Information-diagnostic online SMART platform utilizing an open-source virtual learning environment*

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Abstract

This study explores the development of user requirements, permissions, and system architecture for the Information-Diagnostic Online SMART Platform, designed to adapt an open-source virtual learning environment. The platform aims to create a comprehensive, flexible, and adaptive educational space that fully meets the needs of higher education students. It incorporates a personalized learning approach, which is becoming increasingly essential in modern education. By catering to each student's unique needs, preferences, and learning styles, the platform enhances engagement, motivation, and academic achievement. Personalized learning enables students to progress at their own pace, focusing on areas that require additional support while leveraging their strengths. The SMART platform's architecture is built with scalability, security, and user-friendliness in mind. Its carefully designed user requirements and permissions ensure seamless management of a diverse user base while safeguarding data integrity and privacy. This robust framework supports various educational activities, including real-time diagnostics, feedback mechanisms, adaptive learning pathways, and personalized resource recommendations. Additionally, the platform follows inclusive design principles to ensure accessibility for all students, including those with disabilities and specific learning needs. By integrating advanced analytics and adaptive technologies, the SMART platform provides an interactive and dynamic learning experience that continuously adapts to student progress and feedback.

Keywords

Online education, e-learning, personalized learning in higher education, internationalization.

1. Introduction

Feedback plays a crucial role in the development of any learning platform. Information-diagnostic online platforms enable personalized learning by assessing individual progress and adapting to users' specific needs, enhancing the overall effectiveness of the learning process. Utilizing open-source virtual learning environments optimizes time and resources by reducing software development efforts. The flexibility of incorporating various testing methods allows for a comprehensive evaluation of user knowledge from multiple perspectives. These platforms support continuous progress monitoring, ensuring that learners receive timely insights into their development. Customizing virtual environments to accommodate diverse user needs enhances accessibility and inclusivity in education. Integration with different platforms and services further extends the functionality of online learning, creating a more seamless and interconnected experience. Progress

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tracking systems provide valuable insights into training effectiveness at various stages, while data analytics contribute to refining learning processes and maximizing their efficiency.

As part of the Erasmus+ Smart-PL project, a research team from Khmelnytskyi National University conducted an analysis of learning management systems (LMS) and platforms used by European and Ukrainian educational institutions. The study revealed that online learning and virtual exchange (VE) programs primarily utilize platforms such as Microsoft Teams/Office 365, Moodle, Blackboard Learn, Canvas, and others. These LMS platforms serve as key tools for implementing online information-diagnostic systems in both the EU and Ukraine. Additionally, other digital tools, including Zoom and electronic journals, can be employed to assess learning outcomes.

Tetiana Hovorushchenko, the project coordinator from Khmelnytskyi National University, carried out a survey among students and faculty members to evaluate the implementation of individualized learning approaches at the university. A total of 260 students and 80 lecturers participated in the survey. The findings highlighted the various types of activities currently integrated into the university's educational process:

1. Discussional lectures.
2. Individual practical tasks.
3. Master classes with the participation of employers.
4. Analysis of cases/situations.
5. Individual projects.
6. Group projects.
7. Individual research tasks.
8. Group research tasks.
9. Video lectures.
10. Virtual simulators.
11. Digital laboratories.
12. Electronic training manuals.
13. Interactive training aids.
14. Electronic tests.
15. Interactive games.

The key goals of Erasmus+ Smart-PL project are:

- Enhance students' motivation by implementing a learner-centered approach that accommodates individual needs through differentiated and personalized academic pathways.
- Improve transparency and clarity in education and assessment, including the recognition of non-formal learning, to reduce student anxiety about professional competencies and build confidence in achieving successful outcomes.
- Expand access to higher education for individuals with disabilities and specific academic needs by incorporating inclusive education practices, personalized learning models, and hybrid technologies.
- Strengthen university curricula by refining competency development processes and aligning program outcomes with educational components to enhance the quality of teaching materials.
- Facilitate student mobility through virtual exchanges and credit recognition across universities, countries, and different educational formats (formal, informal, and distance learning).
- Establish effective feedback mechanisms to monitor the performance of students, educators, and administrators.
- Foster collaboration among key stakeholders—including employers, local communities, and regulatory bodies (e.g., the Ministry of Education and Science of Ukraine and the National

Agency for Quality Assurance in Higher Education)—to create a dynamic system for aligning academic outcomes with evolving market needs and technological advancements.

- Prepare highly skilled graduates who meet EU quality standards and employer expectations while promoting a culture of lifelong learning.

To achieve a personalized approach to learning, the following tasks must be addressed: developing methodological support for a personalized learning model, designing an information-diagnostic online SMART platform by customizing an open-source virtual learning environment, and establishing a "Learning with No Limits" co-working center at each partner university.

