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EDITORS
Carmen Elena CÎRNU • Grigore ALBEANU • Natalia BURLACU
Ella Magdalena CIUPERCĂ • Carmen HOLOTESCU • Radu JUGUREANU
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Section 1

Instructional Design in Digital Era

E-learning Strategy in the Elaboration of Courses

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Abstract: *E-learning is an approach to the design, development, and implementation of courses for students in Higher Education. Often in the e-learning concept emphasis is placed only on some components, depending on the experience of those involved in the reasoning. Course developers need to adopt an appropriate definition of this concept and then follow a well-thought-out strategy for implementing it. The e-learning strategy is not always made explicit in curriculum policy documents. It is assumed that academics implement one strategy or another implicitly as part of their professional competences, although this is neither obvious nor true. To ensure a quality process, the e-learning strategy must be explicitly included in the curriculum documents and discussed with those who will implement it. This article describes the strategy for developing and implementing a blended e-learning course. The stages of the strategy are listed, presented, and briefly exemplified. The importance of establishing the e-learning strategy and the awareness of the relevance of each its stage by all involved academics is emphasized.*

Keywords: Course design, E-learning strategy, Blended approach, Digital resources.

1. Introduction

The term e-learning was first mentioned in 1999, in a computer-based training lecture and referred to a strategy for acquiring knowledge and skills through digital channels like the Internet and other electronic media (Bouchrika, 2022). The concept was adopted very quickly by academics and is used worldwide since the beginning of the 21st century. There is no single definition of the concept of e-learning. Analysis of different resources – monographs, studies, manuals, articles – mainly in English, revealed the existence of a multitude of definitions for e-learning, with varying degrees of interference between them. Besides, the

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concept of e-learning is often misunderstood in various contexts, for multiple reasons, because it refers to different constructs, and sometimes because it is interpreted by professionals from different domains.

The e-learning approach is employed intrinsically nowadays in the design of courses: traditional, blended, and online. This integration assumes the recognition and adoption of a relevant strategy, which should describe the goal of the e-courses, the desired results, and the way of achieving those results under the available institutional resources (Clarke, 2003). The analysis of the policy documents related to education at the governmental level revealed a vague reference to Information and Communication Technologies (ICT) concepts, and the terms e-learning and e-learning strategy are missing there (Ministerul Educației și Cercetării al Republicii Moldova, 2022). These terms are mentioned in some way in the strategic development documents of the universities with which we are affiliated.

The State Pedagogical University policy declared the following objectives (Universitatea Pedagogică de Stat "I. Creanga", 2021):

- Increasing the degree of use of ICT in the didactic process, including the use of educational platforms;
- Consolidation of the e-learning education system within the University through the development normative framework, the development of didactic support for the management of digital tools, creating the conditions for the provision of distance educational services, etc.;
- Implementation of e-courses, on the institution's MOODLE platforms, Google Classroom.

The Technical University of Moldova (TUM) laid out the following objectives (Universitatea Tehnică a Moldovei, 2021):

- Diversification and expansion of the educational offer that takes into account national and international trends (ICT, Industry 4.0, FinTech, smart technologies, green technologies, data science);
- Promoting the use of digital tools and resources in educational processes, the continuous development of e-learning and videoconferencing platforms, and the digital library "Online Lessons" (at least 2000 hours recorded every year);
- Reforming part-time education and introducing distance education by applying the experience of online education.

The translation into English of the mentioned objectives follows the original text in Romanian, without any editing. The terms used in this context denote that clarification and a more or less exhaustive description of their meaning in relation to the e-learning concept are needed. The majority of academics have a relatively low experience in the field of ICT and are not familiar with the subtleties of new e-terms; the incomplete or incorrect interpretations of the e-concept have as consequences serious mistakes and/or confusion when designing and implementing e-courses. As the term *e-learning strategy* is absent from policy documents, this means that education stakeholders assume that academics should implement one or another strategy implicitly as part of their professional competences, although this is not a simple task under these conditions.

In this article, the authors briefly analyse the e-learning concept and describe the steps inherent in an e-learning strategy. The strategy is exemplified by the design and implementation of an e-course in the blended format at TUM.

2. E-learning Definitions

There are many definitions of e-learning: provided by the developers of technologies and they stress the role of the technology; offered by organizations and governments which emphasize the role of policies in the field of ICT; provided by academic institutions with a focus on the educational aspect. An international project (Sangrà et al., 2012) carried out a research study under the auspices of the Open University of Catalonia, Spain, with the participation of worldwide experts, having the aim to identify and adopt a unique definition for e-learning. According to this study, the e-learning definitions collected from specialized literature can be grouped into four categories: 1) focused on technologies; 2) based on learning content delivery systems; 3) communication-oriented; 4) based on the educational paradigm.

E-learning definitions focused on technologies. These come mostly from private companies and emphasize the technological aspects of the e-learning concept, the other characteristics being considered secondary. These definitions describe the term e-learning as a use of technology for learning. Examples (Sangrà et al., 2012):

"E-learning is the use of technology to deliver learning and training programs".

"E-learning is to take a course online using a modem, wireless, or cable connection to access academic course material from a computer, phone, or handheld device".

E-learning definitions based on content delivery systems. In these definitions the concept of e-learning is represented as a means of accessing knowledge (through learning, teaching or training). The focus of these definitions lies in the accessibility of resources, but not in the achievement of results. Example (Sangrà et al., 2012):

"E-learning is the delivery of education (all activities relevant to teaching, and learning) through various electronic media".

E-learning definitions based on Communication. In these definitions it is considered that e-learning is a tool for communication, interaction, collaboration; other characteristics of the concept are secondary. Examples:

"E-learning (sometimes called web-based training) is anywhere, any-time instruction delivered over the Internet or a corporate Intranet to browser-equipped learners".

E-learning definitions based on the educational paradigm. These definitions interpret the concept of *e-learning as a new way of learning or as an improvement of an existing educational paradigm*. Most of the authors of these e-learning concept definitions are from the academic field. Examples (Sangrà et al., 2012):

"E-learning refers to educational processes that utilise ICT to mediate synchronous as well as asynchronous learning and teaching activities".

"E-learning is defined as ICT used to support students in improving the learning process".

The definition reached by the authors (Sangrà et al., 2012) following a systematic analysis and research methodology:

"E-learning is an approach to teaching and learning, representing all or part of the educational model applied, that is based on the use of electronic media and devices as tools for improving access to training, communication and interaction and that facilitates the adoption of new ways of understanding and developing learning."

This definition embraces all the mentioned characteristics, but the phrasing is not final. The general conclusion of the study (Sangrà et al., 2012): „E-learning is part of a new dynamic, which characterizes educational systems at the beginning of the 21st century, resulting from the merging of different disciplines, such as computer sciences, communication technologies and pedagogy, given that all definitions contain features from more than one discipline". Consequently, the concept of e-learning will continue to evolve for a long time. In today's world, learning needs change very quickly, and the concept and functions of the e-learning concept must be adapted continuously to these needs.

Researcher Kennet Fee (Fee, 2009), who carried out an extensive analysis of the e-learning concept, reached a similar definition:

"E-learning is an approach to learning and development: a collection of learning methods combined with the use of digital technologies, which provide, distribute and enhance the learning process."

From these definitions, it is concluded that the e-learning concept has four components:

1) learning content, 2) technology, 3) learning design, and 4) communication.

All these components are interrelated and should be interpreted holistically in an integrated approach. For instance, the content of any course is important, but it would be wrong to put it in the first place. Adherents of technological definitions often underestimate the learning process, interpreting it as the manipulation of content. Sometimes, ICT providers emphasize the primacy of content to flatter buyers and promote their technologies. They consider learning as a process of transmission of knowledge from sender/teacher to receiver/student. In their reasoning, e-learning is just the combination of technology and content, and many actors in the field of education have the same opinion. The educational policy documents mentioned in the introduction are in line with this statement.

This interpretation represents a suitable formula for making the content available electronically, including online, but learning requires much more. The information available in the electronic version is not knowledge; moreover, the content does not lead to the development of skills necessary for an individual to be employed. It is not enough to simply make the content available digitally to achieve learning results. It is necessary to understand how people learn and how the learning process should be directed as effectively as possible to achieve the learning outcomes. An effective learning process is a combination of technology, meaningful content, and effective learning design, accompanied by an effective communication process between the subjects involved in this process. These components complement each other and must be carefully combined: the learning design must make the most of the content, and the technology must support both the content and the learning design, as well as the communication if performance results are to be achieved.

3. E-learning Strategy Concept

The e-learning strategy represents guidelines for effectively designing, facilitating, and delivering an e-learning program. The reason for an e-learning strategy is to define the goals for the e-learning program (course) and then logically explain how the institution or faculty proves that the goals have been met. The e-learning strategy is a plan in the form of an educational policy document or a guide, which should describe the goal of the e-courses, the desired results, and the way of achieving those results under the available institutional resources. Teaching and learning within an e-learning approach is challenging, even for experienced teachers. It is crucial that the university stakeholders and the course developers have a deep understanding of the e-learning approach in order to design a strategy and implement it in courses. In this section, we will describe shortly the essential steps for an e-learning strategy (Moore, 2007).

The elaboration of an e-course should begin with a needs analysis that means research and answering the questions: Why do the students need this teaching? What intends the teacher achieve with this e-learning course? What challenge is this e-learning course going to overcome? How will the teachers know if they reached the declared objectives? Very often, the university board decides to implement e-learning because other universities are doing it. Besides, they expect things to just get done by delegating responsibilities to the academic staff. Needs assessment before designing the e-course is often regarded as a waste of time and e-course development is considered the task of teachers as part of their workload. Starting an e-learning course development based on such assumptions may end in a weak result.

The needs analysis may include a simple interview/discussion with students and may imply data collection methods that concern past teaching, past results and desired results, and knowledge of the current students. The analysis should grasp the technology component: which facilities the university may provide? What is the digital literacy level of the staff involved in the elaboration delivery of the courses? The answers to these questions will prevent the staff from deploying forcefully e-learning for solving a problem that is not achievable or is not suitable to solve by this approach. The results of this analysis become a basis for the course design plan and for embodying the expected students' achievements. It will also show gaps in current teaching and will demand changes in teaching & learning approaches.

The next step relates to getting and analysing information about students and is called target-group analysis. Developing e-courses without understanding the students' needs, their knowledge level, and the place of the course in the study program may end in providing too much, too little, or simply, the completely wrong content. It is often the case that e-courses are too difficult, or too easy, or completely irrelevant to the curriculum and labour market needs. Course developers often treat their students with a one-size-fits-all approach in order to deliver the content quickly. But this means indifference to the digital capabilities of the students, to their knowledge; to how they will use the knowledge received from the course. If the course developers will first know the students and will find out what they already know and need to know, they will be able to craft more useful content in a relevant format.

Consecutively, the teachers have to define the competences that the learners should develop by the end of the course. Student competences might be described as knowledge, professional skills, or employment skills in their areas of subject matter expertise. These are skills all students will develop to varying levels during studying the course. The teacher will define the learning outcomes in order to assess the competences' levels students develop. Course designers have the task to ask questions and identify both the desirable and undesirable results of the course. They should define circa 4 – 5 course learning outcomes, depending on the course workload, and should ensure that the content fits these learning outcomes. It is a challenge to create relevant learning outcomes. First of all, they should respect the SMART criteria: specific, measurable, achievable, relevant, and time-attainable (Williamson, 2020). Secondly, the course designer should align the teaching and learning activities and assessments to reflect the scope of learning outcomes. This approach is known as constructive alignment and was developed by John Biggs (Biggs, 1996). A constructive alignment is an approach to learning, teaching, and course design that views learners as fundamental in constructing their own learning, rather than learning being primarily the transfer of knowledge from the teacher to the student (Biggs & Tang, 2011). The 'constructive' part of the model often gets overlooked. The intention of students regarding their learning approach is hidden under the question "will this be assessed?" The students' strategy is to focus on assessment rather than the safer strategy of engaging in learning. The constructive alignment approach forces them to engage with all concepts and content to succeed, in order to achieve the intended learning outcomes. Shortly, constructive alignment requires the teacher to plan learning activities to enable students to develop the skills and knowledge that contribute to the achievement of the intended learning outcomes; to design assessment tasks that can measure the attainment of the learning outcomes; to elaborate content (topics, resources, materials) that supports the learning activities.

The next steps involve both didactic and technological components as it regards elaboration of the course content itself in tight connection with the available technology. The course developer should answer the questions: Which hardware and software, a network connection is available for teachers and for students? Which Learning Management System does the university provide? Are there required applications to be installed for the elaboration of digital resources? Are they relevant to the intended course structure and content? What kind of communication system will the university provide for the students? Does the university have enough bandwidth to run the courses? Also, at this stage, the developer should decide which e-learning model (Fee, 2009) to implement: full online courses, blended learning courses, informal learning, e-performance support; or traditional face-to-face digitally enriched courses.

Then, the proper course elaboration follows. It comprises several steps: a) course scenario with the learning outcomes, content main topics, learning activities, formative assessment tasks, and final summative tasks; b) elaboration and/or identification and updating relevant digital resources: graphics, photos; videos and/or audios, simulations and models et al.; c) assembling these materials in the course authoring tool; d) reviewing the course: checking if the designed course fulfils the constructive alignment approach; the quality of media; text style, typos and grammatical errors, software glitches; e) test the course with a few potential participants, and check if all the functionalities are working properly (course accessibility and navigation, accessibility of resources, technical issues et al.).

The last step in the e-learning strategy is the course evaluation, after running the course with students. This step will determine how effective the course was. This will help the academic staff to figure out what was right and what should be improved in the future. There are different models to determine if this has been achieved. One model is Kirkpatrick’s Four Levels of Evaluation (MindTools, 2022). It includes four metrics:

- **Reaction to learning.** It measures the level of satisfaction, interest, and engagement of students;
- **Knowledge** that measures what knowledge, skills, attitudes, confidence, or commitment was acquired by participants;
- **Behaviour change**. It measures if the students can use their newly acquired skills in future labour;

- **Results and impact**. It measures if the declared learning outcomes were achieved as a result of the teaching & learning experience and whether further course improvement is needed.

A more exhaustive evaluation of the e-courses tackles the perspectives of the different stakeholders such as all internal actors within an institution as well as external stakeholders (Ubachs & Henderikx, 2022).

