VIRTUAL INTERACTIVE LABS TO IMPROVE ONLINE EDUCATIONAL EXPERIENCES: PROTOTYPING A SERIOUS GAME FOR DEVELOPMENTAL PSYCHOLOGY STUDENTS

LABORATORI VIRTUALI INTERATTIVI PER MIGLIORARE LE ESPERIENZE EDUCATIVE ONLINE: PROTOTIPO DI UN SERIOUS GAME PER STUDENTI DI PSICOLOGIA DELLO SVILUPPO

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ABSTRACT
Virtual laboratories are gaining importance in education, offering interactive environments that replicate real situations in a controlled manner, as effective as traditional ones. LEILA is a digital laboratory for studying learning through experiments in simulated contexts. It includes video lectures and serious games, promoting theoretical understanding and practical skills. LEILA represents an innovation in the use of technology to improve teaching.

I laboratori virtuali stanno acquisendo importanza nel campo dell'istruzione, offrendo ambienti interattivi che replicano situazioni reali in modo controllato, efficaci quanto quelli tradizionali. LEILA è un laboratorio digitale per studiare l'apprendimento attraverso esperimenti in contesti simulati. Il percorso didattico include videolezioni e serious game, favorendo comprensione teorica e abilità pratiche. LEILA rappresenta un'innovazione nell'uso delle tecnologie per migliorare l'insegnamento.

KEYWORDS
Virtual lab; interactive learning; innovative education; experimental learning; virtual simulation
Laboratorio virtuale; apprendimento interattivo; educazione innovativa; apprendimento sperimentale; simulazione virtuale

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Introduction

In recent years, education panorama has undergone a radical transformation with the integration of new technologies, including e-learning, virtual labs, virtual reality (VR) and augmented reality (AR) (Rossi et al., 2023; Nagpal et al., 2024). These tools have fostered the emergence of a new educational paradigm called "immersive education", which combines many of these innovations to improve the effectiveness of teaching and learning (Fernandes et al., 2023; Finestrone et al.,2023).

Immersive education has found application in various contexts and its development has been accelerated by the increasing globalisation of education, which has required the removal of barriers to access to ensure inclusivity, regardless of geographical, economic or physical constraints (Selvakumar & Sivakumar, 2023).

The use of interactive digital environments enables greater student participation, facilitating the acquisition of knowledge through direct experiences and highly realistic simulations (Dale, 1969).

One of the most innovative aspects of this transformation is the use of Virtual Reality in educational laboratories. Virtual laboratory simulations offer a unique opportunity to complement traditional learning activities with advanced digital experiences, which allow students to explore complex phenomena safely and effectively (Conole, 2013; May & Achiam, 2014).

Several studies show that active and immersive learning significantly increases information retention, compared to teaching methods based on simply reading or listening, typical of traditional learning (de Jong et al., 2013; Bonde et al., 2014).

The constructivist paradigm of learning, which promotes the active involvement of students in the educational process, reinforces and supports the use of Virtual Reality in laboratories used within educational settings (Huang et al., 2010).

The idea of using student-centred constructivist teaching methods is widely accepted around the world, as traditional teacher-centred teaching methods do not provide sufficient opportunities for students to construct their own learning. (Garrett, 2008).

The acquisition of students' individual skills, intelligence and creative thinking can only be achieved through student-centred teaching methods (Attard et al., 2010).).

Although constructivism is a learning theory that describes the process of knowledge construction, it is the application of what are often referred to as "constructivist practices" (Zemelman et al., 1998), in the classroom and elsewhere,

that provides support for the active knowledge construction process. In this context, laboratories are important components of teaching for students to gain experience. In the laboratory, students become active participants in their own learning process through vision, observation and practice.
However, the structural limitations of traditional physical laboratories, such as equipment availability and safety conditions, often reduce the effectiveness of hands-on learning. In this context, virtual reality and the implementation of virtual laboratories presents itself as an effective solution to overcome such obstacles and provide richer and more personalised learning experiences (Cabrera-Duffaut et al., 2024).In virtual laboratories, students can observe, experiment and interact with elements of the learning environment in an experiential way, enhancing their understanding of concepts (Deryakulu & Simsek, 1995; Zemelman et al., 1998).
Virtual simulations also allow complex, dangerous or impossible experiments to be performed in a controlled environment, reducing risks and costs associated with laboratory activities (Rodrigues, 1997). The use of Virtual Reality, and especially virtual laboratories, in educational contexts not only improves the safety and efficiency of learning, but also provides students with adequate tools to develop advanced cognitive skills, such as problem-solving and hypothesis formulation (Windschitl & Andre, 1998).
In this framework is LEILA, an acronym for Learning Psychology Interactive Lab, a virtual laboratory designed to test and teach theories and practices of learning and education. LEILA is a digital space for conducting experiments, collecting data and analysing the cognitive processes of individuals in simulated educational contexts.
Using advanced digital technologies, it adopts a structured learning pathway that includes an introductory video lecture, an essential interactive screen for customising the experiment, an experiment in the form of a serious game and a final evaluation questionnaire.
This approach fosters greater theoretical understanding and the development of practical skills through the simulation of real psycho-pedagogical situations. The integration of LEILA into courses represents a step forward in the adoption of innovative teaching strategies, exploiting digital technologies to improve the effectiveness of teaching and learning.
This article therefore aims to provide a clear and precise overview of the structure and use of LEILA, highlighting its possibilities and potential impact in the field of training and research in learning and educational psychology.