2. State-of-the-art and related works

As part of the study, an analysis of scientific papers and related works on personalized learning was conducted. For instance, in [1], the authors examined the outcomes of a Virtual Exchange (VE) program that explored how COVID-19 influenced students' motivation for intercultural and pedagogical awareness through multimodal collaborative creativity in virtual environments. The learning environment utilized two platforms, along with digital tools such as Instagram, Wix, Google Sites, and YouTube video editors for communication and content creation. Students also used Zoom for interviews upon completing the VE, and electronic diaries provided by EVOLVE were implemented, allowing participants to document their experiences related to intercultural skills and digital literacy on a weekly basis.

According to the Sustainable Development Goals, access to quality education is a fundamental right for everyone [2]. Paper [3] highlights the crucial role of education in addressing global challenges. The study presents findings from the Virtual School Garden Exchanges (VSGE), where students from different countries engaged in knowledge-sharing on school gardens and related topics through emails, photos, videos, and video conferencing. A qualitative content analysis of semi-structured interviews was conducted, with participants representing various continents, including Europe, Africa, America, and Asia, and consisting of both male and female respondents. The study concluded that VE facilitated international engagement, experiential learning, and exposure to diverse perspectives, offering students opportunities to understand real-world challenges. Teachers employed semi-structured interviews, abductive analysis, and qualitative content analysis models to assess the impact of the program.

Study [4] explores the experiences of German and Swedish students participating in a Virtual Exchange (VE) program and the implementation of assessment methods. The researchers analyzed both quantitative and qualitative data on students' learning outcomes over three semesters. The study was conducted using the Zoom platform, where students completed an anonymous quantitative assessment through a web-based system and an oral qualitative evaluation using digital whiteboards accessible to all participants. An abductive approach was employed for analysis. The findings highlight that VE programs provide diverse opportunities for international student exchanges; however, future efforts will involve alternating between physical and virtual exchanges to enhance the learning experience.

In study [5], researchers conducted semi-structured interviews with educators involved in VE programs. Participants were identified through online research, VE platforms, national and international newsletters, conference networking, and literature review findings. The study included educators from England, Germany, India, Uganda, Mexico, Kenya, Greece, the United States, Peru, and Argentina. Each interview lasted approximately one hour and was recorded via Skype, with transcription and analysis performed using MAXQDA software. The study revealed that educators aimed to facilitate learning in complex intercultural settings, using the differences and similarities among student groups as learning opportunities. The research also considered key competencies for sustainable development. The conclusions emphasized the need for further studies to evaluate real learning outcomes and determine whether virtual environments effectively contribute to achieving sustainable development goals.

Study [6] assessed the impact of VE on students' intracultural learning to improve future intercultural communication. Researchers employed a quasi-experimental design with mixed methods to examine the effectiveness of inquiry-based learning in enhancing intracultural awareness and fostering high-quality intercultural collaboration in distance learning. The study was conducted among first-year university students in Japan, with the analysis focusing on the development of their intercultural competencies.

One of the groups conducted surveys or interviews following the 5E model of inquiry-based learning. In contrast, students in the control group were not required to follow a specific research method and could freely choose their approach using the Internet and other digital resources. The research in this group was conducted independently, without teacher assistance. Meanwhile, in the experimental group, all activities were guided by the teacher through the Microsoft Teams™ platform.

The primary research tool was a survey that included binary and multiple-choice questions, as well as items rated on a 5-point Likert scale. The questionnaire was administered via Microsoft Forms™ to 68 students in the control group and 64 students in the experimental group. Quantitative data analysis was performed using SPSS Statistics 27 (IBM™). Additionally, students completed an open-ended online survey, which was analyzed using MAXQDA Analytics Pro™ Ver.2020, a software designed for qualitative and mixed-method data analysis. The collected data underwent inductive content analysis to ensure thorough examination and interpretation.

Article [7] explores the organization and implementation of the VRTUOSI virtual campus, a program designed to facilitate virtual exchange among five European universities. The paper introduces a Six Sigma-based methodology developed to enhance the quality of VRTUOSI standards, structure, and web implementation, which can also be applied to other European virtual exchange (VE) programs. The system integrates essential learning modules, including tools for assessing student knowledge: the Grades module, which manages student scores; the Progress module, enabling students to track their development throughout the course; and the Exams module, an interactive tool that allows teachers to design and administer online exams in real-time. Additionally, the platform features communication services that enable interaction between students and instructors. The e-Talk module functions as a forum where students can ask questions and engage in discussions with peers and teachers.

Research paper [8] presents findings on postgraduate and master's students participating in Massive Open Online Courses (MOOCs) as part of a joint international program. The study was conducted across two academic programs at Hasselt University in Belgium and Princess Sumaya University of Technology in Jordan. The results indicated a positive reception of VE programs among both students and faculty. However, concerns were raised regarding the formal recognition of MOOCs as university courses. To address this, an evaluation of performance indicators—including online learning quality, content relevance, course selection, VE preparedness, assessment methods, international collaboration, and institutional reputation—was conducted. Surveys were administered to university management, faculty, and students to assess their readiness for MOOCs. Based on the findings, the teaching council will review and determine the credit allocation for these courses. Additionally, feedback from students who completed the MOOCs will be used to refine and improve the courses for future participants.