These are the main steps that are required in an e-learning strategy for the elaboration of an e-course. The faculty from our universities may study the e-learning strategy from the articles or different sessions of training that are organized mainly within projects. Universities do not have a special e-learning strategy document, like guidelines for the academic staff involved in the elaboration of e-courses. It is assumed that academics implement one strategy or another implicitly as part of their professional competences, although this is neither obvious nor true. To ensure a quality process, the e-learning strategy must be explicitly included in the curriculum documents and discussed with those who will implement it.

4. Implementation of E-learning Strategy: Case Study

Before the pandemic period, the e-learning approach was like a free choice both for universities, as entities, and for faculties within each institution. The need to implement e-learning at scale challenged, first and foremost, the teachers. The methodology document adopted by the Ministry of Education, Culture, and Research delegated the responsibilities for the identification of adequate solutions and their deployment to the decision-makers of universities with the successive transmission of the duties to academic staff (Holotescu, 2020). Each university adopted different approaches according to its experience, technologies, and needs. We present, as a case study, the transposing of the described e-learning strategy to the elaboration of the e-course *Computer Networks*. This course is compulsory in several study programs for Bachelor students at the Technical University of Moldova. Students learn about network topologies, physical devices, security issues, layered abstractions**,** routing algorithms and routing protocols**.** By the end of the course, the learners got insights into the inner functioning of a computer network; what is the TCP/IP (Transmission Control Protocol/Internet Protocol) model, how routing algorithms and routing protocols act. Students get the chance to build simple local area networks and get a functional knowledge of IP addressing schemes, and basic network security, and are able to perform basic configurations for routers and switches. Upon successful completion of the course, students earn a Networking Academy badge.

The needs analysis was partially determined by external factors and specifics of the course. Finding a solution to switch to distance learning, at least during certain periods of the semester, required the implementation of an e-learning strategy. But this was not the only reason. The explanation of network concepts and the realization of practical laboratory work in this course require the use of simulations and models that are possible through software applications that emulate the functioning of real networks.

The best e-learning model, in this case, was the blended learning approach (Dumbraveanu & Peca, 2022). Blended learning combines classroom and virtual teaching & learning methods to provide the best learning experience to the students. The collected and the elaborated digital resources – lectures, additional readings, laboratory assignments, and assessment tasks were assembled in an e-course hosted on the MOODLE Learning Management System. This e-course can be equally well used in an online guided format and in a traditional face-to-face format as a reinforcement strategy. The flipped learning strategy in a sandwich mode was also used, taking into account the initial knowledge level of the students, their learning habits and their understanding of the network concepts. The blended model suits most of the students' needs and the teachers' philosophy. The lectures were delivered online in the form of recorded videos, supplemented by additional digital resources structured in topics. Learning activities for each topic were provided to ensure the students' knowledge development, in the form of quizzes, mini-research tasks, and group discussions of tasks and possible solutions to lab problems. The laboratory works were performed in a face-to-face environment using the special software Cisco Packet Tracer for the simulation of the network configuration and tasks. This software allowed students to design models of virtual networks according to the lab requirements, visualize the graphical representations of these networks, monitor the transfer of data through networks, describe and save the outputs, collaborate with their classmates, ask questions, discuss algorithms for solving constraint problems settled as learning and assessment tasks.

The teacher recorded a series of videos, with a total duration of 48 hours, divided into two categories – lectures and laboratories – associated with course outcomes. The explained theory was followed by concrete examples, which simulate the functioning of devices in a real environment. The students were presented with how to efficiently use the software in which they can create and simulate the activity of computer networks. The teacher explained in videos everything the learner needs to understand when working with networks, from setting up switches and routers, by configuring their interfaces and assigning IP addresses, to setting up virtual local area networks. The Technical University of Moldova published in an electronic format 3520 lectures that include 1000 hours of recorded videos delivered by 1345 university staff to 9560 students. The information about these courses is available on the website https://lectii.utm.md/. The course *Computer Networks* is among the top courses by popularity and quality. It was evaluated by a university board that had used an internal quality guide.

The e-learning approach and the e-learning strategy is the biggest challenge for teachers: it requires changes in the learning process and determines the efficiency of educational endeavours. The changes relate to technology, communication, delivery systems, and educational paradigms. The way of combining these components enveloped by teacher philosophy in a concrete learning environment results in various e-learning models. The authors described the implementation of an e-learning model for developing engineering students' competences.

Conclusions

The e-learning strategy represents guidelines for effectively designing, facilitating, and delivering e-courses. It is crucial that the university stakeholders and the course developers have a deep understanding of the e-learning approach in order to design a strategy and implement it in the e-courses. The university e-learning strategy should be documented and available to everyone involved. An e-learning strategy states the purposes and describes the path the academics will take to meet them; it also provides a framework for decision-making at the university and faculty levels.

The e-learning strategy changes many components of the learning process and determines the efficiency of educational endeavours. The components comprise technology, communication, delivery systems, and educational paradigms. The way of combining these components enveloped by the teacher's philosophy in a concrete learning environment represents the implementation of the e-learning strategy. The authors described concisely the meaning of the e-learning concept and the steps that the e-learning strategy implies. The implementation of these concepts was exemplified on the basis of the elaboration and delivery of the course *Computer Networks*, aimed at developing engineering students' competences.

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The Trends of Education after COVID-19

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Abstract: *The trends of education are an open question that intrigued an enormous part of the people, parents, experts, and educators. Good and proper education is the guarantee of the existence and sustainable development of humanity. In the last decades in front of the world civilization emanated many significant challenges, such as climate change with its severe consequences, huge natural disasters, species extinction, economic and political crisis, followed by rising aggression, world war conflicts, migrations, and insecurity for the big part of children and young. Nevertheless, the implementation of innovations has not stopped, even more; the strong, negative influence boosts the proper answers and efforts for survival. Nowadays, digitalization conquers all aspects of human life. Digital remote learning became common. New strategies, new approaches, and new ways of thinking support everyday life. The goals of the review paper are a rough draft of the trends of education that is the most important part of the human to become person, and for humanity to stay sustainable and merciful.*

Keywords: e-learning, education, remote learning, digitalization.

1. Introduction

In the last decades, ICT applications took place in higher institutions, for teaching, learning, and administrative activities and speeded its development because of pandemic (Fahd et al., 2022; Oprea, 2021; OECD, 2022). For the future, L&D team suggested a need to transform learning in an effective and sustainable way, with digital, distanced, and flexible learning context (Palmer & Blake, 2018). The adaptation of education reflects the quick digitization that has not been mentioned before COVID-19 (Kihara, 2021; Manzoor et al., 2021), so in the near future, in-request skills will be different as well as the manner of teaching (Bernard, 2022).

The Great Reshuffle began with the hybrid offices, digitization, remote learning and working, accelerated by the COVID-19 pandemic. According to LinkedIn 150 million new jobs will appears the next five years most of them remotely (Bernard, 2022), and even now the current of such advertisements exist.

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The Organisation for Economic Co-operation and Development (OECD) published manual, future trends of education that starts with the question “Did you ever wonder what the impact of climate change will be on our educational institutions in the next decade?”. In front of our civilization, grasping to have more at any cost, stays not only that but many other similar questions. According to the manual, COVID-19 pandemic appears as the cardinal change point that pushes economic, political, social, and technological drifts which influence education (OECD, 2022).

The article aims to reveal the trends of education for the future generation, due to the alterations that took place from advanced digitalization as a consequence of the pandemic lockdown.

2. Changes in education after the pandemic of COVID-19

In Trakia University during the pandemic of COVID-19 all academic staff made e-learning materials available online. Students start to prefer online exams and distant forms of education that allow them to be more flexible and to study at their own pace from different places. The administration adopted virtual coordination and collaboration, which gives the opportunity quickly to organize and manage the process of education, to announce the schedule of curriculum, exams, meetings, and conferences, check and correct errors, and spread to the people of concern. Even before the pandemic, there was an increase in digitalization as shown in fig.1, the pandemic just speeded up the trend of education.

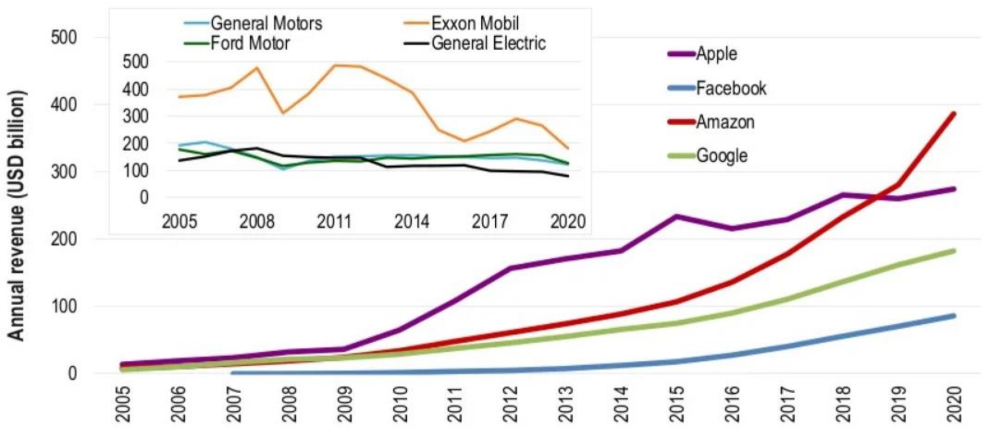

Figure 1. Increasing the role of online platform in the digital transformation (OECD 2019)

The respect that in the future the learning will be highly supported by ITC is widely accepted (Richards, 2007), before the global crisis caused by COVID-19. After pandemic lockdown is mentioned tendency for growing the desire of working distantly (Endresen, 2020; Lund et al., 2022), and put more responsibilities onto machines, providing feedback and coaching remotely (Ancona et al., 2019). COVID-19 has unlocked many more opportunities for membership and cross-institutional collaboration calling for an extra exploration of multi-teamwork (Ancona et al., 2019; Endresen, 2020). According to Josep (2022), e-learning took an important place in education during the pandemic and will remain and expand for the future generation.

2.1. E-Learning after the Pandemic

E-Learning has many advantages proven from the experience; one is that e-learning supports individual learning styles and needs - visual; auditory*; reading & writing; and kinaesthetic* (Hurley, 2022). People learn in a different manner, some of them prefer and learn better when information is produced graphically or they are so-called visual learners; auditory learners favour listening to information; reading & writing learners emphasis better on the written word, and kinaesthetic learners engage all their senses (Flavin, 2021; Hurley, 2022). Nevertheless, taking into account the disadvantages of social isolation, perhaps the best solution and the trend of education development will be hybrid **learning**. According to Burlacu (2021), hybrid education starts to be a **new normal** with lessons and assessments synchronous online and practical training in the labs.

2.2. Hybrid Learning

According to Snelling (2022) the high institutions will never return to the pre-COVID traditional learning programs and methods, which is not realistic or desirable. The changes that took place during the global world pandemic will remain, and perhaps **blended or hybrid higher education** that integrates digital elements into teaching will predominate. In the post-pandemic world, the role and place of digital educational platforms is likely to increase (Valeeva & Kalimullin, 2021). In the post-COVID future there exists an opportunity to take advantage of digitalization and make higher education more effective and more attractive than in the past (Snelling, 2022).

2.3. Microlearning (Or Bite-Sized Learning)

The average student’s attention span is between 10 and 15 minutes (Thuy, 2022). According to Microsoft the pandemic and digitalization shrink human’s attention span to **less than eight seconds** (Ranieri &Co, 2020; Bernard, 2022; Debétaz, 2022; Adam, 2022). According to Halcom (2018), the reduction of the attention span means that people focus and absorb information immediately (Halcom, 2018). Usually, a short attention span is a brief response to extra stress, post-traumatic stress, or excess stimulation, but if it lasts, it may be a sign of an attention disorder (Brennan, 2021). The pandemic has accelerated shifting attention spans (Oliver, 2022), so microlearning must be recognized as a convenient and necessary way of developing education in the future (fig. 2).

Figure 2. The benefits of microlearning (Trang, 2018)

On Figure 2 are giving the main benefits of microlearning, but as with all methods, it has its negatives, for example, it cannot be a good choice for complicated tasks, where much more knowledge and abilities are need it (Trang, 2018), so can be accepted just as an additional resource for full-length taught courses.

Microlearning is only a tool and can be effective, if it is within the context of a wider learning strategy (Udalova, 2022).

2.4. Learning through Online Recruitment

Additionally, the tendency for a closer relationship between business and study programs in high universities can be revealed, after COVID-19. Remote study and working from home became normal practice. According to Ordonez the changes during the pandemic gave new opportunities for building long-term skills that turn into a career or a business (Ordonez, 2022). People start to work from home as virtual assistants, translators, data entry professionals, customer service representatives and sales people (Ordonez, 2022). Examples of remote online jobs are listed below:

Online Tutor – that is in practice, personalised learning, online or in-person, can work and teach kids and people from all over the world. The known online platforms are Tutor.com (https://www.tutor.com/) and Wyzant (https://www.wyzant.com/);

Search Engine Evaluator - an actual human who provides feedback and ratings about what comes up;

Social Media Manager - develop strategies to increase followers, creating social campaigns, producing content, reviewing analytics, and communicating with key stakeholders in a company. It can take hours to come up with engaging content and to post every day on multiple platforms;

Freelance Writer - produce whatever written text is needed by their clients, either working from home or in a rented office space;

Resume Writer - responsible for creating resumes that highlight the skills, experience and accomplishments of their clients;

Transcriptionist - a great way to earn a steady income with flexible hours. If you're an experienced typist with strong grammar skills, this may be a rewarding career for you;

Freelance Web Designer - the process of designing and deploying a professionally built website could take between five and six months, and can do web design without coding;

Micro-Freelancing At Fiverr - Micro jobs—commonly referred to as "gigs", allow to earn extra money as a side income or gain experience and skills as you work on building your resume or beginning your own business;

Virtual Recruiter - a remotely hiring process, without meeting the candidates face to face. Recruiters rely on technology to host video interviews, virtual events, surveys, and assessments to evaluate their applicants remotely;

Online Influencer - to influence the behaviour of their followers, to affect others' purchasing because of their authority, knowledge, position, or relationship with their audience;

Data entry professionals - data entry clerk can be a good job for people who have an eye for details, high school diploma and no need of advanced educational degrees.

