessary for implementing the proposed scientific and applied approach. It examines the analysis of training needs based on competence gaps and proposes methods for personalising the training process according to the trainee's individual competence profile. A model has been developed for creating an individual competence profile and for designing personalised training programmes. The possibilities for integrating expert approaches and generative artificial intelligence into the content development process are analysed. A method for developing content for e-learning courses and a model for parameterising learning content with competencies are also presented.

Chapter 3 describes the process of designing the architecture of a platform for creating individual competence profiles and personalised training programmes. The concept of a web-based architecture is presented, as well as a comprehensive infrastructure integrating the main processes of competence management, parameterisation of learning objects, personalisation of the training programme and analysis of results. The main modules of the platform, their

functional characteristics and the interrelationships between them are described. This creates the technological basis for implementing the models and methods developed in the previous chapter.

Chapter 4 presents a prototype of a software platform for creating a personalised learning pathway based on the learner's competence profile. The chapter is of an applied nature and illustrates the practical implementation of the proposed solutions through screen shots of the system's main modules and interfaces. Brief explanations accompanying the individual screens demonstrate the processes of building a competence profile, parameterising learning content, analysing gaps, generating a personalised learning programme, and tracking results.

The conclusion presents a summary of the research findings. The scientific and applied contributions of the thesis are formulated, and guidelines are outlined for future research related to the further development of the model and the expanded use of artificial intelligence in personalised e-learning.

The thesis comprises **174** pages, **31** figures, **4** tables and **130** references.

CHAPTER 1 – ANALYTICAL REVIEW OF METHODS AND TOOLS FOR CREATING AND MANAGING COMPETENCY PROFILES

1.1 Competency profiles and training needs analysis

In today's environment of rapidly evolving digital technologies, constantly changing professional requirements and the need for lifelong learning, education is increasingly focused on developing practical skills rather than merely acquiring theoretical knowledge. In this context, the competence-based approach is establishing itself as the leading framework in education and corporate training, as it emphasises the learner's ability to apply knowledge, skills and attitudes in a specific professional or educational environment.

For the purposes of this study, competence is regarded as an integrated set of knowledge, skills, experience, attitudes and behavioural manifestations that enable the effective performance of a specific activity[1] . Competence reflects the extent to which this competence has actually been mastered and demonstrated in practice. On this basis, a competency profile[2] can be defined as a structured description of the competencies required for the successful performance of a specific job, role or educational objective. It serves as a reference framework against which the required and actual levels of competence are compared.

Competence profiles are of great importance for improving the effectiveness of training, as they allow for a more precise formulation of expected outcomes, a clearer definition of assessment criteria, and a better alignment between training objectives and the actual requirements of professional practice. In this sense, they are not merely a descriptive tool, but a means of analysing, planning and managing the training process.

Closely related to this is the training needs analysis[3] , which is a systematic process for identifying gaps in learners' preparation. Its main aim is to determine which knowledge, skills or behavioural characteristics are lacking or underdeveloped, so as to justify the need for a

specific training intervention. The analysis can be carried out at individual, group and organisational levels; at the individual level, it is of particular importance for personalised learning.

From both a theoretical and practical perspective, training needs analysis provides an objective basis for decision-making. Rather than planning training according to general frameworks, it can be linked to actual identified needs and specific gaps. It is precisely here that the logical link between the two elements under consideration becomes apparent: the competency profile outlines the desired state, whilst the training needs analysis shows what is lacking in order to achieve it. In this way, they form a common basis for developing adaptive and personalised training solutions tailored to the learner's starting level, pace and specific characteristics.

1.2 Analysis of the current state and trends in the development of e-learning as a means of creating individual competence profiles for employees

1.2.1 Tools for the digitisation of learning processes

The competence-based approach has established itself as one of the leading concepts in modern education, human resource management and corporate training, as it aligns learning with the practical requirements of the workplace. Its core idea is that training should not be assessed solely by the volume of knowledge acquired, but by the trainee's ability to apply it in specific situations, in combination with practical skills, behavioural patterns and attitudes. In this sense, training is viewed as a means of achieving measurable results, rather than merely as a process of acquiring educational content.

The approach is based on several key concepts. Competence is understood as an integrated set of knowledge, skills, attitudes and behavioural characteristics necessary for the effective performance of a specific activity. Competence reflects the actual degree to which the relevant competence is mastered and applied in a specific context. The competency model represents a structured system of competencies and levels of mastery, used as a normative framework for the assessment, development and management of training[4] . The competency profile specifies this framework for a particular position, role or trainee and serves as a basis for the analysis and personalisation of training.

The essence of the competence-based approach lies in shifting the focus from content to learning outcomes. Whereas in traditional models the key question is what should be taught, here the central question is what the learner should be able to do upon completion of the training and to what standard. This has important methodological implications, as it requires the target competences to be identified in advance, their structure to be defined, and the criteria for assessing the degree of mastery to be clarified.

The application of the competence-based approach is of fundamental importance for personalised learning. It enables more precise formulation of objectives, more objective assessment, and a clearer identification of the gaps between the learner's current and target levels. It is precisely for this reason that the competence-based approach can be regarded as a theoretical and methodological foundation for the development of modern learning models, in which content, assessment and the learning pathway are aligned with clearly defined competences. This makes it particularly suitable for a digital and personalised learning

environment[5] , in which decisions should be based on evidence, measurable gaps and pre-set objectives.

1.2.2 Competencies and competency models

Competencies and competency models play a central role in modern training and development systems, as they provide a scientifically sound basis for analysing training needs, assessing training outcomes and personalising the learning process. Whilst the competency-based approach sets out the general logic of focusing on learning outcomes, competencies and the models for structuring them translate this logic into a practically applicable framework. They formalise the characteristics required for the successful performance of a specific professional role and how these characteristics can be used as a basis for development and assessment.

In the academic literature, the concept of 'competence' is regarded as an integrated set of knowledge, skills, attitudes, behavioural manifestations and practical abilities that enable an individual to successfully perform specific tasks in a particular context. It is essential to note that competence is not merely the possession of information, but also encompasses the ability to apply knowledge effectively, to behave appropriately and to achieve results in real-life situations. Consequently, competences can be defined as comprehensive units for describing professional readiness.

Depending on their scope and purpose, competences can be classified into several main groups: general, professional, technical and behavioural [6]. General competences are applicable across a wide range of activities, such as communication, teamwork and critical thinking. Professional competences are linked to a specific role or functional area. Technical competences focus on working with specific technologies, tools or standards, whilst behavioural competences reflect attitudes, adaptability, initiative and interaction style. This classification is of great importance for training design, as different types of competencies require different approaches to development and different indicators for assessment.

A competency model is a structured framework that organises the relevant competencies for a given role, position, organisational level or professional field. It typically includes a description of the competencies themselves, indicators of performance, proficiency levels and assessment criteria. In this way, the model serves as a normative framework for determining what is expected of the trainee or employee and how this expectation is to be measured. From a methodological perspective, the competency model serves to standardise requirements, to compare the actual and desired states, and to plan for development.

Most competency models include several key components: the name of the competency, a definition, indicators of performance, proficiency levels and assessment criteria[7] . It is precisely this structure that allows the model to be used not only descriptively but also for practical purposes – diagnosis, progress tracking and adaptation of the learning pathway. In the context of personalised learning, the competency model is of particular importance because it creates a formal basis for building an individual competency profile. Comparing the target model with the learner's current status enables the identification of gaps, priorities and appropriate learning interventions. In this way, competences and competence models become a

necessary prerequisite for the development of personalised learning programmes in a digital environment.

1.2.3 Learning objects as units of knowledge

Against the backdrop of the digitalisation of education and a growing need for personalised learning solutions, the concept of learning objects is becoming increasingly important in the theory and practice of e-learning. The reason is that the traditional model, in which content is organised into larger, pre-defined courses or lessons, is finding it increasingly difficult to meet the needs of learners with different starting levels, different learning gaps and different learning speeds. In this context, learning objects are regarded as a suitable unit for structuring knowledge, as they allow content to be divided into smaller, independent and reusable components that can be combined according to the specific learning scenario[8] .

From the perspective of learning theory, a learning object can be defined as a basic unit of knowledge that contains cognitive, practical or evaluative value and can be used independently or in combination with other units. This allows learning content to be better managed, categorised and adapted. When the material is structured into separate learning objects, the system can more easily select which elements are necessary for a particular learner, which can be omitted, which should be repeated, and in what order they should be presented. It is precisely this that makes learning objects particularly suitable for competence-based and personalised learning.

Depending on their function, learning objects can be informational, demonstrative, practical, assessment-based or micro-learning. Informational objects present knowledge through text, images, diagrams, infographics or short videos. Demonstrative objects illustrate a process, procedure or model of action through animation, examples or video instructions. Practical objects are aimed at practising skills through tasks, case studies and interactive exercises. Assessment objects serve to check the level of understanding through tests, questions and self-assessment. Of particular importance are micro-learning objects, which are short and focused units designed for the rapid acquisition or reinforcement of a specific objective. It is precisely this type of content that makes personalisation easier to implement in a real digital environment.

The significance of learning objects for personalised learning lies in the fact that they enable the creation of an individual learning pathway tailored to the learner's actual needs. When the system has a library of small, well-defined objects linked to specific competences, it can select precisely those resources needed to address identified gaps. This overcomes the limitations of standardised learning, in which all learners follow the same sequence regardless of their prior knowledge. In this way, learning objects become a key mechanism for achieving adaptability, flexibility and greater effectiveness in the learning process.

1.2.4 Competence management and assessment systems

In the context of digital transformation and constantly evolving requirements regarding employees' knowledge and skills, competence management and assessment systems are becoming increasingly important as a technological and methodological foundation for the planning, monitoring and development of human capital. Their primary role is to ensure a link between the organisation's strategic objectives, the requirements of specific roles and the actual

level of training of the individual trainee or employee[9] . Unlike traditional learning management systems, which are often primarily focused on delivering content and recording course completion, these systems focus on the actual ability to perform professional tasks effectively and its development over time.

The need for such systems stems from the fact that, in many organisations, the processes of defining competency requirements, creating training content, delivering training, assessing outcomes and monitoring their application in the workplace are carried out using separate and loosely connected tools. This fragmentation makes it difficult to build a comprehensive picture of the learner's development and limits the ability to make informed decisions regarding training needs, progress and the impact of training interventions. It is precisely here that competence management and assessment systems have a significant advantage, as they enable an integrated approach to data, assessment and development planning.

Consequently, competence management and assessment systems can be regarded as a key tool for moving from the formal administration of training to the effective management of development. They create the conditions for a more precise analysis of needs, more objective assessment and a better match between the requirements of the work environment and the learner's capabilities. In this sense, they are an essential element in the creation of modern environments for competence-based and personalised learning.

1.2.5 Knowledge management systems

In the modern digital environment, knowledge is established as a strategic resource that has a direct impact on the competitiveness of organisations, the quality of decision-making and the development of human capital. In this context, knowledge management systems play a vital role, as they provide mechanisms for creating, storing, structuring, sharing and reusing knowledge within the organisation[10] . Their importance is particularly significant in environments where training, professional development and competence management are interrelated processes.

By their very nature, knowledge management systems are not limited to the mere storage of information. Their aim is to transform knowledge into an accessible, organised and usable resource that can support both day-to-day work and the training and development of staff. This includes not only documents, instructions and expert materials, but also accumulated organisational experience, best practices, problem-solving strategies and knowledge that is often scattered across different people, systems and information sources. In this sense, such systems create the conditions for capitalising on knowledge and reducing the risk of its loss.

The importance of knowledge management systems for learning is most evident in their ability to provide a reliable and structured framework for creating and updating learning content, supporting self-directed learning, and linking learning resources to specific competences. When knowledge is well organised and described, it can be more easily used to develop learning objects, enrich training programmes, and deliver content tailored to the needs of specific groups or individual learners. In this way, knowledge management systems become a natural complement to LMS platforms and competence management systems.

Despite their advantages, these systems also present a number of challenges. These include the heterogeneity of sources, difficulties in maintaining the currency and reliability of content, the need for integration with training and competency systems, and the need for an organisational culture that encourages knowledge sharing. This shows that successful knowledge management requires not only technological infrastructure, but also clear processes, rules and motivation to participate.

Consequently, knowledge management systems can be regarded as an important component of the modern digital educational and organisational environment. They not only support the storage and exchange of information, but also create a foundation for more effective learning, for utilising accumulated experience, and for linking learning resources to the development of competencies. In this sense, they play a key role in the development of personalised and data-driven learning solutions.