1. LEILA’s description

LEILA, acronym for Learning Psychology Interactive Lab, is a virtual laboratory designed to facilitate the experimentation and teaching of learning and educational theories and practices. It’s a web-app designed to be compatible and usable with all major browsers, thus ensuring high accessibility and usability on different platforms.

LEILA has been designed specifically for use with university students, and especially those taking a course in developmental psychology, allowing them to explore and experience the fundamental concepts of psychology in an interactive and immersive way, offering an innovative and engaging learning experience.

LEILA, therefore, is an innovative digital space for conducting experiments, collecting data and analysing the cognitive processes of individuals within simulated educational contexts.

The platform consists of seven different experimental sections, each of which is dedicated to the in-depth study of a specific area of psychology. Each section offers interactive environments in which users can explore psychological theories and concepts through simulations and digital experiments designed to foster active and immersive learning.

Specifically, the experimental sections included in the web-app are:

- **Cognitivism**: this section explores cognitive theories of learning, focusing on processes such as memory, attention and inhibition. Through virtual experiments, users can observe the functioning of executive functions and test for themselves the most common tests used for their evaluation;
- **Behaviourism**: this section allows users to experience the principles of classical and operant conditioning, based on the studies of Pavlov (1927), Skinner (1938) and Watson (1920). Users can, in this way, explore the principle and role of the most famous concepts of classical and operant conditioning, such as reinforcement and punishment, while also understanding their role in modelling behaviour and understanding how learned behaviour can be modified through controlled environmental stimuli;
- **Constructivism**: in this section, users can explore the role of active experience in learning, based on the theories of Piaget (1952) and Vygotskij (1978).Through interactive simulations, the stages of cognitive development and the concept of the zone of proximal development are

presented, highlighting the importance of social mediation and the concept of learning by doing;

- **Attachment**: this section allows users to observe and analyse the relational dynamics between caregiver and child, paying great attention to the attachment theories proposed by Bowlby (1969) and Ainsworth (1978). The digital simulations reproduce experimental situations such as the 'Strange Situation', offering a direct opportunity to understand different attachment styles and their implications on social-emotional development;
- **Observation of child behaviour**: this section introduces users to the methodologies for observing children's behaviour, which are fundamental to psycho-pedagogical research. Through digital behaviour analysis tools, users can practise identifying interaction patterns and applying observational coding protocols;
- **Educational Robotics**: this section explores the role of robotics in learning, showing how technological tools can support the development of cognitive and social skills in children. Interactive simulations allow users to design robotics-based educational experiences, observing how students interact with these tools to solve problems and develop computational thinking;
- **School psychology**: the last section focuses on the practical applications of psychology in the school context. Through case studies and simulations, users can analyse intervention strategies for supporting students with learning difficulties and special educational needs, recognise and develop individualised educational plans and personalised teaching plans, and explore the role of the school psychologist in promoting well-being and motivation to study.