Many companies are searching for online workers: Adobe; Aetna; Amazon; Alight Solutions; Citizens Bank; CrowdStrike; CVS Health; GoDaddy; Great Assistant; Dell; GitHub; HubSpot; iMPact Business Group; Kaplan; Kforce; HealthlineMedia; ModSquad; ICF; Lincoln Financial Group; Philips; Salesforce; NerdWallet; Pearson; Red Hat; Slack; Stitch Fix; Tanium; Thermo Fisher Scientific; Toast, Inc.; Twilio; Upwork; Pegasystems; Okta; LanguageLine Solutions; UnitedHealth Group; Vista; Vituity (Howington, 2022; Ordonez, 2022).

Companies and policymakers should facilitate workforce transitions and to support additional training and education programs for workers (Lund et al., 2022).

3. Post-pandemic period and trends in education

Blended and hybrid learning seem to be the future of higher education (Singh et al., 2021). Students prefer in-person and synchronous online learning over asynchronous and find them more effective, because of social-emotional reasoning (Gillis& Krull, 2020; Nguyen et al., 2021). Therefore, students favour video-based courses with a high number of practice tests, considered as the most effective form of learning (Szabó, Bálint et al., 2022). The L&D team discovered a switch from the Netflix model of learning to YouTube and transformation of lecturers from Subject Matter Experts into facilitators, with a preference for virtual learning as those strategic changes are linked to the pandemic. Virtual learning facilitation requires a number of distinct skills, emphasis on the micro-session design, virtual interaction, managing the engagement, safe spaces, and keeping sessions balanced for different virtual learner types. Also, it was discovered that the direct conversion of in-person training into a webinar or virtual learning session is not a good model and didn’t work (Palmer & Blake, 2018). Hence, education in a post-pandemic should combine the advantages of e-learning with important pedagogical goals allied with in-person teaching (Manzoor et al., 2021).

According to the L&D team, future education should be focuses on (Palmer & Blake, 2018):

- Virtual-first learning design;
- Collaboration and social learning strategies;
- Integration of coaching and performance-focused learning;
- Empathy in learning design;
- Tapping into emotion, imagination, and energy of your learners;
- Prioritisation of measurement in learning.

The main trends for the development of education according to Thuy (2022) in the near future are: Online learning; Mobile learning; Distance learning; Personalise learning; Blended learning; Project-based learning; Social-emotional learning; Gamification; Home-schooling; Bite-sized Learning (Microlearning). The similar trends of educational technology applying during and after pandemic according Maddie (2022) are: virtual reality (VR), augmented reality (AR), gamification, big data, flexibility (asynchronous learning; student autonomy; online communities), artificial intelligence, e-Learning (Maddie, 2022). According to Manzoor et al. (2021) the smartphone and software companies should develop technologies that can facilitate learner retention during the post-pandemic state.

The fragile points of further digital education, according to Singh et al. (2021) are the digitalization itself, the growing dependence on the internet, digital devices, Wi-Fi, innovative technology and software, and additionally social isolation.

4. Trends of development in the research after COVID-19 - data set, and collaboration

In the global turmoil, cloud computing became a response for many organizations, and adoption as a response to future crises and post-crisis transition. It was declared the growth of digital repositories and systems providing access to research results, citation, data sharing, and monitoring of research results, this is the cloud of open science and such resources are ORCID, Scopus, Mendeley, etc. (fig. 3) (Drach et al., 2022).

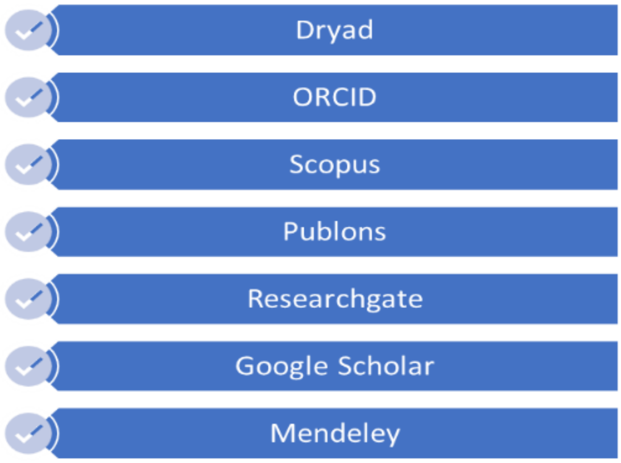

Figure 3. Digital cloud data set for spreading the science information (Drach et al., 2022)

In the future the research and collaboration will be with implementation and utilization of cloud computing (Theby, 2022).

5. Conclusion

The innovations, speeding of technology and all society styles of life drastically take place in all fields, particularly in the learning process and education. Therefore, the traditional old methods of knowledge acquisition cannot be rejected, just can be advanced with the new trends that come across. With the rise of migration, climate changes, poverty, and social conflicts all over the world the best way to keep education is a clear combination of all appropriate methods that mankind knew. Perhaps, the rising question is, whether humanity is becoming more unwise or cleverer, but for sure it is important, not to lose our identity and the habit to read and calculate alone without the "help" of AI assistants in the near future.

Training and education are unseparated parts of economic development, business, and sustainable development. Hence, should be prepared for the new tendencies, accept and adopt their benefits, and diminish the worst effect of unpleasant changes. The technology, learning culture, and learners' requirements are altering all the time and that requires not being fearful to make experiments and to try new strategies for business and education in order to adapt and be competitive.

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Digitalisation and remote learning

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Abstract: *Digital technology nowadays is applied in all spheres of life, especially in education digital remote learning became common. The pandemic of COVID-19 boosted and speeds up remote learning and digitalization. Countless institutions quickly organised and adapted their programs and curriculums for online delivery. In a short time, the e-materials and courses were amplified in a huge amount and became ordinary, replacing the traditional face-to-face teaching. After two years of the pandemic, the high institutions adopted digital remote learning and blended learning; new strategies were developed and applied to mitigate learning loss. Hence, numerous researchers thought that perhaps in the future remote learning will continue to take an essential part in acquiring a piece of new knowledge and skills. The aim of the article is to overview the positive and negative effects of digital remote learning, the leading trends, and the developed systems for monitoring and assessing the quality of learning process.*

Keyword: digital learning, remote learning, Remote Learning Readiness Index.

1. Introduction

The COVID pandemic gave "social learning" lessons (Abonyi, 2022). During the pandemic the nature of learning altered intensely with the incredible rise of remote learning, delivered by digital technologies as a combination of TV, radio, or online distributed through different digital mobile platforms (Li & Lalani, 2020; Whalley et al., 2021; Avanesian et al., 2021; Shehzadi et al., 2021; Lohr et al., 2021; Walters, 2022; OECD, 2022; Munoz-Najar et al., 2022). COVID-19 lockdown demonstrated the privileges of working at home (Whalley et al., 2021), and confirmed that digital remote education is a refundable investment reducing by 40% to 60% time spent for the academic staff and learners (Gutierrez, 2013; Gautam, 2020).

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Online working increases productivity by 30% (Gutierrez, 2013). According to the World Economic Forum throughout the pandemic about 1.6 billion or 94% of the world's school-age children were out of the classroom, learning remotely from home, and around 63 million teachers connected with their pupils on digital platforms (Hurley, 2021). The usage of ICT was expanded globally with the improvement of Internet connectivity and digital infrastructure (Mutrik et al., 2021). The governments provided remote learning options, usually on digital platforms, and tried to increase access to the connectivity and devices needed to effectively access those platforms (Hurley, 2021). Some schools and governments provided students in need with digital equipment (Li & Lalani, 2020).

Nowadays, all virtual activities have become common, such as video-forums, conferences, and virtual meetings. Digitalization and remote activities proves as saving time, and with high efficiency for the participants and organisations. E-Learning found constantly place in education, moving towards implementation of innovations and developing new methods and strategies of training. Nevertheless, with the benefits comes and the cost of negative effects.

The goal of the paper is to review the positive and negative effects of remote digital learning and the trends in the field of future education.

2. The benefits of digital learning

Digital remote learning benefits both students and educational institutions by:

- *Unlimited access to the learning materials full-time* – that ensures a flexible learning process, when and where is possible, and eager;
- *Facilitate collaboration* – by video conferencing, shared documents, common projects and discussions (Koh & Kan 2020), no requests of spending time and money for travelling and accommodation;
- *More resources available to the learners* – potentials to hold more information up to 25-60% if compares to classroom traditional face-to face learning 8-10% (Gutierrez 2013; Gautam 2020; Josep 2022);
- *Better engagement* - organisations can achieve an 18% boost in employee engagement (Gutierrez 2013);
- *Personalised learning* - the mobile devices allow the development of Personal Learning Environments (PLEs) that permit easy obtaining educational excellence (Whalley et al. 2021). Digital technologies expand learning opportunities, people can learn on request, depending on what they need and want, personalising their learning process. Personalisation makes the learning process more adaptable and more effective;
- *Facilitates new digital learning strategies* – COVID-19 boost the changes and manner of teaching and learning all over the world, new digital learning strategies appeared (Gautam 2020), and became

predominant, many free online courses, virtual labs and classrooms, libraries, and virtual teachers (Lupanda, 2020), the researchers think that it is un inescapable results of the influence of the Fourth Industrial Revolution (Whalley et al., 2021);

- *Preparation for work in the coming future* - a great way to prepare students for future employment, through the use of technology and also in the ability to learn how to use new digital tools. Distance learning advances student responsibility (Zalite & Zvirbule, 2020);
- *Building peer communities* – the new technologies allows grouping of students by common interest and traits, establish connections and built communities that benefits everyone;
- *Boosts accountability* – flexibility and control over the education;
- *Student progress tracking* **-** ability to track student progress closely, attendance and exams (Walters, 2022), which gave possibilities to assess the strong and weak points in the systems for e-learning (Beblavý et al., 2019).

Digitalisation delivers more, cheaper, and better learning (Gutierrez, 2013; Beblavý et al., 2019; Gautam, 2020), enhances the possibility to learn remotely. Through digital learning, “old” subjects are introduced by new structured and systematic methods, generating new subjects and new skills significant for working and taking part in society. According to the IBM Company by implementing the eLearning programs, participants absorb new information five times faster (Gutierrez, 2013). Digital learning is a highly efficient solution to lower the costs of education and training. It provides more opportunities for learning to more people, without significantly increasing costs. This decreases the cost of education and training, allows producers to develop economies of scale and new business models, lower entry barriers to education and training. Additionally, digital technologies improve the quality of learning, enhancing its effectiveness in terms of individual results and for society. Teaching methods are enriched by novel technologies that increase interactivity and participation in class.

In order to assess the alterations in education and the new tendencies are invented different methods and are established new parameters, with the different signs, used to create models applying to the management of the training process and education for the further sustainability and economic growth of the society.

3. Remote Learning Readiness Index (RLRI) for monitoring the world education

Education is broadly accepted as a fundamental resource, both for individuals and societies (Roser & Ortiz-Ospina, 2016). Remote Learning Readiness Index (RLRI) appears in response to school closures during COVID-19 pandemic lockdown as a new composite indicator of UNICEF that illuminates which parts of the education system need to advance in order to provide all scholars with remote learning opportunities. In the future, remote learning will continue to play a significant role in delivering education and to support students (OECD, 2022). Moreover, school closures can happen due to environmental disasters, or negative aggressive conflicts leading to dislocation and immigration of people (Chuang et al., 2018; Avanesian et al., 2021; Villegas, 2021).

The RLRI is based on four principles *Simplicity* - simple methodology, easy to be understand and replicate; *Sustainability* - circles of assessment annually as new data emerges; *Usability* - analyse education systems by level and domain, and to conduct policy discussions at the national level; *Robustness* - statistically robust in terms of its performance. The index is composed of three domains: *households, a government's policy, and the emergency preparedness of the national education sector*; the main aim is to reinforce the importance of investment into remote/digital tools to deliver education, which however should not be done at the expense of in-person learning (Avanesian et al., 2021; United Nations Children's Fund, 2021).

- *Household-level factors or Individual's learning outcomes* – access to information and communication technology (ICT) at home, important for the remote learning ability. Another factor is a parental education in the household environment;
- *Availability of digital learning* – the government should have a remote learning policy, and use broadcast channels as radio or television, online platforms. It is important to support teachers by providing them with training on how to teach classes through remote channels;
- *Institutions and policies for digital learning* - the academic staff needs of proper digital technology and tools. In fig. 1 are performed the results of that criteria for the different countries (OECD, 2022).

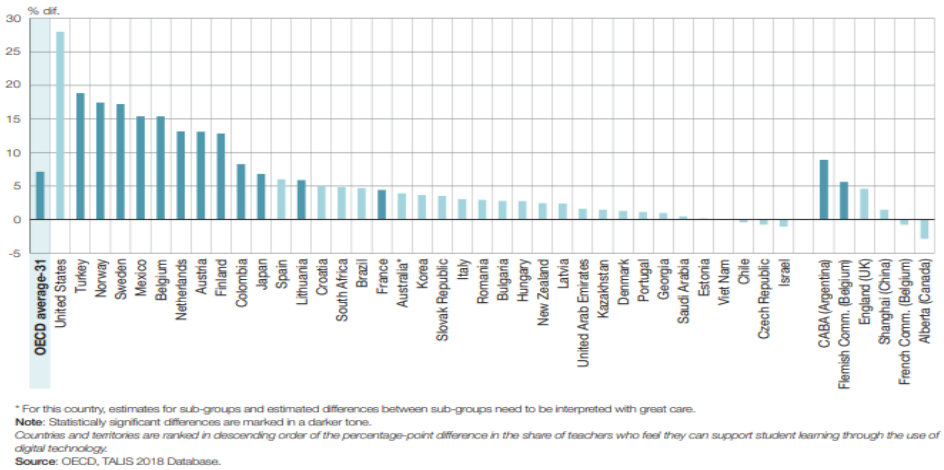

Figure 1. Teachers' digital self-efficacy by school digital resources (OECD 2022)

The RLRI is a part of UNICEF's Strategic Plan monitoring framework, each one of UNICEF country offices rates their country's education sector on a scale from 1 (weak) to 4 (strong), look on fig. 2. High remote learning readiness can be achieved with an effective policy and advanced household-level factors. In the RLRI the advancement in one component could not compensate for lower performance in another one. Remote learning systems must be planned as a chain that is only as strong as their weakest link. The successful delivery of remote learning depends on a country's accomplishment well in all three domains.