1.2.6 Creating training content

The creation of learning content is an essential part of modern e-learning, as the effectiveness of the entire learning process depends on its quality, structure and applicability. The development of online and blended forms of learning, particularly following the COVID-19 pandemic, has heightened the need to develop digital resources that provide not only access to knowledge, but also opportunities for practical application, learner engagement and measurable outcomes. This need is particularly evident in fields such as artificial intelligence[11] , computer programming and mathematical modelling, where learning must combine theoretical training, exercises and assessment of the level achieved. This leads to a growing demand for high-quality digital resources – text-based, visual, video and interactive – that can be used in various learning scenarios[12] .

In a competence-based learning environment, content creation should not be viewed as a standalone technical activity, but as a process directly linked to the learning objectives and predefined competences. Once the competence profile has been established, the learning materials are developed to correspond to the specific competences that need to be developed. New micro-learning courses and modules are created using a content authoring tool, with each learning object tagged with the competences it aims to develop. In this way, the content becomes modular and goal-oriented, and individual learning elements can be used as part of a broader personalised training programme.

The use of integrated artificial intelligence in the development of learning materials is of particular importance. It enables the automatic generation of various types of content that support both the presentation of knowledge and the active participation and assessment of the learner. These include text explanations and descriptions, assessment questions, graphics and interactive elements. This capability significantly speeds up the process of creating materials and allows for faster adaptation of content to identified needs. Automated generation does not eliminate the need for methodological logic and expert oversight, but it creates the conditions for greater productivity and a wider variety of learning resources.

Alongside AI-generated elements, multimedia resources also play a key role in boosting engagement and aiding learning through richer forms of presentation. The training content can

include video lessons, simulations, animations and role-play scenarios. These formats are particularly suitable for developing competencies that require not only knowledge, but also behaviour, judgement and reaction in a specific situation. For example, a competence such as 'Conflict Management' can be developed through simulation games involving difficult conversations with clients. In this way, training focuses on practical application and the modelling of real-life professional situations, rather than merely the reproduction of information.

The creation of educational content is closely linked to the technological tools used. Authoring systems provide an environment for developing courses, micro-learning modules and assessment elements. The LMS platform organises access to content, links it to user roles, tracks progress and manages the learning process. Support for standards such as SCORM and xAPI[13] enables compatibility with external resources and the collection of data on learning activity. The content creation tool itself is designed for the design and development of learning materials directly linked to competency models, enabling the rapid creation of courses and micro-learning, and the automatic generation of content sections via integrated artificial intelligence[14] . In this way, the process of developing learning materials fits into a broader infrastructure that brings together content, management, tracking and personalisation.

A key advantage of this approach is that the learning content is not created as a universal resource that is the same for everyone, but as a system of learning objects that can be combined according to the learner's specific needs. This allows for a more precise match between identified gaps and the materials provided. Each learning element can be included in a personalised learning pathway based on the learner's current level of competence, test results, previous training records or managers' assessments. In this way, the content becomes an active component of the personalised learning model and serves not only as a source of information but also as a means of addressing specific gaps.

Consequently, the creation of educational content in the context of e-learning and competency-based learning requires a combination of pedagogical logic, technological flexibility and opportunities for automation. The inclusion of AI-generated texts, questions, graphics and interactive elements, as well as the use of video, simulations, animations and role-play scenarios, broadens the scope of learning resources and enhances their applicability. When these resources are linked to specific competencies and managed through appropriate systems, conditions are created for the development of personalised training programmes tailored to the actual needs and progress of learners.

1.2.7 Classification of online training courses

Online courses and digital learning materials are establishing themselves as the primary approach to training students, staff and adult learners in the context of lifelong learning. Among the main reasons for their widespread adoption are the optimisation of time and costs, better organisation when teaching large groups, and the possibility of standardised content delivery. Consequently, both formal educational institutions and non-formal training organisations are gradually shifting their practices and resources towards distance learning. E-learning is developing rapidly, and the COVID-19 pandemic is further accelerating the digitisation of educational processes and driving a mass shift towards learning in a digital environment. In parallel, the market for Massive Open Online Courses (MOOCs)[15] is expanding, and the

digital transformation is also entering the business environment, including sectors where such solutions were until recently considered difficult to implement.

The effective implementation of e-learning is typically based on three main categories of software solutions. First is the Learning Management System (LMS)[16] , which is used to manage users and roles, deliver content and track progress. Secondly, there are synchronous video and audio learning systems of the 'virtual classroom' type[17] , which provide interaction similar to that in a traditional lecture theatre. The third important component consists of digital learning content authoring tools (Authoring Tools)[18] , which enable the creation, updating and reuse of learning resources. In this technological environment, the concept of an 'online course' proves difficult to standardise, as there are numerous variations depending on the delivery method, the media used, the degree of interactivity and the approach to instructional design[19] .

One of the main classifications of online courses is based on the delivery method. This category is divided into synchronous, asynchronous and blended formats. Synchronous courses take place in real time and require the simultaneous presence of the instructor and learners in a virtual environment. They provide direct communication, rapid feedback and a higher degree of interaction. Asynchronous courses, on the other hand, offer greater flexibility, as learners can work through the content at a time and pace that suits them. Blended formats combine the advantages of both approaches, combining independent study with scheduled sessions for synchronous interaction. This classification is particularly important because it has a direct bearing on the organisation of the training, the learner's workload and the opportunities for personalisation.

Online courses can also be categorised according to the structure and scope of their content. In this regard, there are both comprehensive courses with a larger volume and a clearly defined syllabus, as well as shorter modules, micro-learning units and standalone digital resources. Larger courses are suitable for the systematic acquisition of knowledge and skills within a broader subject area, whilst shorter, focused formats facilitate the rapid mastery or consolidation of a specific topic. It is precisely this flexibility that allows training to be tailored to different objectives, different starting levels of learners and different professional needs.

Another key classification is based on the degree of interactivity and the way content is presented. Some online courses are built primarily around text and visual resources, whilst others include videos, quizzes, simulations, discussions, practical tasks and interactive learning objects. The higher the level of interactivity, the greater the opportunities for active participation, self-assessment and adaptation of the learning process to the learner's behaviour and progress . From this perspective, the variety of formats is not merely a technological issue, but a factor that directly influences the effectiveness of learning.

Classification according to the target audience and the context of use is also of significant importance. Some online courses are geared towards formal education, others towards corporate training, and others towards a mass open audience, as is the case with MOOC models[15] . The differences here concern not only scale, but also the method of organisation, the level of prior preparation, the degree of standardisation and the expected outcomes. In a corporate environment, a closer link between content and specific competencies, roles and organisational

goals is often sought, whilst in massive open courses, accessibility and a broad range of learners predominate.

Consequently, the classification of online courses is not a formal categorisation of types, but a necessary foundation for understanding the diversity of models in e-learning. It shows that online learning is not a single, uniform format, but a system of different solutions that vary in terms of delivery method, structure, degree of interactivity, technological implementation and target audience. It is precisely this diversity that creates the conditions for more flexible planning of the learning process and for the development of personalised training programmes tailored to the specific profile and needs of the learners.

1.2.8 Personalisation of training programmes

The personalisation of training programmes is a process of adapting the content, sequence, complexity and delivery method of the training to the characteristics of the individual learner[20] . Unlike the traditional approach, in which all participants follow the same training programme regardless of their starting level, experience and gaps in knowledge, personalised learning takes into account the learner's individual profile and builds an appropriate learning pathway on that basis. Personalisation is therefore not merely a technical option for selecting individual resources, but a comprehensive methodological approach in which the learner and their actual development needs take centre stage.

The need for personalisation stems from the fact that learners do not constitute a homogeneous group. They differ in terms of prior knowledge, professional experience, learning pace, motivation, cognitive characteristics and the context in which they apply their knowledge. Consequently, providing the same content to everyone often leads to low effectiveness: for some, the training proves too basic; for others, too complex; and for others still, partially irrelevant. This is precisely why personalisation is seen as a necessary step towards increasing the relevance and effectiveness of e-learning.

The implementation of personalised learning requires alignment between the learning content, the assessment mechanisms and the learner's profile. To this end, the content is broken down into small learning units, which are described in terms of competences, linked together, supplemented with assessment and analysis components, and delivered on the basis of a constructed competence profile. In this way personalisation is not reduced to a one-off choice of resource, but becomes a dynamic process in which the various elements of learning can be selected and combined according to the learner's current status and progress.

Personalisation can take place at various levels. It may involve adapting content, changing the sequence of learning units, adjusting the level of difficulty, varying the pace of progression, as well as providing different forms of support and assessment. For example, a learner with a higher starting level may skip basic learning objectives and move directly to more complex modules, whilst a learner with identified deficits may receive compensatory content, additional examples or more practice. In this sense, personalisation can be diagnostic, when based on initial assessment and prior knowledge, and competence-based, when implemented by comparing the individual's profile with the target competence model.

Effective personalisation requires a higher degree of formalisation and integration than most traditional solutions offer. To create a personalised learning programme, the learning content must be broken down into smaller units, described in terms of competencies and metadata, linked to assessment mechanisms, and incorporated into an environment that allows for dynamic selection and sequencing according to the individual's profile. Alongside this, there are also limitations related to the need for better content structuring, the development of competency models, the availability of reliable assessment mechanisms, and higher requirements for the technological infrastructure and the quality of the data on which the process is based.

Despite these limitations, the personalisation of training programmes is emerging as one of the most promising areas in the development of modern e-learning. It facilitates a transition from standardised to adaptive and competence-oriented solutions and creates the conditions for a more precise alignment between the learner's profile, the expected outcomes and the learning content provided. For this reason, personalisation should be viewed not merely as a technological possibility, but as a fundamental principle in the design of modern training programmes.

1.3 Current challenges in creating and managing a personalised employee learning profile

The creation and management of a personalised employee training profile involves a number of contemporary challenges, stemming both from the limitations of the software solutions used and from the specific nature of the organisational environment. Regardless of the maturity of e-learning technologies, the practical implementation of personalised training remains a complex process, as it requires simultaneous consideration of individual differences among learners, the availability of appropriately structured content, and coordination between numerous technological and organisational components.

One of the main problems stems from the heterogeneity of the trainees. Employees differ in terms of prior training, professional experience, learning pace, learning strategies and motivational profiles. This makes it difficult to apply a model in which everyone goes through the same sequence of content and is expected to achieve similar results. In the absence of a reliable mechanism for establishing the baseline and identifying actual gaps, personalisation remains superficial and does not lead to a real improvement in training effectiveness.

Another significant challenge is the need for better structuring and organisation of the learning content. In order to enable the creation of a personalised learning profile, learning resources must be divided into clearly defined units, described by metadata and linked to specific competences. In many cases, the content exists as relatively self-contained courses or modules, but not as sufficiently flexible elements that can be combined according to the specific needs of individual employees. This hinders the automated selection of suitable resources and limits the possibility of truly adaptive learning.

Another key issue relates to the development and maintenance of competency models. A personalised learning profile requires clearly defined target competencies, proficiency levels and assessment criteria. In practice, however, many organisations lack a sufficiently formalised competency framework, or it is not directly linked to the training content and assessment tools.

This makes it difficult to compare the desired and actual status of the employee and makes it harder to identify the specific gaps that need to be addressed through training.

Personalisation is also heavily dependent on the availability of reliable mechanisms for assessment and data collection. In order to create and update a learning profile, it is necessary to use diagnostic tools, test results, data on the learner's behaviour, assessments from line managers or other sources of information. When this data is incomplete, disconnected or inconsistent, the system cannot form a sufficiently accurate picture of the employee's needs. In this way, personalisation is hampered not only by a lack of content, but also by a lack of quality data on which to base it.

Technological requirements also pose a significant challenge. The creation of a personalised learning profile requires integration between various systems – learning management platforms, authoring tools, competency management systems, analytics modules and progress tracking tools. When these systems operate in isolation or use different data models, the ability to build a comprehensive and dynamic employee profile is limited. Consequently, the problem lies not only in the availability of individual technologies, but in the absence of a sufficiently well-connected and functioning infrastructure.

Alongside technological factors, organisational conditions also play a significant role. Creating a personalised learning profile requires alignment between learning objectives, staff development policies, the role of line managers, and the organisation's willingness to maintain up-to-date data on employees' competencies and progress. In the absence of such coordination, even the best software solutions cannot ensure full personalisation, because training remains disconnected from actual work processes and the organisation's strategic objectives.

Consequently, the main current challenges in creating and managing a personalised training profile for employees can be summarised in several areas: differences between learners, insufficient structuring of content, difficulties in formalising competency models, limitations of assessment mechanisms, high data quality requirements, and the need for integration between different systems and organisational processes. It is precisely these difficulties that justify the need to develop a more comprehensive model, methods and software tools for analysing training needs, building individual competency profiles and creating personalised training programmes.

