Journal of Digital Pedagogy

2 – 2023

ISSN 3008-2021

digital-pedagogy.eu

The Journal of Digital Pedagogy publishes studies, analyses and essays contributing to the development of the area of digital technologies in education. Frequency: one issue per year.

The Journal of Digital Pedagogy is edited in partnership by:

- Institute for Education (Bucharest)
- Faculty of Psychology and Education Sciences, Teacher Training Department - Alexandru Ioan Cuza University, Iasi
- Faculty of Political Sciences, Teacher Training Department – National School of Political and Administrative Studies, Bucharest

Journal of Digital Pedagogy (online)

ISSN 3008-2021

ISSN-L 3008-2021

https://doi.org/10.61071/JDP.3008-2021

Address: 54 Doctor Louis Pasteur str., Bucharest 050536

Webpage: Digital-Pedagogy.eu

Contact: office@iEdu.ro
+40 722 458 000

Institute for Education (Romania)

Journal of Digital Pedagogy

Vol.2 No.1 (2023)

ISSN 3008-2021

digital-pedagogy.eu

Digital-Pedagogy.eu Institute for Education

Journal of Digital Pedagogy
2023, Vol. 2, No. 1, pp. 3-7
ISSN 3008-2021
https://doi.org/10.61071/JDP.2310

Instruments of Learning: Know the Worth of Educational Tools

Oana Onciu

University Alexandru Ioan Cuza, Department of Psychology and Educational Sciences, Iasi, Romania
onciu.oana@uaic.ro
https://orcid.org/0009-0009-7780-8896

Abstract: Have you ever wondered why some musical instruments cost millions of dollars? What could make an instrument worth that much money, and how is it different from other instruments that are more affordable? But does this difference in value and quality extend beyond the world of music? Can we apply similar principles to educational tools and instruments?

Perhaps. Whether it is a digital tool that engages students with interactive content, a hands-on activity that encourages critical thinking and problem-solving, or a traditional tool like a textbook or chalkboard that forms the backbone of classroom instruction, the quality and effectiveness of educational instruments can have a significant impact on student outcomes. In this article we will explore (I) a short history of educational instruments and (II) how teachers should differentiate between these.

Keywords: digital learning, digital teacher, digital tools, educational instruments

I. From Socrates to Smartboards

Just as a Stradivarius violin requires an exquisite blend of materials and craftsmanship to produce its unparalleled sound, the educational landscape thrives when equipped with tools and instruments that mirror the same meticulous attention to detail, quality, and efficacy. These remarkable instruments wield the power to amplify student learning and pave the way for a resounding success.

The history of educational instruments stretches back to antiquity when civilizations like the Sumerians and Egyptians used symbolic pictographs and hieroglyphics as the foundations of teaching reading and writing. Even in ancient Greece, the great philosopher Socrates employed a technique of probing questions, with these questions serving as instruments for a form of instrumentalised methodology to foster learning.

Received: 20.05.2023. Accepted: 22.05.2023

Citation:

Onciu, O. (2023). Instruments of Learning: Know the Worth of Educational Tools. *Journal of Digital Pedagogy, 1*(1) 3-7. Bucharest: Institute for Education. https://doi.org/10.61071/JDP.2310

In the Middle Ages, manuscripts and textbooks surged in popularity, accompanied by a host of instruments like abacuses, astrolabes, and compasses that brought mathematics and science to life. The ground-breaking invention of the printing press in the 15th century revolutionized education by enabling the mass production of books, unleashing an era of knowledge dissemination and textbooks as invaluable teaching tools.

The 19th century witnessed remarkable advancements in educational instruments, epitomized by the birth of the blackboard and its trusty companion, the chalkboard eraser. With these visual aids, teachers could vividly illustrate concepts and diagrams, revolutionizing the way knowledge was imparted. It was during this period that pioneering educational psychologists such as Jean Piaget and Lev Vygotsky emerged, unveiling theories on children's learning processes and emphasizing the pivotal role of tools and instruments in shaping their educational journeys.

The journey of educational instruments is one of constant evolution, driven by an insatiable quest to optimize the learning experience. From ancient civilizations to the transformative present, these instruments have played a vital role in nurturing minds and fuelling intellectual growth. As we delve deeper into the realm of educational instruments, let us acknowledge their profound impact and embrace the boundless possibilities they offer for creating a brighter, more enlightened future.

The 20th century witnessed a remarkable shift as educational films, radios, and televisions took centre stage, igniting a world of possibilities. Because in the ever-evolving landscape of education, technology has forged its path, captivating minds and transforming classrooms. But the story doesn't end there. The latter part of the century paved the way for educational software and the mesmerizing integration of multimedia in teaching.

Fast forward to the present, we find ourselves amidst what we can name "a digital renaissance" in education. The drumbeat of technology grows louder, beckoning us to embrace its transformative power. Online learning platforms, digital textbooks, and educational apps have become the lifeblood of modern education, creating a seismic shift in how knowledge is imparted and absorbed.

Yet, the winds of change go beyond mere tools and gadgets. They carry the echoes of progress, reflecting the dynamic interplay between educational theory, technology, and the ever-shifting fabric of society. A remarkable distinction emerges when we compare the educational instruments of the past with those of today — a divergence in technological sophistication. Gone are the days of humble blackboards and textbooks, for the present is adorned with a dazzling array of digital marvels. Online learning platforms whisk us away on immersive educational journeys, educational software unlocks doors to interactive exploration, and virtual reality tools transport us to realms previously unimaginable.

Another key difference is the breadth and diversity of subdomains that instruments are developed to address and assess. In the past, many educational tools were focused on basic literacy and numeracy skills, such as reading, writing, and arithmetic. However, modern instruments address a much wider range of subjects and learning objectives, including science, technology, engineering, and mathematics (STEM) fields, as well as social sciences (SEL) fields, humanities, and the arts.

Additionally, modern educational tools often incorporate multiple modes of learning, such as visual, auditory, and kinesthetic learning, which reflect a growing understanding of the diversity of learning styles and needs among students. They also often include features for assessment and feedback, such as adaptive learning algorithms and performance tracking, which can help students and teachers monitor progress and adjust their approaches to learning accordingly.

As we peer into the future, one cannot help but wonder: What untold wonders will emerge next? How technology – or maybe something else – will continue to reshape the landscape of education, moulding minds and fostering boundless curiosity? Today, there is a wide range of educational tools available to address a vast array of learning objectives and styles, enabling students and teachers to engage in dynamic and engaging educational experiences.

> *Overall, the use of educational instruments and tools has become increasingly sophisticated and diverse over time, reflecting the changing needs and goals of educational systems in humanity.*

II. A Guide for Teachers

Although it is improbable for an educational instrument to command a price tag in the millions, akin to the revered Stradivarius violin mentioned earlier, there are nevertheless essential benchmarks that a discerning teacher can employ when assessing the worth and efficacy of such tools. Take into account the following considerations:

- **Quality of content**: A high-quality educational instrument should have content that is accurate, relevant, and engaging for students. This includes things like clear explanations, interactive features, and a variety of media types (such as text, images, and videos).
- **Alignment with curriculum**: An effective educational instrument should be closely aligned with the curriculum and learning objectives of the class. This means that it should address the specific knowledge and skills that students need to master, and should be designed to support the teaching and learning goals of the teacher.
- **Accessibility**: A valuable educational instrument should be accessible to all students, regardless of their learning needs or abilities. This means that it should be designed with accessibility features.
- **Evidence of effectiveness:** A truly valuable educational instrument should have a track record of effectiveness in improving student learning outcomes. This could include evidence from research studies, testimonials from specialists, or data showing improvements in educational performance.
  By taking these factors into account, teachers can evaluate the quality and value of educational instruments and make informed decisions about which tools to incorporate into their teaching practice. While the "cost" of an educational instrument may not be measured in dollars, the impact it has on student learning can be immeasurable. And yet in time, the impact may generate dollars; to measure indeed.

Equally, for teachers in the classroom, it is important to be familiar with the different types of educational tools and instruments available and how they can be used to enhance learning. Some tips that may be useful include:

- **Alignment with learning objectives**: The educational tool should align with the learning objectives of the lesson or unit. If it does not, it may be ineffective or distract from the intended learning outcomes.
- **Quality and reliability**: Teachers should be careful to select high-quality educational tools that have been tested and validated for their intended use. This can help to ensure that the tool is reliable and effective.
- **Accessibility and inclusivity**: Educational tools should be accessible and inclusive to all students, regardless of their abilities or learning styles. Teachers should consider the needs of diverse learners and choose tools that are adaptable or customizable to meet their needs.
- **Age appropriateness**: The educational tool should be age-appropriate and relevant to the developmental level of the students. Tools that are too simple or too complex can be ineffective or overwhelming for students.
- **Privacy and security**: When using digital educational tools, teachers should be careful to protect student privacy and ensure that the tool is secure and free from potential data breaches or hacks.
- **Ethical considerations**: Teachers should be mindful of the ethical considerations related to the use of educational tools, such as issues related to data privacy, bias, and fairness. They should be aware of any potential risks or unintended consequences associated with the tool and take steps to minimize them.

By being mindful of these factors, teachers can choose and use educational tools in a way that maximizes their effectiveness and minimizes potential risks or negative impacts on students.

> *However, if we want to connect with the profound purpose of education — the axiological function of teaching individuals to generate new knowledge — we discover that the ultimate teacher is not only an applier of education but also its creator.*

And so, for those courageous teachers who embark on the quest to craft an educational instrument, several key elements demand careful consideration:

1. Vision and Purpose: A remarkable educational instrument begins with a clear vision and purpose. It requires a teacher who envisions a transformative learning experience that goes beyond rote memorization and embraces the cultivation of critical thinking, creativity, and problem-solving skills. By defining a compelling purpose, the teacher sets the stage for an instrument that empowers students to become active participants in their learning journey.

2. Student-Centred Approach: At the core of every exceptional educational instrument lies a student-centred approach. Recognizing the diverse needs, interests, and abilities of learners, the teacher designs an instrument that tailors to individual strengths while fostering collaboration and inclusivity. By placing students at the heart of the educational process, the instrument becomes a catalyst for personalized growth and development.

3. Engagement and Motivation: An effective educational instrument captivates students' attention and fuels their intrinsic motivation to learn. It leverages innovative teaching methods, interactive technologies, and real-world

applications to create an engaging and immersive learning environment. By igniting curiosity and kindling a passion for knowledge, the instrument sparks a thirst for learning that endures beyond the confines of the classroom.

4. Flexibility and Adaptability: In an ever-evolving educational landscape, an exceptional instrument demonstrates flexibility and adaptability. It embraces change, seamlessly integrating emerging technologies, pedagogical advancements, and evolving societal needs. The teacher continuously evaluates and adjusts the instrument to meet the dynamic demands of education, ensuring its relevance and effectiveness.