		Lowest Domain			
		High	Medium-High	Medium-Low	Low
2nd Lowest Domain	High	5 Stars	5 Stars	4 Stars	3 Stars
	Medium-High	5 Stars	4 Stars	3 Stars	2 Stars
	Medium-Low	4 Stars	3 Stars	2 Stars	1 Stars
	Low	3 Stars	2 Stars	1 Stars	1 Stars

Figure 2. Methodology of aggregating the final score

Legend: **1 star** – the country needs to invest in a remote learning system; **2 stars -** the majority of students do not have access to the remote learning; **3 stars -** country's remote learning systems are relatively resilient; **4 stars -** well-established and resilient systems of remote learning; **5 stars -** best readiness for remote learning and highest resilience to crises.

The RLRI exhibits high-risk countries of losing proper education, and presume ways of improving and increasing remote learning and teacher training (Avanesian et al., 2021).

4. Index of Readiness for Digital Lifelong Learning (IRDLL)

That indicator was involved with the project, collaboration between the Jobs & Skills Unit of CEPS and Grow with Google. The Index of Readiness for Digital Lifelong Learning (IRDLL) assesses the process of learning for the 27 EU's countries and exposes the stage of digitalisation in education (Beblavý et al., 2019). On Fig.3 the projections of the prediction model for total world population by level of education up to 2100 is estimated from the free available World data set, named "Our World in Data" (Roser & Ortiz-Ospina, 2016).

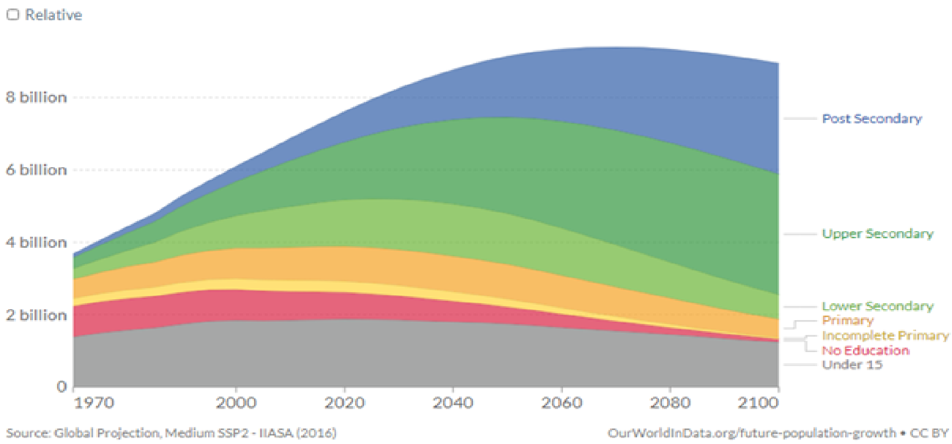

Figure 3. Prediction – model and projections of the total world population by level of education (Roser & Ortiz-Ospina, 2016)

Education is a presumption of economic growth and human-wellbeing. The model of learning outcome are calculated by a 'production function' (Glewwe & Muralidharan, 2016):

A = α(s, Q, C, H, I),

where: ***A*** **-** is skills learned (achievement); ***s*** **-** is years of schooling; **Q -** is a vector of school and teacher characteristics (quality); **C -** is a vector of child characteristics (including "innate ability"); **H -** is a vector of household characteristics; **I -** is a vector of school inputs (children's daily attendance, effort in school, doing homework, and purchases of school supplies).

5. Remote learning and negative effects of social isolation

Social isolation is not normal for humans and they cannot cope with this for a long period of time (Hämmig O., 2019; Pietrabissa & Simpson, 2020). Social quarantine in fewer than 10 days can create long-term psychiatric symptoms effects up to 3 years far ahead (Brooks et al., 2020). The reported consequences claim confused people's perceptions about what is "right to do/not to do", "to say/not to say", and "to think/not to think", resulting from unclear, threatening, conflicting information, so a decision is moved by the dread of an imperceptible enemy, cultivating a new universal belief based on vulnerability-to-harm, and human-beings poses a direct threat (Nardone & Portelli, 2005). Moreover, after a long time of social isolation and threats to their life, people start to avoid social relations by a choice, behaviour that gradually replaces old worldview and interpersonal relationships (Pietrabissa & Simpson, 2020).

Also, social isolation generates tension and stress affecting mental health and academic achievement (Limón-Vázquez et al., 2020). During the pandemic, students frequently complained of headaches, bad mood, lack of control, nervousness, little fulfilment from activities, overwhelming, and insomnia (González-Jaimes, 2020; Brabner, 2021). In Mexico City, the activity of psychological support lines was increased by 40% (Limón-Vázquez et al., 2020), to mitigate the negative mental health effects to the communities was recommended to keep healthy life and to avoid excessive undesirable communications and interactions (Limón-Vázquez et al., 2020; Trujillo, 2020; Navarrete, 2020; Sistac, 2020).

Not all students like remote learning, because of missing face-to-face direct communication with the teachers and other learners (de Haas et al., 2020). Nevertheless, digital remote learning will continue to play an important role in the future (Gautam, 2020; United Nations Children's Fund, 2021; Avanesian, et al. 2021; OECD, 2022; Alakrash & Razak, 2022). The Student Futures Commission survey found that 66% of students want a blend teaching, 45% online activities at least once or twice a week and 21% prefer mostly online study, with in-person activities once or twice a week (Brabner, 2021). Correspondingly, the changes in the nature of education formulate a new 'Future Educational System' (Whalley et al., 2021), with more possibilities and challenges, with the implementations of innovations that corresponded to the Fourth Industrial Revolution and to the amendments of everyday life.

6. Conclusion

Many open questions exist and arise in front of the governments, political makers, and common people. Digital learning, study, and working from distance were not new approaches to solving the problems and realisation of tasks using ITC and high technology. Nevertheless, the rapid speed of innovations implemented in all spheres of life up to now was not pointed out before. Many researchers use the phrase „fourth revolution" or „the time of change" for business, education, and the way of thinking. Hence, humanity is at the front of big challenges and needs to cope with the best solutions for the future generation. Remote learning, long life-learning, acquiring new qualifications and pieces of knowledge are necessary and obligatory for a good adaptation, human mental health, and social prosperity.

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Instructional Design for Developing Informatics Competencies

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Abstract: *This paper describes a brief overview of an instructional design in the Informatics discipline, which is based on the SOLO taxonomy, Bloom's taxonomy, ASSURE instructional design model, Honey and Mumford learning style questionnaire, and flipped classroom strategy. The purpose of implementing this instructional design is to promote personalised and differentiated learning, develop competencies in the informatics discipline, and increase the students' results. The learning activities were differentiated according to the student's learning style, as it is important in teaching to take into consideration the student's learning preferences just at the beginning of the instructional design. It investigated the instructional design effects on the teaching process and student acquisitions framework in order to improve learning. By implementing the flipped classroom strategy, the students become more active, engaged in the learning tasks, and have a higher responsibility for their learning. The result shows the impact of the described instructional design and its pros and cons.*

Keywords: Instructional design, Informatics competencies, ASSURE model, BLOOM's taxonomy, SOLO taxonomy.

1. Introduction

Today, technologies are part of the educational process, as we are in an increasingly complex digital age. Due to the Covid-19 pandemic and the transition of the educational process to online format, technologies are used in education on a much wider scale than before. During the pandemic time, huge improvements have been made in the technologies and applications offered for use in education, as well as advances in teachers' understanding of how to use these opportunities to promote and facilitate learning. Certainly, teachers gained more confidence in technologies and have used them to lighten their workload, to improve teaching and to facilitate learning. Thus, the instructional design has developed greatly. It was adapted to contemporary requirements and emerging trends as well as future opportunities of students that tend to form the competencies within the discipline

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students need to integrate into society. All systems in society require specialists who could easily integrate and adapt to the rapid changes that occur due to technologies, who could learn continuously and approach things critically. Therefore, the instructional design presented in this research bases on the learner-centred paradigm, the effectiveness of the educational process and the student's intrinsic motivation, developing to students the self-instruction of their own learning. The students will be able to manage their own instructional process by themselves guided by the teacher.

According to Gagne (Gagne, 1992, p. 3), the instructions are “a set of events that affect learners in such a way that learning is facilitated”. Branch (2018, p. 23) emphasises the instructional design as “a system of procedures for developing education and training materials in a consistent and reliable fashion”. Both interpretations are focused on a design to accomplish a goal of learning and have a direct effect on students’ learning. The goal of instructional design is “to make learning more efficient, more effective, and less difficult” (Morrison et al., 2019, p. 4), determine the relevant content and techniques, and improve the students’ performance in the most effective and efficient manner by solving an instructional problem. Currently, although we have a competency-based curriculum, many teachers often approach the instructional course design from the perspective of content, determining what needs to be covered in the allocated time. Instead, an instructional designer approaches the task by first defining the problem, identifying learning needs, and establishing students’ learning style and their level of knowledge, applying the initial tests, learning style questionnaires, and formative assessments. Subsequently, it provides insight into the designed course revision and after that, determines what knowledge, skills, techniques, and methods are needed to solve the instructional problem and avoid including irrelevant content and spending extra time. Therefore, the instructional design is founded on “what we know about learning theories, information technology, systematic analysis, educational research, and management methods” (Morrison et al., 2019, p. 8). Further, Branch (2018, p. 23) considers instructional design as also founded on the general systems concept, which is described as being “systematic, systemic, responsive, interdependent, redundant, dynamic, cybernetic, synergistic, and creative”. These features allow a systems approach to facilitate the complexity of an instructional design in order to increase learning outcomes by requiring diverse implementations of the components that form the system.

Regardless of the discipline teachers deliver or the locations in which they teach, their success depends on their own ability to design effective instruction adapted to the individual and shared learning needs of students. Although an unprecedented variety of powerful teaching resources are available online, i.e. educational courses, educational games, educational platforms, educational software, podcasts, etc., they are only effective if teachers know when to use them and how to facilitate learning using them.

The trends of the 21st century and their influence on the education of contemporary students demand a change in the field of education. Hence, teachers, who will act as educational designers, are needed. Success teachers require the skills of an educational designer to approach instruction with clear purpose and objectives, and to identify and frame instructional challenges, using a broad repertoire of instructional models, strategies, and technologies. According to Kilbane and Milman (2014, p. 4), an educational designer involves a new mindset, a wide skill set, and a high-quality tool set. They emphasise the new mindset enables a teacher to approach the practice with augmented control over relevant aspects of the instructional process; the various skill sets include systematic approaches to instructional planning and assessment processes; the high-quality tool set encompasses a collection of powerful models, strategies, and technologies for teaching. Thus, the teachers will be able to effectively support various students, coordinate the many resources available for teaching, and adapt and implement instruction flexibly in contemporary classrooms.

2. Instructional Design Model

During the pandemic, teachers began to use technologies much more often in the educational process to make teaching and learning possible. Although it has returned to a classroom teaching-learning regime, teachers continue to make their work easier by taking advantage of the possibilities offered by technology. Despite all these opportunities, education still faces some deficiencies as the inefficient use of technologies in accordance with the specific contents, needs of the students, their attitudes, and their interest. Morrison et al. (2019, p. 5) state that instructional design is "a process for solving skill and knowledge deficiencies", for overcoming educational lacks, and for facilitating learning using technology, as educational technologies are at their means. Burlacu (2012, pp. 235-241) emphasised an approach to instructional design in the digital age, based on educational software. Therefore, well-designed instruction helps teachers to elaborate more suitable activities in accordance with students' needs.

The instructional design, presented in this paper, aims to detect deficiencies that directly affect student performance at the Informatics lessons in the Lyceum "Spiru Haret" from Chisinau, the Republic of Moldova, and then use a systematic process to design instruction to acquire more efficient and effective outcomes than in regular learning. Thus, in this study, the ASSURE learning model was applied. The ASSURE instructional model consists of six stages, i.e. Analyse, State, Select, Utilise, Require and Evaluate (ASSURE), which require to follow for creating effective learning and teaching.

2.1. Analyse Learners

The first stage in planning provides a systematic approach for analysing student characteristics that influence their ability to learn. According to Smaldino et al. (2005, p. 49), the students' analysis consists of the general characteristics, specific entry competencies, and learning styles. The analysis information is used to design the lesson plan for learning conforming to the needs of every student. Thus, in accordance with the Education Code of the Republic of Moldova (2014, p. 18), Article 31, the students from "Spiru Haret" lyceum are organised in science and humanities profiles, and level classes as K-10, K-11 and K-12. In order to benefit from instruction, diagnostic tests were applied in each class at the first Informatics classes or at the beginning of a new module to determine the specific possessed level of skills and knowledge of each student. The identification of the specific entry students' competencies is a decisive component of designing lessons and help teachers to design more appropriate activities to the student's needs. It can also be done in an informal way, by asking questions to students in class.

However, to increase the involvement of students in the learning process and to design the activities and assessments for achieving the goals, it was taken into consideration the appropriate student's learning styles. Honey and Mumford's learning style questionnaire was applied at the beginning of the academic year. The questionnaire categorises students as theorists, activists, pragmatists, and reflectors. Although most students have characteristics of all four types of styles, Honey and Mumford's questionnaire helps them to find out which predominant learning style they own, completing the 80 statements, 20 of which are related to each type. The results of the questionnaire help teachers design activities appropriate to students' needs to improve their achievements, and classify and organise students in efficient working groups, thus differentiating learning tasks. In addition, the Mint Human Resources provides to complete online the Honey and Mumford's questionnaire, English version. At the end of the accomplishment, the platform displays the accumulated score for all four types of style.

Pritchard (2009, p. 43) highlights the Honey and Mumford styles by giving a description of each one. He relates activists as learners who prefer to practise new experiences and activities rather than to read, listen, or plan; reflectors as learners who prefer to stand back and observe, to collect data painstakingly, including previous experiences and the ideas of others, before reaching any conclusions or decisions; theorists as learners who prefer to adapt and integrate all of their ascertainment of new information into new or existing frameworks of understanding, determining the relationship between their and others' observations, therefore, they are highly successful in problem-solving approaches, taking logical and one-step-at-a-time approach; pragmatists as learners who prefer to seek out and use new ideas before making a judgement on their value, and therefore, they are highly successful in problem-solving situations.

Therefore, on the one hand, knowing the student's learning styles, the teacher can differentiate the tasks so that each student is actively involved in the educational process, effectively conducting the activity when working individually. On the other hand, by grouping students into work groups in accordance with their learning styles, we could encounter impediments according to the insufficient number of students with the same learning style, while the activity planned requires group work. In these cases, these "unpaired" students are joined to the work group appropriate to the second dominant learning style.