The study presented in [9] examines online assessment tools and their application in virtual learning at the Polish-Japanese Institute of Information Technology (PJIIT). The research explored the Edu system, which enables the creation of basic quizzes and tests. However, the need for a more flexible and responsive system arose, leading to the proposal of ASP technology integrated with a Microsoft SQL Server database. A key requirement was the ability to design diverse question formats, incorporate graphics, and support mathematical expressions using LaTeX. As a result, the system provided educators with full access to student performance data, including scores, IP addresses, time spent on assessments, and other relevant metrics.

Paper [10] addresses the challenges of online education, particularly in response to the COVID-19 pandemic, which necessitated the rapid adoption of digital learning methods and curriculum

adjustments. As a solution, the TA in Residence (TAiR) program was introduced, featuring regular review visits, structured experience exchange sessions, and participation in faculty development seminars. The article also highlights the assessment processes used for students in the Department of Computer Science, emphasizing the importance of evaluating learning outcomes in an online environment.

The authors of [11] explored the digitalization of higher education in Eastern and Central Europe. To achieve this, they examined theoretical aspects of education digitalization, analyzed trends and challenges in digitizing higher education in these regions, and proposed recommendations for improving the system. The article reviews several indices, including the Network Readiness Index, the Digital Skills Gap Index (DSGI), and the IMD World Digital Competitiveness Ranking, to assess the technological readiness of universities and the digital competencies of both teachers and students. A case study of a Ukrainian university's adoption of e-learning tools and an online learning environment is also presented. The study utilized SWOT analysis to evaluate the digitalization of higher education.

In study [12], the authors focus on online learning platforms and the assessment of learning outcomes through Massive Open Online Courses (MOOCs). They also examined various methods for analyzing behavioral pattern detection data, specifically employing a session-based approach to analyze user interactions with websites. The study utilized elbow and k-means clustering techniques. The findings revealed that most users tend to remain on websites for short periods, and the design of materials on different platforms influences the number of clicks and the structure of user engagement.

Paper [13] addresses the challenge of improving educational technologies in light of the issues that emerged during the COVID-19 pandemic. The authors analyzed various platforms such as Moodle, Google Classroom, edX, Coursera, FutureLearn, Khan Academy, Schoology, Classdojo, Seesaw, and CenturyTech. It was found that one of the most widely used distance learning systems at universities is the Moodle platform. The authors focus on the Questionnaire module, a survey tool used for evaluating and promoting online learning. This module can gather data from students, which can enhance mutual understanding and improve the learning process. The evaluation technology presented by the authors can be integrated into any educational system, thanks to the universal features provided by Google services. The developed technology is particularly beneficial for studying individual factors of cognitive independence in education facilitated by electronic learning tools. Key advantages of this technology include the ability to organize adaptive learning, the flexibility to implement surveys in any electronic educational system, user-friendliness, and a modular structure.

However, none of the studies reviewed focus on developing an online platform for personalized learning with virtual exchange elements. Therefore, the creation of an Information-Diagnostic Online SMART Platform, based on adapting an open-source virtual learning environment, is a crucial and timely task for providing a personalized learning model.

3. Methodology & theoretical background

The goal of the personalized learning approach in higher education is to enhance the educational experience by adapting it to the unique needs, interests, and learning preferences of each student. This approach seeks to accomplish several key objectives [14-17]:

- Boost student engagement and motivation – By offering relevant and meaningful learning experiences, personalized learning increases student interest and encourages active involvement in their education.
- Enhance learning outcomes – Customizing learning paths helps students achieve better academic results and a deeper understanding of the subject matter, allowing them to learn at their own pace and focus on areas where they need the most support.

- Support diverse learning styles and needs – Personalized learning accommodates various learning preferences and requirements, ensuring all students, including those with disabilities or specific learning needs, have equal opportunities to succeed.
- Promote independence and self-direction – Encouraging students to take charge of their learning fosters critical thinking, problem-solving skills, and the ability to independently navigate their educational journey.
- Increase flexibility and accessibility – Offering flexible schedules and diverse instructional methods makes higher education more accessible to a wider range of students, including non-traditional learners and those with demanding schedules.
- Encourage lifelong learning – Cultivating a mindset of continuous learning and adaptability prepares students for ongoing personal and professional growth, equipping them with the skills necessary for long-term success.
- Utilize technology for improved education – Employing advanced educational technologies and data analytics enables more efficient and effective teaching, providing real-time feedback and personalized recommendations to enhance the learning experience.

The overall goal of personalized learning in higher education is to create a more effective, inclusive, and student-focused educational environment that equips students to navigate the complexities and challenges of the modern world.