5. Continuous Assessment and Improvement: A truly outstanding educational instrument thrives on continuous assessment and improvement. The teacher employs a variety of assessment methods to gauge student progress and identify areas for enhancement. By collecting and analysing feedback, the instrument evolves, refining its design, instructional strategies, and content to maximize student learning outcomes.

6. Collaboration and Professional Growth: The creation of an extraordinary educational instrument is not an isolated endeavour. It calls for collaboration with colleagues, sharing best practices, and engaging in ongoing professional development. By nurturing a culture of collaboration, the teacher harnesses collective expertise, expanding the horizons of what the instrument can achieve.

7. Ethical Considerations: In the pursuit of crafting an educational instrument, ethical considerations must guide every decision. The teacher ensures that the instrument promotes fairness, respects students' diverse backgrounds, and safeguards their well-being. By upholding high ethical standards, the instrument becomes a force for positive transformation, nurturing a sense of integrity and social responsibility.

In essence, the educational instruments are the conduits that bridge the gap between abstract knowledge and tangible understanding, guiding students on transformative journeys of discovery. At their core, educational tools possess the remarkable ability to bridge the gap between theoretical concepts and practical understanding. They provide the scaffolding upon which students can build their understanding, enabling them to grasp complex ideas and delve into the depths of various subjects. Through the strategic integration of these tools, educators can bring clarity and tangibility to abstract notions that might otherwise remain elusive. These instruments of learning come in a myriad of forms, ranging from traditional resources like textbooks, whiteboards, and manipulative to cutting-edge digital platforms, simulations, and virtual reality experiences. Each tool serves a unique purpose, offering various ways for students to engage with the material, participate actively in the learning process, and develop a deeper understanding of the subject matter. Moreover, educational tools hold the potential to ignite curiosity, stimulate critical thinking, and foster creativity among students acting as catalysts for exploration. In the ever-evolving landscape of education, the value of educational tools cannot be overstated. They form the backbone of instructional strategies, offering teachers' versatile means to engage students, differentiate instruction, and address individual learning needs. By leveraging the strengths of various tools, educators can create a rich tapestry of learning experiences that cater to diverse learning styles and foster inclusive classrooms.

> *Instruments of learning are not merely accessories to education; they are the substance that breathes vitality and efficacy into teaching and learning.*

Instruments of learning are not merely accessories to education; they are the substance that breathes vitality and efficacy into teaching and learning. To discuss the importance of it would be a loss of time. From the time-honoured blackboards and textbooks to the awe-inspiring digital platforms and immersive virtual reality tools, the evolution of these instruments has revolutionized education, embracing accessibility, inclusivity, and boundless engagement within the classroom's hallowed walls.

Yet, like any magnificent symphony, we must harmonize with caution. By investing in or even better creating high-quality, effective educational instruments, we can create learning environments that are engaging, inclusive, and ultimately more successful for students.

And so, educational tools and instruments have played a critical role in shaping the way we learn and teach. From blackboards and textbooks to digital platforms and virtual reality tools, the evolution of educational instruments has allowed for greater accessibility, inclusivity, and engagement in the learning experience. However, as with any tool, it is important to be mindful of their strengths and limitations and to choose and use them in a way that maximizes their effectiveness and minimizes potential risks or negative impacts on students. Their quality, value, and impact vary immensely, and because the educational instruments proved to be such important catalysts over time, teachers are invited from now on to explore the depths of this so-common subject.

So, have you ever wondered why some musical instruments cost millions?

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** Please note that some of the references provided may focus on broader topics related to education and technology, rather than specifically addressing the history and differentiation of educational instruments. However, they can provide valuable insights into the impact of educational tools and technologies on teaching and learning.*

Digital-Pedagogy.eu Institute for Education

Journal of Digital Pedagogy 2023, Vol. 2, No. 1, pp. 8-13

ISSN 3008-2021 https://doi.org/10.61071/JDP.2311

Preconditions for the development of the integrated learning analytics and action research model for Lithuanian general education schools: theoretical insights and research design

Aleksandra Batuchina

Post doctoral fellow, Klaipeda University, Department of Pedagogy
aleksandra.batuchina@ku.lt
https://orcid.org/0000-0003-0012-9421

Evelina Brazauskienė

PhD student, Klaipeda University, Department of Pedagogy

https://orcid.org/0009-0008-9127-896X

Kamilė Kesylė

PhD student, Klaipeda University, Department of Pedagogy

https://orcid.org/0009-0009-1399-6082

Julija Melnikova

Senior Researcher, Klaipeda University, Department of Pedagogy

https://orcid.org/0000-0001-6078-6963

Abstract: The integration of technology in education holds promise for revolutionizing learning experiences by improving efficiency, enriching content, and empowering educators and learners alike. Learning analytics (LA) emerges as a crucial tool, utilizing data within virtual learning environments to scrutinize and refine the teaching/ learning process. However, despite the abundance of data, educators often lack the expertise to effectively utilize this information, impeding its potential to enhance

Received: 15.11.2023. Accepted: 24.11.2023

Citation:

Batuchina, A., Brazauskienė, E., Kesylė, K., Melnikova, J. (2023). Preconditions for the development of the integrated learning analytics and action research model for Lithuanian general education schools: theoretical insights and research design. *Journal of Digital Pedagogy, 2*(1) 8-13. Bucharest: Institute for Education. https://doi.org/10.61071/JDP.2311

teaching methods and student outcomes. Furthermore, the ethical and practical boundaries of employing learning analytics remain undefined.

This article endeavours to explore the foundational prerequisites for devising an integrated Learning analytics and Action research (LAAR) model. This model seeks to equip educators in general education institutions with the tools to monitor learners and teaching/learning dynamics in digital settings, facilitating data-driven decision-making for pedagogical improvements. Employing the Design science research methodology, particularly focusing on cognitive artifacts like human-computer interfaces, this research aims to address existing methodological limitations and propose novel solutions. By aligning with the socio-technical nature of learning analytics systems, involving diverse stakeholders and technology, this approach aims to foster the interpretation and application of analytics data in educational contexts.

Keywords: learning analytics, action research, education research design, innovative pedagogies

Introduction

Learning in digital environments makes sense when the application of technology strengthens and makes the learning process more efficient, enriches the learning content, helps the teacher to apply learning methods more effectively, and the learner to monitor the learning process and change learning behaviour in a timely manner in order to achieve better learning results.

Monitoring and analysing the teaching/ learning process is supported by learning analytics, which can be used to analyse the data generated by learners in the virtual learning environment, with the aim that the learning and teaching processes allow the teacher to perform interventions more effectively, to advise or consult learners in a timely manner in order to increase their academic success (Misiulienė, 2021; Volungevičienė, 2021).

In digital learning environments, there is enough data provided by learning analytics about learner behaviour and results, but teachers do not have enough competencies to use this data to improve the learning and teaching process, there is a lack of recommendations on how to evaluate the impact of learning analytics (Tsai, Gasevic, 2017). Furthermore, it is important to define the limits to the application, effectiveness, and legitimacy of learning analytics. Scientific evidence is needed to address these issues to serve educational organizations using virtual learning environments. This is also an international problem (Hernández-de-Menéndez, Morales-Menendez, Escobar, et al. (2022); Kew, Tasir, 2022; Ong, Singh, 2021), which is becoming more and more relevant every year.

> *There is a huge potential of learning analytics in monitoring and improving the teaching and learning process, noting a gap in teacher competencies to effectively use the data.*

The aim of the article is to discuss the preconditions for the development of an integrated learning analytics (LA) and action research (AR) model (LAAR), which would enable teachers of general education schools to monitor learners and the teaching/ learning process in digital learning environments and to make data-based decisions to improve pedagogical practice.

The research will use the Design science research methodology (Hevner et al., 2004) applied to cognitive artefacts, e.g. human-computer interface, categories (Dolgopolov, 2018). The suitability of the methodology for learning analytics research is based on the following statements: LA is a socio-technical type of system; LA includes participants (teachers, students, educational institutions, etc.), EdTech, teaching/learning design methods, teaching/learning tools; LA systems are artifacts that manifest as support systems for people who need to be able to interpret analytics data and act on analytics results in learning/ learning contexts (Ferguson et al., 2016; Wilson et al., 2017). Scientific design research is applied to finding new alternatives for solving problems, in this respect this methodology is close to the methodology of activity research (Ketokivi, Hameri, 2009; Carstensen, Bernhard, 2019; Mertler, 2021).

1. Justification of the problem's relevance

Modern research on learning analytics as well as practice in general education schools prove its importance in solving issues related to monitoring learners and the learning process (Mayer-Schönberger, Cukier, 2014; Rupšienė et al., 2021): determining students' learning skills (Williamson, 2016; Mangaroska et al., 2019), collecting data on student progress (Ifenthaler et al., 2019), personalizing and adapting the learning process (Peng et al., 2019; Ifenthaler et al., 2020), student assessment (Sclater, Mullan, 2017), quality of teaching/ learning activities (Maseleno et al., 2018), identification of students from risk groups (Mangaroska and Giannakos, 2018; Williamson, 2016), reduction of exclusion (Kurvinen et al., 2020), etc.

Main beneficiary groups of learning analytics are teachers.

One of the main beneficiary groups of learning analytics is teachers (Khine, 2018), on the other hand, it is the willingness of teachers to use data to improve pedagogical activities that connects the essence of learning analytics with the needs of educational theory and practice, educational content and understanding of how students learn (Ferguson et al., 2016; Khine, 2018; Mandinach, Gummer, 2016; Wilson et al., 2017). Research (van Leeuwen et al., 2021) highlights the need to help teachers master Learning analytics technologies to monitor learners and improve the teaching/ learning process. Other studies (Zhu, Urhahne, 2018) emphasize the need to develop teachers' competencies to effectively use learning analytics data for pedagogical decisions. Research in Lithuanian educational institutions has actualized the necessity of teachers' competences for working with data - starting from "reading" and understanding learning analytics reports (data summaries), ending with their correct interpretation and making data-based pedagogical decisions (Volungevičienė et al., 2019; Rupšienė et al., 2021).

To improve pedagogical decisions, teachers are traditionally offered the action research (AR) method (Altrichter et al., 2005; Hinchey, 2008), which according to modern research data (Nunes, McPherson, 2019; Mazza, Dimitrova, 2004) is particularly suitable for learning and teaching monitoring in digital environments. The purpose of action research is not only the summarization of data and its interpretation, but also the application of results to improve practical activities (Hinchey, 2008). Several models of pedagogic action research have been found in the literature, such as e.g. EMAR model (Nunes, McPherson, 2004), teacher inquiry model (Mertler, 2021). However, these action research models were not combined with learning analytics capabilities.

Learning analytics can provide teachers with powerful tools to help them explore teaching and learning practices by automatically collecting, analysing, and visualizing relevant data (Dyckhoff, 2012).

