



# WP3: Participatory Action Research on Needs and Prioritisation Map



## TABLE OF CONTENTS

<b>Chapter 1 Introduction to Intelligent Tutoring System (ITS)</b> .....	<b>2</b>
1.1 Definition and characteristics of Intelligent Tutoring Systems.....	2
1.1.1 What are Intelligent Tutoring Systems? .....	2
1.1.1.1 Dataset availability and explainability of AI techniques .....	3
1.1.1.2 Dataset availability and explainability of AI techniques .....	3
1.2 Brief history of Intelligent Tutoring Systems .....	6
1.2.1 Adaptation to Higher Education.....	7
1.3 Importance of Intelligent Tutoring Systems in higher education .....	8
Content recommendation.....	8
Virtual reality and augmented reality .....	8
Plagiarism Detection .....	9
Inclusive and personalized education.....	10
Continuous training and professional development.....	10
Informal education and lifelong learning.....	10
Research and development in education .....	11
1.4 The Future of Education: Intelligent Tutoring Systems.....	11



## Chapter 1 Introduction to Intelligent Tutoring System (ITS)

The search for innovative and effective methods to enhance learning is an ongoing process. Intelligent Tutoring Systems (ITS) are emerging as a powerful tool with the potential to transform the way we learn and teach.

Unlike traditional methods, ITSs harness the power of technology to deliver personalized, adaptive and immersive learning experiences. These systems can assess each student's progress, identify their strengths and weaknesses, and adapt content and activities accordingly.

In this chapter, we will thoroughly explore the features, applications and benefits of ITS. We will analyze how these systems are revolutionizing education at various levels, from individualized tutoring to non-formal and informal education. Besides, we address the challenges and opportunities presented by implementing ITSs and discuss their potential to transform the future of learning.

#INTELLIGENTTUTORINGSYSTEM #HIGHEREDUCATION #LIFELONGLEARNING

### 1.1 Definition and characteristics of Intelligent Tutoring Systems

#### 1.1.1 What are Intelligent Tutoring Systems?

In the current educational landscape, Intelligent Tutoring Systems (ITS from now on) are presented as innovative tools with the necessary potential to transform the way we learn, teach support and evaluate students in Higher Education. To better understand their impact, it is crucial to accurately define what ITS are, distinguishing them from other traditional educational tools. Now, we find ourselves at a crucial point regarding technological advancements, and higher education must be at the forefront, progressing simultaneously to keep up with them.





### 1.1.1.1 Dataset availability and explainability of AI techniques

We will begin with the definition of an Intelligent Tutoring System. Martínez-Durán, JA, & Calvo, A. (2021) define it as “computational systems designed to deliver instruction and support teaching-learning processes intelligently through interaction with the student”. The revolutionary aspect of IT is **its understanding of the interactions with learners**, providing a more complex perspective on their questions instead of replying repetitively.

ITS offer an innovative and powerful alternative to traditional tutoring systems, with great potential to improve the quality and equity of education. However, it is important to consider that ITS are still in development and that their effective implementation requires careful planning, adequate resources and specialized training for teachers and tutors.

The choice between ITS and traditional tutoring will depend on the specific needs of the educational context, the characteristics of the students and the available resources. In some cases, a combination of both approaches may be the most appropriate solution.

As technology advances and costs decrease, ITS are likely to play an increasingly relevant role in the future of education, complementing and, in some cases, replacing traditional tutoring systems

### 1.1.1.2 Dataset availability and explainability of AI techniques

ITS have very outstanding characteristics that make them great allies for the revolution, which brings their entry into the higher education system. We will follow the pedagogical trend that places the student at the center of the teaching-learning process, and, in their environment, learning patterns will be built. This movement is not revolutionary, since great pedagogues such as John Dewey or Lev Vygotsky began to develop it in the 20th century. However, it is more viable to develop in the classroom thanks to the use of ITS that offer the opportunity to adapt a set of principles to the different learning profiles that current students present.

#### **Identification of the individual characteristics of the student body.**

The student will be at the center of the process, which means that it is important to have a set of data to be able to analyze the learner and generate the most convenient itineraries pathways. In the interaction with the students, the individual needs and learning styles of each student must be identified, considering their academic history, their performance and their projects. Another important aspect will be the learning style, which will determine the way in which information is best acquired, whether visual, auditory, analytical, creative or Kinesthetic.





A determining parameter will be the most common errors during learning, the strategies used for enhancing their understanding, and the time needed by the student to carry out the learning process.

Finally, we must not disregard the personal interests and motivations of the student, their personal and professional goals, as well as the motivation they have to continue. All these inputs provided to the system will locate and analyze the complex patterns of student behavior that generate personalized learning paths that can predict future performance and adapt activities accordingly.