1.4 Conclusions

The analytical review conducted shows that, in the contemporary educational and organisational environment, the need to transition from standardised to flexible, adaptive and competence-oriented training models is becoming increasingly apparent. The theoretical frameworks and technological solutions examined confirm that e-learning can no longer be viewed merely as a means of delivering content in digital format, but as a comprehensive environment for analysing, planning, implementing and monitoring the individual development of the learner. Competency profiles, training needs analysis, learning objects, competency management systems and knowledge management systems play a particularly important role in this process, as they form the basis for a more precise alignment between the requirements of the professional environment and the actual status of learners.

The review shows that the competence-based approach provides a suitable methodological framework for overcoming the limitations of traditional training. It allows training to be oriented not only towards the acquisition of content, but also towards the development of specific knowledge, skills and abilities necessary for performing a particular professional role. In this sense, the competence profile can be viewed as a central reference framework through which job requirements are described, whilst the learner's individual profile serves as a true reflection of their current level. Comparing these two profiles makes it possible to identify gaps and justify appropriate training interventions.

The review also shows that the personalisation of training programmes is a logical and necessary direction for the development of e-learning, but its implementation requires a significantly higher degree of formalisation and integration than most traditional solutions offer. In order to create a personalised training programme, the learning content must be divided into smaller units, described in terms of competences and metadata, linked to assessment mechanisms, and incorporated into an environment that allows for dynamic selection and sequencing according to the learner's individual profile. This justifies the need to develop, in the next chapter, methods for personalising the learning process, as well as a model for parameterising learning content with competencies.

Another important conclusion from the analytical review is that existing software solutions in the field of e-learning, competence management and content creation often address individual parts of the problem, but rarely ensure full integration between needs analysis, competence profile development, content parameterisation, the generation of a personalised training programme, and the tracking of results. It is precisely for this reason that there is a need to develop not only individual methods, but also a comprehensive model and platform architecture that unites these processes within a single environment. This logic is directly continued in Chapter 3, which outlines the design of a web-based architecture, a comprehensive infrastructure and core modules for building a competency profile, configuring training objects, personalising the training programme and analysing results.

Of significant importance is also the conclusion that the development of generative artificial intelligence and modern analytical technologies opens up new opportunities for the automation and optimisation of content development, diagnostics and personalisation processes. However, these opportunities should be utilised within a clearly defined model that combines expert knowledge, competency frameworks and technological mechanisms for control and adaptation. Therefore, the following exposition logically envisages the development of both a model for integrating closed expert systems with content from OpenAI and a method for creating and parameterising training content suitable for personalised training scenarios.

Consequently, the analytical review conducted allows us to draw the well-founded conclusion that there is a need for a comprehensive scientific and applied approach that brings together within a single framework: an analysis of training needs, the development of a competency profile for a professional role, the creation of an individual competency profile for the learner, the personalisation of the training programme, and the technological implementation of these processes within a software platform. It is precisely this necessity that determines the transition to the next section, in which the aim and objectives of the thesis are formulated.

CHAPTER 2 – MODELS AND METHODS FOR CREATING INDIVIDUAL COMPETENCY PROFILES AND PERSONALISED TRAINING PROGRAMMES

2.1 Training needs analysis based on competence deficits

Competency gap-based training needs analysis is founded on the understanding that training needs can be determined by comparing the required level of competency for a given professional role with the actual status of the specific trainee. In this model, the competence gap is regarded as the primary indicator of training needs, and the analysis itself serves as a mechanism for objectively identifying missing or underdeveloped knowledge, skills and behavioural characteristics. In this way, training is geared not towards pre-defined universal programmes, but towards specific differences between the target and individual profiles.

This approach is linked to Competency-Based Training Needs Analysis (CBTNA), which focuses on the relationship between competency gaps, the quality of training and the practical outcomes of learning. Its main value lies in the fact that it allows training programmes to be aligned both with the requirements of a specific role and with the organisation's strategic objectives. Rather than organising training around general themes or standard courses, the content is determined on the basis of actual gaps in training that need to be addressed through targeted training interventions.

Methodologically, the analysis involves several sequential steps. Firstly, a competency profile for the professional role is developed, describing the knowledge, skills and competencies required to successfully perform the role in question. In the next stage, the trainee's current status is determined through appropriate forms of assessment and evaluation. A comparison is then made between the target profile and the actual level, with any identified gaps interpreted as deficits. It is precisely these deficits that serve as the basis for determining training needs and deciding what type of training is required.

A key advantage of this approach is that it establishes a formal and consistent link between the analysis, the content and the expected outcomes. The gap is not viewed in abstract terms, but as a measurable difference between two states – the required state and the current state. This makes it possible to develop personalised training programmes in which the training content is selected and organised according to specific gaps and the expected learning outcomes. In this way, needs analysis ceases to be a standalone diagnostic stage and becomes an active element of the overall model for creating an individual competence profile and a personalised learning pathway.

It is particularly important that, in this context, the role of data processing and analysis technologies is also taken into account. The approaches examined show that artificial intelligence-based tools can assist in the assessment of competences and streamline data analysis with greater efficiency and consistency. This creates the conditions for more precise diagnosis, faster identification of gaps, and more informed decision-making regarding subsequent training. In this sense, training needs analysis based on competence gaps is not merely a theoretical model, but a foundation for building data-driven and technology-supported solutions in personalised e-learning.

Consequently, a training needs analysis based on skills gaps can be regarded as a key method for moving from general and standardised training towards adaptive training programmes tailored to

the learner's actual situation. It ensures a more precise identification of needs, a better alignment between training and professional requirements, and a basis for the subsequent personalisation of content and the learning pathway.

2.2 Methods for personalising the learning process

The digitalisation of education highlights the need for the learning process to take account of the actual diversity of learners and to provide mechanisms to support individual progress. In this context, competence-based personalisation is establishing itself as an approach in which learning pathways are adapted to the specific skills, gaps and learning dynamics of the individual learner. Digital education can increasingly rarely be viewed solely as a technical tool for distance learning, but rather as a complex ecosystem where technological solutions, pedagogical practices and specific human needs intersect[21] . The traditional 'one course, one sequence, one time for all' model is organisationally convenient, but systematically underestimates the differences between learners and often leads to lower motivation, inefficient use of resources and incomplete achievement of planned outcomes.

One of the main methods of personalisation is the use of diagnostic assessments, which determine the learner's starting point and identify any gaps in their knowledge. This approach allows content to be selected not in advance and uniformly for everyone, but according to the learner's actual needs. Diagnostic logic is particularly important in competence-based learning, as it establishes a link between the individual profile, the target competences and the learning resources that should be provided. In this way, personalisation is based on evidence rather than general assumptions.

A key approach is to integrate a competence framework into the LMS, so that the learning management system serves not only to deliver courses but also to track the development of specific competences. Following such integration, each learning object can be tagged with one or more competencies, and assessment results can be linked to appropriate resources. If a gap in a particular competence is identified, the system can recommend a module that specifically develops it. This establishes a logical link between competence, content, assessment and progress, enabling more transparent tracking and more informed personalisation [22] .

Another important method is adaptive content sequencing. In this approach, the order of the learning materials is not fixed but is determined by the learner's progress towards specific competences. Instead of a linear sequence, a dynamic pathway is formed, in which subsequent activities are unlocked once mastery of previous elements has been confirmed. In practice, this can be achieved through 'if-then' rules set by instructional designers, or through AI-based mechanisms that use data to optimise the sequence. This logic reduces the likelihood of gaps accumulating and allows for faster progress among learners who have already mastered part of the content.

Personalisation is also supported through the use of learner profiles and competence maps. The learner profile brings together information on prior knowledge, achievements, gaps, preferences and pace of progress, whilst the competence map provides a structured overview of the links between individual competences and their development. Comparing these two levels makes it possible to determine not only what is missing, but also in what sequence and with what

resources the gap should be addressed. In this way, personalisation moves from a static allocation of content to the dynamic management of an individual learning pathway.

Further opportunities are created by the use of artificial intelligence, which supports automated data collection and analysis, predictive analytics and the generation of personalised recommendations. AI can improve the accuracy and scalability of personalisation, but it also raises requirements regarding transparency, ethical principles and the control of biases. It follows, therefore, that technological support must be combined with responsible pedagogical and organisational implementation.

Consequently, the personalisation of the learning process requires a combination of several interrelated methods: diagnostic assessments, the integration of competence frameworks into learning systems, the adaptive sequencing of content, the use of competence profiles and maps, and the application of artificial intelligence. It is precisely this combination that creates the opportunity to build flexible learning pathways that adapt dynamically to the profile and needs of each learner and ensure greater learning effectiveness in a digital environment.

2.3 A model for integrating closed expert systems with content from OpenAI

The integration of artificial intelligence into education creates new opportunities for data analysis, content adaptation and automated support for learners. Of particular significance in this context is the use of AI within closed expert systems[23] [24] , which are built for the needs of a specific organisation and work with its internal resources, such as procedures, instructions, manuals and internal policies. Unlike general-purpose public solutions, these systems operate in a controlled environment and are designed to address specific training and organisational tasks. When enriched with content from OpenAI, they expand their contextual base and enhance their capabilities for explanation, recommendation and learning support.

The need for such a model stems from the limitations of one-size-fits-all approaches to education. Uniform curricula and standardised content often fail to account for differences between learners and lead to uneven outcomes. Some learners struggle due to a mismatch between the content and their current level, whilst others lose motivation due to a lack of sufficient challenge. Personalisation, supported by AI and implemented through closed expert systems, allows the learning experience to be adapted to the specific needs of the individual and linked to the organisation’s actual objectives, such as induction, skills development or meeting certification requirements[25] .

The proposed model is based on combining two types of knowledge sources. On the one hand, there is internal corporate knowledge, which provides a reliable, subject-specific and organisationally relevant context. On the other hand, external content from OpenAI is incorporated, contributing generative capabilities for explanation, summarisation, formulation of recommendations, and facilitation of dialogue with the learner. Combining these two layers allows for greater system flexibility without losing the connection to the specific domain and the organisation’s internal rules. In this way, the closed expert system is not replaced by a generative model, but is extended through it.

A key element of the model is its integration into the organisation’s existing educational infrastructure. This involves developing APIs, connectors or plugins[26] to ensure reliable data

exchange between the AI components and the LMS system[27] . This creates a technological foundation for linking internal knowledge sources, OpenAI's generative capabilities and learning management processes. The integration is accompanied by testing for interoperability, scalability and security, including load testing and controlled pilot implementations. This is necessary as the model's effectiveness depends not only on the quality of the generated content, but also on the reliability of the entire technological environment.

The model also calls for an interdisciplinary approach to development and refinement. Educational experts, subject matter experts, engineers and data specialists should work together in a continuous cycle of refining requirements, verifying results and adjusting the system. In this process, feedback is not viewed as a final stage, but as a continuous mechanism for improving the solution in response to changes in content, organisational objectives and learner profiles. This makes the model adaptive not only in relation to the individual user, but also in relation to the organisational environment itself.

The expected outcomes of integrating AI into closed expert systems relate to a higher degree of personalisation and more effective design of learning pathways. Through algorithmic analysis of internal documentation and external content, the system can offer personalised recommendations, assist learners with more appropriate explanations, and adapt content to individual needs, preferences and learning styles. This creates an opportunity to transition from static to dynamic and context-sensitive learning, in which knowledge is delivered according to the specific situation and the specific learner.

Consequently, the model for integrating closed expert systems with content from OpenAI can be seen as an important step towards building more intelligent, adaptive and organisationally relevant learning solutions. It combines the advantages of a controlled internal expert environment with the generative capabilities of modern AI technologies and creates a foundation for more precise personalisation, richer learner support and a closer link between training and the organisation's actual needs.