Inclusive learning is a central tenet of personalized learning. As stated in [18], inclusive education involves placing all students, regardless of their challenges, in age-appropriate general education classrooms within their local schools. In these settings, students receive high-quality instruction, interventions, and support to help them succeed in the core curriculum. The principles of an inclusive environment are illustrated in Figure 1.

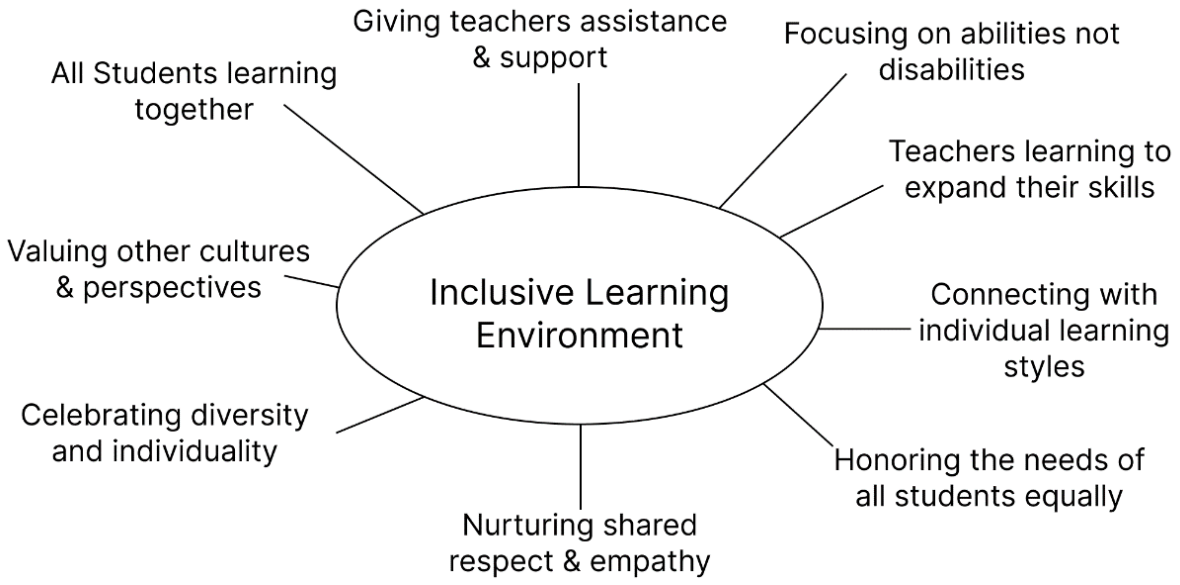


Figure 1: Inclusive learning environment [14].

As noted in [19], students with disabilities who spend more time in inclusive environments tend to achieve higher scores on language ability tests (Figure 2).

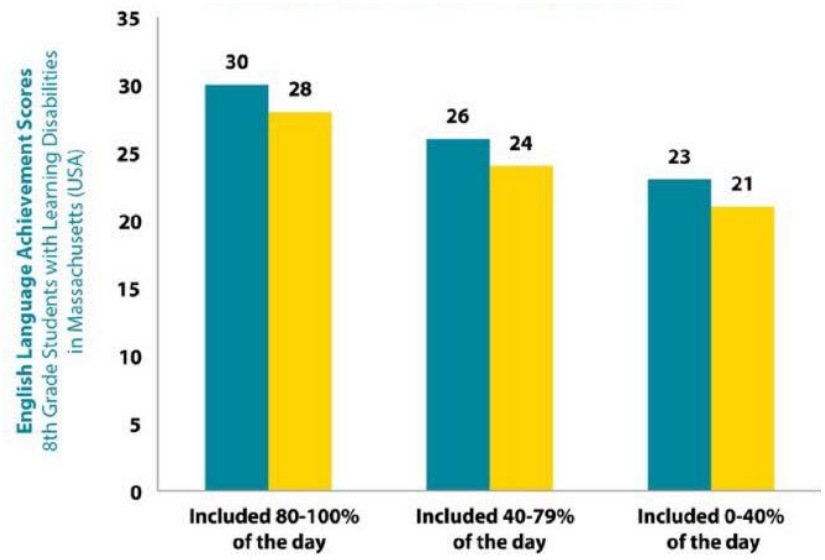


Figure 2: Students with disabilities who are educated in general education classrooms tend to outperform those who are taught in segregated settings [19].

Another essential principle of personalized learning is intercultural understanding, which includes the following components (Figure 3): recognizing and respecting culture – exploring cultural identities, comparing cultural knowledge, beliefs, and practices, and promoting respect for cultural diversity; interacting and empathizing with others – communicating effectively across cultures, embracing diverse perspectives, and fostering empathy; reflecting on intercultural experiences and taking responsibility – reflecting on intercultural interactions, addressing stereotypes and prejudices, and bridging cultural gaps.