2.2. State Objectives

In the second stage of ASSURE model (Smaldino et al., 2005, p. 53), the teachers have to state the goals and objectives as accurately as possible into a more focused and delimited form, linked to a subject content and its curriculum, and specify the degree of acceptable performance. The instructional goals and objectives are highly significant in both the instructional process and the assessment process, being guidelines for both teachers and students. The goal points out what students have to achieve. Thus, the objectives describe the expected learning performance by showing progress toward the intended goal and they help both teachers and students focus their attention and efforts, and allow instruction to be more relevant and effective. Objectives help students best organise their time and effort. In Mager's view (1997, p. 31), useful objectives include performance, describing what the student is expected to do, conditions under which the performance is expected to occur, and criteria, which describe the level of competencies that must be reached.

Accordingly, in the case of this experiment, the SMART framework, established by Doran in 1981 (p.36), was used to create the instructional objectives. It helps teachers to define Specific, Measurable, Assignable, Realistic, and Time-related (SMART) objectives. The objectives, formulated by using the SMART framework, are specific to the improvement content, precise and clear for students; measurable, which suggests an indicator of progress; assignable, which specifies who will achieve it; realistic, which states what relevant results can really be achieved by given available resources; time-related, which specify when the result can be achieved (Doran, 1981, p.36). However, to formulate the objectives, measurable verbs such as those associated with BLOOM's taxonomy and SOLO (Structure of the Observed Learning Outcome) taxonomy were used. The cognitive dimension of the reviewed BLOOM's taxonomy is organized into six categories (Anderson et al., 2001, p. 5): (1) Remember; (2) Understand; (3) Apply; (4) Analyse; (5) Evaluate; and (6) Create, while SOLO taxonomy, it has five aspects which are: (1) Prestructural – no idea; (2) Unistructural – one idea; (3) Multistructural – many ideas; (4) Relational – relate ideas; (5) Extended abstract – extend ideas (Biggs & Collis, 1982, p.36). Anderson et al. (2001) defined each category of the cognitive process dimension of BLOOM’s taxonomy in detail, making comparisons with other cognitive processes, and reuniting cognitive processes with knowledge. According to their interpretation (Anderson, 2001, p.66), each instructional objective should be formulated by preceding the phrase "The student is able to ..." or "The student learns to...", followed by a measurable verb. A list of measurable verbs for each category of the cognitive dimension was also specified by the authors.

In this experiment, the flipped BLOOM’s taxonomy was used. For instance, in the topic "Loop statements", i.e. For loop, While loop or Repeat loop (Pascal programming)/Do ... While loop (C/C++ programming), students will receive a sheet with a program sequence. The code sequence will make a continuous repetition of the code using the "goto" statements. The resumption will be stopped with the "if" statement, checking a condition and redirecting the execution either to repeating the run of the code or to the end of the code, interrupting the execution.

In the case of this task, the SMART objective is based on BLOOM's taxonomy and will be formulated as follows: The students will be able to rewrite the program sequence in five minutes, using at least one type of loop statement, i.e. For loop, While loop or Repeat/Do ... while loop. This objective is specific to the subject and, therewith, it is clear what the students have to accomplish.

It is measurable. The quantitative measurement will be the accomplishment of the task using at least one loop statement. However, the student can accomplish the task in three ways, using all three types of learned loop statements. The measurement is also qualitative, the execution of the task being done in the allocated time.

The objective is achievable. It is supposed that at the time when the task was given, all students are able to achieve it, using at least one type of loop statement. If it happens that a student did not complete the task in any way, then the instructional model will have to be reviewed and the instruction redesigned with the intention that all students succeed in completing the task in at least one way.

The objective is also relevant because of the students' involvement in examining the program sequence, in making the transfer of knowledge to rewrite the code sequence, in finding the most optimal way to rewrite the code in the allocated time. Both the objective and the task follow the development of intrinsic motivation by allowing the students to choose the way in carrying out the task. Each student usually chooses the achievement way, which was understood best. Therefore, the teacher can give new tasks that strengthen knowledge where necessary.

In addition, the objective includes a limited time (five minutes) for completing the task. The time to accomplish a task was calculated from the teacher’s done task time multiplied by three. Thus, for the achievement of a task for the students, it is allocated three times more time in relation to the time that the teacher need to achieve the task.

Another SMART objective example, however based on the SOLO taxonomy, is as follows: The student will be able to argue in two minutes about what would happen if the While/Do...while statements does not exist, giving at least one real-life example. Before the task, students will watch a short film in which daily life based on actions that require loop statements will be shown. Then the students will have to find an example either from the watched video or from their personal life and to argue the given example. Arguing the necessity of the loop statements, it will give the students much more confidence and motivation for learning programming. Living in a digitised world, every transaction or authentication requires entering a verification code. This code is obviously checked using the Do ... while statement. There are many other real-life examples that require confirmations, checking passwords, checking whether certain fields have been filled in an online form, etc., where their execution would be much more difficult without the While or Do ... while loop statements.

Therefore, the BLOOM's taxonomy is used mostly to set questions and items, not to evaluate open-ended responses to formulated questions and item types. The SOLO Taxonomy (Biggs &Collins, 1982, p. xi) is "the only instrument available for assessing quality retrospectively in an objective and systematic way that is also easily understandable by both teacher and student" and it may be used as an instructional evaluative tool of student's learning quality. SOLO Taxonomy provides a deeper understanding and learning based on complexity. In Table 1, it is described the specific aspects of BLOOM's taxonomy versus SOLO taxonomy.

Table 1. BLOOM's Taxonomy vs SOLO Taxonomy

BLOOM's taxonomy	**SOLO taxonomy**
A traditional taxonomy focuses on knowledge based on the judgments of the teacher.	It is focused on the teaching and learning processes based on research on student learning.
It refers to the type of thinking or processing required in completing tasks or answering questions.	It refers to the type of structural thinking required in completing tasks by increasing the complexity.
The teacher decides the complexity and difficulty of the activities and creates tasks for accomplishment.	Both the student and the teacher can create new learning tasks involving the complexity of thinking.
It refers more to tasks with increasing difficulty and less to tasks based on complexity.	It refers to tasks based on complexity relating to other knowledge, subjects, and domains. Increasing difficulty is not required.
It is not established the assessment criteria for judging the outcomes of the activity.	It is established explicitly as the assessment criteria for judging the outcomes.
It gives students an ambiguity in the intended purpose and, most of the time, the task is less connected with real-life situations.	It provides students with clarity in the intended purpose and the connection of tasks with real life.

In fact, both taxonomies are useful and help to increase the students' achievements, improve learning, and enhance their involvement in the educational process. In addition, both are easy to adapt to any subject, provide direction to the instructional process, convey instructional purpose to students, and provide a foundation for assessing students' learning.

Because of this experiment, we can say that the activities should be designed with the objectives pursued and the assessment criteria as points of reference. It should not be announced all the lesson objectives at the beginning of the lesson at once, it should be announced before each activity to make students comprehend what skills and knowledge have to be achieved. Thus, we will have a much more productive and efficient feedback and evaluation process. Otherwise, it is a risk that students will complete the task by misinterpreting what was asked of them. These confusions are encountered, most of the time, in learning tasks based on experiments, learning through problematization, learning through discovery, learning based on projects, case studies, and other learning methods that involve a more extensive study.

2.3. Select Methods, Technology, Media, and Materials

In the third stage of the ASSURE model (Smaldino et al., 2005, p. 56), the teachers need to select strategies, technology, media, and materials, which would connect the students to the stated objectives. The process involves selecting the appropriate methods for the established learning tasks, choosing media and technology suitable for accomplishing the method, and selecting, modifying, or designing specific materials for achieving the objectives.

For instance, in this instructional design, it was used a wide range of techniques and methods, i.e. one-sentence summary, think-pair-share, some-minutes (1/2/3/4/5 minutes) paper, as easy as 6 – 3 – 5, input-output, idea links, problem-based learning, Phillips 66, case studies, jigsaw, misconception check, mind mapping, organised random search, classroom opinion polls, infographic, pass the problem, product improvement checklist, jeopardy, etc., as well as media resources such as flip charts, slides, video-tutorial, graphics, posters, animation, simulation, online courses, online discussion, and virtual classes (Google classroom).

Furthermore, a wide range of online tools and platforms was used that facilitate the teaching process, i.e. Kahoot, Google Forms, Quizlet, Mentimeter, LearningApps, LiveWorksheets, Biteable, Fotobabble, Canva, Padlet, Symbaloo, Filmora, QR Generator, Crossword Labs, Wheel of names, Jeopardy Labs, GitHub, etc. Several models, techniques, and methods that would reduce the teacher's workload and improve the educational process were emphasised by Pearsall (2018), VanGundy (2005), and Higgins (1994). The development of a new lesson design asks the teacher to select other strategies, technologies, media, and materials relevant to the topic that could enhance the lesson.

Some selected materials were often modified, and other ones were designed and redesigned to the students' characteristics, as it was not possible to find suitable materials for all topics according to the student's needs and objectives in the online environment. If the students know where they are going, know exactly what they are trying to learn, and have adequate material for learning, then their progress is more accurate and their learning becomes easier and more relevant.

2.4. Utilise Media and Materials

The fourth stage of the ASSURE model (Smaldino et al., 2005, p. 61) concerns making a lesson or activity plan as to how to use the media, materials, and technology that were selected. In this step, it is important to follow the "5 Ps" (i.e. Preview the materials, Prepare the materials, Prepare the environment, Prepare the learners, and Provide the learning experience), applying to either teacher-based or student-centred instruction. The preview materials stage assumes viewing selected materials before using them as instructional materials to eliminate any impediments and gaps. If the needed materials were not found, the teachers have to collect all the materials, media, and equipment that need to carry out the activities and redesign them to secure any necessary additional materials. Prepare the environment stage involves the factors granted for any instructional situation, such as comfortable seating, climate control, a convenient power source, and suitable lighting. Sometimes, it requires a darkened room. Preparing the learners' stage implies defining clearly the learning objectives for students. In addition, the teachers highlight certain specific aspects of the lesson and the assessment criteria. The students have to know about assessment criteria before learning the content. These aspects would increase the students' attention and motivation. Providing the learning experience step involves the effectiveness of the instructional experience. In this research, the activities are student-centred in accordance with flipped classroom strategy. Being limited by class hours, the teacher applied the flipped classroom method, involving students in the design of transmedia learning activities guided by their teacher (Gutu, 2019, p. 241). The flipped classroom method promotes personalised education opportunities, engages and motivates students in their learning, improves the students' achievements, and is easy to apply in any classroom.

2.5. Require Learner Participation

The fifth stage of the ASSURE model (Smaldino et al., 2005, p. 61) requires learner participation. The active participation of students in the learning process enhances their learning. In this step of instructional design, the assessment activities involving self-assessment, peer assessment and co-assessment were planned. The assessment activities help students to recognize their weaknesses and strengths, and to work on areas that need improvement (Gutu, 2022). The self-assessment facilitates self-directed learning and allows students to reflect on their own work by setting achievement goals. Peer assessment enables students to improve their work speed and improve critical reflection on their peers' work by making constructive assessment judgments. The co-assessment leads to deeper learning, improves learning skills, and stimulates the acquisition of the necessary skills. To have more involved students, the activities have to be design as student-centred, be connected with real life, and be provided in a trendy way.

Another approach to actively involve students in the educational process is to apply the flipped teacher approach. The student-teacher will be involved in the design of the lesson and the activities, and their accomplishment. He will guide the class students in the learning process by giving them descriptive feedback. Therefore, the student-teacher will come to the lesson with the learned content to be able to carry out the lesson. The teacher will monitor the entire course of the lesson and make suggestions when necessary.

2.6. Evaluate and Revise

The final stage of the ASSURE model (Smaldino et al., 2005, p. 68) is to evaluate and revise the instructional design. After instruction, the teachers have to evaluate the impact and effectiveness, methods and media, assess students' achievements, detect the discrepancies between what was designed and what was achieved, and revise the instructional design to improve it. The assessment procedure should correspond to the specified objectives in the second stage of the ASSURE model. Evaluation of methods and media is also very important as they help to deliver information to students. An activity carried out with an inappropriate method can lead to ambiguities and uncertainties. For this reason, teaching methods and techniques must be selected very carefully, as well as how to use them, and adapt them to the various needs of students. The ASSURE instructional model is only successful if it is used consistently to improve the quality of instruction.

The instructional design is based on some questions that the teacher have to ask himself before starting the design, such as: What will the student do? What will the student use this for? What has to happen next? Will students be able to do this differently in a new way? Will this task make students reflect, judge, criticise or hypothesise? What should be highlighted from this topic? Is this the suitable method/technique to provide the information on the topic? etc.

This instructional model described above was applied to Informatics lessons with the aim of developing subject-specific competencies (Gutu, 2022), ensuring active engagement in deep learning, enhancing students' outcomes, and increasing the number of students who choose Informatics as a baccalaureate exam. In the design/redesign of the instruction, it was taken into consideration all the aspects that affected the teaching and learning in this experiment.

3. Instructional Design Pros and Cons

The instructional design described above is a student-centred model, which helps to maintain a greater emotional and safe environment, detect each student's readiness for learning, and increase students' engagement and success. It can be used to design the activities that are carried out in both in-class and online education due to the use of technologies.

This instructional design involves the formulation of clear, measurable, and SMART objectives in accordance with the BLOOM's and SOLO taxonomy for each student and differentiates the learning tasks within the diverse needs of students and their own learning style, being a considerable advantage in motivating the student in learning. It enhances structural-complex thinking skills and depth of knowledge. It provides an assessment for learning. The instructional design promotes the understanding of goals and assessment criteria by the students, setting future goals for achievements. It can be applied to each lesson or individual activity.

A disadvantage of this instructional model is the increased attention it requires when developing learning activities to maintain a balance between their difficulty and complexity. Obviously, to go through all the steps in designing the lesson or activities, it is time-consuming in stating the objectives and criteria, creating the materials, and selecting the appropriate strategies. However, once the necessary content, needed media, designed lessons plan, assessment criteria, strategies, and technologies suitable for the activities have been found or have been designed, they can be reused many times with some insignificant changes.

Another disadvantage of this instructional design is that some students may not embrace the flipped classroom approach (Gutu, 2018, p. 125) or one of the types of assessment for learning. In this case, the teacher have to have an alternative way for these students.

In fact, after rigorous work, well-structured activities are collected, with appropriate strategies for the accomplishment of the activities, which will lead to an increase in school results, develop a deep understanding for each student, and enhance the involvement of students in the educational process. Nevertheless, education is constantly changing and when the students' success depends on their future life, the teachers have to predict this future and design learning experiences that will develop understanding and skills suitable for the future.