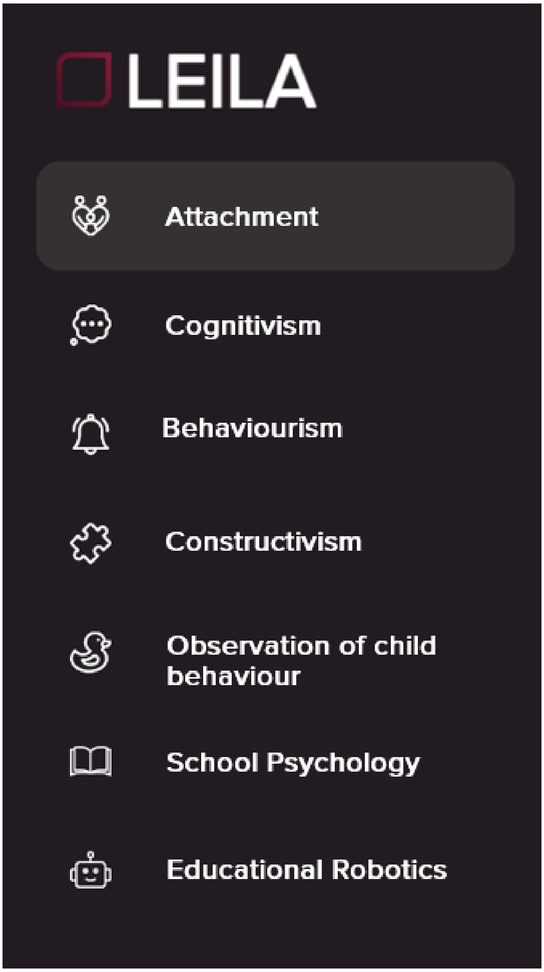

Figure 1. Selection panel for experimental section

LEILA exploits advanced digital technologies to offer a didactic path structured in four main phases, which allow interactive and personalised learning:

1. **Introductory video lesson**: a real theoretical lesson on the selected topic, necessary to provide a theoretical framework on the themes that will subsequently be explored in an immersive manner through interaction with the experiment;

2. **Interactive screen**: fundamental for allowing users to personalise the experiments, choosing specific variables based on their own needs and in-depth analysis, to favour a tailor-made didactic experience;

3. **Experiment**: presented in the form of a serious game, students interact with immersive simulations that replicate real psycho-pedagogical situations, providing the foundations and fostering concrete and experiential learning;

4. **Final evaluation questionnaire**: necessary to verify the understanding of the concepts covered and to collect data on the effectiveness of the training pathway, thus providing an objective assessment of the learning acquired.

Each phase of this course is essential to ensure deep and focused learning, supporting students in their academic growth and practical understanding of the topics covered.

2. LEILA's Structure

LEILA's teaching framework is articulated according to a well-structured methodology, which takes the student through a progressive and experimental learning path.

This methodology is developed through sequential phases, starting with the selection of the area to be explored, passing through an interactive immersion in the video lesson, and ending with a practical test and involvement in an actual experiment.

The first stage of the methodological process involves the selection of the experimental section to be explored. For each section, several experiments were designed in the form of a serious game, ensuring broad thematic coverage and a coherent and in-depth learning path.

Then, once the experimental section of interest has been identified, the student proceeds to choose the specific experiment to carry out. At this stage, a list of experiments available within the selected section is provided, each accompanied by a brief explanatory description. This description provides an overview of the aims and operating methods of the experiment, thus facilitating the student in selecting the activity best suited to his or her needs and level of preparation.