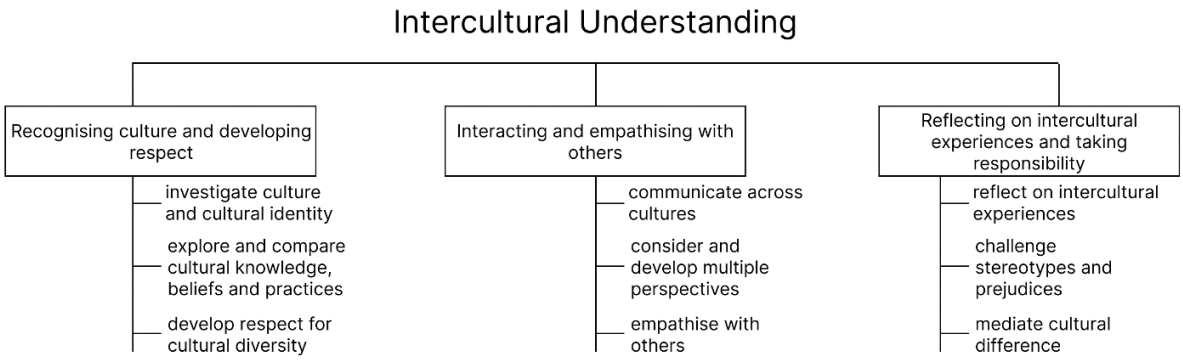


Figure 3: Intercultural Understanding principles.

Another key component of personalized learning is the ability to receive feedback from students, which helps maintain the teacher-student connection and allows for adjustments to the educational program based on individual student needs. Professor George Dafoulas, in his works [20-23], suggests using analytics to track student feedback and their responses to various educational components. However, tools that automatically gather reviews and statistics offer much more effective and reliable data [24-27].

Our study proposes an Information-diagnostic online SMART platform, adapted from an open-source virtual learning environment, which will include not only virtual learning elements but also features for the automated collection of statistics on students' engagement and feedback regarding the course.

4. Specifications and architecture of the information-diagnostic online SMART platform utilizing an open-source virtual learning environment

The SMART-PL information-diagnostic online platform will serve as a diagnostic tool designed for educational purposes. This platform will offer a range of features and functionalities to assess, analyze, and provide insights into educational needs. Below are some possible components and features that could be included in an information-diagnostic online platform for education:

1. Assessment Tools: Diagnostic Tests – Tailored assessments to measure a user's proficiency in various subjects or skills; Learning Style Assessments – Identifying individual learning preferences to customize educational content.
2. Personalized Learning Paths: Adaptive Learning – Modifying the difficulty and content of materials based on user performance; Recommendation Engine – Suggesting relevant courses, modules, or resources according to diagnostic results.
3. Progress Tracking: Performance Analytics – Offering detailed insights into strengths and areas for improvement; Goal Setting – Enabling users to set educational goals and monitor their progress.
4. Feedback Mechanism: Detailed Feedback – Providing specific feedback on incorrect responses and areas for growth; Peer and Expert Feedback – Allowing users to receive feedback from peers or experts in the field.
5. Collaborative Features: Discussion Forums – Promoting collaboration and discussions among users.
6. Real-time Support: Chat or Help Desk – Offering immediate assistance from educators or support teams; FAQs and Tutorials – Providing self-help resources for troubleshooting common issues.
7. Integration with Learning Management Systems (LMS).
8. User-Friendly Interface: Intuitive Design – Ensuring an easy-to-use platform that is accessible to users of various ages and backgrounds; Responsive Design – Enabling access across different devices.
9. Content Authoring Tools: Built-in or compatible authoring tools – Facilitating course content creation.

The user categories and permissions for the Information-diagnostic online SMART platform, based on the adaptation of an open-source virtual learning environment, are as follows.

Ordinary users have access to a restricted set of system features.

Unregistered (Guest) – registration function.

Registered – authorization, view platform content.

Student – take diagnostic tests; select educational content based on personal needs; view system recommendations for learning materials; enroll in courses; access performance analytics; set and track educational goals; receive feedback from experts and peers; offer feedback to other students; participate in discussions on the forum; seek help from educators and support staff.

Educator (expert) – manage courses (create/edit courses); upload course content; facilitate discussions on the forum; provide feedback to administrators; give feedback to students on incorrect answers or areas for improvement; monitor student progress; assist students via the help desk; provide tutorials, FAQs, and resources for self-help and troubleshooting.

Administrator (support staff) – manage the SMART platform (create/edit/delete courses); design Course Templates with user-friendly interfaces; control user access and permissions; oversee the Discussion Forum; assist Educators and Students; provide FAQs on platform usage for Educators and Students; offer feedback to Educators and Students.

A system architecture for the information-diagnostic online SMART platform, adapted from an open-source virtual learning environment, has been designed based on specific requirements and functionalities. The architecture is depicted in Figure 4 as a diagram.