### **Custom content.**

When focusing on the student, we must keep in mind that, although the content is always the same, the way in which this knowledge is presented does not have to be the same for all students. ITS, with the prior information provided by the student about their learning patterns, will be able to personalize how the content is presented, selecting what is truly relevant to their learning, their interests, their needs and the level of understanding, adjusting the complexity and depth, but guaranteeing that the content is acquired. To ensure this learning process, we will work with activities, but again, they can be personalized based on the learning style or challenges that the student faces. This personalization will help adapt and adjust the difficulty of the activities based on a logical, progressive and rhythmic sequencing appropriate to the student's profile.

This entire process responds to the concept of “Scaffolding of learning” also known as scaffolding, it is a metaphor used in the educational field to describe the process of temporary support that is provided to students so that they can reach new levels of knowledge and skills. This approach is based on the idea that learning is a constructive and collaborative process, in which students need the guidance and support of others to advance their cognitive development, and ITSs have the perfect place in that role. Thus, complex tasks could be divided into less complex tasks, offer examples, clues or problem-solving models, and provide immediate feedback on the student's performance along with suggestions for improvement.

### **Adaptation in real time.**

ITS have the ability to adapt the educational experience in real time, based on progress and individual response, adjusting it to the profiles of the student. This feature allows them to offer personalized and effective learning, optimizing the process of acquiring knowledge and skills.

On the one hand, immediacy makes learning routes personalized but dynamic, and can change as the student's vital needs, personal or professional objectives and motivations do.





On the other hand, timely and detailed feedback is essential for effective learning. This feedback helps the student identify their strengths and areas for improvement. For feedback to work and improve student learning, it must be specific and provide detailed information about what the student did well and what can be improved. It should be descriptive, explaining the reasons for the success or failure of the activities and, above all, it should provide the student with concrete suggestions on how to improve their performance.

### **Continuous assessment.**

As we have seen previously, the use of ITS adapts to the teaching-learning process, and that includes evaluation. Continuous evaluation is a cornerstone in ITS, enabling measurement of student progress as well as gathering valuable information to adjust learning experiences in real time.

This evaluation is holistic and multidimensional, which directly affects various aspects of learning beyond memorization or the evaluation of knowledge itself. Thus, outstanding aspects such as problem solving, critical thinking, creativity and communication will be considered. In addition, all possible perspectives are regarded (self-assessment, peer and external) providing a comprehensive overview of the progress, possible difficulties and potential of the student body.

Finally, the way information is gathered is critical. This intelligent system will base its analysis on applying concepts, solving problems and performing tasks in real or simulated contexts. This analysis can be carried out in different formats such as

- Portfolios that include works, projects, presentations and reflections, identifying patterns of learning and development.
- Self-assessments that encourage student reflection on their own learning, allowing them to identify their strengths, weaknesses and areas for improvement.
- Adaptive tests that adjust the level of difficulty based on the student's performance, providing an accurate and personalized evaluation.
- Educational games that integrate evaluation in playful and motivating environments, enabling the student to learn and evaluate their progress in an entertaining way.

In this way, ITS offer a valuable tool to optimize learning, encourage active student participation, and develop metacognitive skills that are key for academic and personal success.

### **Adaptation to context.**



HITS project has received  
funding by the European Union – Italian National Agency INDIRE  
Agreement n. **2023-1-IT02-KA220-HED-000152340**



These intelligent systems create personalized experiences that not only personalize educational content and activities but can also tailor the learning environment to meet the individual needs and preferences of each student. This feature allows you to create more inclusive, accessible and effective learning experiences for everyone. In this way, it becomes a support tool that can integrate accessibility arrangements such as screen readers, voice recognition software and subtitles, enabling students with visual, auditory or motor disabilities to access and fully participate in learning. It can offer content translation options into different languages, for students who aren't fluent in the system's first language. In addition, as expected, it offers assistance through live chats, discussion forums and virtual tutors. So that students can get help and support when they demand it.

Lastly, although not as critical, it offers the option of having a personalized interface, enabling students to choose the appearance of the system, including colors, fonts, font size and contrast, to optimize visual comfort and accessibility. On the other hand, it can offer different navigation options, such as drop-down menus, keyboard shortcuts, and voice commands, to suit the student's preferences and abilities. Finally, it can present the information in an organized and structured way, using visual resources such as icons, images and diagrams, to facilitate understanding and access to the content.

## 1.2 Brief history of Intelligent Tutoring Systems

Intelligent Tutoring Systems are not new but have evolved over the decades due to the work of visionary researchers and educators.