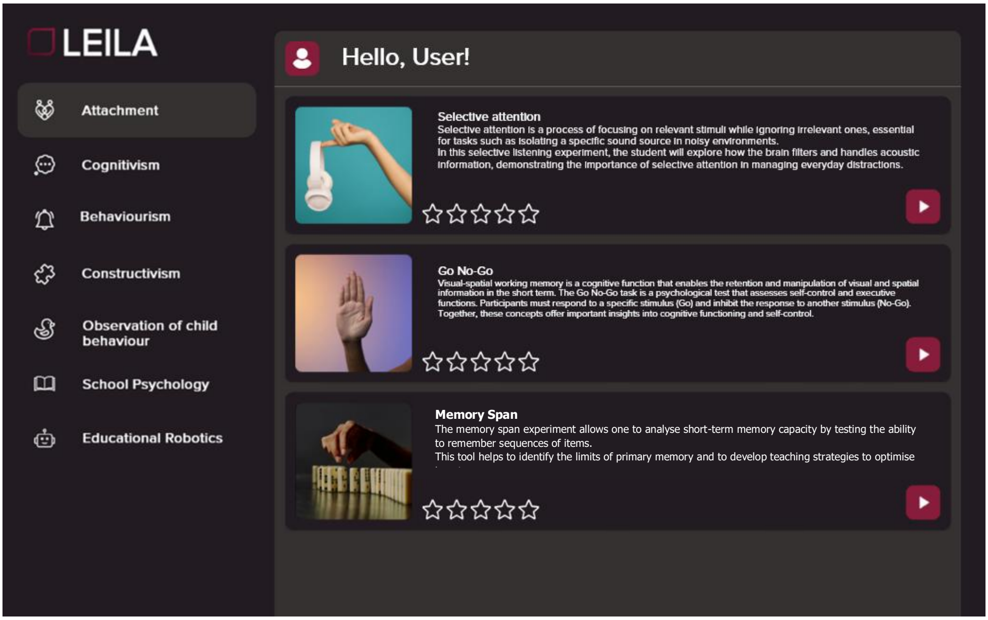

Figure 2. Exercise selection-Cognitivism Section

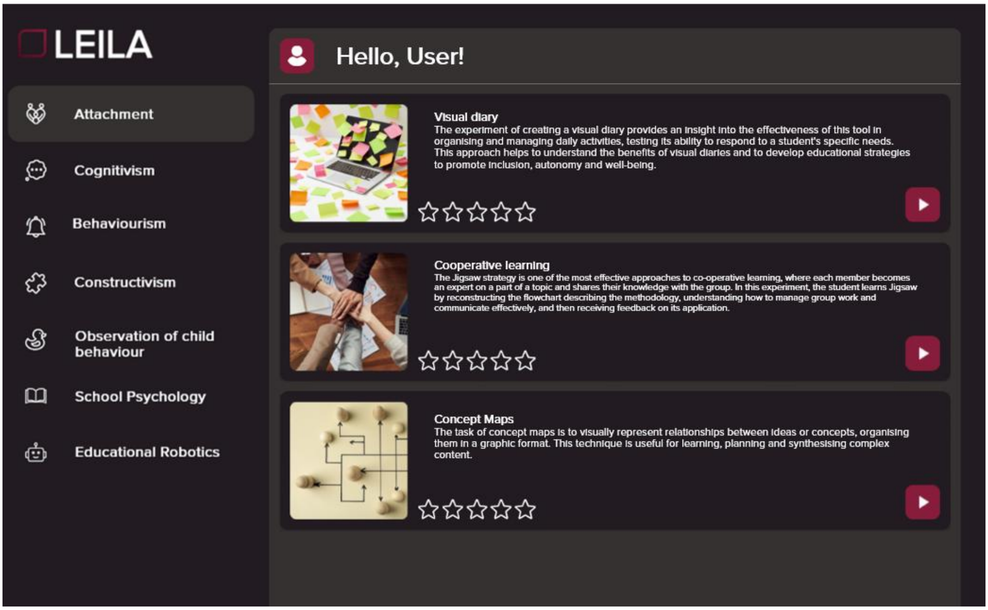

Figure 3. Exercise selection-School Psychology Section

Once the experiment has been selected, the student accesses a dedicated interface, within which various preparatory activities can be undertaken before starting the actual experiment.

In this screen, the student has:

- *Video lesson*: a fundamental element of the LEILA platform, which consists of a structured lesson lasting approximately 3 minutes. This video lesson goes into detail about the topic covered in the experiment. The video lesson not only provides the theoretical background, but also illustrates the purpose of the experiment and how it enables the learning of the concept studied to be tested and consolidated.
- *Detailed description of the experiment*: an essential step that guides the student in understanding how the experiment works. The objectives, procedures and any variables involved are clarified, facilitating thorough preparation prior to practical execution.
- *Customising the exercise parameters*: the platform allows certain experimental parameters to be modified, thus enabling the experiment to be adapted to the specific needs and requirements of the student, fostering a personalised approach to learning.