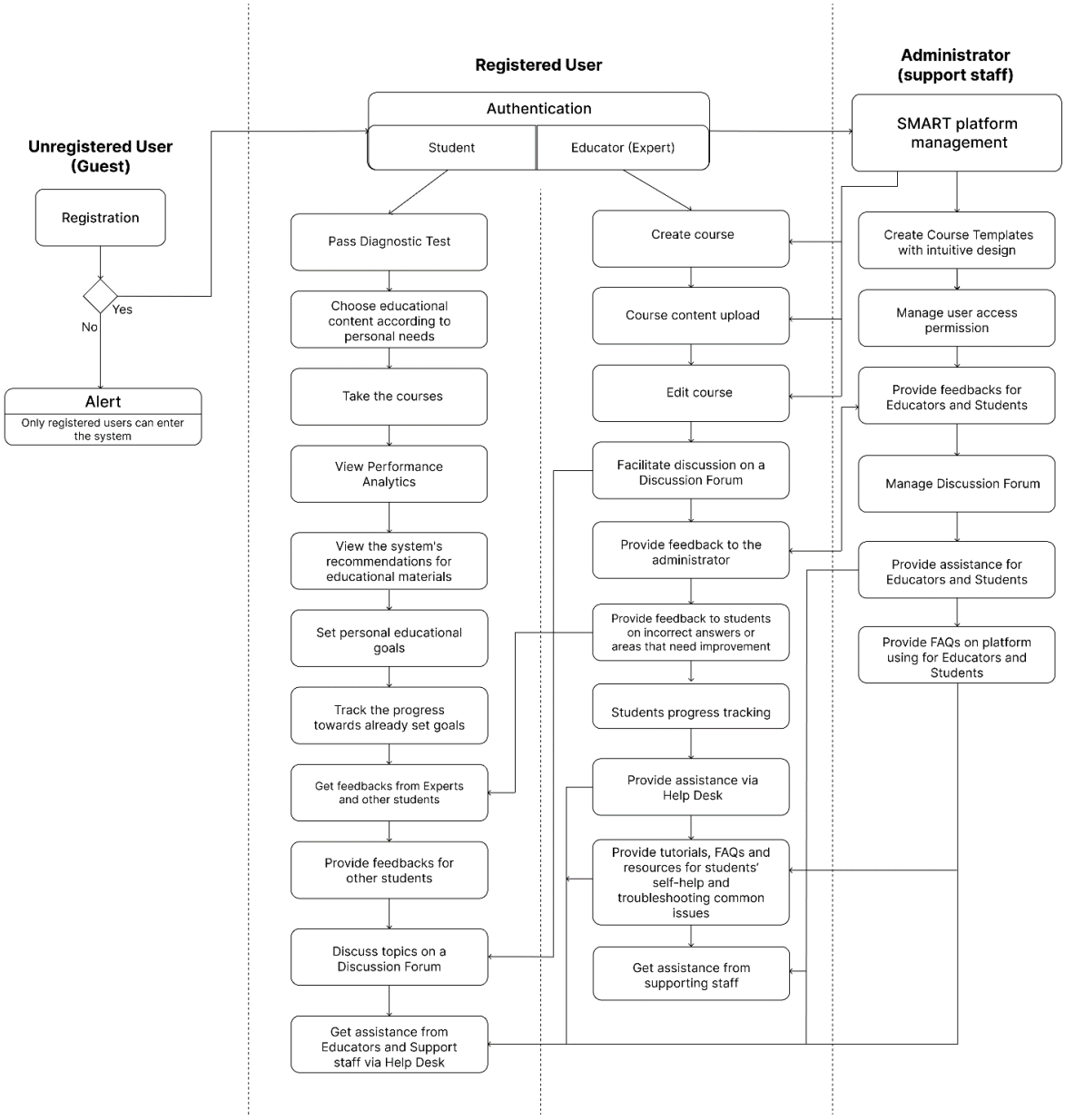
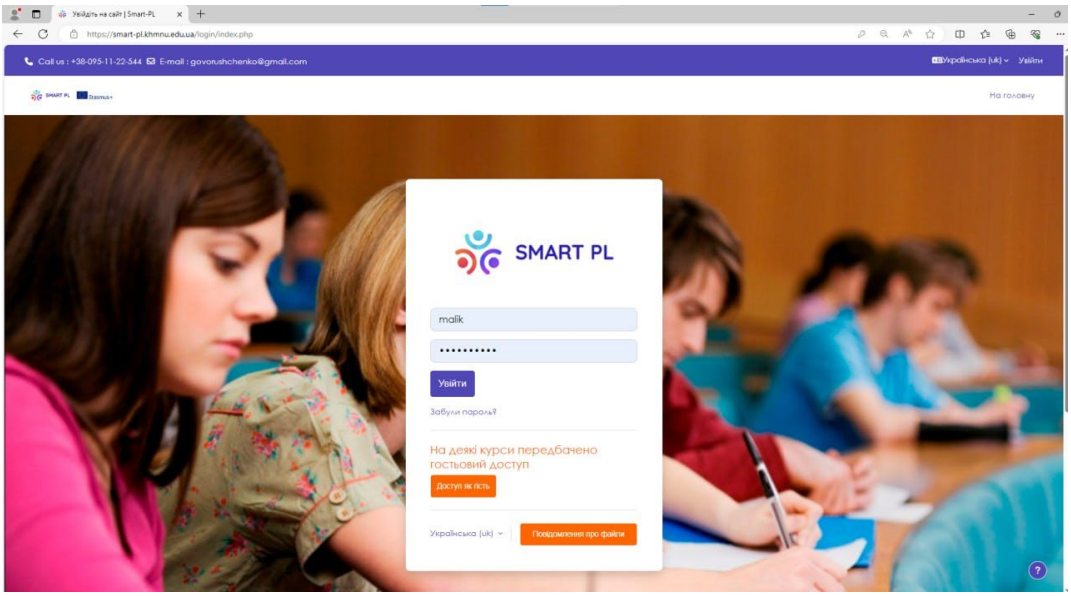