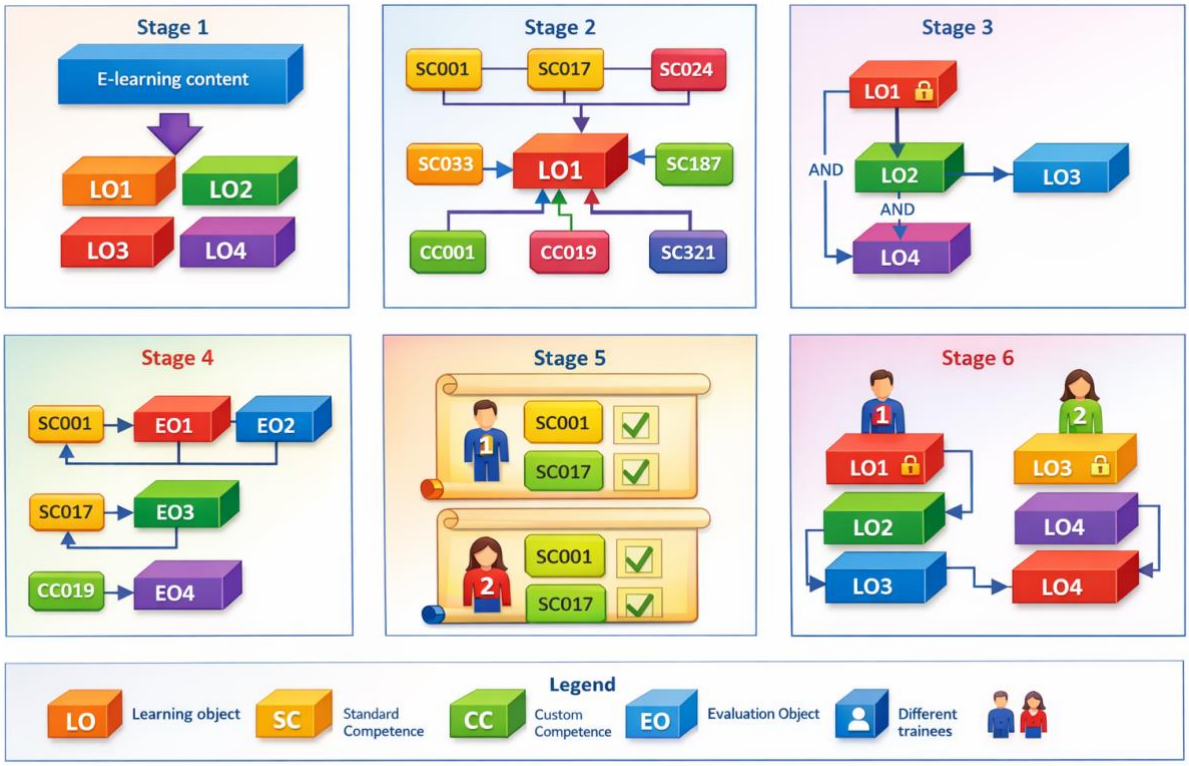
2.4 Development of a model for creating individual competency profiles and personalised training programmes

The development of a model for creating individual competence profiles and personalised training programmes is based on the need for training to be linked not to universal content, but to the actual situation of the specific trainee. The main logic of the model is to ensure a clear link between the job profile, the results of the assessment and the training content, so that training decisions are based on identified gaps and predefined objectives. This creates a methodological framework in which analysis, profiling and content selection become interlinked elements of a single process.

At the heart of the model lies the distinction between a target competence profile and an individual competence profile. The target profile describes the competencies required for a specific position, role or training objective, whilst the individual profile reflects the actual competencies possessed and the level of mastery of these by the specific trainee. Comparing

these two levels allows gaps to be identified, which then form the basis for subsequent training planning. In this way, the model creates a transition from a general description of requirements to a specific solution for the development of the individual learner.

A key element in this process is the alignment of learning content with competencies. Learning resources are described, classified and structured according to their role in addressing specific gaps. This allows the content to be used not as a pre-determined course, but as a system of learning objects that can be selected and combined according to individual profiles. In this way, the model establishes a link between needs analysis and the actual design of the training programme. The sequence of these stages is shown schematically at1Figure . Stages in the development and delivery of personalised e-learning



1Figure . Stages in the development and delivery of personalised e-learning

The model also includes a method for developing content for e-learning courses, designed with a focus on modularity, reusability and customisability. This means that learning materials should be structured in such a way that they can be incorporated into different individual learning pathways without the need to develop entirely new content each time. Such an approach increases the flexibility of the learning system and enables a more precise match between the learner's needs and the resources provided.

The model also takes into account the role of generative artificial intelligence in the creation and adaptation of learning resources. An approach is proposed for the controlled use of generative AI, in which expert-validated knowledge is combined with capabilities for the automated generation, updating and adaptation of content. This does not negate the need for control and

methodological consistency, but creates conditions for greater efficiency in the development of personalised learning materials and for a quicker response to changes in learners' needs.

A key outcome of the developed model is that it provides a logical and methodological framework for comparing target and existing competences, for setting priorities in training, and for designing a tailored learning pathway. This overcomes the limitation of traditional standardised programmes, in which all learners go through the same content regardless of their actual needs. Instead, the personalised learning programme is formed as a sequence of learning resources and activities selected on the basis of the learner's specific skills gap profile.

Consequently, the developed model can be regarded as a basis for building personalised training programmes, in which needs analysis, the competence profile, content parameterisation and technological support function as a unified system. It creates the conditions for a more precise identification of training needs, a more targeted selection of content, and a more flexible organisation of the training process according to the learner's actual characteristics and progress.

2.5 Method for developing content for e-learning courses

The development of content for e-learning courses should be based on the understanding that e-learning does not merely change the channel through which knowledge is delivered, but also transforms the very logic of organising and managing the learning process. The online environment provides more flexible access, better traceability and more efficient use of learners' time, but at the same time places higher demands on the way in which learning content is created and structured. In the context of constant technological and social change, lifelong learning has become a necessity, requiring the development of courses capable of meeting diverse needs, levels of preparation and learning objectives.

A significant challenge in e-learning is the difficulty of creating a personalised learning environment tailored to the individual characteristics of each learner. Learners constitute a heterogeneous group, differing in terms of prior knowledge, learning pace, motivation and cognitive strategies. Therefore, it cannot be expected that identical content and a uniform learning path will lead to similar results for everyone. It is precisely here that the content development method must ensure a transition from standardised courses to more flexible structures that allow adaptation to the learner's profile and gaps in knowledge.

The proposed method is based on the understanding that content should be developed as a system of learning elements, rather than as a monolithic course with a fixed sequence. This implies modularity, a clear distinction between learning units, and the possibility of reusing individual resources in different programmes and scenarios. In this way, the e-course can be structured so that different parts of it are activated or skipped depending on the identified needs of the specific learner. Thus, content development is directly linked to the personalisation of learning.

The method also involves linking the learning content to target competences. Rather than organising the course solely by topic, individual learning modules are designed to contribute to the development of specific knowledge, skills and competences. This allows the content to be

used in a more targeted manner when building individual learning pathways and facilitates the matching of competence gaps with the appropriate resources to address them. In this sense, content development is not a standalone process, but part of a broader system for competence management and personalised learning.

The interactive nature of the content also plays a significant role. Effective e-courses do not merely present textual information, but incorporate interactive components, assessment elements and forms of active participation that facilitate better learning and enable progress to be tracked. This is particularly important in an environment where the content must not only inform, but also support diagnosis, practice and assessment of the results achieved. Consequently, the development method should simultaneously provide knowledge, engage the learner and collect data on their progress.

2.6 A model for creating e-learning courses using generative artificial intelligence

Generative artificial intelligence opens up new possibilities for the development of online training courses, as it enables not only the processing and classification of information, but also the creation of text and multimedia content. Models of this type are based on deep neural networks and natural language processing techniques, which enable them to understand context, generate coherent text and produce content in various formats. In education, these capabilities are applied to the creation of teaching materials, the development of exercises and the provision of automated support for learners[28] . However, the educational value of the results depends not only on the model itself, but also on the data, context and rules governing the generation process.

The creation of e-courses using generative AI cannot be reduced to the automatic generation of text. An effective course requires a structured process in which the technological capabilities of AI are combined with pedagogical logic, expert oversight and clearly defined learning objectives. In this regard, the model is based on several sequential technological steps: data collection and pre-processing, training or fine-tuning of a generative model, and validation of the content through human expertise. This sequence is necessary to ensure that the generated materials are not only formally correct, but also aligned with the subject matter, the learners' level and the learning objectives.

The model is based on the creation of a corpus of educational resources, including textbooks, articles, images and multimedia materials. This corpus undergoes pre-processing to ensure the relevance and consistency of the input data. The generative model is then adapted to criteria such as linguistic competence, topical accuracy and pedagogical guidelines. The final stage is content validation, during which subject matter experts and educators check its accuracy, consistency and appropriateness. It is this expert review that minimises the risk of errors, inconsistencies and inappropriate phrasing.

The methodology for generating educational content using generative AI comprises four main stages. The first is AI-based content generation, in which explanations, examples, case studies and other learning materials are created. Generative AI allows this content to be created more quickly and adapted to pre-defined criteria, ensuring it remains consistent and relevant[29] . From a methodological perspective, it is important to specify in advance what type of

knowledge is being targeted – facts, concepts, procedures or skills – and what level of detail is required.

The second stage involves breaking the content down into small, independent ‘bites’ of knowledge. This approach makes the content more flexible and better suited for reuse, adaptation and integration into various learning scenarios. Rather than viewing the course as a monolithic resource, it is built from smaller units that can be combined according to the specific needs of the learners. This facilitates easier personalisation and a more precise link between learning content and specific learning gaps.

The third stage involves organising these ‘bites’ into different types of content. The units of knowledge generated in this way can be organised into explanatory texts, examples, practical tasks, assessment questions and other forms that meet various pedagogical objectives. The fourth stage involves generating screen designs, including interactions and visual elements. In this way, the model is not limited to textual content but also encompasses the organisation of the learning experience in an electronic environment. This is important because the effectiveness of online learning depends not only on the content but also on the way it is presented, structured and linked to the learner’s actions.

Consequently, the model for creating e-learning courses using generative artificial intelligence can be seen as a combination of automation, modularity and pedagogical control. It enables faster creation of learning materials, more flexible structuring of content and better opportunities for adaptation to different learning objectives and learner profiles. At the same time, the model sets a clear requirement for expert validation and methodological consistency, so that technological efficiency is combined with quality and educational value.

2.7 Conclusions

This chapter has outlined the key models and methods required to create an individual competence profile and to develop personalised training programmes. The study showed that effective personalisation of learning requires a clear link between the analysis of learning needs, the description of target competences and the selection of appropriate learning content. For this reason, the analysis of competence gaps was considered a central mechanism for identifying the difference between the required and actual levels of training, and thus as a basis for decision-making regarding the content and sequence of training.

The proposed personalisation methods demonstrate that the training process can be organised in a more flexible and targeted manner when the trainee’s individual profile is taken into account. The developed model for creating an individual competence profile and personalised training programmes provides a logical and methodological framework for comparing target and existing competences, for setting training priorities, and for building a tailored learning pathway. This overcomes the limitation of traditional standardised programmes, in which all learners go through the same content regardless of their actual needs.

A key finding of the chapter is the justification of the role of learning content as an active element in the personalisation process. It was demonstrated that, for personalised learning to be technologically feasible, content must be developed in a structured manner, with the potential for customisation, reuse and linking to specific competences. In this context, the use of

generative artificial intelligence reveals additional opportunities to accelerate development, support authors and create more flexible educational resources, not as an end in itself, but as a tool within an overall methodology for quality and applicability.

Consequently, the findings of Chapter 2 confirm that the creation of personalised learning programmes requires the joint application of a competency description model, a method for analysing gaps, a mechanism for content selection, and technological tools for development and adaptation. This forms a scientifically and methodologically sound foundation upon which, in the next chapter, a platform architecture capable of implementing the proposed models and methods in a web-based software environment can be built.

CHAPTER 3 - ARCHITECTURE OF A PLATFORM FOR CREATING INDIVIDUAL COMPETENCE PROFILES AND PERSONALISED TRAINING PROGRAMMES

3.1 Design of the architecture of a web-based platform for managing personalised competence profiles.

The design of the architecture for a web-based platform for managing personalised competencies is based on the need for the e-learning process to be organised as a unified digital environment that integrates content creation, competency definition, assessment, analysis of results and the creation of personalised learning pathways. The modern e-learning process involves the coordinated participation of various roles – subject matter experts, curriculum designers, e-learning developers, trainers and administration – which requires not only pedagogical logic but also a well-structured technological architecture. The main objective is to provide a more optimised and faster personalised learning pathway for each learner, thereby simultaneously reducing the time taken to acquire knowledge and increasing motivation to complete the course.

The proposed architectural model is built on a web-based environment in which individual functionalities are not isolated but integrated into a common process for managing competencies and training. A key element in this environment is the authoring tool, through which the training content is developed and structured. This role is illustrated byFigure2 , showing the main screen of the AT, which serves as a central environment for creating and organising interactive training resources. The architectural significance of this component lies in the fact that it is here that the parameterisation of the content and its linking to the competency model begins.