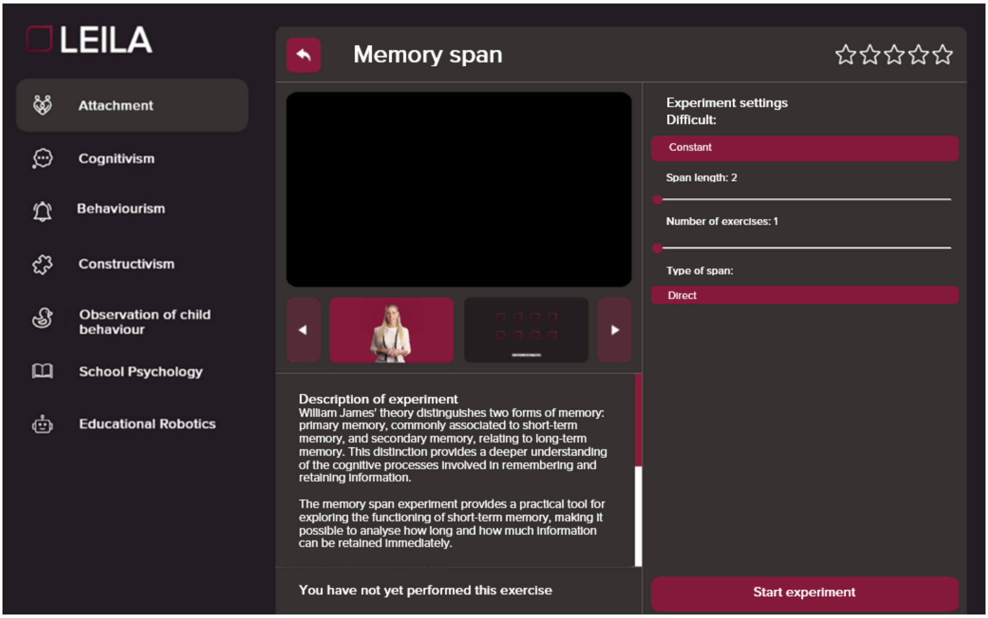

Figure 4. Experiment screen

After completing these three preliminary activities can the student proceed to perform the actual experiment, applying the acquired knowledge in a practical manner and verifying the effectiveness of his or her learning.

At the end of the experiment, the platform provides immediate feedback on the execution carried out, offering the student initial feedback on the correctness of the operations performed and the results obtained.

This feedback is essential to allow immediate self-assessment and to identify any conceptual or procedural errors.

In addition to the operational feedback, the student is submitted to a structured self-assessment questionnaire consisting of multiple-choice questions designed to test the level of understanding and learning acquired with respect to the subject matter covered in the experiment. The questions are designed to explore different levels of knowledge, from theoretical understanding to the ability to apply the concepts learned in practice.

The integration of immediate feedback with structured assessment is a central element of the teaching methodology adopted in LEILA.

In this way, the virtual laboratory does not merely provide an interactive experience, but follows a rigorous pedagogical path, combining theory and practice in an immersive and adaptive learning environment.

This approach progressively consolidates the student's skills, promoting active and conscious learning, in line with the most advanced experimental teaching methodologies.

The integration of these steps contributes to structuring an organic and focused didactic pathway that favours experiential learning through a progressive approach, ranging from theoretical acquisition to practical experimentation.

Conclusions

The adoption of immersive technologies, such as virtual reality (VR) and virtual labs, has profoundly revolutionised the educational landscape, responding to the challenges of an increasingly globalised and technological world (Zafeiropoulos et al., 2023).

In this context, LEILA emerges as a concrete example of an interactive laboratory that integrates these technologies, promoting active and personalised learning.

The modular structure that characterises LEILA not only offers students a concrete experience of applying psychological theories, but also stimulates critical reflection and analytical thinking through direct interaction with simulated educational scenarios.

LEILA offers simulations covering a wide range of psychological topics, from cognitivism and behaviourism to the dynamics of attachment and school psychology. These experiments highlight the importance of an experiential approach in learning, which not only promotes the memorisation of theoretical concepts, but also promotes the development of advanced cognitive skills, such as complex problem solving and hypothesis formulation.

Furthermore, the possibility of customising the learning experience through the selection of experimental variables and direct interaction with the collected data provides a unique opportunity for each student to adapt the experiment to their own learning style and level of preparation. This approach, which integrates theory, practice and immediate feedback, is a further strength of LEILA, which fully responds to the principles of constructivism, promoting active and dynamic learning (Jonassen & Murphy, 1999).

Currently, we are engaged in the development and implementation of the last experiments to be integrated into the platform, with the aim of subsequently starting a data collection, supported by statistical analysis, that will allow us to quantitatively assess the effectiveness and real impact of the use of LEILA in the educational context.

LEILA virtual laboratory is an important resource for educational research. Its ability to simulate complex psycho-educational contexts makes it possible to analyse and test hypotheses safely and effectively, opening new perspectives in the field of learning. As technology continues to evolve, the integration of tools such as LEILA into teaching practices looks set to be a key avenue for making education more inclusive, innovative and up to date.

However, despite its great potential, LEILA has some limitations. One of the main challenges relates to its highly interactive nature, which might be challenging and complicated for students who, on the contrary, prefer more traditional learning methods or have difficulty adapting to advanced technologies.

For this reason, it is essential to continuously monitor and improve the impact of LEILA, especially through the collection and analysis of statistical data on the use of the platform. In the future, the implementation of more complex experiments integrating other emerging technologies could further enrich the training offer, providing even more personalised and adaptive experiences.

In conclusion, LEILA virtual laboratory represents a promising resource in the field of psychology education, with the potential to become a key tool in the evolution of teaching practices in the educational and school context.

Author contributions

All authors have contributed equally to the article.

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