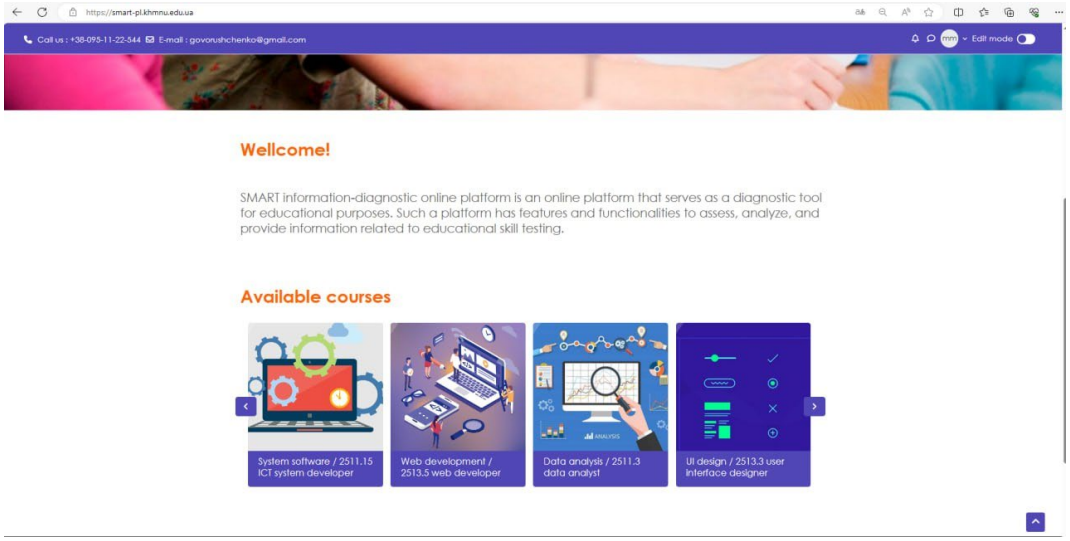
Figure 4: Architecture of Information-diagnostic online SMART Platform Utilizing an Open-Source Virtual Learning Environment.

5. Results & discussion

In this study, the Information-Diagnostic Online SMART Platform was created by customizing an open-source virtual learning environment. Figure 5 illustrates the main window interface, which includes a login form (a) and a course overview (b). Figure 6 showcases the user profile page, featuring selected courses (a) and course descriptions. The authors' future work will involve testing the system to support real student virtual exchanges as part of the Erasmus+ SmartPL project.

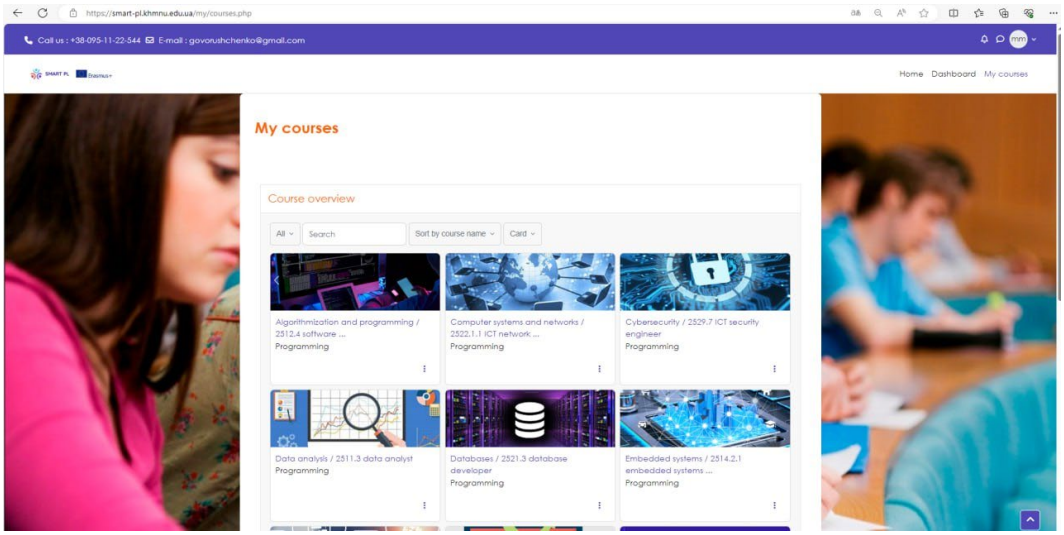


a)