However, by providing a summary of data, LA does not provide information about how the learning process is going, how the curriculum, content, etc. should change. (Volungevičienė et al., 2019). The teacher must interpret these indicators, reflect on them and decide how these data should be used and analysed for monitoring learners, improving the teaching/learning process and developing the curriculum, i.e. integrating LA into the AR cycle (Berg, 2001; Dyckhoff et al., 2013; Mertler, 2021). Integrating LA with AR emphasizes the aspect of human decision-making: perceiving information, making a decision based on data, and implementing a specific action/ intervention based on it (Dyckhoff et al., 2013). i.e. promotes a human-centred learning analytics approach (Buckingham Shum et al., 2020).

The model is seen as a practical tool to enhance pedagogical practices and can potentially benefit various stakeholders, including learners, school leaders, and IT administrators.

There are no LA and AR models for general education teachers in the literature. The research-based integrated LA and AR model could become a practical tool that will help teachers to observe learners and the learning process in digital learning environments, to reflect, understand and improve pedagogical practice, developed teachers' data analysis and application of its results in practice. The LAAR model could also be useful for other target groups (e.g. learners), interested parties (e.g. school leaders, IT administrators, etc.).

2. Research design

The artifact being developed - an integrated LAAR model - should become a practical tool enabling teachers of general education schools to monitor learners and the teaching/ learning process in digital learning environments and make data-based pedagogical decisions. Qualitative methods will be used to substantiate the scientific applied problem and create a prototype: analysis of sources (in terms of political, legal, strategic documents, scientific articles, research data, etc. in LA and AR education), focus group interviews of target groups and various interested parties (1. teachers, learners and their parents, school leaders; 2. IT specialists, educational policy makers - a total of about 20 focus group participants are planned). The created prototype will be tested and evaluated by Lithuanian school teachers (at least 10) using the advanced learning platforms Eduten Playground and Learnlab in the educational process. The test will be focused on 3 main research questions: 1. Analysis and understanding of student and learning process monitoring data, 2. Data-based reflection of pedagogical practice, 3. Implementation potential of action research. Qualitative methods (e.g. semi-structured interviews with teachers piloting the prototype, observation, case narratives) will be used to collect research data. Data analysis will be based on grounded theory. The research results will be continuously presented and discussed at international conferences (at least 3 reports), scientific journals (at least 3 scientific publications) related to LA in education research areas.

The LAAR prototype would consist of a structural model (5 interacting areas: target groups and stakeholders (e.g. teachers); context (e.g. technological, pedagogical, etc.); goals and objectives (e.g. monitoring of learners, personalization of learning, etc.); digital learning environments and the data they generate (qualitative and quantitative, their summaries, aspects of data protection, confidentiality and ethics, etc.); methods (statistics, information visualization, etc.), 6 stages of the pedagogical activity research cycle (identify problems, formulate questions, use data, transform data into information, turn information into a solution/ pedagogical intervention, evaluate results), about 60 questions related to the above-mentioned areas, factors and limitations affecting LAAR) and a process model (integration of LA, AR activities into a continuous cycle).

The result of the research is the didactic justification of the prototype, testing and methodological recommendations for teachers, but the created tool can be digitized in the future, and could also be integrated into educational technologies.

3. Selection of distance learning platforms for research

Two digital learning environments (regarded globally as the most technologically and pedagogically advanced) are proposed for the study. The learning analytics integrated in these learning platforms are of all types: 1) summative and descriptive, 2) formative, 3) predictive and prescriptive, but based on different methodological approaches. Eduten Playground is an AI-powered gamified math learning platform designed to develop well-defined math skills. This platform is characterized by high-quality and informative quantitative learning analytics tools. Its content is translated into Lithuanian and harmonized with the general programs of Lithuania. The LearnLab platform offers teachers and students mind mapping, book creation and other digital tools for learning about 21st century learning. the most important concepts and concepts for a person by integrating the knowledge of various educational subjects and applying the principles of "deep" learning. Learning analytics on this platform is focused on formative assessment and providing feedback to each student by collecting qualitative data on the overall development of students. The content of the platform is combined with general education programs.

The choice of such platforms is best suited for analysing the possibilities of learning analytics for monitoring learners and the learning process.

- Comparing the methodological approaches of these two platforms would be very important for designing future scenarios.
- These platforms promote inclusive and engaging learning(s).
- These technologies promote self-directed, adaptive, personalized learning models.
- 2022 - 2023 according to data, 73 Lithuanian general education schools use the Eduten Playground platform and 8 schools use the Learnlab platform.

It is also an important fact that there are already experienced teachers in Lithuanian general education schools and teachers who will just start using these platforms in the educational process (in the course of the EdTech project, more and more schools are acquiring licenses). This is relevant for the study, as it will allow differentiation of the target group of the study.

Conclusions

The integration of technology in learning environments has the potential to enhance the efficiency of learning processes, enrich educational content, and empower educators to employ more effective teaching methodologies while enabling learners to monitor and adapt their learning strategies for improved outcomes.

Learning analytics serves as a pivotal tool in monitoring and analysing the teaching and learning process, utilizing data generated within virtual learning environments.

However, despite the wealth of data available, educators often lack the expertise to leverage this information effectively, hindering its potential to enhance teaching practices and student success. Moreover, there remains a pressing need to establish boundaries for the application, efficacy, and ethical use of learning analytics.

This article aims to explore the foundational requirements for developing an integrated Learning Analytics and Action Research (LAAR) model. This model seeks to equip educators in general education schools with the means to monitor learners and the teaching/ learning process in digital environments, enabling data-driven decision-making to enhance pedagogical practices.

Adopting the Design science research methodology, particularly concerning cognitive artifacts such as human-computer interfaces and categories, the research will seek to address the limitations of existing methodologies and propose new solutions. This approach aligns with the socio-technical nature of learning analytics systems, involving diverse participants, educational technology, teaching/ learning design methods, and support systems for interpreting and acting on analytics data in educational contexts.

Ultimately, this research aims to contribute to the field of education by providing new insights into the development of a comprehensive LAAR model, offering practical strategies for educators to harness the potential of learning analytics and improve the teaching and learning experience in digital environments.

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Digital-Pedagogy.eu Institute for Education

Journal of Digital Pedagogy 2023, Vol. 2, No. 1, pp. 14-24

ISSN 3008-2021 https://doi.org/10.61071/JDP.2375

Navigating Learning Paths with EDSense: An AI-Powered Learning Platform

Marius Ivanov

Altfactor
marius.ivanov@altfactor.ro

Dragoș Sebastian Cristea

Altfactor, ”Dunarea de Jos” University of Galati

https://orcid.org/0000-0001-8227-4854

Mihai Vlase

Altfactor, ”Dunarea de Jos” University of Galati

https://orcid.org/0009-0008-6806-0380

Dan Munteanu

Altfactor

https://orcid.org/0000-0002-9518-2366

Abstract: In the realm of contemporary education, the integration of advanced technology is not just a trend but a necessity. "EDSense" emerges as a cutting-edge platform at the intersection of educational needs and technological innovation. This paper focuses on the development of a social educational platform, leveraging artificial intelligence (AI) uniquely designed to support the official educational curriculum, catering to a wide range of users from students and teachers in grades I-XII in Romania, to adult learners. Central to EDSense is the use of AI for personalized learning experiences. This includes the implementation of sophisticated recommending systems that adapt to individual learning styles and progress. Personalized quizzes, crafted using AI algorithms, offer a tailored approach to assess and reinforce learning. Furthermore, EDSense employs sentiment analysis to gauge and respond to the emotional and cognitive states of learners, thereby enhancing the overall learning experience. The platform stands as a testament to the potential of AI in revolutionizing education. By combining educational content with state-of-the-art technology, EDSense aims to provide an engaging, effective, and highly personalized learning journey, setting a new standard in educational technology.

Received: 20.11.2023. Accepted: 27.11.2023

Citation:
Ivanov, M., Cristea, D.S., Vlase, M., Munteanu, D. (2023). Navigating Learning Paths with EDSense: An AI-Powered Learning Platform. *Journal of Digital Pedagogy, 2*(1) 14-24. Bucharest: Institute for Education. https://doi.org/10.61071/JDP.2375

Keywords: elearning platform, artificial intelligence, intelligent learning platform, AI-powered platform, AI-based learning, elearning design

1. Introduction

The main objective of this work is the applied research and technological development of an educational social platform based on artificial intelligence technologies, designed for learning and disseminating specific educational knowledge as outlined in official school programs. The EDSENSE platform is intended for both students and teachers from grades I-XII in Romania, as well as for adults (e.g., parents) interested in the educational process. Therefore, the development of the proposed technological platform involved the design of a large-scale intelligent distributed system that will incorporate: high-quality educational content created in collaboration with recognized educators for the quality of the educational process, and intelligent subsystems for recommendation, content search, personalized questionnaire creation or learning plans, user communication, as well as sentiment analysis based on posted comments. These subsystems will provide the possibility of creating a personalized/ adaptive context.

The motivation for developing such a platform stems from the fact that current e-learning platforms do not simultaneously address aspects such as: a) knowledge being transmitted by both teachers and students; b) posts, searches, comments, and intellectual involvement being easily achieved; c) artificial intelligence modules supporting each user with relevant material, aiding them in the learning process; d) stimulating creativity, involvement, and the ability to formulate opinions complementary to those presented by tutors; e) incorporating a wide range of AI and Machine Learning modules covering various situations, from personal AI assistance to exploratory data analysis (EDA); e) supporting learning through the implementation of a large-scale collaborative paradigm; f) integrating a variety of software technologies such as web, artificial intelligence, mobile applications, augmented reality, social networks, gamification, machine learning, and statistics.

It is important for modern educational platforms to be able to develop large digital communities centred around specific educational content derived from the official curriculum, with various levels of granularity (e.g., a subject, a chapter, a concept). Thus, a digital community will consist of all users who follow a particular element and actively contribute to its development through comments, likes, and communication with other users within the respective topic. From the perspective of artificial intelligence technologies, the design and development of the EDSense platform architecture were based on specific architectural elements, including:

a) The EDSense technology platform is built around the synergy of the latest artificial intelligence techniques: deep learning, recommendation systems, content filtering systems, and intelligent search engines;
b) The 'Intelligent Digital Page' represents a central architectural element of the EDSense platform, enabling content personalization, aggregation of informational components, content provided by artificial intelligence subsystems, and the communication subsystem;
c) The EDSense platform contains uses artificial intelligence modules to learn about users' characteristics, competencies/ skills, and individually assists them throughout the learning process, offering personalized content based on their interests and activities within specific educational areas;
d) The EDSense platform will include an intelligent module for automatic refinement of user-posted comments (identifying inappropriate text content);
e) The platform features an efficient/ probabilistic intelligence-based item knowledge search engine;
f) The EDSense platform contains an innovative module based on modern data exploration and analysis techniques (machine learning), which will provide relevant knowledge about user engagement in different categories (classes, subjects).