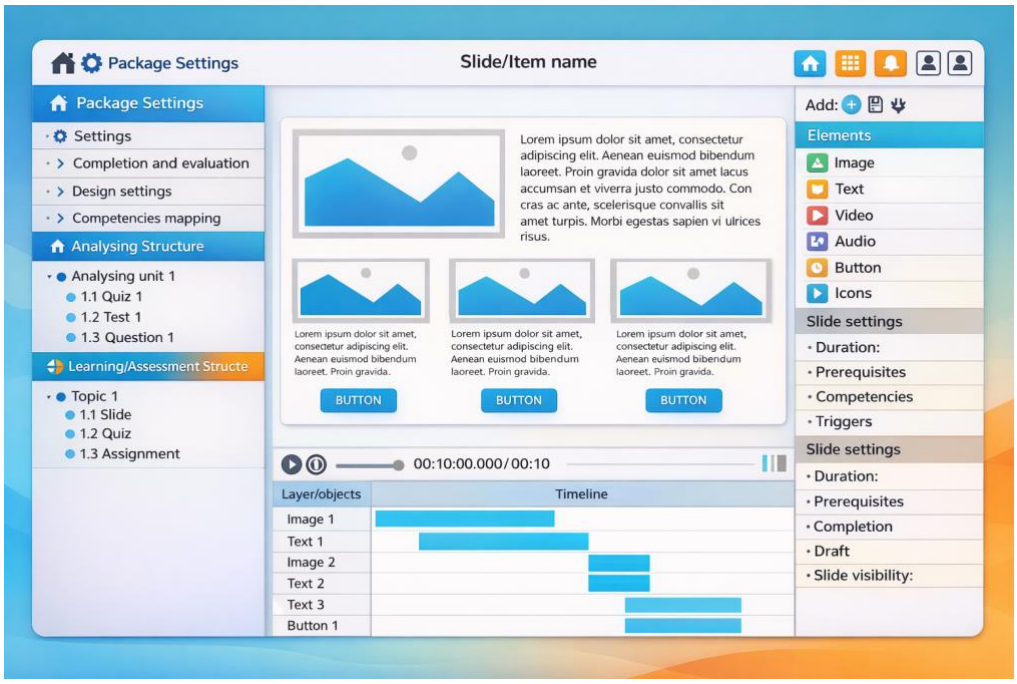


Figure2 . AT main screen

A key feature of the platform is that the learning content is not treated as a standalone resource, but as part of a system for developing and assessing competences. This requires each learning unit to be linked to one or more competences. This process is illustrated inFigure3 , which shows a competence being added to a slide. It is here that the link between the learning object and the learning objective is established, creating the possibility for the content to be used to address specific gaps and to be incorporated into a personalised learning programme.

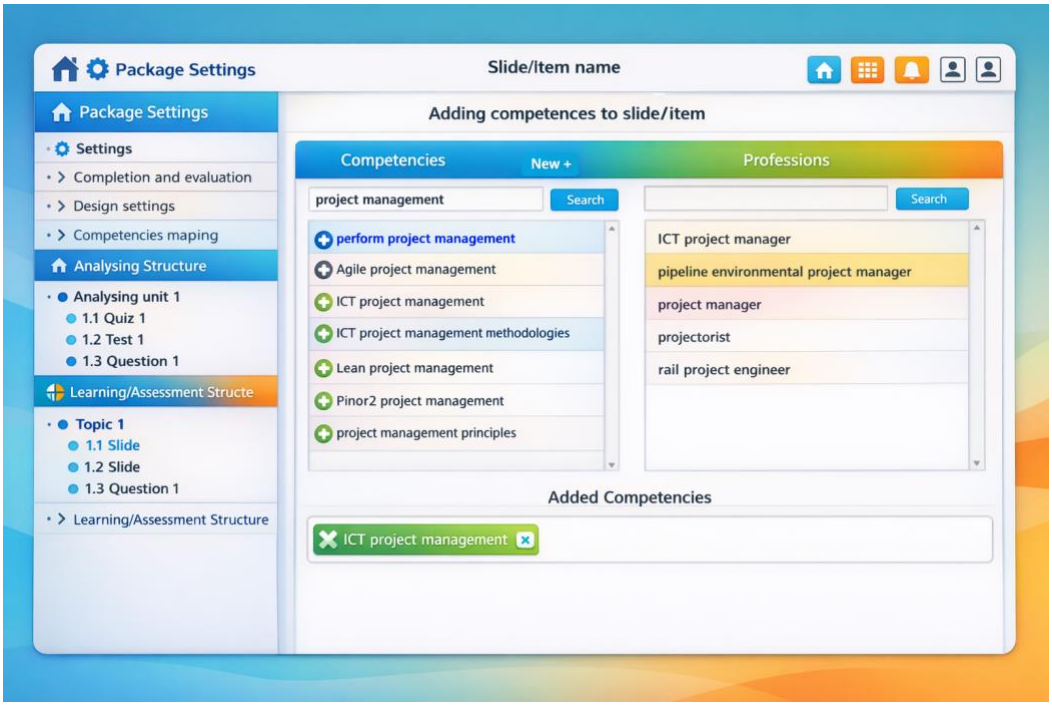


Figure3 . Adding a competency to a slide

The architecture also includes a mechanism for quantifying the expected level of mastery of each competence. This is necessary so that the system can not only establish a link between content and competence, but also assess whether the learner has achieved a sufficient level of mastery. This logic is presented inFigure4 , which illustrates the determination of the required percentage for each assessed competence. In this way, the platform supports not merely a qualitative description of knowledge and skills, but a formalised model for measuring the degree of mastery and for making decisions regarding the next steps in the learning process.

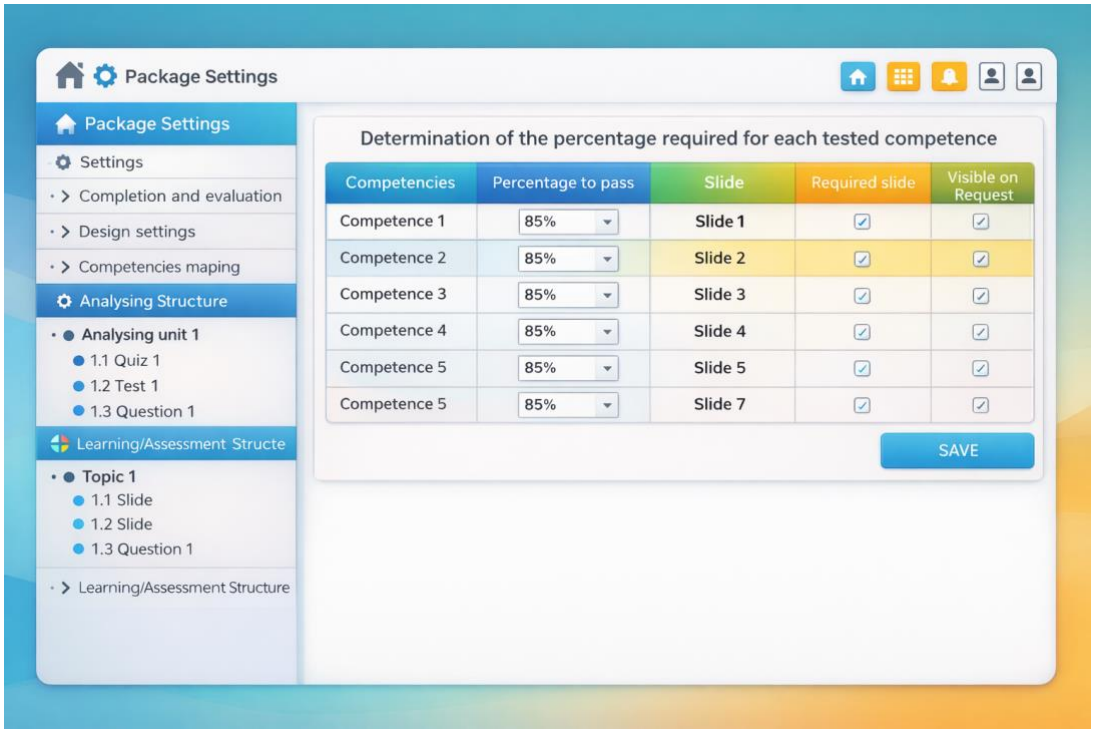


Figure4 . Determining the required percentage for each assessed competence

Another important aspect of the architectural design is the ability to continuously track the links between content, competences and outcomes. This is illustrated inFigure5 , which shows the monitoring of competence mapping. Such functionality is necessary to ensure consistency between the set learning objectives, the learning resources used and the assessment elements. From an architectural perspective, this means that the platform supports not only data storage but also an analytical layer through which it is possible to monitor the extent to which the content actually covers the relevant competences and whether the training model has been applied correctly.

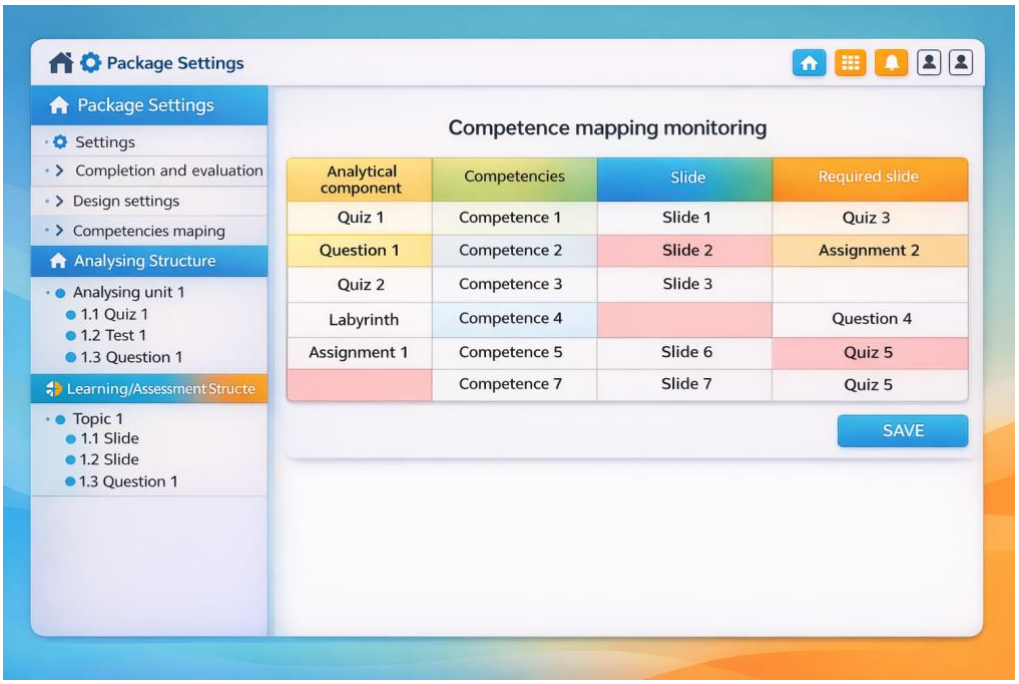


Figure5 . Monitoring of competence mapping

The final step in this process involves processing the results of the analysis and using them as the basis for personalising the learning pathway. This is illustrated byFigure6 , which shows the result of passing through the analysis module. Here, the architecture fulfils its primary function – to collect data on the learner's performance, compare it with the competency model, and use it to determine subsequent training. In this way, the platform becomes a tool not only for delivering content, but for managing the entire cycle: diagnosis, analysis, interpretation and adaptation of training according to the individual profile.

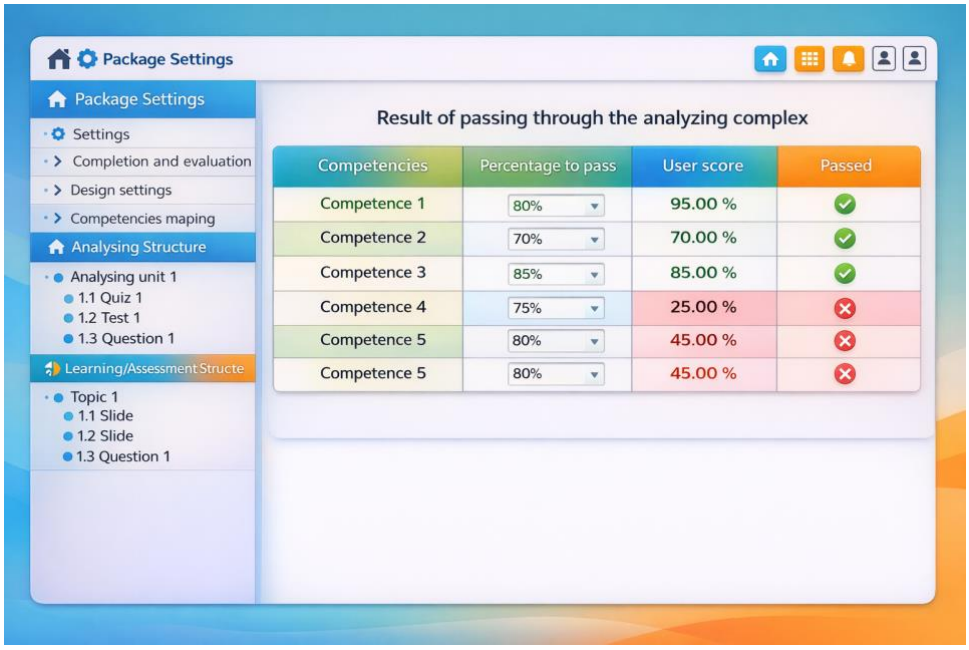


Figure6 . Result of passing through the analysis complex

Consequently, the design of the architecture for a web-based platform for managing personalised competences involves the creation of an integrated environment in which the

authoring tool, the competence model, the assessment mechanisms and the analytical functions work in harmony. The relationship between these components is traced sequentially through Figures 7–11, which illustrate the main stages of content creation, linking it to competencies, setting mastery criteria, monitoring mapping and analysing results. In this way, the architecture creates a technological foundation for the implementation of personalised, competence-based and data-driven e-learning.