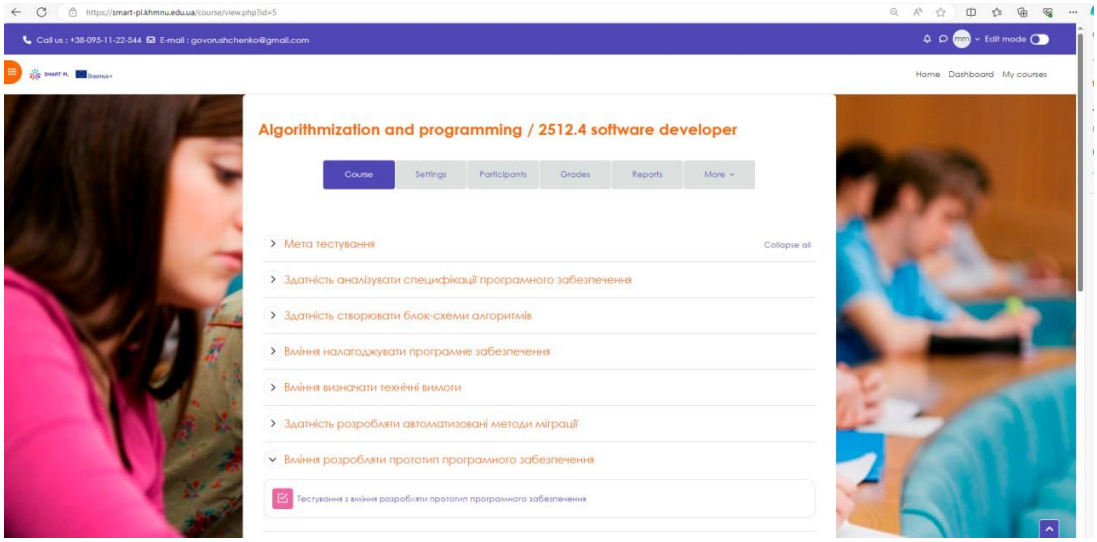


b)

Figure 5: User Interface of the main window of Information-diagnostic online SMART Platform Utilizing an Open-Source Virtual Learning Environment.



a)



b)

Figure 6: User profile picture and courses description of Information-diagnostic online SMART Platform Utilizing an Open-Source Virtual Learning Environment.

6. Conclusions

In this study, user requirements, permissions, and system architecture for the Information-Diagnostic Online SMART Platform, based on the adaptation of an open-source virtual learning environment, were developed. This platform is designed to offer a comprehensive, flexible, and adaptive learning environment that meets the diverse needs of higher education students.

The personalized learning approach proposed within this platform is increasingly important in today's educational environment. It addresses the unique needs, preferences, and learning styles of each student, thereby boosting engagement, motivation, and academic performance. By offering customized educational experiences, personalized learning allows students to progress at their own pace, focusing on areas where they need the most support and building upon their strengths.

The SMART platform's architecture prioritizes scalability, security, and user-friendliness. Key elements such as user requirements and permissions are carefully crafted to ensure the system can accommodate a wide range of users while ensuring data integrity and privacy. This robust framework supports various educational activities, including real-time diagnostics, feedback, adaptive learning pathways, and resource recommendations.

Additionally, the platform's inclusive design principles ensure that higher education is more accessible to all students, including those with disabilities and specific learning needs. By incorporating advanced analytics and adaptive technologies, the platform delivers a dynamic and interactive learning experience that responds to individual student progress and feedback.

In conclusion, the Information-Diagnostic Online SMART Platform offers a forward-thinking solution that aligns with the principles of personalized learning. It enhances the educational experience for students while also supporting educators in providing high-quality, tailored instruction. As higher education continues to evolve, the implementation of such innovative platforms will be essential in addressing the diverse needs of the student population and preparing them for future challenges. Future efforts will focus on further developing the system and conducting experiments with students from the partnering universities of the Erasmus+ SMART-PL project to facilitate virtual learning experiences.

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Declaration on Generative AI

During the preparation of this work, the authors used Grammarly in order to: grammar and spelling check; DeepL Translate in order to: some phrases translation into English. After using these tools/services, the authors reviewed and edited the content as needed and take full responsibility for the publication's content.

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