In summary, the EDSense platform aims to complementarily contribute to the support/ improvement of educational processes in the traditional educational system, promoting a new, modern approach supported by cutting-edge intelligent technologies. Formally, students can become sources of knowledge with dissemination potential. Within a distributed knowledge system, students can represent active nodes in the dissemination of knowledge, enhancing the entire system as a whole.

2. Literature Review

The integration of artificial intelligence (AI) in educational e-learning platforms has the potential to revolutionize the way people learn. Current strategies for enhancing e-learning platforms have already incorporated AI to improve user experience, facilitate more effective learning, and offer personalized recommendations. In order to keep up with the ever-evolving educational landscape, e-learning systems need to be adapted to meet the needs of both teachers and students (M. Liu & Yu, 2023). This requires new pedagogical approaches and cognitive strategies to ensure the efficient transmission and delivery of learning resources (M. Liu & Yu, 2023). Additionally, without proper supervision and guidance, unmotivated learners may fall behind. Furthermore, users can choose components to meet their needs for teaching and learning, and e-learning platforms can be an integration of related components that support instructional or learning models (Gao et al., 2021). The available technologies to generate novel and exciting courses are continually changing, and course content should be promptly updated to provide students with the most current information (Omar et al., 2011). Artificial intelligence (AI) can be used to improve e-learning platforms in various ways. AI can be used in e-learning platforms through adaptive hypermedia information retrieval systems, adaptive annotation systems, adaptive recommendation systems, adaptive web navigation, and adaptive feedback (Gros & García-Peñalvo, 2016). AI algorithms can be used to evaluate students' current learning conditions using online tests, and provide adapted modules to identify their learning gap (M. Liu & Yu, 2023). Adaptive learning or personalized learning aims to tailor the massive information available to learners based on their features, preferences, background, and learning behaviours (Zhang & Aslan, 2021). AI can assist students by providing personalized study materials and offering feedback based on their strengths and weaknesses (Murtaza et al., 2022). AI can also be used to monitor or assess student progress, and alert teachers if there are any problems with student performance (M. Liu & Yu, 2023). The current strategies of e-learning are being constantly upgraded with the help of emerging technologies (Gros & García-Peñalvo, 2016). As a result, the use of AI in e-learning is on the rise, as AI can provide personalized learning [2]. AI-driven e-learning platforms are good for students as they can access the same content from the comfort of their home (Saleh, 2022), and AI-driven platforms can deliver personalized content (Collins et al., 2003). The use of AI in e-learning can also provide a better understanding of learners' needs and allow for more customized learning strategies. For instance, AI-driven platforms can address cheating during e-learning (Omar et al., 2011) and provide better learning conditions during pandemics (Tang et al., 2023). Additionally, AI can facilitate personalization and customization of the learning process (Montebello, 2014), by providing personalized course material and feedback to learners based on their characteristics (Luan et al., 2020). AI can also enable the creation of intelligent tutoring systems (Eryılmaz et al., 2019), improve the quality of electronic information talents in the mobile network industry, and provide good hardware portability for e-learning platforms through the use of edge computing (Gao et al., 2021). With the emergence of artificial intelligence (AI) technologies, online learning environments have become more adaptive and sophisticated. AI-driven adaptive learning solutions are rapidly being implemented to improve the user experience and increase the efficiency of learning (Chiu et al., 2023). For instance, AI can be used to construct adaptive hypermedia information retrieval systems, adaptive annotation systems, adaptive recommendation systems, adaptive web navigation, and adaptive feedback. Adaptive learning utilizes a data-driven approach to identify students' needs faster and enable the delivery of personalized learning at scale (Dogan et al., 2023).

3. Results and discussion

The implementation of the EDSense educational platform is based on the development of a modular technological architecture grounded in a suite of modern technologies (web development frameworks, recommendation systems, content filtering systems, search systems, sentiment analysis systems, computer graphics, gamification, scalable data structures, etc.).

The EDSense educational platform integrates collections of personalized DSPs (Digital Smart Pages) that are utilizing elements of gamification and augmented reality. These intelligent pages are composed of four categories of components (Manual, Multimedia, Benchmark, Collaborative Intelligent Learning), components that are consuming data stored in specialized data repositories and that are using the algorithms implemented in five intelligent modules: a) search engine, b) recommendation system, c) sentiment analysis module, d) personalized questionnaire generation system, e) user communication system). These modules, which makes the platform an intelligent one, are to be further presented.

Smart Component I, the 'EDSense Intelligent Search Engine,' has the primary objective of providing relevant links for various user-initiated searches. The problem of retrieving stored data (information) is not a trivial one, as it is a challenging issue, especially in a way that can satisfy all users, from novices (who desire a simplified system) to specialists (who require precise and extensive searches). Given that data is managed through file systems, the solution was to overlay a retrieval system (expert information retrieval system) - as shown in Figure 1 - that would provide the possibility of searching based on various criteria.

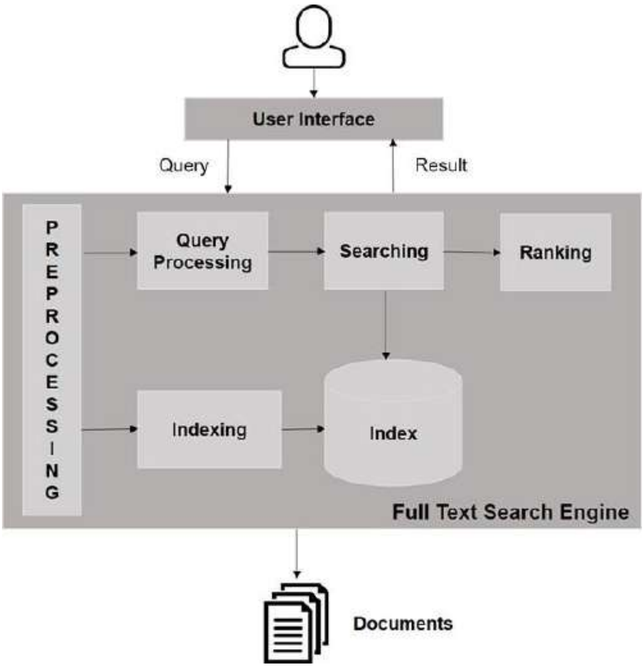

Fig. 1. Search Engine – information retrieval system

The basic idea was that the user comes with a request to search for information, and the platform must provide results as close as possible to the user's requirements. Therefore, the focus in implementing such a system should be on two elements:

a) Extracting search criteria from the user's request (at a higher level, the user can specify the type of search in a as natural language as possible);
b) Actually storing and retrieving meta-information (information about documents) that allows for finding (preferably quickly) documents based on specified parameters.

Regarding the extraction of criteria, this can be done through various technologies such as artificial intelligence or specialized text parsers. However, what needs to be obtained as a result of this stage should be a formalized request in an explicit format that can be taken over by the second component of the system. This second component has the role of storing meta-information and effectively retrieving it. The storage/ modification of the structures used to store information must be closely related to the file system (when creating/ modifying/ deleting a document, changes must also be made in the retrieval system). As for the implementation of the search system, ElasticSearch-type database servers were used to store the structures used for storage in the form of tables in a database with structures determined by predefined ontologies. To avoid data redundancy, each physical document could have attached within the retrieval system a record with the meta-information of the structures containing the sought information.

Smart Component II, the 'Educational Content Recommendation Module based on User History,' provides EDSense users with personalized recommendations in the form of ordered lists of articles. The recommendation system attempts to predict the most suitable knowledge products for students using user preferences and certain constraints. To accomplish this task, the system collects user preferences, which can either be explicitly expressed (e.g., ratings) or inferred from their actions (e.g., navigating to a specific page might be interpreted as an implicit preference for the items on that page). Recommendation systems emerged as an independent research field in the mid-1990s (Isinkaye et al., 2015), becoming a significant subset of information filtering systems. These systems are tools and techniques that provide suggestions for articles to be presented to users (Rivera et al., 2018). The term "article" is the general term used to refer to what the system recommends to users. Articles can be characterized by their complexity, value, or utility. The value of an article can be positive if it is valuable to the user or negative if it doesn't align with the user's preferences, indicating that the user made an incorrect choice in selecting the article. A recommendation system typically focuses on a specific type of product, and as a result, its design, user interface, and fundamental recommendation technique are tailored to provide useful and effective suggestions for that specific type of product. Recommendation systems have proven to be valuable means of coping with information overload in recent years. Ultimately, a recommendation system addresses this phenomenon by suggesting new articles to a user that haven't been experienced yet and may be relevant to the current task. Upon a user's request, depending on the recommendation technique, context, and user needs, the system generates recommendations using various types of user information and data (available items and previous transactions stored in a database). Subsequently, the user can navigate through the recommendations, allowing them to provide immediate or subsequent implicit or explicit feedback. All these user actions can be stored and used later to generate new recommendations in subsequent interactions. There are several advantages for EDSense users from the perspective of a recommendation system: a) Increased User Satisfaction: A well-designed recommendation system can enhance the user experience with the website or application. Users will find the recommendations interesting, relevant, and presented in a user-friendly design. The combination of efficiency, accuracy, recommendations, and an easy-to-use interface will increase the system's usage and the likelihood of users accepting the recommendations; b) Better Understanding of User Needs: Another important function of recommendation systems, which can be extended to many applications, is describing user preferences, whether collected explicitly or predicted by the system. The service provider can then reuse this knowledge for various purposes; c) Increased User Loyalty: A user should be loyal to the educational platform, recognizing the student when visited and treating them as a valuable visitor. This is a typical feature of a recommendation system since many such systems calculate recommendations based on information obtained from the user's previous interactions (e.g., ratings given to products). As a result, the more the user interacts with the application, the more refined their model becomes.