3.2 Model of a comprehensive infrastructure for the creation and management of personalised competence profiles

In a rapidly changing economic and technological environment, organisations face the need to continuously update their employees' knowledge, skills and behaviour. Globalisation, automation, digital transformation and the growth of knowledge-based sectors require more flexible learning systems that ensure measurable and personalised human capital development. Traditional LMS solutions primarily perform content delivery and tracking functions, but often fail to provide an integrated link between learning resources and the competency models used in strategic human resource management. As a result, training programmes remain standardised and insufficiently tailored to the actual needs of individual employees or groups.

To overcome these limitations, a comprehensive infrastructure is required, designed as an integrated learning ecosystem in which each module is interconnected and operates within a unified framework. Such a model ensures connectivity between all stages of the process – from defining competencies and creating content to delivering personalised learning pathways, validating outcomes and analysing impact. Data flows bidirectionally between the individual components, enabling real-time adjustments, reducing administrative burden and enhancing the learner experience. The overall logic and interactions between the modules are presented in Figure7 , which illustrates the closed loop from competency modelling, content tagging and personalised sequencing to assessment, automation and analytics.

Figure7 . Infrastructure for creating and managing personalised competency profiles

The architecture operates on a shared data model that enables competence-based personalisation throughout the entire training process. It is underpinned by several coordinated data layers. The first is the competency model layer, which includes competency elements with unique identifiers, proficiency scales, weights or priorities for individual roles, and types of evidence of mastery. The second is the learner profile layer, which contains the current level of competence mastery, information on the validity and currency of evidence, as well as preferences and constraints related to learning. This creates a basis for comparing target requirements with the actual status of the specific learner.

A comprehensive infrastructure is not merely a collection of tools, but an environment in which each module performs a distinct function whilst sharing a common information base with the others. It is precisely this synergy that enables consistency, accuracy and coherence to be achieved between the strategic objectives of HR management and individual learning pathways. In this way, the infrastructure becomes a strategic mechanism for competence-based talent development, rather than merely a technical tool for administering training.

A key outcome of the model is that it creates the conditions for building and maintaining personalised competency profiles as dynamic, rather than static, structures. The analysis of results, the link between content and competencies, and the possibility of automatically reordering the learning path allow the learner's profile to be updated according to their progress. This ensures a continuous cycle of diagnosis, training, assessment and further refinement of needs.

Consequently, the model of a comprehensive infrastructure for creating and managing personalised competence profiles can be regarded as the technological and organisational foundation for competence-based e-learning. Through the integration of competence modelling, content parameterisation, prior knowledge analysis, automated resource provision and follow-up analyses, it becomes possible for training to be more flexible, more effective and more closely aligned with the actual needs of learners and organisations.

3.3 Conclusions

This chapter outlines the architecture of a platform for creating individual competence profiles and personalised training programmes, through which the models and methods proposed in the previous chapter are technologically implemented. The analysis showed that for personalised training to be practically applicable, it is necessary to build an integrated web-based environment that combines competence management, the configuration of training objects, the generation of personalised programmes, and the tracking of training outcomes.

The developed architectural concept demonstrates that the effectiveness of such a platform depends not only on the presence of individual functional modules, but on the clear definition of their roles, interrelationships and sequence of operations. In this sense, the comprehensive infrastructure model provides a foundation for the coordinated flow of the entire process – from defining competency requirements and building a profile, through the analysis of gaps and the selection of learning resources, to the provision of a personalised learning pathway and the subsequent assessment of the results achieved. This creates the conditions for a transition from

fragmented and loosely connected solutions to a comprehensive system for managing personalised learning.

It is particularly important that the proposed architecture lays the groundwork for scalability, modularity and subsequent expansion. By clearly distinguishing the main functional components, the platform can be adapted to different organisational contexts, learner types and requirements for learning content. Furthermore, the architectural model supports the integration of analytical mechanisms and intelligent technological tools, including those based on artificial intelligence, without disrupting the overall logic of the system.

Consequently, the results of Chapter 3 demonstrate that the developed architecture constitutes the necessary link between the methodological framework of the thesis and its software implementation. It demonstrates that the proposed approach to building an individual competence profile and personalised training programmes can be realised as a coherent, technologically sound and applicable platform. This naturally leads into the next chapter, in which the architectural solutions are presented in the context of a developed prototype.

CHAPTER 4 – PROTOTYPE OF A PLATFORM FOR CREATING AN INDIVIDUAL COMPETENCY PROFILE AND PERSONALISED TRAINING PROGRAMMES

This chapter presents a prototype of a software platform for creating and delivering a personalised learning pathway based on the learner's competence profile. The platform combines key functionalities related to the management of personalised training programmes, the development of interactive content, the description and accumulation of competencies, and the management of access to training resources. The main idea is to assist organisations in planning, creating, delivering and monitoring the learning process, whilst ensuring a higher degree of personalisation. The system is designed to facilitate the work of both learners and other participants in the process – training organisers, trainers, content authors and administrators.

4.1 Competency-based personalised training programme management system

The management system for personalised training programmes implements the core logic of the platform, providing an environment for delivering training, tracking progress and monitoring results. It is designed to support not only standard participation in e-learning, but also more precise management of the learning process depending on the user's role and the results achieved. Learners access content via an interactive player, which displays the course elements, progress and completion requirements. The platform provides information on both the completion status and the results of the assessment components completed, which forms the basis for analysing the level achieved and for subsequent training planning. An important part of this module is the ability to review results in detail – both at course level and at the level of specific assessment components and individual answers. This allows the learning process to be monitored not only administratively but also analytically, with a focus on the actual performance of learners. At the end of this cycle, the system also maintains a learner profile, in which information on completed training, results and development over time is accumulated. Visually, this logic is represented by*Figure8* . Learner profile, which shows how information on accumulated learning experience is stored and structured within the system.

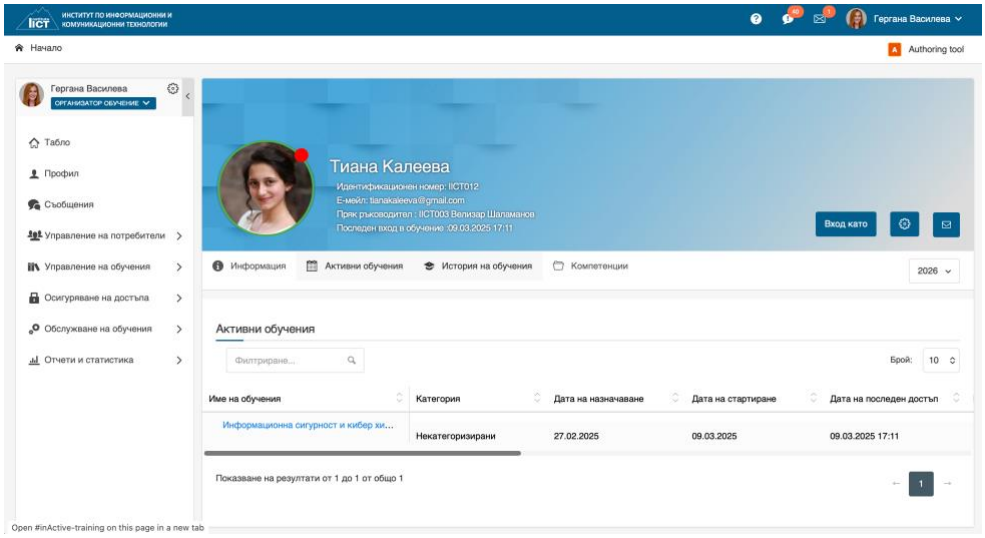
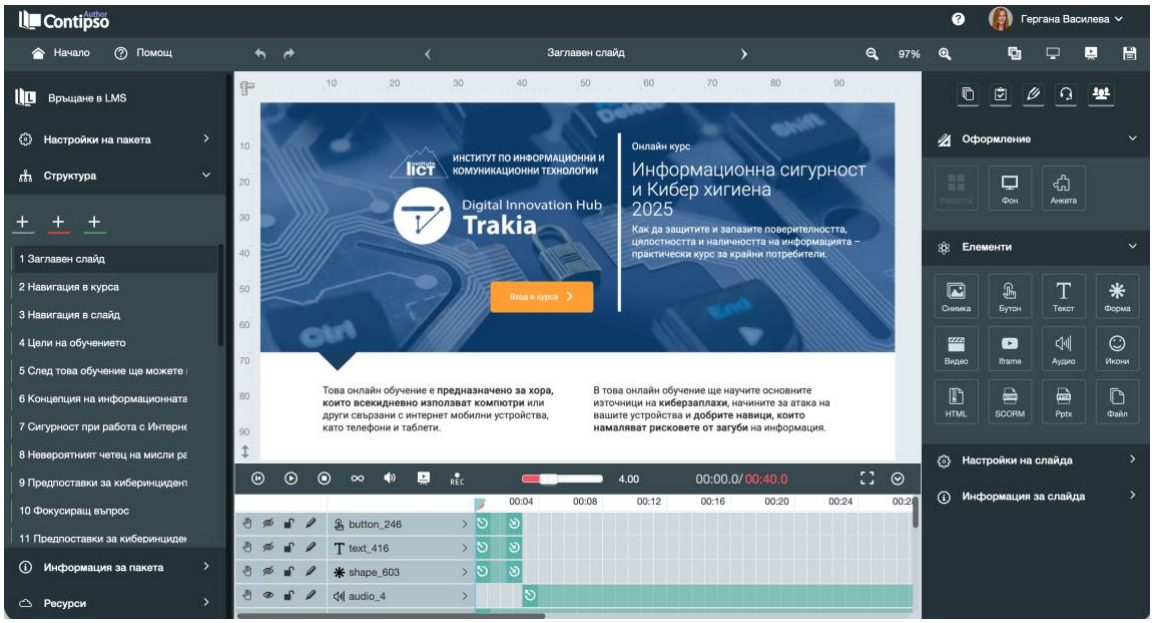


Figure8 . Learner's file

4.2 Tool for developing interactive training

The interactive learning development tool is the environment through which educational content is created, edited and organised. Its main function is to provide authors and editors with the ability to develop interactive, multimedia and structured training materials, which can subsequently be used in the personalised training programme management system. The tool's home screen is organised as a library of training courses, templates and resources, through which access to individual content packages is managed and the overall organisation of the materials being developed is maintained. A key feature of the tool is the ability to add interactivity, through which the content can respond to the learner's actions and guide them through different scenarios. This is particularly important when building adaptive and personalised learning pathways, as it allows conditions, choices and alternative routes to be embedded within the content. In addition, a module for creating and managing tests has been implemented, which allows for the development of various types of assessment components, the configuration of questions, weightings, question banks and conditions for administration. Furthermore, requirements for completing the training can be set, relating to mandatory screens, tests, tasks and other elements that determine the progression logic. This functionality transforms the tool not merely into a content creation environment, but into a means of modelling a comprehensive interactive learning experience. This is illustrated by*9* . Screen for adding interactivity, which shows how mechanisms for active interaction and branching of the learning process are introduced into the content itself.



9Figure . Screen for adding interactivity

The tool also includes a module for creating and managing tests, which allows for the development of various types of assessment components, the configuration of questions, weightings, question banks and conditions for administration. This enables assessment to be an integrated part of the learning process, rather than merely a final stage following its completion.