4. Conclusion

The instructional design described in this paper, uses both BLOOM’s and SOLO taxonomies, which help us to formulate suitable learning objectives based on both difficulty and complexity. Thus, the set of assessment criteria was created to guide the students in their learning. In addition, it was used for assessment of learning activities (i.e. self-assessment, peer assessment, and co-assessment) to help students to detect their weaknesses and strengths, and work on the areas that need improvement. This increase the students’ achievements and involvements in the learning activities, promoting an assessment culture. By applying the instructional design, the activities become well-structured, deeply understood, and easy to carry out. The collected tool set embraces specific materials, media, strategies, and technologies for teaching, making learning more effective, efficient, and engaging.

The application of this instructional design made the students more involved in the learning process, even in the development of the didactic material, made them more motivated due to the deep understanding, made them more aware of what they need to learn due to the evaluation criteria, and all of this contributed to enhanced learning and improved student results. The implementation of activities involving assessment for learning made the students more confident, reflective, engaged in their learning, and less worried about summative assessments.

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Capstone Project: From Theory to Practice

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Abstract: *Due to the didactic methods based on the tradition of theorizing, including the practical aspects of education, and scholastic custom, having become routine, which without doubt disadvantages the training and development of specific skills declared in the university curricula for studying engineering disciplines. Because some of the given disciplines should be practical, the author debates in this article the didactic strategies built around the creative, and/or research, and/or design activities of expert systems prototypes, capitalizing on the so-called Capstone Project concept. This work is a case study that falls within the field of Education Science and covers topics at the intersection of University and Vocational Didactics, and also Computer Science Didactics. Beside the presentation of the research approach, the author reviews the specialized literature related to the applicability of the Capstone Project. She then analyses, in a descriptive manner, the case study design; the data regarding the students' feedback was then collected after completing their experiences on the Capstone Project, made by their own conception; these are in places expressed in statistical terms.*

Keywords: Capstone project, Creative didactics, Design of didactic activities, Students' research activities, University-level engineering education.

1. Introduction

Certainly, the necessary professional skills that confirm the work capacity of an engineering graduate should be formed in correlation with the industry for the activity in which he is prepared. In our case, we are talking about the ICT (Information and Communications Technology) industry. Yesterday's engineering graduate student, the applicant for being employed in certain positions in various areas of the ICT industry, as also his skills, although analysed and often tested by recruiters, will be demonstrated continuously by the employed, and also will be verified over time by the prospective teammates and employer.

In this sense, the study programs responsible for the specialists' training in these fields should include subjects in which the flexibility of using certain strategies and

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didactic methods to form and develop future graduates, such as those widely applied in the professional life of a coder and/or programmer. For example: quality assurance tester for software and not only; web developer; cyber security specialist; systems analyst; software engineer; cloud systems engineer etc.

We attest to the existence of several reasons that complicate the successful formation of the mentioned skill set. Among these are: (1). The list of required formatting skills is lengthy; (2). The methodological particularities of skills' development fall into didactic strategies developed and implemented in the long term; (3). (Burlacu, N., 2016; Burlacu, N., 2021) The study of some subjects, especially the fundamental ones that are usually taught in the first semesters of the bachelor's degree level, tends to use certain teaching methods-learning-assessment, much closer to traditional methods; (4). There are not many university facilities that allow the integration of didactic methods that would support the development of research skills and ICT product creation.

Commonly, this practice can be applied in the final years, because students already have an accumulation of skills in several areas of professionalization. They are very well familiar with: programming languages; algorithmizing techniques; data structures; programming environments, and builder software that generates source code and where the developer does not necessarily have to write it himself.

The author sees the solution of a future, substantially more successful insertion in the labour market for graduates with degrees in various professional areas in ICT fields in the implementation of more flexible teaching strategies, based on the stimulation of creativity and engineering research to support today's students in the formation and development of a set of skills, extended from the version of skills specific to their field of activity, such as critical thinking, time-management, self-directed learning, analysis and synthesis of evidence, the ability to demonstrate in-depth knowledge on a specific topic, the potential to undertake independent research, commitment to improving the degree of personal development through reflection, as well as undertaking the obligation to increase emotional strength to adapt to change etc.

In this context, the author proposes the massive avoidance of didactic methods based on the tradition of theorizing, including the practical aspects of education, custom that have become routine, which undoubtedly disadvantages the training and development of specific skills declared in university curricula for studying engineering disciplines, which should be primarily practical. Thus, in the present research, the author debates the didactic strategies built around the creative and/or research and/or design activities of some expert system prototypes, valorising on the concept of the Capstone Project, in a case study held at the Technical University of Moldova (TUM) within the Applied Computer Science (ACS) and Information Management (IM) study programs, during the 2019-2022 academic years.

Currently, the Capstone Project concept is not defined in the specialized literature, but it has an impressive scope in the USA educational system from which it was inspired. Broadly speaking, the given concept can be found in the scientific literature under a different name to the Capstone Project. For example, in describing their teaching and research experience, the authors of certain scientific studies regarding the Capstone Project used notions such as (Grant & McLaren, 2007) “capstone course” or (Gallagher & McGorry, 2015) “capstone experience”.

The novelty and originality of this article consist in informing of actors from the European education area, interested in the development of university didactics and, in particular, of the didactics of engineering disciplines – university teaching staff; methodologists concerned with the organization of the didactic process, especially at the educational micro-management level, i.e. the organization of teaching-learning-evaluation activities; scientific researchers; staff members responsible for study programs; and also the students - about the specific approaches of a course based on the Capstone Project concept, on the example of engineering education in the Republic of Moldova.

2. About Capstone Project

2.1. The Analysis of Specialized Literature

The majority of researchers agree (Burke & Dempsey, 2021) that “Capstone projects are unique in the way they assess your knowledge and skills gained through an educational program. In the following sections, you will find some of the main defining features of designing and conducting a capstone project”. At the same time, the same authors (Burke & Dempsey, 2021) try to dispel the existing myths about Capstone Projects. Thus, in their opinion “The most prevalent myth associated with a capstone project is calling it a mini-thesis, which does not do it justice, as there are fundamental differences between these two final-year assessments. Yet, we have heard both students and academics referring to it this way for years. Even though it is understandable, given that thesis have been in the academic lexicon for centuries, it undermines the important role that capstone projects play in education, which relates to enhancing educators’ research-based practice capacity, instead of primarily adding value to a research base”.

In the scientific literature, there are contradictory opinions regarding when and where Capstone Projects (CP) can be integrated. The authors of some papers state that CPs are the projects that can be carried out by students in the last year of professional studies, usually at the university level (Margaret E. Madden et al., 2013). Others come up with ideas for implementing CPs in the study of STEAM subjects in high school classes, especially Mathematics (Lynette Hammill, 2011). The Capstone Project has the ability to include several components, thus CP being distributed as an individual task per student, it would represent a final work with several parts, as follows (Margaret E. Madden et al., 2013):

- **“Interdisciplinary Major (25-48%):** A student-designed, forward-thinking major with at least two different fields of study”, one of them mandatory will be the field of their professionalization;
- **“Integrative Core (42-49%):** Problem-based multidisciplinary, own student-driven applied learning occurring throughout the curriculum”;
- **“Internship Experience (2-10%):** Required real-world experience away from home campus”.

2.2. Theoretical and Applied Considerations Researched by the Author

In our view, since Capstone Projects are a pinnacle of evidence-based practice, they could be used as ways of summative and/or final assessment with the aim of demonstrating the entire set of knowledge, skills, and abilities acquired by the learner throughout the study period (of a course, training etc.). Such a project is one that culminates with the entire educational experience accumulated, as a rule, either at the end of a course or at the end of a year of study etc.

In the university environment of the Republic of Moldova, as a form and idea, they can be somewhat associated with end-of-year theses or examination projects in disciplines that have a corresponding potential. Their applicability is very extensive, especially in the final years of university studies and, in our opinion, especially in the areas of training new engineers. All these types of activities can be completed, as appropriate, with the development of applications based on personalized, practical, and unique tasks. Assignments for such types of activities can be formulated and disseminated both individually for each student and for a distinct group of students.

Regarding project activities valid for a group of students (Burlacu, 2022):

“In case of acceptance by the teaching staff and/or the institutional regulations regarding collaborative work, the assignments are formulated for the entire work group, thus it is possible to organize both the collaborative activity within each team, as well as the interconnection of several work groups, with common interests in regard to collaboration and mutual assistance, either during the integral development of one or multiple projects, or only on certain dimensions and themes of the project(s), depending on the inter-group conventions, but also on the conditions stipulated by the teacher”.

Individual projects are preferable in cases when (Burlacu, 2022):

- “The topic of the project and / or the field of its development is clearly delimited by the research problem and does not foresee its expansion at the level of a group project;

- The type of activity is determined as being individual in the internal normative acts of the educational institutions and / or the external ones, issued by the relevant ministries, their originality being one of the basic criteria explicitly reflected in the rigor documents;
- If the teaching staff considers it appropriate to distribute individual tasks for the elaboration of some projects (either based on solving problems or based on research etc.) in order to clearly outline the area and / or the theme and / or the objectives of the activity for each individual student”. Such a decision should be dictated by the intention:
    - to be as correct as possible in carrying out an assessment, measurement and marking of the product of the learner's activity;
    - to reduce and / or eliminate possible copying, plagiarism, and academic fraud during evaluative activities and / or in the teaching process, in general (Burlacu & Irimiciuc, 2017).

3. The Methodology

3.1. Target Group & Didactic Environment

This study reflects the experience implemented at TUM, the Faculty of Computers, Informatics, and Microelectronics (FCIM) within the Expert Systems (ES) and Expert Management Systems (EMS) courses, included in the VI semester of the Applied Computer Science (ACS) and Information Management (IM) study programs, respectively. The research experience took place throughout the 2019-2020, 2020-2021, and 2021-2022 academic years, on a total sample of approximately 164 students. All students were in the final (third) year of studies in the undergraduate cycle. Although at first glance it seems that the disciplines of Expert Systems and Expert Management Systems have only a specific tangent in the given scientific and professional fields, the truth is that these courses have more similarities than differences. Therefore, based on the structural and content congruence of the subjects in question at the faculty level, the decision was made to combine the third-year groups from the study programs with the specialties of the *Applied Computer Science (ACS)* and *Information Management (IM)* into a single stream.

The analysis of the content components of the Expert Systems and Expert Management Systems courses confirms the need to study the same academic content in the same proportion and with the same modules / themes / concepts / programming principles etc. for both specialties. Given the fact that until the formative assessment, the content taught in the theory lessons has an identical structure for both specialties, there are no differences in the teaching of the subject during the lecture hours.

While in the case of IM groups at the level of laboratory lessons, there is a need to intervene with some additional details in the interpretation of the application of the theoretical concepts addressed in the course. The phenomenon can be explained by the fact that at the time of starting the study of the discipline - either Expert Systems or Expert Management Systems - the curricular background, responsible for the professional training of the representatives of the ACS and IM groups, is different.

At the time when the Expert Systems / Expert Management Systems course had started, the students of the ACS and IM groups had some knowledge of the logic programming language PROLOG, which is one of the operationalization tools in the laboratory lessons, although the prerequisites for the ACS and IM students were dissimilar, thanks to some differences from one study program to another study program, which is normal and justified.

As for PROLOG, it is a rather archaic programming language, with a certain area of applicability, which is decreasing day by day and, unfortunately, not far from being very popular, which also complicates things, but which, at the same time, caused the (re-) conceptualization of the Expert Systems / Expert Management Systems course in such a way that it should: (1). not to be exceeded, (2). to come at least with a dose of motivation, able to capitalize on all the knowledge of the final year students, (3). to demonstrate to them that, although they know a lot, the field of specialization can always surprise them with something new, (4). to generate intrigue situations for them during their own learning, which at the end (5). to materialize in some educational outcomes at least unexpected for them as learners.

These purposes should be able to arouse some interest and satisfaction after working in the course, at most to wish to continue to carry out research and / or studies in the field of Expert Systems / Expert Management Systems, especially since this does not only mean PROLOG.

3.2. The Applied Assessment Process

In order to determine for us, as instructional designers, the state of affairs at the beginning of the course regarding the knowledge of some key concepts related to the application of the PROLOG language, the area of its use, the degree of perception of the concepts related to ES / EMS etc. we have created and disseminated a Google form for completion among the representative sample of ACS & IM students. Finally, the completed forms were processed and demonstrated a certain level of knowledge of the items to be evaluated among the students.

Speaking in statistical terms, the series of data obtained from the initial survey demonstrates that the simple arithmetic mean of the marks accumulated by the sample of respondents was approximately 6.57 (out of 10 maximum possible points). We note that the average of the accumulated score could have been affected by several factors. We assume that some students did not have the most serious attachment to the purposes of filling out the form, and others managed to forget about it after the vacation and the winter session some notions and / or failed to strengthen to a more serious level the usual knowledge previously within the courses that form the set of prerequisites.

An additional pro argument that made us accept the assessment process scenario described below and the fact that both the Expert Systems course from Applied Computer Science and the Expert Management Systems course from the Information Management study programs are taught in the year III studies and provided for a very small number of contact hours, corresponding and credits, running only during 6 weeks in the spring semester, but which must come with convincing educational outcomes regarding the level of professional skills of the future licensed specialists in Computer Science at the end of the semester and the final year of university studies in the undergraduate cycle. Obviously, for the same reasons, it was necessary to customize the course evaluation process. Therefore, it was decided to approve the following staged assessment scenario:

Stage I - the formative assessment included an individual theoretical research project with themes formulated for each student. The research condition formulated by the course holder required the descriptive and comparative analysis of at least two programming paradigms, one of which, necessarily, was the logic programming paradigm. In the assignment's conditions it was also stipulated as mandatory the following: (1). The analysis of the concepts and principles of the functionalities of the programming paradigms with their exemplification through various code sequences developed in various programming environments that facilitate the development of applications through the given paradigm; (2). Optionally, the student could review some descriptions of the programming environments that he used in his research.

Stage II is equivalent to the thesis of the year for the representatives of the ACS groups and to the examination project for the students of the IM groups consisting of the elaboration and detailed description (conceptual and behavioural) of an expert system prototype for a socio-economic or scientific field by using the language of PROLOG programming.