Some motivations and advantages for why service providers would want to introduce recommendation systems have been mentioned earlier. Additionally, users may desire such a system if it efficiently supports their tasks or goals. Therefore, a recommendation system must balance the needs of these two players by offering valuable services to both parties (teachers – students). Herlocker (Herlocker et al., 2004), in a work that has become a classic reference in this field, defines eleven tasks that a recommendation system could implement, and which the EDSense platform has taken into account:

a) Find some good items: Recommend to a user, in the form of a ranking, certain articles along with the anticipation (e.g., on a scale from one to five) of the user's preferences. This is the main task of a recommendation system found in most educational systems;

b) Find all good items: Recommend all articles that can satisfy user needs. This is especially valid when the number of articles is relatively small or when the recommendation system is of critical importance (e.g., in medical or financial applications);

c) Annotations in context: Given a specific context (e.g., a list of articles), mark certain articles based on the user's long-term preferences. For example, a recommendation system for a certain knowledge item will display only those shows from the existing list that are the most compatible with the user;

d) Recommend a sequence: Instead of focusing on generating a single recommendation, the focus is on recommending a series of articles that are enjoyable as a whole. Typical examples include recommending a lesson to learn, a problem to solve, or a personalized quiz;

e) Recommend a bundle: Suggest a group of articles that go well together. For example, learning about a single concept can consist of various other concepts related to the core one. From the user's perspective, these various options can be considered as a single knowledge journey;

f) Just browsing: In this type of task, the user browses the manuals without an imminent intention to solve some problems or learn. The task of the recommendation system is to help the user view only articles that are more likely to fit within their area of interest for that browsing session;

g) Find credible recommender: Some users do not trust recommendation systems, so they "play" with them to observe the quality of recommendations. In this regard, many recommendation systems offer certain special functions, different from those required to obtain recommendations, to allow users to test their behaviour;

h) Improve the profile: This feature refers to the user's ability to provide the recommendation system with information about their preferences. This is a fundamental task that is strictly necessary to provide personalized recommendations.

If the system has no knowledge about the current user, then the recommendations provided to them will be the same as those provided to an "average" user;

i) Express self: Some users are not interested at all in receiving recommendations. What matters most to them is the ability to contribute with ratings and express their opinions or beliefs. This task provides satisfaction to users and, as mentioned earlier in the description of service providers' motivations, acts as a lever to maintain a strong connection with the application;

j) Help others: Some users are happy to contribute information (e.g., ratings for certain knowledge articles) because they believe that communities benefit from this information. This could be a motivation for entering information into a recommendation system that is not frequently used. For example, in an educational recommendation system, a user who has solved a problem is aware that the rating entered into the system is much more likely to be useful for other users;

k) Influence others: In online recommendation systems, there are certain users whose primary goal is to explicitly influence others in order to purchase specific products. There are also so-called malware users who may use the system only to promote or "penalize" certain articles.

Smart Component III, the "User Comment Analysis Module for Continuous Improvement of Educational Content Using Sentiment Analysis Techniques," is used within the EDSense platform to gauge the attitudes of platform users (students) towards the available educational content. Interest in natural language processing (NLP) and, consequently, the extraction of opinions from often subjective text has notably increased. Sentiment analysis has been the subject of research for a long time, as seen in the works of Das and Chen (Das & Chen, 2007) and Tong (Zhao et al., 2012), particularly concerning opinions expressed in the educational. It is important to note that sentiment can be classified in terms of positivity at various levels, such as document, sentence, or feature, involving words that express emotions (e.g., angry, sad, happy). For instance, in the context of user comments analysis (Drus & Khalid, 2019), words could be classified into positive and negative categories. Furthermore, some approaches consider a neutral class (with a value of 0) and assign values to words on a scale from -5 to +5. In this case, the scale has been reduced from -3 to +3, considered sufficiently fine for public discourse (Li et al., 2019), and even further, from -1 to +1. In general terms, sentiment analysis involves extracting opinions from text. It also encompasses subjective analysis, as seen in Dave (Dave et al., 2003), where sentiment analysis involves "processing search results for a specific item, generating a list of product attributes (quality, features, etc.), and aggregating opinions for each of them (poor, mixed, good)." Furthermore, sentiment analysis includes various types of analysis and evaluation. Moving beyond subjectivity, sentiment analysis has also focused on objectivity in text, resulting in the classification of texts into two main categories: objective and subjective. This classification is often more challenging than polarity classification (Mihalcea & Tarau, 2004). Today, there is a vast amount of "sentiment" available in social media, including Twitter, Facebook, forums, blogs, etc. Sentiment analysis provides organizations with the ability to monitor opinions about their products/ services and reputation (referred to as feedback) from various social media platforms in real-time and take actions accordingly. The initial classification of analysed texts (sentences/ phrases) may take into account the criterion of subjectivity, resulting in two main classes: objective, containing concrete information, and subjective, containing explicit opinions, beliefs, and views about specific entities. Notable authors with significant contributions and comments on sentiment analysis include (Kenyon-Dean et al., 2018; B. Liu, 2012; Narayanan et al., 2009; Shelar & Huang, 2018; Taboada, 2016; Zhao et al., 2012).

Document-level sentiment analysis is the simplest form of sentiment analysis, assuming that a document contains an opinion about a single main object expressed by the author of the message. In the literature, two approaches to document-level sentiment analysis are found: supervised and unsupervised. The supervised approach involves having a finite set of classes, and documents need to be classified, with training data assigned to each class. The simplest case involves two classes: positive and negative. Additionally, a neutral class can be added, or a numerical scale can be considered for document classification (e.g., SentiWordNet3 (Kardinata et al., 2021)). Using the training data, the system learns a classification model, typically employing classification algorithms like Support Vector Machines (SVM) or K-nearest neighbours (KNN). This classification is then used to label new documents into their respective sentiment classes. Authors like (Khanal, 2010) have shown that good accuracy can be achieved even when representing each document as a "bag of words." More advanced representations involve considering parts of speech (POS), sentiment lexicons, and parsing structures at the lexical unit level. The unsupervised approach to document-level sentiment analysis relies on determining the Semantic Orientation (SO) of specific phrases within the document. If the average SO of these phrases exceeds a predefined threshold, the document is classified as positive; otherwise, it is considered negative. There are two main approaches for selecting phrases: a set of predefined POS models can be used to select these phrases (Turney, 2008), or a lexicon of sentiment words and expressions can be utilized (Taboada, 2016).

Sentence/ phrase-level sentiment analysis (specific to EDSense development): A single document can contain multiple opinions, even about the same entity. When we want a clearer picture of opinions expressed about an entity (object, being, organization, location, etc.), we need to analyse at the sentence/ phrase level. The initial assumption is that we have knowledge of the identity of the entity mentioned in the text. Furthermore, we assume that each sentence contains only one opinion. This assumption can be achieved by breaking down the sentence into propositions (a text fragment containing a predicative verb), where each proposition contains only one opinion. Before analysing the polarity at the sentence level, we need to determine whether the sentences are subjective or objective. Only subjective sentences will be further analysed. Most methods use supervised techniques to classify sentences into two classes (Hatzivassiloglou & McKeown, 1997). The main premise is that neighbouring sentences should have the same subjective classification. These sentences can then be classified into positive or negative classes. It has also been shown that it is advisable to adopt different strategies for this type of analysis (Narayanan et al., 2009). At a semantic level, challenges can arise from questions, sarcasm, metaphor, humour, elements that are difficult to detect, especially in certain contexts (e.g., political contexts). The aforementioned approaches work well when either the entire document or each analysed text fragment refers to a single entity. However, in many cases, people talk about entities with multiple attributes, and of course, opinions vary. This often occurs in comments about products, services, etc., or in discussion forums dedicated to various categories of entities (such as political figures, cars, cameras, smartphones, and even pharmaceutical products). Emotion-based analysis is a research problem that focuses on recognizing all forms of sentiment expressions in a given document and the aspects they refer to. The classical approach, increasingly used by the public relations departments of large companies/ commercial organizations, involves identifying the emotional nature of comments regarding product quality, services, brand image, etc. In natural language, this entails extracting all nominal structures (NPs) and then retaining only those whose frequency exceeds an experimentally learned threshold (Pooja & Bhalla, 2022). Emotion-based analysis also focuses on recognizing all forms of sentiment expressions in a given document and the entities they refer to. In other words, it identifies evaluative aspects mentioned explicitly in sentences. However, there are many opinions that are not explicitly mentioned in sentences and must be deduced from implicitly mentioned sentiment expressions.

Smart Component IV, the 'Automatic Generation of Personalized Questionnaires (smart quizzes) according to user profile' starts from the assumption that assessments that require students to pause and test do not thoroughly assess their comprehension of a subject. On the other hand, assessments utilizing artificial intelligence offer continuous feedback to educators, learners, and parents. This feedback sheds light on the student's learning approach, identifies areas where assistance may be required, and tracks their advancement in achieving their educational objectives. Over the course of many years, extensive research has consistently demonstrated that the evaluation of knowledge and comprehension cannot be effectively conducted solely through a sequence of 90-minute exams. The predominant approach to exams is fraught with anxiety, unenjoyable experiences, potentially deterring students from pursuing education, and necessitates the diversion of valuable time away from the pursuit of knowledge for both learners and educators. Despite the global recognition that these tools are crude, we continue to depend on them, pushing students into universities and jobs without adequately preparing them for what lies ahead. It is possible that one of the factors contributing to the enduring prevalence of traditional assessment methods, such as standardized tests, is the lack of appealing alternatives. Moreover, these alternatives have proven to be just as, if not more, unpredictable and unreliable than current examination systems. To illustrate this point, let us consider how marks attained through coursework in the school education system have been incorporated into students' overall exam grades. Concerns regarding the extent to which students are solely responsible for their coursework have resulted in a decline in the appeal of this option, prompting a return to traditional examinations. Within higher education, the implementation of "open book exams" has aimed to alleviate the burden on students to memorize copious amounts of information. While this approach may provide some relief, it merely addresses a fraction of the larger issue at hand, namely the strain placed on memory. There are still other aspects that cause stress and cannot be relied upon, including the conditions of the exams, the narrow scope of the assessment, and the reliability of the grading process. Nevertheless, things have changed now and we have a practical and financially appealing option within our reach. We possess the technological capabilities to construct an advanced assessment system, one that is powered by artificial intelligence (AI). However, the question remains whether we are willing to challenge conventional practices and embrace this innovation from a societal and ethical perspective. The use of AI in education has been a topic of study in academia for over three decades. The goal is to create clear and precise forms of educational, psychological, and social knowledge that are often left unspoken. The evidence from current AI systems that evaluate learning and offer tutoring is encouraging, as they have shown to be accurate in their assessments. By providing a deep, fine-grained understanding of when and how learning actually happens, AI serves as a powerful tool to unlock the mysteries of education. To achieve this, AI assessment systems require specific information, such as the curriculum, subject area, and learning activities that individual students are engaged in. Additionally, details about the steps taken by each student during these activities are crucial. Lastly, AI systems must take into account what defines success within each activity and step towards completion. By applying techniques like computer modelling and machine learning to this data, the AI assessment system can accurately evaluate a student's knowledge in the studied subject area. AI assessment systems have the capability to evaluate various skills of students, including collaboration and persistence, as well as their personal characteristics such as confidence and motivation. The AI system collects and processes information over a significant duration to form an assessment of each student's progress. Unlike a brief 90-minute exam, this duration can span an entire school semester, a year, or even multiple years. The output generated by the AI software offers valuable data that can be synthesized and interpreted to create visual representations. The visualizations, known as Open Learner Models (OLMs), serve as representations of a student's knowledge, skills, or resource needs. These models assist both teachers and students in comprehending their performance and its evaluation. To illustrate, an AI assessment system gathers information regarding a student's accomplishments, emotional state, and motivation. By analysing this data, an OLM can be created with the aim of: (1) aiding teachers in understanding their students' learning approaches so they can tailor their future instruction accordingly; and (2) empowering students to monitor their own progress and encourage introspection on their learning journey. AIAssess (Box 1) serves as a universal AI evaluation system that represents merely one method of gauging a student's knowledge and comprehension. This system is apt for disciplines like mathematics or science and draws from preexisting research instruments. Nonetheless, an assortment of AI methodologies, including natural language processing, speech recognition, and semantic analysis, can be employed to assess student learning effectively. For subjects such as spoken language or history, as well as skills like collaborative problem-solving, a fitting combination of tools would be necessary.