Since the early 1950s intelligent tutoring was well established as an endeavor area and it was already well recognized that different interaction policies and cues of student confusion led to different learning outcomes. However, it was not until the early 1980s that instructional psychology began to shift its focus toward topics and tasks that had real-world relevance, addressing the issue by connecting its findings to broader social needs. (Romero-Salón 2020). This took place essentially because of the appearance of intelligent and adaptive computer systems capable of automating the process of providing effective research-based instruction of the sort that has been proven effective in their laboratories over the previous 30 years. This new research approach in instructional psychology went beyond the traditional applications of 'drill and practice' and 'practice and feedback' to a broader range of educational goals based on the delivery of instruction that can be tailored to the needs of the individual.

The first applications in this area, dating back to 1956, supported the research already undertaken at that time in cognitive psychology and focused on mathematics teaching and logical reasoning tasks. While much of the initial momentum for smart tutoring applications was driven by an interest in the practical applications of that research and a desire to improve





education. Our main concern here is smart tutoring in general and research on tutoring systems, particularly at higher education levels. In this area, much of the currently relevant research dates back to the 1970s and it is based on instructional philosophy that has informed much of the past psychological research on instruction in complex domains. (AIDhaen 2022).

Over the past 40 years of developing smart tutors, a lot has been learned about how to strengthen the power of AI-based tutoring systems. Part of this growth can be attributed to advances in computers and digital technologies. There has been continuous improvement in the graphical user interface and other computer technologies that make interactions with smart tutors smoother and more efficient. These technological improvements continue. Currently, they include a resurgence of interest in project-based learning, learning from big data, and large-scale automated assessment.

Great advancements have been made in understanding the principles of learning and the characteristics of intelligent tutors. They are adaptive and interactive activities. They present course material in a cascade of small, well-sequenced steps and adjust to the cognitive and affective needs of students. We can group these activities into four categories. They encompass different forms of student support, effective combinations of learning resources and well-designed learning activities. In the realm of problem solving, researchers continue to identify and understand the conditions under which feedback is effective. Feedback is also useful for students of humanities and laboratory sciences. There is strong evidence to support the use of solid and elaborate feedback in mathematics. In some cases, we understand that it is not beneficial, such as in cases where a solution is right or wrong and does not require any explanation.

### **1.2.1 Adaptation to Higher Education.**

In recent years, the presentation of Explainable Artificial Intelligence (XAI) has been celebrated, which places emphasis on the transparency and explainability of the AI algorithms used in ITSs, enabling educators and students to better understand the decisions made by the system and build confidence in its use.

ITS become more sensitive to the context in which they are used, suiting teaching to the characteristics of the educational environment, culture and the specific needs of students. Greater interoperability and compatibility are sought between ITSs and existing educational systems, facilitating their implementation and adoption on a large scale.

Overall, the last decade has been an innovation era and accelerated progress in the field of Intelligent Tutoring Systems. Technological advances have brought new possibilities to personalize learning, have made it more accessible and attractive, and have enhanced collaboration between students. As these technologies continue to develop, we can expect to





see an even greater impact of ITSs on education, transforming the way we learn and preparing new generations for success in an ever-changing world.

Intelligent Tutoring Systems are at a crucial point in their evolution, with enormous potential to transform the educational landscape. By addressing current challenges and taking advantage of the opportunities offered by new technologies, we can build a future in which SITs are essential tools to provide all students with a personalized, engaging and effective education.

### 1.3 Importance of Intelligent Tutoring Systems in higher education

Intelligent Tutoring Systems have proven to be versatile and effective educational tools, with a wide range of applications in various educational scenarios. Responding to individual needs of each student, offering personalized learning experiences, and using cutting-edge technology make them a valuable resource for improving the quality of education and promoting effective learning. Some of these applications can be:

#### Content recommendation

Intelligent Tutoring Systems can recommend relevant and personalized educational resources for each student, based on their interests, needs and learning style. This is achieved through techniques such as:

- Student profile analysis including academic interests, learning style, and learning pace.
- Learning history analysis including the content the student has seen, the activities the student has carried out and their performance on evaluations.
- Recommendation technologies, through collaborative filtering and machine learning, to suggest relevant and personalized educational resources.

The benefits in this area are broad and diverse, since students have access to a wide range of quality educational resources that fit their interests and needs. Students can learn in a more personalized and effective way by focusing on content relevant to them. In addition, the guidance and recommendation of relevant content can increase students' motivation to learn, optimizing time by not having to search for educational resources randomly.

#### Virtual reality and augmented reality

Intelligent Tutoring Systems can create simulated, interactive learning environments enabling students to experiment and apply concepts in realistic contexts. This is achieved through techniques such as:





- Immersive simulations that transport students to different places, times or hypothetical scenarios. Enabling students to experience historical events, explore scientific environments, or practice medical procedures in a safe, controlled environment.
- Augmented learning environments, overlaying digital information on the real world, creating interactive and contextualized learning experiences.