The themes for the given research were formulated individually for each student; they have a unique character at the level of the entire torrent. When formulating the assignments, the area of scientific interests of each student was taken into account. The themes were stated here, such as (see Table 1):

Table 1. Examples of themes for developing the prototype of an expert system / expert management system

No.	*Topic of the expert system prototype / expert management system to be elaborated*
1.	Creation of an expert system emulator of methodological recommendations for studying the English language.
2.	Prototype of an expert system for methodological recommendations for studying the Romanian language by foreigners.
3.	Development of an expert system emulator for a job recommendation.
4.	Creating an expert system for recommending musical bands.
5.	Prototype of an expert system for determining tourist destinations.
6.	Building an expert movie recommendation system emulator based on user preferences.
7.	Creating an expert system for suggesting electronic devices, based on user needs.
8.	Development of a prototype of an expert system for the selection of automobiles.
9.	Development of an expert system prototype for restaurant menu automation.

Stage III provided for the elaboration of the examination project for the representatives of the ACS groups. The students were asked about the problem of transposing the idea of the expert system prototype developed earlier in the year thesis (at stage II) (see Table 1) into an expert system emulator created by means of another ICT tool. As an alternative computer tool for ES / EMS application development any other programming language than PROLOG could serve, programming environments traditionally recognized as dedicated to working with other programming paradigms, such as C / C++ / C#, JAVA, PHP, Python etc. In the basic conditions of this assessment project, the obligation to equip the SE / SEG emulator application with a graphic interface, but also functionalities that ensure human-computer interaction, was specified.

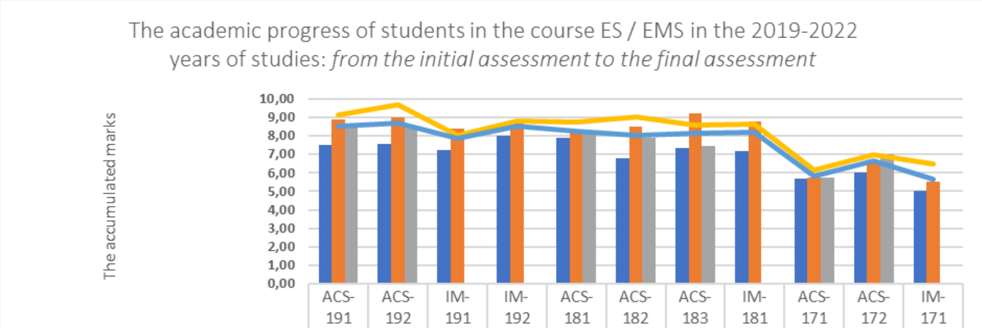
Throughout the semester, during the organization of both formative and final evaluations, the themes proposed for research were formulated, placed on the cloud, and proposed to the students for analysis and subsequent registration with the restriction that in an academic group the respective theme has to be chosen only by one student. The restriction was specified in this way because it was desired to carry out individual projects and not in groups.

An additional reason for accepting this particular assessment formula was the desire to increase the rate of the uniqueness of works, to create more pronounced conditions for fair competition between representatives of the same torrent and / or academic groups of students. Since the assignment is only repeated at a rate of 1:1 in an academic group or at a rate from a minimum of 1:1 (for the formative assessment of stage II & III) to a maximum of 1:3 (for the formative assessment of stage I) in a students' stream then within their public presentations (which were also mandatory) (1.) the similarities and differences between the projects with the same and/or similar themes as approach, originality, complexity, creativity etc. will be evident; (2.) the principles of objectivity, transparency, impartiality etc. will be respected as mentioned above.

This way of organizing evaluation activities is very flexible from the perspective of its applicability because it can be used in the traditional didactic process, as well as the hybrid one, as well as the online one, a fact that characterizes it as a tool for organizing assessment, having a strong educational potential for developing the spirit of fairness, personal involvement and fair competition of the learner, but not only. The projects were publicly supported; therefore, the given form of carrying out the educational activity allowed both the training and testing of the public speaking skills of the students.

4. Capstone Project: Achieved Results and Students' Perception

The actual data collected for the given study were accumulated throughout the teaching-learning-assessment process of the university course of Expert Systems and Expert Management Systems and was formed from the set of grades obtained by the representatives of the ACS & IM groups during 2019-2020 & 2020-2021 & 2021-2022 academic years from initial assessment tests, formative assessment no.1, year thesis assessment and final assessment (see Figure 1).



	ACS-191	ACS-192	IM-191	IM-192	ACS-181	ACS-182	ACS-183	IM-181	ACS-171	ACS-172	IM-171
Initial assessment (Diagnostic)	7,50	7,55	7,25	8,00	7,87	6,80	7,33	7,17	5,67	6,00	5,00
Formative assessment 1	8,86	9,00	8,37	8,83	8,20	8,50	9,22	8,75	5,75	6,50	5,50
Thesis of the year	8,62	8,53			8,13	7,89	7,44		5,75	7,00	
Final assessment (Exam)	9,14	9,67	8,00	8,80	8,73	9,00	8,56	8,64	6,17	7,00	6,50
General average	8,53	8,69	7,87	8,54	8,23	8,05	8,14	8,18	5,83	6,63	5,67

Figure 1. The averages, per group, of the grades accumulated by students gr. ACS & IM (2019-2022)

The MS Excel program was used for data processing, and for their more explicit representation, the use of custom combined diagrams (Combo Custom Combination) was used, which is intended for the more complex representation of data, including those that are embedded as diagrams (set either by row or column value) in other charts. In other words, Combo Custom Combination is a chart made up of a combination of other charts. At the end of the processing of the collected data, the progress of the academic success of the students in the discipline in question became evident.

Figure 1 illustrates the dynamics of the students' academic success based on the grade averages they earned as representatives of the ACS and IM in the didactic assessments of the Expert Systems / Expert Management Systems course in the 2019-2022 academic years. The given diagram reflects the average success of all groups of students that make up the general sample of the study (N=164) from the initial assessment and the formative assessment in relation to the marks from the assessment of the year's thesis, but also in relation to the results (grades) of the final assessment (yellow curve). The maximum grade value is 10 and the minimum grade value is 5 for all samples taken into account when processing the data and creating the chart in Figure 1.

At the end of the course, we were curious to get feedback from the learners who for the first time, both for them and us, went through didactic activities in a hybrid and online format, through online assessments, organized by us on several levels around the culminating projects, described in this paper. Being in the final year of studies, often many of the beneficiaries of the course had something to say, comment on. Moreover, during the lessons, but also the consultation hours, we intentionally initiated some discussions that would help us find out the students' opinions regarding the didactic and evaluative course designed for the ES / EMS discipline.

Speaking about the feedback received from the students at the end of the ES / EMS course, among them there were testimonies from which it emerged that the majority of the representatives of the student-respondent contingent found that they had made some discoveries about themselves, such as is shown in Table 2.

Table 2. Students' feedback reflected in the questionnaire at the end of the SE / SEG course

Findings made by respondents	*No. of positive reactions, %*
They determined the personal ability to aggregate the knowledge obtained both in the course and during other university courses;	*70%*
Students determined that they have a much higher creative potential than they imagined;	*58%*
Respondents understood that even though they were already at the end of their university studies, there was knowledge and/or information that they had heard about at the ES/EMS course. Also, students applied given knowledge and/or information for the first	*65%*

time in the ES/EMS assessments that they were challenged to perform them in the format proposed by the teaching staff;	
They found that now, at the end of the course, they understood what it's like to really ("for real", quoted from the students' expression) theoretical research with applied impact;	*62%*
Thanks to the format of public presentation and support of the projects, students revised their attitude towards the intellectual, and creative capacity and the degree of involvement of many of their colleagues;	*31%*
For the first time students, our respondents heard and, respectively, for the first time they tried to transpose an application prototype, created based on a programming paradigm, into an IT product created with alternative IT tools, not necessarily very actively recommended by specialists from various ICT fields;	*77%*
Given the fact that students were very thoroughly informed on the issue of research originality, but also on the issue of plagiarism, for the first time they were faced with the obligation to respect research ethics, the appropriate citation of bibliographic reference sources;	*87%*
The students were surprised that they managed to achieve a result that at first, they perceived as unrealistic one to achieve.	*70%*

What could be more valuable than personal experience on the road of professional training? Or, as per (Hurston, Z., N., 1997) "Research is formalized curiosity, it is poking and prying with a purpose".

5. Conclusions

Our research allows us to come up with the following findings regarding the methodology of applying didactic assessment based on Capstone Projects. The described approach could serve as a guiding material and/or a source of inspiration for colleagues interested in integrating Capstone Projects into their professional practice.

The assessment methodology presented in the paper is a long-term assessment strategy focused on practical and research activities generating learning products with added value from a formative, qualitative and creative point of view.

Given that the public presentation of the research project results component was part of the design of the assessment method described above, which was later executed, allowed students to (1). Develop the ability to structure arguments, materials, and/or evidence collected during research; (2). Increase their ability to analyse, synthesize, and present research content; (3). Improve their competence in formulating and issuing reasoning regarding the object of research; (4). Form constructive networks (networking) with their colleagues, based on the principles of transparency, involvement, and honesty; (5). Increase their competence in the computer-aided design and implementation of applications grounded in the ES / EMS field, using an expansive spectrum of IT tools; develop their academic writing skills in compliance with the deontological norms of research etc.

Due to establishing the appropriate connection between the objectives and the outcomes of the discipline, the students were able to form and develop their strategic thinking, which greatly benefited them at the interview stage regarding the elaborated projects.

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Open Education Pedagogies: Toward Ecosystem-based Theoretical Model of Learning and Communication in Educational Management

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Abstract: *This paper aims to describe the conceptual framework of developing an ecosystem-based theoretical model of learning and communication in educational management affordable in a diversity of learning environments. It is founded on the interconnection of three topics in a global ecosystem of learning and communication, named the lifelong learner, open educational resources (OER), and the metaverse. A learning unit that "connects" biotic and abiotic components in a comprehensive whole is planned, developed, and supported by the investigation using the metasystems learning design theory as its conceptual framework. The usefulness of deep learning is increased by metacognitive knowledge and experience. Hypothetical, by metacognitive experience the student(s) may be better at acting as an important stimulus, either real or virtual, and differentiating important from non-important concepts if they will be able to link ideas across multiple degrees of complexity. The results showed that learning design with metacognitive tasks cannot be achieved without cognitive and affective tasks. Metacognitive experience and active stimulus helped the students to acquire new knowledge and practical skills and reduce misconceptions in a diversity of learning environments. To increase the efficiency of the ecosystem model it is recommended to increase the number of metacognitive tasks.*

Keywords: ecosystems, Metaverse, knowledge ecology, learning, educational management, responsibility.

1. Introduction

Open pedagogy, also known as open educational practice, open education pedagogies is a term that aims to describe the use of open educational resources (OER) to support teaching, learning, and assessment, including self-directed learning and/ or autodidacticism. There are five educational methods, according to

https://doi.org/10.58503/icvl-v17y202206

Relieve (2022), which are constructivist, inquiry-based, reflective, collaborative, and integrative. The problem is that open pedagogy and its practical applications cannot neglect the evolution of Internet technologies. Combining the prefix "meta," which denotes transcendence, with the word ‘universe’, which refers to a parallel or virtual environment connected to the real world, creates the novel concept of ‘Metaverse’.

According to Fernández and Camargo (2022), a society that values human progress in learning and communication should be developed, and the ecological teacher training program should be seen as its fundamental component. We are currently in the third Internet technology wave, known as the Metaverse (Collins, 2008; Tlili et al, 2022; Inceoglu & Ciloglugil, 2022). According to Tlili et al (2022), with Facebook's statement that it was rebranding and promoting itself as Meta, Metaverse saw a surge of interest. To the best of our knowledge, no study has specifically focused on ecosystems models of learning and communication in educational management, even though many studies have conducted literature reviews to summarize the findings related to the Metaverse, in general, and systematically summarizing the findings related to the Metaverse in education, in particular.

In a metaverse, managing education entails much more than just having organizational management or leadership skills. First, since both the educational institution and the student (s) operate inside an open system, maintenance of the self-directed learning capacity is more important than learning in a formal education system. Second, the development of green skills is crucial for the development of the green industry and green jobs, which can be considered a new mission of global learning. The phrase "green skills" refers to a sustainable environment and sustainable growth of human societies, which requires the active engagement of all students in understanding how to evaluate their knowledge (e.g. metacognitive knowledge and experience). Therefore, planning, developing, and maintenance of green skills for self-regulated learning capacity in a diversity of learning environments is crucial to foster students’ interest and motivation to learn.

The pedagogy of green skills relies on ecosystem-based theoretical models of learning and communication. These models are a group of models dealing with human-computer and computer-computer interactions, taking into account the impact of external factors and stimuli on the human mind, decisions, and behavior. The ecosystems' approach emphasizes awareness of the global interrelationships between human and non-human elements, including communication with agents begged by artificial intelligence elements. In our opinion, in the Era of openness and, therefore, of open educational pedagogies, educational management theory needs a novel approach based on ecosystem models of learning and communication.

To cover the gap between open pedagogy, specific features of the Metaverse, and ecosystem-based models of learning and communication, this article conducts an online survey of the significance of learning and communication ecosystems in educational management. The questions of the survey are extracted from scientific databases to reveal the research trends, focus, and limitations of this research topic, and the answers are obtained from educational managers, who attended the teacher-training course. The obtained results highlight the study gap between open pedagogy's affordability and the characteristics of learning and communication ecosystem models in educational management, administration, and leadership, taking into consideration the variety of learning contexts.

In search of a different approach to educational management, this study seeks to understand how educational managers in schools feel about the practical application of ecosystem-based theoretical models of learning and communication in educational management. Using this novel approach, the article aims to answer two research questions:

1) How significant are traditional ecosystems notions in a cutting-edge management approach for education? (from the perspective of educational managers)?
2) How useful is the ecosystem model of learning and communication for educational management?

This article discusses the possibility of transformation in the global education pedagogy and educational management brought about by open education pedagogies. The world has changed so much in the last few decades that the role of pedagogy and educational management has also changed. We need to think about how to improve pedagogy and educational management, and how we can help our students to be more adaptive and accommodative to the diversification of learning environments. There is so much for learning designers to do because the scientific principles of pedagogy and educational management established more than one hundred years ago cannot be aligned to open education pedagogies of recent global education. In sum, the results of this study present a roadmap for future research that should be considered to improve ecosystem-based models of communication and learning in educational management around the globe as well as to improve metacognitive knowledge and experience in the Metaverse.