Smart Component V, the 'User-to-User Q&A Communication System,' extends the functionality of the EDSense platform by providing users with an interactive environment/ context to enhance their engagement with the platform and the overall knowledge dissemination process. With this component, users will be able to: a) Write various comments associated with different knowledge elements (articles) presented within the DSPs (Digital Study Plans); b) Submit requests for assistance on various knowledge topics; c) Send personalized messages to other users. User-to-user communication must adhere to the strictest security rules, giving users the ability to report any inappropriate content transmitted through the platform. Therefore, it is necessary to define a spam filter to analyse various characteristics of text messages through which they are classified as spam or legitimate. Developing such functionality involves various approaches, including textual analysis using machine learning techniques or the analysis of specific text features typical of spam messages (e.g., forged headers, time of delivery), all requiring frequent updates due to constant attempts by spammers to evade detection by altering the representation of keywords (intentional misspellings or using visually similar characters with different meanings - e.g., 0-o, i-l, rn-m, etc.) and inserting text content that appears legitimate to machine learning-based classification methods (Amayri & Bouguila, 2010; Awad, 2011). In recent years, many issues, including spam detection and classification, have been addressed using artificial intelligence. Classification is the process of making a decision based on examples of correct decisions; thus, it is a supervised learning technique because it requires a pre-classified dataset. During the training process on this dataset, it becomes clear which property of the data indicates membership in a particular class, and this information is saved in a model that will be used for classifying new data. The text classification implemented within this component involves associating a text with a predefined text category. Each word in the document is considered an attribute of the document, creating a vector of attributes containing the words from the text. To improve the classification process, certain frequently occurring words in a vocabulary (e.g., "and," "the," "of," "a") can be removed, or words can be grouped into 2–3-word groups called n-grams. Several algorithms have been developed to solve this classification problem (Bhowmick & Hazarika, 2018), including Naive Bayes, decision trees, neural networks, logistic regression, and more. Among these, the most commonly used algorithm for text classification is Naive Bayes (Metsis et al., 2006). Naive Bayes is a probabilistic classification algorithm, and its decisions are based on probabilities derived from the preclassified dataset. Additionally, the 'smart' attribute associated with the communication system comes from the fact that this system will be able to identify users with the most suitable skills for resolving help requests. These users will receive specific notifications related to the request made, and their identification will be based on recommendation algorithms, as described earlier.

4. Conclusions

As an AI-powered learning platform, EDSense was emphasized in the current paper as a significant step forward in educational technology. By integrating advanced algorithms, it created a personalized and adaptive learning environment, with a high potential for widespread educational impact through its ability to target a diverse range of learners, from primary school students to adults in Romania. The platform's unique approach to understanding and addressing the varied learning needs of individuals is showcased through its use of sentiment analysis and adaptive recommendation systems. By providing additional learning materials and supporting the official educational curriculum, EDSense offers a comprehensive educational resource for both students and educators. The presented platform is capable to enhance the student engagement and improving learning outcomes through personalized quizzes and learning paths. As EDSense continues to be developed and fine-tuned, it is expected that more advanced features will be introduced, and a deeper understanding of educational requirements will be gained. Also, as AI technology progresses, EDSense can adjust and include new innovations, guaranteeing its relevance and effectiveness in the ever-changing realm of educational technology. Ultimately, the evolution of EDSense from an idea to its realization signifies the revolutionary impact of technology on education, offering a more captivating, individualized, and efficient learning encounter for everyone involved.

* * *

The project "Ed-SENSE - Innovative educational platform for collaborative, collective and individual training, based on an artificial intelligence, gamification and augmented reality system" is financed from European funds through the Regional Operational Program (POR) 2014-2020, Priority Axis 1 - Promoting technology transfer, My SMIS Code: 150022

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Digital-Pedagogy.eu Institute for Education

Journal of Digital Pedagogy 2023, Vol. 2, No. 1, pp. 25-37

ISSN 3008-2021 https://doi.org/10.61071/JDP.2377

Early Childhood Development: The Influence of Digital Technology on Psychological Processes and Mechanisms

Viorela Mihăilă-Popa

University of Bucharest, Faculty of Psychology and Education Sciences – Bucharest, Romania

popa.mihaila-popa.viorela2020@credis.unibuc.ro / viorelagpopa@gmail.com

https://orcid.org/0009-0008-6033-7277

Abstract: Despite the novelty and excitement of the promise that technology will revolutionize education, as it has revolutionized many other fields (medicine, industries), programs in recent years have shown that technology alone does not have the power to change education for the better (Blackwell et al., 2014, para.4). Still, people can do this, if they are willing to learn *how*, *why* and *when*. In other words, first, the devices were introduced and the infrastructure created, then administrators and teachers began to learn how to use it, with support in some countries, without support in others. Would a reverse approach have been more useful? For instance, specializing teachers and subsequently equipping schools with the necessary infrastructure? We are in a situation where there are sometimes early education institutions where there is equipment, but education managers and teachers do not have the full picture of *how* and *when* to use it, and what are the implications of this usage.

Given observations and studies carried out in the school environment, we wonder how equipping kindergartens with tablets and other screen devices would work? What makes digital technology really useful in early childhood education? What should be the motivation for the introduction of digital technologies in early education?

This paper provides psychological and educational benchmarks for the use of digital technologies in preschool educational institutions, as well as in the context of family education.

Keywords: early childhood, psychological mechanisms, cognitive processes, effects of digital technologies, digital technologies in education, digital competences, digital intelligence

Introduction

To highlight the effects that digital technology has on the cognitive development of children younger than 6 years old, we first need a classification of their causes.

First, we can consider a direct source, which involves the child's use of the device, and an indirect source, which refers to exposure to how other family members or close acquaintances use them.

Received: 26.11.2023. Accepted: 20.12.2023

Citation:

Mihăilă-Popa, V. (2023). Early Childhood Development: The Influence of Digital Technology on Psychological Processes and Mechanisms. *Journal of Digital Pedagogy, 2*(1) 25-37. Bucharest: Institute for Education. https://doi.org/10.61071/JDP.2377

Thus, the indirect source (in this context) that produces effects on the child's cognitive development is precisely the model provided by the parent, namely their behaviour in relation to digital technology (when, how, how much, why does he use the phone, tablet, TV, video game console) but also of older siblings or other family members or the narrow circle of adults (e.g. the educator). In this case, the child is exposed to digital technology (content, context, duration) and learns a certain pattern of behaviour towards it, through imitation.

A second source is the child's use of a digital device (phone/ tablet/ television/ desktop computer/ laptop). In this case, the interaction with digital technology is direct. This interaction is the subject of interest for the present paper and which I will detail further, the one that the cognitive sciences investigate and the one that, in fact, needs conclusive results to be able to guide children's education. About the first source, psychology has already provided numerous theories and studies that explain its importance and how it works.

We considered it useful to organise the information obtained from the bibliographic research according to the mental process addressed or studied by the researchers. So here are some observations related to perception, representation, memory, thinking, attention, motivation, and imagination. We have also added information about language acquisition and learning, complex processes that build on those previously stated.

1. Perception and Representation

Perception and representation are the first mental processes that mediate the interaction between the child and the environment. Through these cognitive processes the child forms a mental representation of space, time and everything received through the senses: images, smells and tastes, tactile and auditory sensations. Representation is a psychic mechanism that facilitates the human ability to refer to objects in their physical absence. The more the child interacts with the environment through the senses, the richer the representation of an object and space, and can provide meaningful details in the absence of the physical object. Perception plays an essential role in the formation of representation, which is why direct interaction between the child and objects is essential in learning. The motor and sensory centres are very well developed in the first years of life, which is why the child's main need, both physical and mental, is to access the environment through all their senses. The sensorimotor centre activates more when children interact directly with the object. According to psychologist Jean Piaget, this period is characterised by children's need for concreteness and movement. From this point of view, digital activities do not support sensory development, sight, the most targeted of which is the sense that continues to develop until the age of 10. (Tang et. al, 2021, para. 5)

Let's take, for example, the digital alternative of an object, namely its image. Without this yet being concretely explored, what the child receives about that object is only visual and auditory. The sense of touch is not exploited in its depth, but reduced to feeling a smooth, flat, uniform surface. Moreover, the sound and the visual are not interconnected from the beginning on a psychic level, which is why, before the young child can associate the image he sees on a screen with a sound, he needs to make this association in the concrete environment. The relationship with the adults around him shapes the relationship between the sounds he hears, the movement of the lips and the face of the speaker. This is how the child learns to associate a certain sound with a picture.

The same happens with the other senses. If, for example, the child eats in front of a screen (so he will look at something other than what he receives as food), the child will not be able to make associations between the taste, the image, the smell, and the texture of the food he is eating. Visually, he receives information (what he sees on the screen) and through the other senses, other information. Moreover, attention plays an essential role in learning and in this case, attention is captured by the image.

Apart from creating Pavlovian conditioning by associating feeding with watching the content of a screen, thus creating an addiction, the child has not formed at a mental level the correct associations between the information it receives through the senses. Clarity, an essential feature of representations of the world in which the child lives, is lacking.

A study conducted on a group of 847 children aged between 2 and 5 years (Jusienė et al., 2019, para.2), confirmed the unfavourable associations between screen use during meals, daily screen time and consumption of unhealthy food (junk food) during early childhood. Of the parents interviewed, only 44% confirmed that they never use screens during meals.

If at the age of 6 months, the child manages to imitate an action equally well if it is presented in a video recording or live, the same does not happen after the age of 1 year when the *video deficit* appears (Barr, Muentener, Garcia, 2007). Basically, the child does not perceive the content displayed on a screen as real.

Therefore, most studies highlight the importance of the adult's active participation in the relationship with the child as the main factor in their learning and cognitive development.

2. Attention

Attention is a psychic phenomenon of selective activation, concentration, and orientation of psycho-nervous energy to optimally carry out mental activity, with the distinction of cognitive processes. Attention is directly involved in the learning process.