It becomes clear that by using it, students would learn through real experience, applying concepts and solving problems in simulated contexts that resemble the real world. Undoubtedly, educational simulations and games are more attractive and motivating for students, increasing their participation and commitment to learning, through the development of practical skills, such as problem solving, critical thinking and decision-making in a safe and controlled environment. Lastly, experiential learning and interaction with simulated environments promote better long-term knowledge retention.

### **Plagiarism Detection**

Intelligent Tutoring Systems can identify and prevent plagiarism in academic works, promoting originality and intellectual integrity:

- through the comparison of texts with a large database of academic works, articles and websites to identify possible cases of plagiarism.
- through the analysis of writing style, identifying inconsistencies or unusual similarities with other texts
- through the detection of plagiarism patterns such as copying and pasting text without citing sources or paraphrasing without adequate attribution.

The advances are more than evident, but we highlight that it promotes originality and intellectual integrity, reduces the risk of academic sanctions through the promotion of values such as academic honesty and ethics, improving the quality of academic works



## **Inclusive and personalized education**

Intelligent Tutoring Systems can be adapted to the individual needs of students with visual, hearing, motor or cognitive disabilities, providing them with specific tools and resources to facilitate their access to learning.

The offers for the student body include multiple advantages, from personalized tutoring aimed at helping them overcome difficulties and improve their situation at risk of social exclusion, to the use of alternative and augmentative communication systems where Artificial Intelligence acts as an ally, providing immediate feedback and accurate in situations of danger or personal risk.

## **Continuous training and professional development**

Lifelong learning is another area of higher education where ITS have a determining role, since they can be used to train professionals in technical and transversal skills, such as the use of specific software, communicating ideas or managing people.

ITS can help professionals prepare for training and certifications by providing personalized study materials, mock exams, and detailed feedback on their performance.

## **Informal education and lifelong learning**

Intelligent Tutoring Systems have proven to be invaluable tools in formal education, but their potential extends far beyond the traditional classroom. In the field of non-formal and informal education, ITS have the power to transform the way people learn and acquire knowledge outside of structured educational environments.

In non-formal education, ITS can offer customized training programs for individuals to acquire the skills needed to enter the labor market or improve their career prospects. Another area of action is a healthy lifestyle, worked on through the prevention of diseases and improving the general well-being of people. Besides, social and citizen participation is worked on through fostering education about rights and civic duties, promoting values such as tolerance, interculturality and respect for the environment.

In informal education, ITS has a critical role; they can be used to learn hobbies and leisure activities, such as playing a musical instrument, practicing a sport or cooking. This can contribute to personal enrichment, entertainment and socialization. Searching for people's motivations and passions are key for keeping people motivated to continue and seek their complete personal development. Furthermore, perhaps this awakes in them new avenues of professional development.





## Research and development in education

One of the largest areas of action of ITS is the field of educational research and development. Due to their multiple options and immediate response, they can gather valuable data on student behavior and learning, enabling researchers to identify patterns, develop theoretical models and assess the effectiveness of different teaching strategies.

Like technological advancement, teaching methodologies must advance and keep up with the new technologies offered by the market. So, they can be used to experiment with new teaching methodologies, such as adaptive learning, project-based learning or collaborative learning.

Finally, the greatest feature of ITS is the personalization power they have; they can serve as a basis for the development of personalized educational tools, adapted to the specific needs of each student and learning context.

### 1.4 The Future of Education: Intelligent Tutoring Systems

Intelligent Tutoring Systems have come a long way since their inception in the 1960s, evolving from simple programmed learning systems to sophisticated tools powered by artificial intelligence and machine learning. Throughout their history, ITS have demonstrated enormous potential to transform education, offering personalized, adaptive and effective learning experiences for students of all levels and backgrounds.

Today, ITS are at a tipping point, with the ability to revolutionize the way we learn and teach. Technological advances in artificial intelligence, big data and other emerging areas are opening up new possibilities for creating more sophisticated, personalized and accessible ITSs.

However, for ITS to reach their full potential, a few key challenges need to be addressed such as ensuring equitable opportunities for access to ITS for all students, regardless of socioeconomic background, geographic location, or technological skills. Another challenge refers to their integration with teaching practice by providing them with the necessary training and support to make the most of these tools.

Despite these challenges, the future of Intelligent Tutoring Systems is promising. The combination of innovative technologies and sound pedagogical approaches can transform education into a more personalized, engaging and effective process for all students. ITS has the potential to democratize access to high-quality knowledge, close educational gaps and prepare new generations for the challenges of the 21st century.





In short, Intelligent Tutoring Systems are not just an educational tool of the future, but a reality that is already transforming the educational landscape. As we continue to develop and implement these systems responsibly and effectively, we can build a future in which all students have the opportunity to reach their full potential.



**HITS** project has received  
funding by the European Union – Italian National Agency INDIRE  
Agreement n. **2023-1-IT02-KA220-HED-000152340**