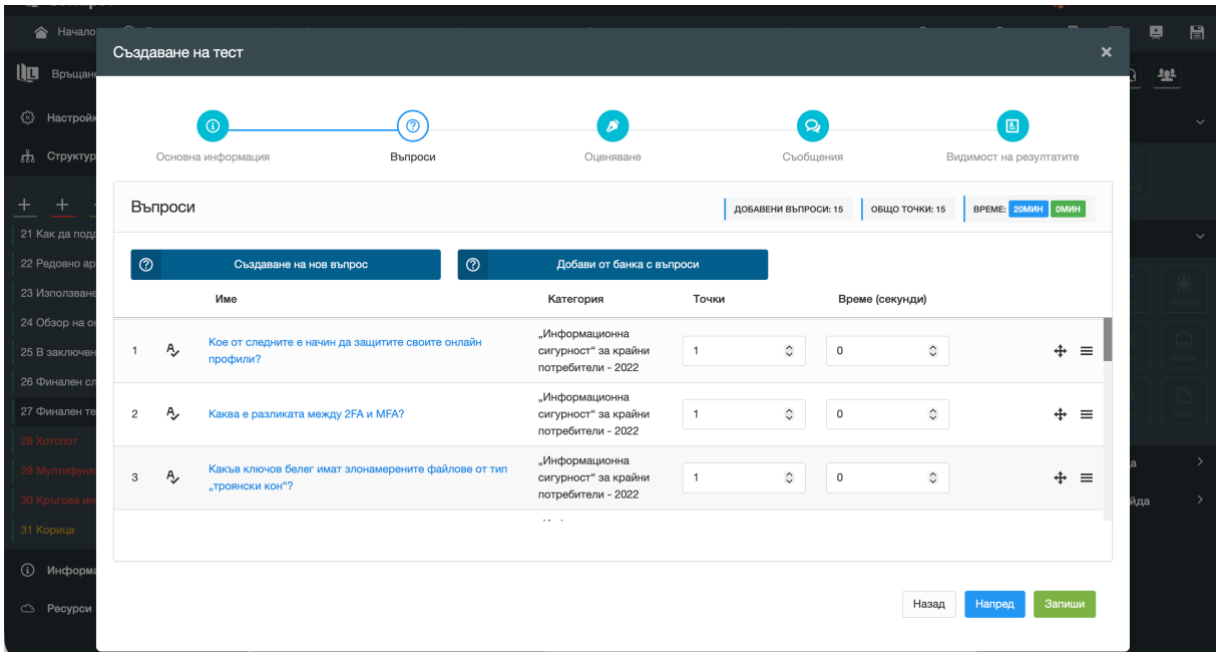


Figure10 . Screen for creating and managing tests for assessing competences

Another key feature is the ability to configure the requirements for completing the training. This allows conditions to be set relating to mandatory screens, tests, tasks and other components that determine the progression logic and successful completion of a given training course.

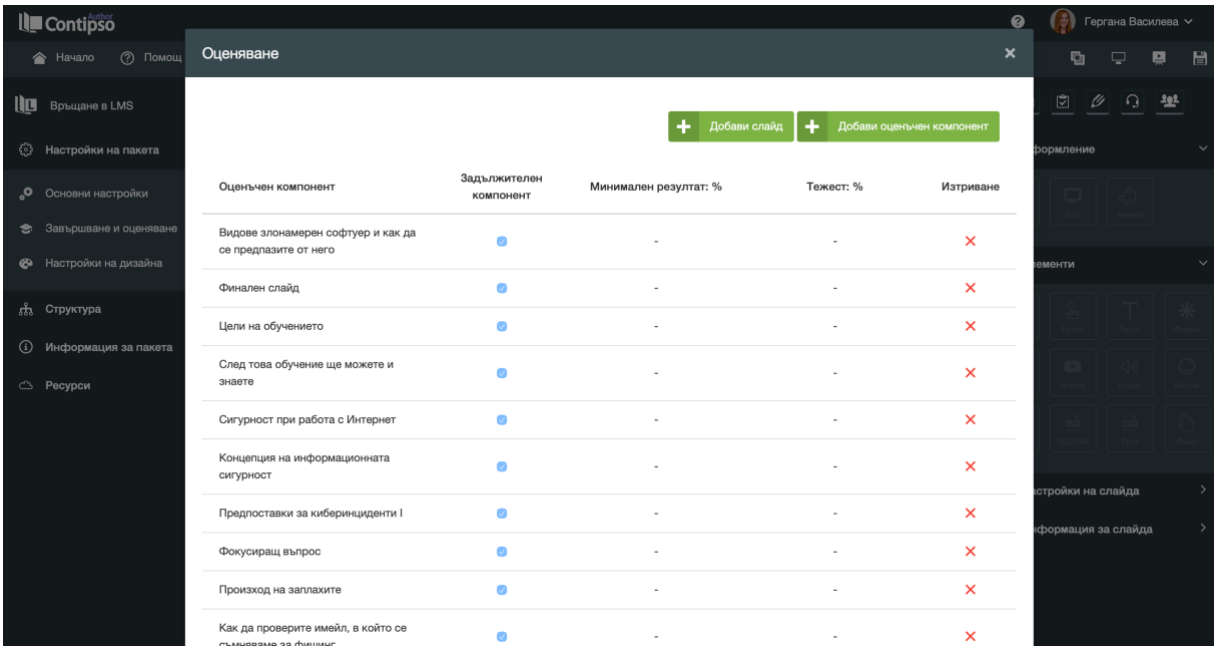


Figure11 . Screen for configuring course completion requirements

4.3 Competency Management Module

The Competency Management Module is key to implementing the competency-based approach within the platform. Its primary function is to establish a link between the training content and the competencies that are to be developed and assessed during the training process. The system

features an interface for mapping training content to competences, through which individual screens, topics or training units can be linked to specific competences. In this way, the content is parameterised and can subsequently be used to generate personalised learning pathways tailored to individual gaps and target requirements. Upon successful completion of a training course or specific elements thereof, the certified competences are accumulated in the learner's profile. In this way, the system maintains information on the learner's development and creates the basis for subsequent analysis of gaps, planning of future training, and tracking of progress over time. In this sense, the module has a dual function – on the one hand, it describes the content through competences, and on the other, it maintains the individual competence profile as a dynamic structure that is updated depending on the learner's results. This logic is illustrated in*Figure 12* . Screen for describing training content using competences, which shows how the link between learning elements and target competences is established within the system.

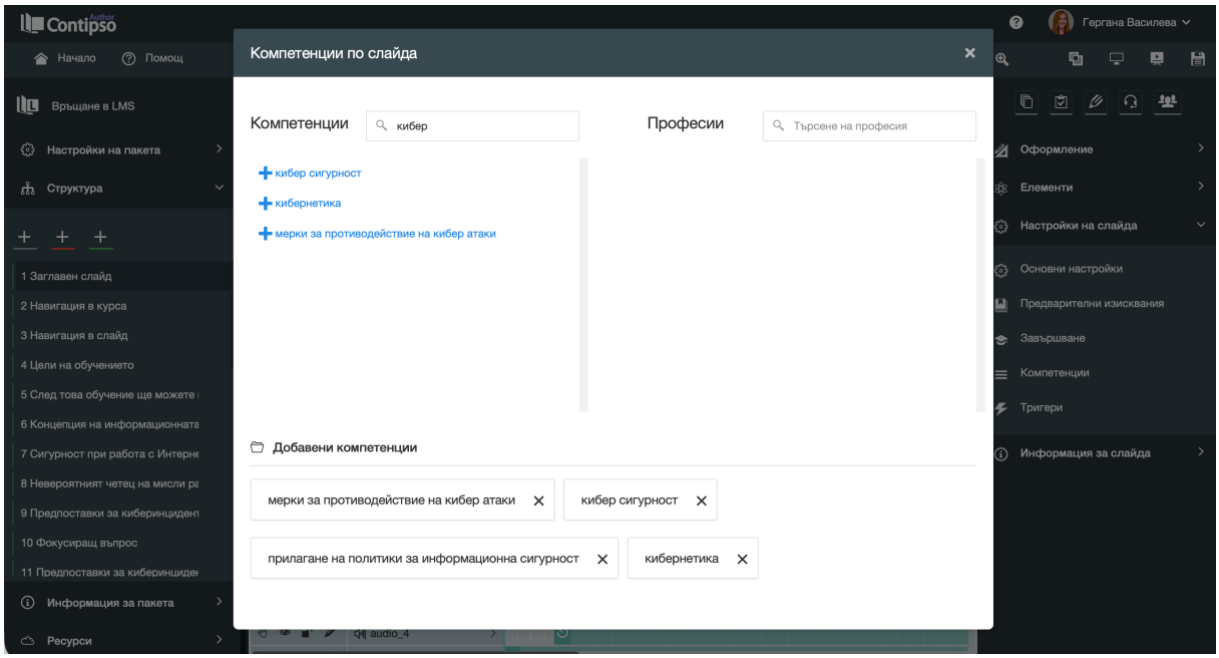


Figure 12 . Screen for describing training content with competences

Upon successful completion of a training course or specific elements thereof, the certified competences are accumulated in the learner's profile. In this way, the system maintains information on the learner's development and creates the basis for subsequent analysis of gaps, planning of future training, and tracking of progress over time.

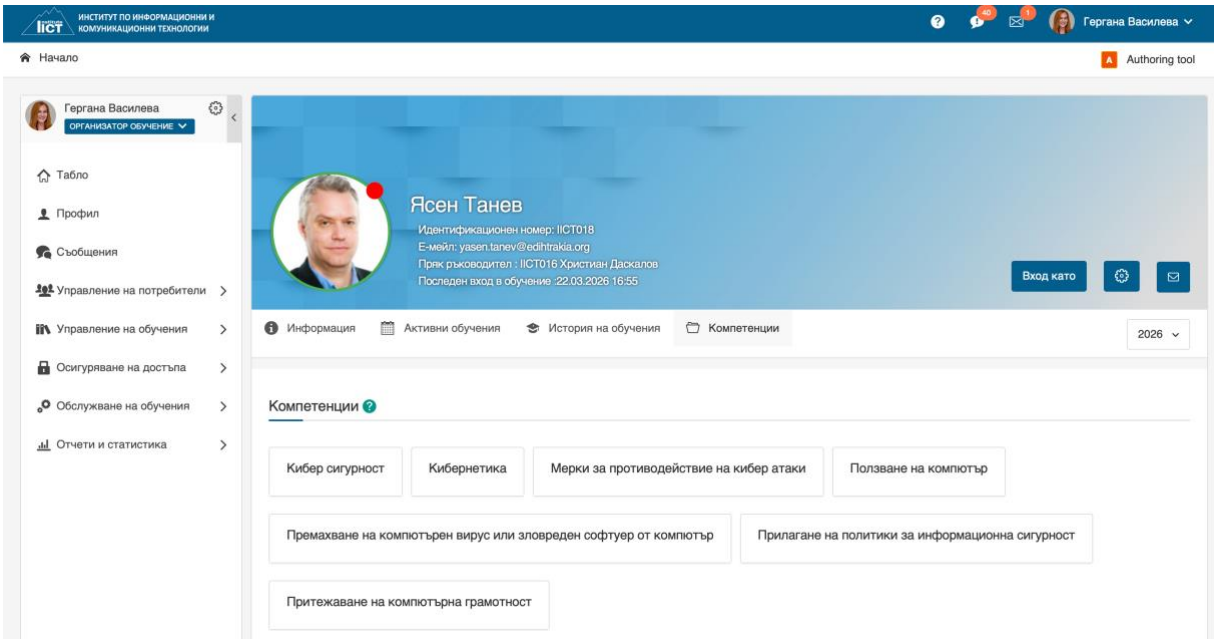
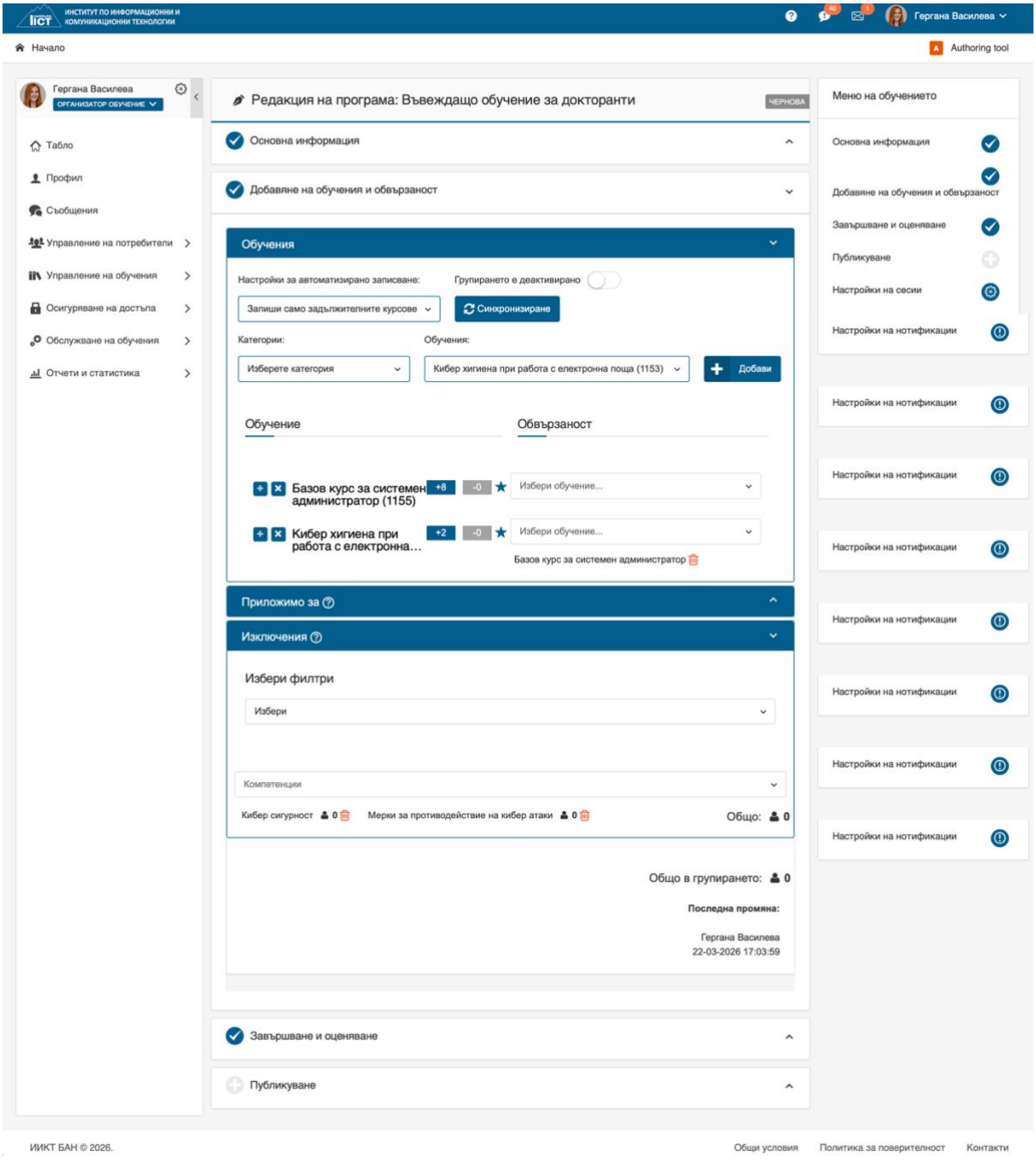