The peculiarity of the functioning of different nervous circuits means that there are practically at least three interruptions per minute of attention to simple stimuli - 8-10s. (Bucur, 2019, p. 9) Thus, in the age range of 1-3 years, the stability of attention is around 10-15 minutes and increases to 20-25 minutes in the next 3 years. Concentration is an attribute of attention, and it keeps developing, being influenced by training, interest and the importance of the activity.

During the first years, the child trains their ability to concentrate with activities that arouse their interest and involve repetition, following a sequence. The structure, clarity, and relatively slow speed of the adult's movement support the development of this type of attention.

The attention most often stimulated by digital device screens is involuntary attention. Maintenance is done through strong, visual and auditory stimuli and feedback markers that validate the child's inputs. However, overstimulation is tiring and does not provide space for the necessary breaks to "decant" the information.

The success of an app is measured in maintaining attention, and stimuli such as those provided by some apps and games make this possible in ways that ultimately lead to addiction.

According to Dr. Michael Manos, director of the Cleveland Clinic's ADHD Assessment and Treatment Centre, children ages 5 and younger who spend 2 or more hours in front of screens are 8 times more likely to be diagnosed with attention problems such as ADHD and others. (Manos apud. Novak, 2021, para. 4) The main two reasons are 1). The intensity and repetitiveness of visual stimulation in a very short time and 2). Immediate gratification. Compared to the virtual world, the real world offers a much slower pace that, for a mind accustomed to overstimulation and instant gratification, no longer holds interest.

The brain operates with two main types of attention: involuntary attention and voluntary attention. As previously mentioned, it is involuntary attention that prevails in the early years of life, while voluntary attention engages concentration and will, being sustained and directed. Digital environments especially act on involuntary attention, which is why excessive training of this type of attention has a negative impact on voluntary attention and concentration.

Another study led by Canadian researchers (Tamana et. al, 2021) showed that 3-year-old and 5-year-old children's use of digital devices for more than 2 hours are likely to meet the criteria for diagnosis with ADHD.

The increase in time spent in front of screens is associated with attention problems, and one of the reasons could be precisely the lack of ability to select the content, the phenomenon of attention not yet being matured enough to be able to function in the case of overstimulation.

Pierre Laurent, former marketing director at Microsoft and Intel and father of three children aged 9, 15, and 17, argued in 2015 (The Guardian, 2015, para. 16) that although you can give your child an hour of screen time per day, content created for kids is specifically designed to keep their attention outside of actual screen time or device use. "There is no intention to hurt the children but there is an intention to keep them engaged, attentive." App and game makers "don't want to give you time to wander off and start using another media product, so they resort to addictive elements," he claims, a finding also made by other mentioned authors, such as prof. Howard Gardner, neurologist prof. Dr. Manfred Spitzer and prof. in cyber-psychology and Europol academic consultant Mary Aiken.

3. Thinking

As for thinking (cognition), it is not automatically logical and can sometimes be misdirected if it is not trained in reasoning. This training begins in early childhood.

A phenomenon associated with overstimulation caused by long-term exposure to digital media is Accelerated Thinking Syndrome (SGA). This is described at length by Prof. Cury and manifests itself in school children and teenagers through agitation, starting discussions out of context, and lack of concentration. Prof. Cury describes this syndrome as having three main causes: the excess of visual and sound stimuli produced by television, the excess of information, and the visually aggressive consumption policy (Cury, p. 70).

Regarding this phenomenon, Prof. Dr. Spitzer claims that "To be able to perceive something so quickly, our visual system must protect itself against overload." (Spitzer, 2020, p. 220). The doctor argues that this is made possible by suspending attention for a quarter of a second, during which automatic stimulus processing processes stop processing other stimuli until the current stimulus is perceived and processed. This leads to the interruption of attention as a protective mechanism against overstimulation.

Multitasking and attention deficit are two of the effects associated with this phenomenon, detailed in the following chapters.

As for the formation of mathematical thinking, essential in everyday life, it starts from the concrete. How is the satisfaction of this need reflected in the child's activity in the virtual space? Does the virtual space reflect the surrounding reality? How do apps and games that parents give to children feed the child's psyche? Just as a healthy and tasty food preparation nourishes the child's body, what children receive through senses and language is what nourishes their psyche in the continuous search for relevant experiences.

Mathematical thinking is based on the sensory-motor exploration of the concrete. The concrete precedes the iconic and the symbol.

Numbers are processed by the brain from 3 perspectives: 1). as a sensory and motor fact related to the fingers and the surrounding objects. 2). As a point there is a line in the parietal lobe 3). In word form in language centres. (Spitzer, 2020, p. 150)

Based on this knowledge, a study was conducted on how the use of fingers in numeracy and mathematical calculation at an early age has an impact on mathematical thinking in adulthood (Domahs et al., 2010, para.20). Two groups of subjects were drawn up, one German and one Chinese, with an average age of 25 years. Why were these two nationalities chosen? In Chinese culture, children learn to count to 10 using one hand, while in German culture, as in most European countries, children learn to count to 10 using both hands.

The experiments aimed to measure the response time in the case of comparing two numbers. The results showed a different reaction time decrease in the two groups of subjects, thus: while the Germans became slower when comparing numbers greater than 5, the Chinese became slower when comparing numbers greater than 10. Clearly, the subjects did not use their fingers to count during the experiments, but the study demonstrated that the use of fingers and counting on fingers from childhood is integrated at the psychic level through representations and decisively influences the ability to operate with numbers and mathematical thinking.

4. Imagination

The child uses creative, intentional imagination (directs all their energy and attention to the creation of works) and makes an original redesign starting from the perceived concrete when making a drawing or a collage. One of the features of imagination is that of being influenced by reality: the child needs the images that he himself forms with the help of the visual sense.

Imagination is a complex psychic mechanism, difficult to study in young children and yet extremely obvious. Most often this takes the form of a role-playing game in which the child experiences a reality by being the author of the scenario, but also through artistic expression: drawing, dance, and music.

Imagination is a process of distortion of reality. To be able to deform it, a child must master it well enough to manipulate and alter it in a creative, that is, useful way, with the possibility that its products can be anchored in the real, in the concrete.

Creativity is a form of imagining unusual solutions that use available resources in an unexpected way to provide a solution to a given situation. So, creativity is more than combining and recombining digital images/elements usig the available tools.

About the artistic products (drawings, collages, musical compositions) obtained through the use of digital applications, the American teacher and researcher Howard Gardner draws attention that "applications could represent the 'ultimate lock' (Gardner, 2015, p. 143)" and offers the Songwriter Pad application as an example. Thus, the products created by children with the help of applications that offer a set of predefined objects and tools to be used in a certain way, ”are circumscribed by the choices that the designers made when they configured the application” (ibid., p.143). In other words, it is limited, controlled creativity. The raw material provided by the apps limits the possibilities and excludes other possible variants that the child's mind could realise.

From another point of view, imagination also means fantasy and the child cannot distinguish between fiction and non-fiction before the age of 6-7. (Church, updated: 2020). Knowing this, we can understand the situations in which children look for in the real environment that exists in the virtual environment and it is very difficult for them to understand the notion of the unreal. So the virtual can create even greater confusion between what is real and what is not real, as some fantasy stories do. Moreover, a study published in 2015 showed that, unlike adults, young children prefer true stories more than fictional, fantastic ones (Barnes, Bernstein, Bloom, 2015).

Another study mentioned by H. Gardner in his work Generation App (2015), carried out on a group of school children, showed that students who listened to a story on the radio developed more imaginative answers about the continuation of the story than children who watched the story on television and which produced narratives that repeated the original. (Valkenburg & van der Voort, 1994 apud. Gardner 2015). The study highlighted the ” visualisation hypothesis” according to which ”children's exposure to ready-made visual images restricts their ability to generate new images of their own” (Gardner, 2015, p. 144).

5. Memory

Regarding memory, Dr. Cury claims that “*there is no such thing as pure memory. [...] Memory is specialised in making us creators of new ideas*” (2017, p. 136), being the ”reservoir of imagination” (Zlate, 2009, p. 178).

Whether we are talking about working memory or long-term memory, the construction of this reservoir is constantly made based on childhood experiences. Some of these experiences go directly into the *mneme*, the unconscious memory that although we cannot directly access, it guides the reactions, reflexes and behaviour of each individual.

Moreover, memory is directly influenced by emotion, emotion being the one that encodes certain information. They say people won't remember what you said but they will remember how what you said made them feel. In other words, memorization is carried out directly emotionally, it directly influences behaviour, without the reason being able to be explained, made aware.

Moreover, memory supports learning, being a mechanism that extracts from the child's experience everything relevant to encode information that is then transformed into knowledge through the process of thinking.

Take object learning for example. In order to highlight how the manipulation of objects, thus the activation of the psychic motor centre, supports the learning of objects, the German researcher Markus Kiefer and his colleagues (Soden-Fraunhofen et. al, 2008 apud. Spitzer, 2021, p.156) carried out a study on a group of 28 students from Ulm. They were asked to assimilate conceptual notions about 64 "noobjects" (invented objects), namely image, name, category, shape, and particularity. By isolating different characteristics of the "new objects" in turn, the researchers were able to highlight the interdependence between the ability to process newly acquired content and how it was assimilated. In the case of the students who manipulated the newly learned objects, the motor brain activation pattern entered the conceptual structure. In other words, how something is learned directly influences how it is remembered and accessed later. The reduction of the sense of touch and manipulation when using a mouse and its associated click or an action of tracing a finger on a digital screen, affects the memorization of objects viewed on these devices, their learning mode. So, "he who is about to know the world must necessarily turn to the real world." (Spitzer, 2020, p. 156).

6. Self-Control and Volition

As for self-control, it is not an innate ability, the child has the potential to develop it throughout the first years of life. "Kindergarten is, in terms of neurobiological development, pure frontal lobe training." (Spitzer, 2020, p.211)

Along with self-control, working memory and mental flexibility are brain functions that facilitate attention, focus, and learning.

According to an international study conducted on a group of 416 newborns, regular exposure to digital content at the age of 4 months could be correlated with a lower level of inhibition ability at the age of 14 months. (McHarg, Ribner, Devine, Hughes, 2020)

"Self-control always equates to the inhibition of reflex behaviour" claims the neurologist Spitzer (2020, p. 209), and the willpower is the essential psychic function in acquiring self-control. This is involved both in inhibiting actions that harm oneself and others (inhibitory will) but also in mobilising resources to succeed, to perform a difficult task or to overcome an obstacle.

How does exposure to digital content influence the development of volition?

Take, for example, solving a puzzle. In a digital application, moving pieces is done by simply dragging the pieces across the surface of the screen. Regardless of their shape, their position in the game, thickness, texture, and tactile sensation are the same. The effort is often reduced by the drawing effect of the piece or the visual effect before placing the piece when it is close to the space where it would fit. The action is much simplified.

In the concrete environment, completing a puzzle requires much more effort, skill, and coordination of movements and takes much longer, requiring active will, which helps the child to overcome the obstacle and complete the puzzle. Therefore, a greater effort trains more willpower and consequently also perseverance (formed based on previous experiences in which willpower led to success) but also resilience (the ability to bounce back after a failure).

7. Motivation

If we stick to the example of the puzzle, we notice that the way to solve it, as well as other digital games, changes the functioning of motivation, orienting it from the inside to the outside.

The child usually receives, in a virtual game, an external gratification that overlaps and, in many cases, supersedes the expression of their own joy for success. Gratification and success play a decisive role in building motivation. Intrinsic motivation is that type of motivation that comes from within the person, is self-fuelled to support the self-fulfilment of one's own needs and desires, and focuses on action. For this reason, this type of motivation supports the individual's independence of thought and action.

In contrast, extrinsic motivation is generated by the reaction of the environment or others (other children, parents, teachers) to an individual's success. In the case of digital devices, the feedback system they provide (sounds, vibrations, or visual effects) emulates external validation and undermines self-evaluation, directing motivation toward the outcome rather than the process.

Take for example the tower building game.

When it is built from concrete pieces, made of wood or other material, the visual harmony works as an error control, the child alone validates whether it fits or not, rethinks the way of placement, relies on their thinking. In this case, the child has the opportunity to enjoy their success, the concrete activities offering him numerous opportunities to improve what he does, without setting certain standards.

In this case, motivation is stimulated on the one hand by the tendency to perfection, and on the other hand by the anticipation of satisfaction and the moment of success.

In the case of a digital matching game, the validation is programmed automatically, and the self-assessment is replaced by the standard application/game validation. Thus, the achievement of a result is encouraged, and less the process of achieving it.

8. Language

Regarding language, the studies carried out so far have highlighted the speed with which children learn to speak in the first months of life, something that can also be observed in everyday life, both by parents and teachers.

Seeking to better understand how language acquisition works, researchers have conducted several studies that have identified a "video deficit effect". Practically, they were able to highlight the fact that up to 3 years old, children learn and develop communication skills much better through interaction with a human being than through interaction with an electronic device.

Moreover, in the case of second language acquisition, a study has shown that this is facilitated exclusively by direct interaction between a native speaker and the child. In a study conducted by the German researcher Kuhl and his collaborators (2003), two experiments were conducted on groups of 16 children aged between 9 and 10 months. In the first experiment, a group of children were exposed to 12 sessions of 2.5 hours of Chinese (Mandarin) in which a native speaker read for 10 minutes and then played for 15 minutes, with the adult making eye contact with the children. The second group, the control group, was exposed to the same amount of time and type of activities as group 1 but conducted in English, their mother tongue. In total, the children spent 25 hours in the company of the natives. After one year, the level of recognition of Chinese syllables in both groups was measured and, obviously, the first group recorded an average recognition rate of 65.7%.

In the second experiment, the conditions from the first experiment were repeated (the same number of children, the same age, the same time spent in the experiment), but the way of exposure was changed. Instead of native speakers, video recordings of native speakers, a video reproduction of the activities from the first experiment, were used for one group, and audio recordings were used for the second group. After a year, the researchers measured the level of recognition of Chinese sounds in the two groups of children and found that electronic, audio-video, and audio media did not lead to learning (para. 19). In conclusion, direct and immediate interaction with a native speaker at the age of 9-10 months is sufficient to ensure the learning of a foreign language and the use of audio-video devices does not produce learning in this case.

Private speech, as defined in the Anglophone specialist literature, or children's *soliloquy*, is a phenomenon that appears around the age of 3 and manifests itself as a verbal expression of internal dialogue. Children talk out loud without addressing anyone in particular. This behaviour can be observed in moments of individual play, both in role-playing games and in games of another type or with other objects. In children, soliloquy is a form of self-regulation also used in problem-solving activities.

An experiment carried out on a group of 5-year-old Italian children, 16 of whom were girls (Bochicchio et al., 2022) showed that the same activity carried out in the concrete environment and then in the digital environment, had a different impact on how children use soliloquy during play. The children talked to themselves as they built the tower using concrete materials while building the tower through a digital app greatly reduced the extent of the monologue. The researchers added that it may be that the parents who, by associating the screen with "quietness", have induced this behaviour in the children.

The Russian psychologist L. Vygotsky was the first to write about the soliloquy 36 years ago. He believed that language and thinking are two separate systems at birth and that come together around the age of 3 when they become interdependent: thinking becomes verbal, and speech becomes representational. (McLeod, 2023, para. 69). According to his theory, the soliloquy is essential in the cognitive development of children and its purpose is not communication but self-regulation, the external monologue becoming the inner voice after the age of 7.

This study could contribute to the understanding of the link between DT use, inhibition of young children's soliloquy, and changes in self-control ability from preschool ages.

From the point of view of language, one of the relevant aspects at this age is vocabulary. This is the easiest to highlight at a young age, observed and quantified. The number of words, correctness of expression, and complexity of utterances reflect the level of language development at this age.

A government-funded and nationally representative longitudinal study called Growing up in Ireland studied the cognitive, social, and emotional development of 9,001 Irish children aged 9 months to 5 years between 2008 and 2013. According to researchers, the number of 3-year-olds who use at least one screen device daily has increased by 18% over the past 10 years. (Beatty et al., 2018, p.1) Based on interviews with parents and visits to educational institutions, researchers were able to find out that only 2.6% of children aged 5 did not have access to screen devices, and 56.4 % of children of this age were involved in mixed activities such as movies and TV programs (ibid., p.5). Also, children who used digital devices to access educational content spent less time on average than other children who used the same devices for entertainment On vocabulary tests, children who played video games scored the lowest, compared to the other children (ibid., p.7). In conclusion, the type of activity has a greater influence on the development of children's vocabulary compared to the time spent in front of a screen, which contributes to shaping the importance of the content offered on digital media.

A study conducted by the American psychologist Daniel Anderson, today a professor emeritus of the University of Massachusetts, was conducted in 2005 and led to the definition of the concept of "video deficit" (video deficit) present in children younger than 2 years old. TV programs/videos defined as "educational" (e.g.: Baby Einstein) and shown to children during the experiment did not produce learning.

A study published in 2019 and carried out by the American researcher Hutton and his colleagues in partnership with the Educational Neuroimaging Center on a group of 47 babies (average age 7 months) highlighted an association between the use of digital content by children for a while longer than indicated by the AAP, i.e. more than 2 hours over the 1 hour/day recommendation, and the microstructural integrity of brain white matter that supports language and emerging literacy skills in preschool children. (Hutton et. al, 2019a, para. 28)

In another study by Hutton and his colleagues, published in 2019 (Hutton et. al, 2019b, para. 1), the authors looked at how the brains of 27 children between the ages of 4 and 5 work. years and a half, in 3 different but comparable situations. In the first situation the children listened to the audio recording of a story (audio), in the second situation they watched a story illustrated in a book and read by an adult and in the third situation they watched an animated story. Each of the 3 moments lasted approximately 5 minutes and was followed by a discussion session about the content of the story. Regarding the level of understanding of the story, the illustrated version and the audio version produced similar levels of understanding while the animated version produced a lower level of understanding than the other two. In terms of MRI imaging, it showed that the most associations between attention, visual perception and imagination, and language are made with the picture story. The illustrated version of the story particularly activated visual perception and imagination. In conclusion, while audio stories develop the imagination, picture stories provide an integrated learning experience that engages both language and attention and visual perception.

According to Glen Steele, professor of paediatric optometry at Southern Tennessee College of Optometry, USA, "a child's ability to see when an adult is looking at an object and try to reach for that object" has a decisive influence on vocabulary development. He claims that a child who makes eye contact with their parent often enough to identify the objects at which the parent is looking influences him to know about 335 words by the age of 18 months compared to a child who does not follow their parent's gaze and who will only be able to identify 197 words by the same age. (AOA, 2019, para. 7) He argues that the 1990s rule, when doctors recommended 20-second breaks for every 20 minutes of TV, no longer works today when children hold their phones and tablets very close to their faces, instead this recommends compliance with WHO indications and frequent breaks in the exposure of young children to digital content.

9. Physical Development

It is important to mention, without being the main theme of this paper, that the psychological approach to the impact of technology on children is currently seconded by the approach from the physiological perspective of this phenomenon, namely how the use of digital technology impacts physiological processes both at the level of the brain as well as from the level of psychomotor development.

Of course, studies on changes at this level could not be carried out on very young children, which is why the mentioned results refer to the next stage of development, of school children.

A study carried out in 2015 (Takeuchi et al., apud. Gottschalk, 2019, p. 14) demonstrated that watching TV programs affects psychomotor development, as children who regularly watch TV programs are much less involved in physical activities, without that this study can generalise the results. (given a small sample and other limitations)

In another study carried out in 2015 by Ciccarelli (Ciccarelli, M. et al., p.1), he showed that the use of computers and devices with screens (phones, tablets) involves the adoption of positions that are not beneficial to the body, which depending on the duration, can lead to the appearance of dysfunctions in the skeletal-muscular system, especially in the area of the neck, trunk and upper limbs. All the more so as the development of the body in children is strongly accelerated in the first 6 years of life. The tool used to determine the risk determined by the use of ICT devices by children is RULA (Rapid Upper Limb Assessment) and the score obtained in the case of 11 children was greater than 2, which means an existing level of risk. Unfortunately, however, this tool, widely used in workplace ergonomic assessment for adults, does not include unconventional positions adopted by children during play, which is why the results remain at an exploratory level.

Conclusion

For a responsible use of digital technologies in early childhood education, at least two conditions should be met beforehand.

The first condition would be the scientific substantiation of how digital technology can be used beneficially in the education of preschool children.

The second condition consists of an adapted pedagogical training of teachers regarding the constructive use of digital technologies for children's development.

However, the development of digital technology and its rapid penetration into the professional and personal space makes this unlikely, and the expectation is that teachers will use their knowledge, acquire digital technology skills, and become creative in their use of digital technology in children's education. Could this approach better support young children's digital literacy? But how?

On the one hand, the omnipresence of digital technologies gives rise to the need to know how to relate to it, to extract the best it can offer. But what exactly, research on the human mind will reveal to us in time. For the moment, caution and limitation are the two principles circulated by government institutions, and the trend is to encourage digital literacy, from adulthood to early childhood. On the other hand, companies promote products for educational purposes, without this explicitly expressed purpose being scientifically supported.

Faced with these new challenges, teachers have the responsibility to support the adaptation of children to the world they live in and to give a new direction, an educational one, to digital technologies. To create activities where digital technologies are subordinated to education and not the other way around. To seek balance and stay in constant contact with new research, to continue to question and learn. Therefore, we are talking about a new competence of educators and a new behaviour, in the classroom and in partnership with parents.

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