Figure 13 . Learner profile showing all competences accumulated from successfully completed training courses

4.4 Access Management

The access management module is designed to ensure the controlled provision of training courses and programmes in accordance with predefined rules, user characteristics and the logic of the learning path. Its importance is particularly significant in an organisational environment where access to courses often depends on job role, organisational affiliation, previously completed training, or other conditions. The system includes the ability to create a training plan and set prerequisites for access to a specific course. In this way, a sequence between training modules can be defined, as well as conditions for unlocking new content upon meeting specific criteria. This facilitates the management of personalised learning pathways and ensures that the learner gains access to the relevant content at the right time and once the prerequisites have been met. In addition, the system provides user management functionalities, including the creation, editing and maintenance of user profiles, as well as the use of user data for the automated allocation of access to training courses and programmes. Furthermore, organisational structure management is supported, allowing the creation of a hierarchical organisational structure, the assignment of line managers, and the restriction of access to specific directorates, departments or units. In this way, the module combines the logic of personalised learning with real organisational dependencies and administrative rules. This functionality is illustrated in*14* . Creating a training plan and adding prerequisites for course access, which demonstrates how the system implements conditional and sequential access to training resources.



14 Figure. Creating a study plan and adding prerequisites for course access

In addition, the system provides user management functionalities, including the creation, editing and maintenance of user profiles, as well as the use of user data for the automated allocation of access to training courses and programmes. This ensures the administrative sustainability of the process and enables more precise management of the learning environment.

5. Conclusion and summary of the results

This thesis examines the issue of analysing training needs, building individual competence profiles and creating personalised training programmes within the context of modern e-learning. Based on the analytical review conducted, it has been established that existing solutions in the field of e-learning, competence management and the development of learning content in most

cases address separate aspects of the learning process, but rarely offer an integrated approach that ensures a consistent link between competency requirements, learner assessment, gap analysis, content parameterisation and the personalised delivery of training resources.
In line with the stated aim of the thesis, an approach is proposed that combines **a model, methods and software tools** for analysing training needs, creating individual competence profiles and delivering personalised training programmes. Within the scope of the research, the role of the competence-based approach is justified as a suitable foundation for building adaptive training solutions, as it allows for the formalisation of job requirements, the assessment of the trainee's current status, and the identification of gaps to be addressed through training.

Chapter 2 sets out **the** key **models and methods** required to implement the proposed approach. A model has been developed for constructing a competency profile for a professional role, which enables a systematic description of the knowledge, skills and competencies required to perform a specific professional role. A method for analysing training needs based on competence gaps is proposed, in which the difference between the target job profile and the trainee's current status serves as the basis for identifying training needs. A method has also been developed for personalising the training programme according to the trainee's individual competence profile, whereby the training content is selected and organised depending on the identified gaps and expected outcomes.
As part of the proposed scientific and applied approach, a model has been developed for creating individual competence profiles and personalised training programmes, which ensures a link between the job profile, the results of the assessment and the training content. A key element in this process is the proposed model for parameterising training content with competencies, which allows learning resources to be described, classified and utilised according to their role in addressing specific gaps. A method for developing content for e-learning courses is also proposed, focusing on modularity, reusability and suitability for personalisation.
The study also examines the possibilities for using generative artificial intelligence in the creation of educational content. In this regard, a model is proposed for the controlled use of generative AI in the process of developing training resources, combining expert-validated knowledge with capabilities for automated content generation, adaptation and updating.

Chapter 3 outlines **the architecture of a web-based platform** for creating individual competence profiles and personalised learning programmes. A comprehensive infrastructure has been designed that integrates competence management, the configuration of learning objects, the personalisation of the learning programme, and the analysis of learning outcomes. The main functional modules of the platform are defined, and their roles, interrelationships and place within the overall process of personalised learning management are described.
The results obtained show that the objective set for the thesis has been achieved at the conceptual, methodological and architectural levels. A model for constructing a competency profile for a professional role, a method for personalising the training programme, the architecture and functional capabilities of a personalised learning platform; and in the following chapter, these concepts are put into practice through the implementation and description of a prototype software system for creating a personalised learning pathway. In this way, the thesis offers a comprehensive scientific and applied foundation for the transition from a theoretically

grounded competency-based approach to a technologically feasible model for personalised e-learning.

Chapter 4 presents the developed prototype of a software platform for creating a personalised learning pathway based on the learner's competence profile. This chapter is of a practical and applied nature and aims to illustrate how the model, methods, architecture and functional dependencies developed in the preceding chapters can be implemented in a working software environment.

The main focus of the chapter is on the visual and functional presentation of the system through screen shots of the individual modules and interfaces. These demonstrate the main processes within the platform related to the creation of a competence profile, the configuration of training content, the analysis of gaps, the generation of a personalised training programme, and the tracking of results. The descriptions accompanying the images aim to clarify the purpose of the individual screens, the system's operational logic, and the link between the theoretically developed concepts and their practical implementation.

In this way, Chapter 4 serves as a natural continuation of Chapters 2 and 3, presenting the implementation of the proposed solutions in a practical context. Whilst the previous chapters developed the conceptual model, methodological framework and architecture of the platform, this chapter demonstrates their concrete implementation in a prototype software system. This makes it possible to assess the practical applicability of the proposed approach and to demonstrate its potential for real-world use in a personalised e-learning environment.

Scientific and applied contributions

In view of the work carried out in the thesis and the results obtained in the course of the research, **the** following **scientific and applied contributions** can be formulated:

1. **A method has been developed for personalising the training programme according to the learner's individual competence profile**, which enables the selection, organisation and adaptation of training content in accordance with identified competence gaps and specific learning objectives.
2. **A model has been developed for creating individual competence profiles and personalised training programmes**, through which learning objects are transformed into structured and usable elements for the dynamic construction of individual learning pathways.
3. **A model has been developed for the use of generative artificial intelligence in the creation of educational content**, which expands the possibilities for generating, adapting and updating learning resources whilst maintaining the necessary expert control.
4. **A model of a comprehensive software environment for managing personalised learning has been developed, and the requirements for the functional capabilities of the individual modules have been defined**, which provides a basis for the development and description of a prototype system for creating a personalised learning pathway in the next chapter of the thesis.
5. **An architecture and prototype of a web-based platform for creating personalised learning programmes** based on the learner's competence profile have been

developed, with the main functional modules, data flows and interrelationships between the processes of diagnosis, personalisation, content delivery and results analysis. The main functional modules of the system have been developed and the prototype has been tested in an operational environment.

Publications on the topic of the thesis

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4. Blagoev, I., Vassileva, G., Monov, V.. A Model for e-Learning Based on the Knowledge of Learners. Cybernetics and Information Technologies, 21, 2, pp. 121–135, 2021, ISSN:1311-9702, SJR: 0.42(Scopus) https://doi.org/10.2478/cait-2021-0023

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Directions for future research

The results obtained in this thesis outline opportunities for expanding and building upon the research in several promising directions related to the application of artificial intelligence in the analysis of learning needs, the construction of competency profiles, and the personalisation of training programmes. The development of AI-based technologies creates the conditions for a shift from predefined rules and models to more adaptive, self-adjusting and data-driven learning management systems.

One of the main directions for future research relates to the use of artificial intelligence for the automated development and updating of individual competency profiles. In this study, the competency profile is viewed as the result of a comparison between job requirements, assessment results and the structure of the training content. In the future, this process could be significantly expanded through the application of AI models that analyse the learner's behaviour in the digital environment, the results of tests and practical tasks, the manner of interaction with the content, and the dynamics of their progress. This would enable the creation of more dynamic and self-updating profiles that reflect not only the current state but also trends in the development of competencies.

Another important area is the development of intelligent mechanisms for recommending and generating personalised learning content. Future research could analyse how generative AI models and recommendation systems can be used to automatically create variants of learning resources tailored to the learner's level, their gaps, preferred learning style and professional context. Particularly promising is the exploration of the possibility of automatically adapting the complexity, format and sequence of content in real time, so that the training programme changes dynamically according to the learner's performance.

There is also significant potential for future development in the area of using large language models as intelligent learning assistants. Such systems could support learners through explanations, guiding questions, examples, micro-summaries, automated feedback and adaptive support when difficulties arise. From a research perspective, this raises questions regarding the accuracy of the generated responses, the pedagogical adequacy of AI support, the level of trust in the system, and the possibilities for integrating such assistants within competence-based learning.

Another promising direction is the development of hybrid models that combine expert rules and machine self-learning. Such an approach would allow the advantages of expert-defined competency models and assessment criteria to be preserved, whilst utilising the benefits of AI for identifying patterns, predicting learning gaps and proposing optimal development strategies. In this context, future research could focus on creating more robust and explainable AI solutions that do not merely automate individual tasks, but support pedagogical and managerial decision-making.

The area of explainable artificial intelligence (Explainable AI) in educational systems is also particularly relevant. When using AI for assessment, recommendation and personalisation, there is a need for the system's decisions to be understandable to learners, as well as to teachers and administrators. Therefore, future research could focus on developing mechanisms for transparency and interpretability, through which to justify why a particular learner has been

recommended specific content, how their competence gap has been identified, and on the basis of what data their profile is updated.

Last but not least, future research should also examine the ethical, organisational and regulatory aspects of the use of AI in personalised learning. With the growing use of algorithms for the assessment and adaptation of training programmes, issues relating to data protection, model reliability, the avoidance of bias and the guarantee of equitable access to training opportunities are becoming increasingly important. This implies a need for further research into the development of robust frameworks for the responsible use of AI in educational and corporate settings.

In summary, the future development of the issues under consideration is closely linked to the deeper integration of artificial intelligence into learning and competence management systems . This integration has the potential not only to increase the level of automation, but also to lead to a qualitatively new generation of personalised learning environments capable of analysing, predicting, adapting and supporting learning in a more intelligent, flexible and effective manner.

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