1.1. Educational management and leadership

Educational management is a field of research and practice that focuses on how educational institutions are administered, according to Bush (2006, p. 1). The decision-making process for achieving the objectives of the educational organization is the basis of educational management. However, factors from outside the school environment have an impact on students' perceptions of learning objectives and educational outcomes as well as learning and communication in both the physical world and the Metaverse. These factors have a significant impact on the goal and mission of educational organizations, as well as on the learning and communication strategies of learners.

The problem is that while educational management was established as an area of study in the previous century using scientific management concepts, over time its theorists and practitioners started to develop models based on experience in schools and colleges. Due to the lack of a single, all-encompassing theory, there are several models of educational management, administration, and leadership. However, most of them are knowledge ecology-focused. The concept of knowledge ecology, known also as the ecology of knowledge, refers to gaining meaning and value from fruitful conversations: art and science. The knowledge ecosystem is more related to a knowledge management strategy that tries to encourage the dynamic evolution of knowledge interactions between entities to enhance critical thinking, creativity, and decision-making through better evolutionary networks of cooperation and collaboration.

This is a contradiction with the role of pedagogy and educational management in an education Metaverse. As was noted by Zhai et al. (2022), technology support, business interaction, and rule design make up the bulk of the education metaverse's scope. The foundation of the entire framework is the business interaction, and interaction is the basis for developing both the technology and the regulations. Through digital mapping, which configures the real subject's physical, cultural, psychological, and spiritual existence, teachers and students in the metaverse gain virtual identities, creating a mirror incarnation in the educational metaverse.

Educational management is frequently seen as being mostly related to practical undertakings and the experience of educational managers and leaders. What is the role of educational leadership? Connolly, James, and Fertig (2019) acknowledged that although educational management and educational leadership are crucial concepts for comprehending organizing in educational institutions, there is still disagreement about what they mean, how they differ, and how valuable they are for educational organizing and learning. In their opinion, there are conceptual discrepancies between educational management and educational leadership, and these inconsistencies could be eliminated by responsibility as a state of mind of a leader in education.

In our opinion, responsibility is not only about the identification of one of the best leadership models (i.e. distributed leadership, data-based leadership, effective leadership, normative, etc.) or/and leadership styles (i.e. contingent, participative, managerial, moral, transformational, and instructional) in educational settings, but also about the identification of the best model for learning and communication in a diversity of learning environments. Therefore, an ecosystem model of learning and communication could be the most affordable model in educational management.

1.2. The impact of ecosystem models on educational management

In the global context of data-driven educational management, organization, and leadership, priority is given to knowledge ecology and ecosystems of learning and communication. However, the ecosystem approach in teaching, according to Cook (1970), entails gathering and coordinating information before presenting it in the context of a comprehensive system. Abiotic variables and biotic community composition should be discussed in the ecosystem structure courses. Furthermore, the ecological processes should be the main focus of the courses covering the role of ecosystems. Therefore, the ecosystem approach places a strong emphasis on highlighting the total interdependence among several systems, elements, and environments.

The term ‘learning and communication ecosystem comes together with digital technologies, open educational resources, and open pedagogy. According to Lane et al. (2021), the learning ecosystem is a fully open ecosystem that can reach learners where they are. This means that technology-enhanced learning contexts and the open landscape of the digital environment impact learning and communication. Increasingly, learning and communication take place in open and networked learning environments, which are characterized by rising complexity, dramatic changes, and unexpected impact on the mind and behavior.

One of the recent investigations of publications related to ecosystem models of learning and communication showed three tendencies: first, the predominance of the ecosystem approach in research regarding teacher professional development; second, there is more research available aims to reveal the ecosystem functions on individual style and, third, the studies focused on ecological teacher training program within the diversity of contexts, systems, and environments and, third, the ecosystem-based training methodologies for the development of in-service teachers' competencies.

Among papers dealing with issues of in-service teacher professional development, we found interesting ideas about the urgent need to provide training based on an ecosystem approach aligned with best practices and with teachers’ and schools’ needs in a global society. From this perspective “*an ecosystem approach operates under the coordination of a governance model, features a central hub, and conceptualizes the relationships of the organizations as a network. Ecosystems are underpinned by value co-creation, and shared logic and can be non-geographical*” (Falkner, Vivian & Williams, 2018). The core of the ecosystem is anticipated to be the network of lifelong learners learning and communicating in a diversity of physical and virtual environments.

The ecosystem functions in a teacher training program are complex, multidimensional, and dynamic. However, in many respects, the driving forces of stimulus and students’ responses are not well understood. In theory, ecological functions deal with bioenergetics processes, the flow of energy, and the cycling of elements. The existence of the ecosystem itself depends upon the phenomenon of the conversion of energy. In learning design, the ecological functions deal with the electrical energy of a knowledge management system, which keeps the functionality of the system. In the ideal situation, the system’s functionality depends on the *energy flows* (i.e. catalyzed by various stimulus-response actions, learning, and communication activities), *the cycling interactions between matter, information, and energy* (i.e. materialized in a student's portfolio), *competition* and *self-development* of metacognitive knowledge and metacognitive experience.

2. Method of research

The purpose of the study was to find out how educational managers and in-service teachers perceived the cost-effectiveness of ecosystem-based models of learning and communication in their activities and classrooms. An online survey is used as the research methodology. The survey was completed by teachers taking part in a formative program at our university. The number of respondents who responded to the online survey is equal to 61. Thus, the research was done by educational managers and in-service teachers from public pre-university schools.

2.1. The affordability of ecosphere in educational management

Lamont Cole described the ecosphere as a closed ecological system of a planet in which various types of matter and energy are continuously interacting (fig. 1). Do you believe that this idea is significant for school management?

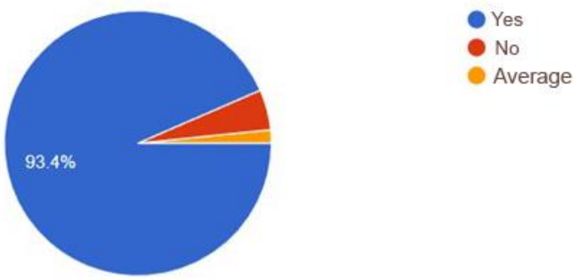

Figure 1. The importance of the ecosphere in school management

During the second question, respondents had to identify the interdependence between the ecosphere and the ecosystem of learning and communication. It was observed that educational managers and in-service teachers are interested in the topic of ecosystem-based models of learning and communication in educational management and their practical applications in daily activities.

2.2. The scope of the ecosystem from the viewpoint of in-service teachers

According to Artur Tansley's definition from 1935, an ecosystem is a unit of functioning and organization of the ecosphere made up of a biotope, which is an ever-present living environment made up of substances, factors, and relationships between those factors, and a biocenosis, which is a supra-individual level of organization of living matter and describes all living organisms collectively (fig. 2). Do you consider the school to be an ecosystem?

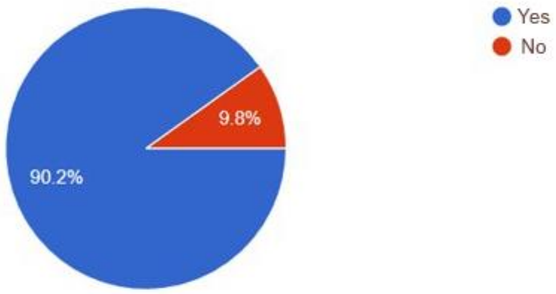

Figure 2. The school is an ecosystem

The school as an ecosystem of learning and communication means the focus on language literacy in a diversity of learning environments. However, the ecosystem relies on a group of living things that interact with one another and their physical and digital surroundings. It has significant ramifications for how we arrange schools and behave in them if we think of them as ecosystems of learning and communication. Interdependence is a cornerstone of any ecosystem. This implies that events in one area of the system have an impact on other sections of the system.

2.3. The scope of learning and communication ecosystem

The learning and communication ecosystem is made up of people, content, technology, learning culture, strategy, data, and dynamic processes (fig. 3). Do you agree with this idea?

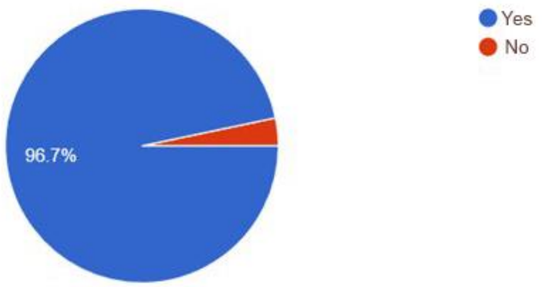

Figure 3. The complexity and dynamicity in a learning and communication ecosystem

This result relies on the second principle of the ecosystem. Another fundamental idea is that learning and communication ecosystems are designed to develop and adapt to global dimensions. As a result, when adjustments are made, such as when university ideals are destroyed, there might be highly negative results. The patterns of how people gain competencies and other results, as well as knowledge, skills, and capacities, are all affected. Professional competencies of certain categories of learners may eventually lead to acting in an unanticipated way in the future that might be dangerous for educational sustainability.

2.4. The importance of humanization the educational management

Many academics stressed the value of humanizing educational management (Trkman & Cerne, 2022; Chappell et al., 2016). If we consider a school to be an ecosystem, we understand that we need to be concerned with every part of the institution and its management. Regardless of whether a component is visible or not, the school as a whole is the result of all of its interactions and interdependencies. Additionally, educational management is a derivative of the much larger ecosystem that is as much determined by its worst schools as by its greatest. The following is our query regarding this concept:

The most important role in the ecosystem of learning and communication belongs to people (fig. 4). Do you agree with this idea?

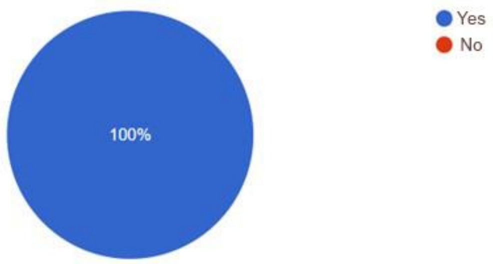

Figure 4. The importance of humanization the educational management

2.5. The affordability of learning and communication ecosystem in educational management

In sum, the learning and communication ecosystem in the post-COVID period is affordable in educational management and leadership. For instance, Arar et al. (2022) noted altered leadership and instructional approaches at their institutions in the post-COVID period. Chandler et al. (2022) report on the variability and dynamics of ecosystems. The query we're putting to our responders is, as follows: Is the learning and communication ecosystem model helpful for managing education? (fig. 5).

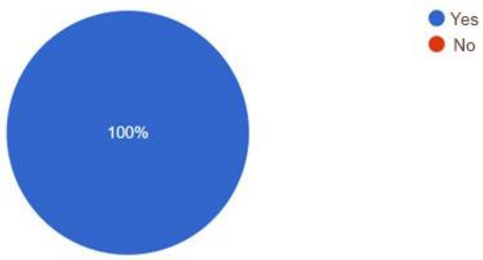

Figure 5. Total agree regarding the affordability of learning and communication ecosystem in educational management

3. Conclusion

Nowadays the idea of ecosystem models of learning and communication should be ‘connected’ with the metaverse. The metaverse is the sign of the third wave of the Internet revolution. In general, as was noted by Mystakidis (2022), the post-reality universe, a permanent and persistent multiuser environment fusing physical reality with digital virtuality, is the foundation of the metaverse idea. It is built on the convergence of technologies, such as virtual reality (VR) and augmented reality, that allow for multimodal interactions with digital items, virtual surroundings, and people (AR). The metaverse introduces new levels of social interaction and teamwork because of interconnected online 3D virtual environments (3DVE).

The metaverse describes the variety of technological developments as well as a significant change in how humans relate to technology. The Metaverse may be explored via the use of immersive technologies like Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), and 3D data (such as point clouds, 360° photos, and movies). The implications of the Metaverse on pedagogy and educational management of learning and communication are already being investigated by academics worldwide. As a result, the terms ‘Education Metaverse’ (Mystakidis, 2022), ‘Edu-Metaverse’, and ‘Metaverse for Learning’ have emerged as significant terms and concepts to research in this field.

The Metaverse is built on diverse technologies that allow for multimodal interactions with people, learning objects, and real-virtual settings. However, for the creation of successful learning experiences that make use of the affordances of this medium, understanding how to properly design, manage and use the Metaverse in teaching, learning and communication are still essential. On the one hand, the Metaverse raises ethical challenges, such as security, digital hygiene, privacy, equity, accessibility, and intellectual property. On the other hand, Metaverse is a sign of openness and of open pedagogy, management, and leadership, which are more dynamic and flexible. Therefore, “open textbooks play an important role in skills development. They provide open access to global knowledge and offer a collaborative way for problem-solving, critical thinking, and development of on-demand skills” (Railean, 2019).

A new educational metaverse gap, related to the importance of focusing on metacognitive knowledge and experience, is starting to take shape. To understand this global challenge, it is important to answer several questions regarding educational management theory and practice. Thus, how important is it to explore the ecosphere in school management; is this a school an ecosystem or not; what is the scope of the learning and communication ecosystem; how important it is to humanize the learning and communication ecosystem, and if learning and communication ecosystem models are helpful for managing education.

Analyzing answers of 61 respondents to an online survey it was observed that educational managers and in-service teachers are concerned about ecosystem-based models of learning and communication and their importance in school management. Respondents agree that educational management should be humanized and that the learning and communication ecosystem is an affordable model of educational management. From this perspective, open educational pedagogies should be focused on the unique role of a life-long learner in an ecosystem of learning and communication.

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Section 2

Software Solutions and Innovative Technologies

Monitoring students' attendance in synchronous teaching/learning activities for online classes: a challenge for university's teachers

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Abstract: *During the last two years, the academic space was under the formidable pressure of online teaching, caused by the pandemic disease spread all around the world. In this context, teachers from colleges and universities tried to adapt teaching methods and strategies for monitoring students' learning in appropriate ways. Using frequently technological tools or conference apps as Webex or Zoom, teachers discover some useful opportunities and functions of these apps. Students' attendance on face-to-face academic activities as courses or seminaries were realized by students themselves by writing down the name on a piece of paper. On the other hand, the online apps offer sometimes some technical opportunities to monitor the student attendance through a small but effective program, added to the main application. This represents an elegant and accurate manner to monitor students' attendance, useful for teachers who adopted it. This article presents a simple, free and accessible online software tool that is useful in monitoring students' attendance providing a report about the frequency and duration of student participation in online courses conducted through the Webex application.*

Keywords: COVID-19, Webex, attendance, university.

1. Attendance of university students during COVID 19 – an overview

Higher Education Institutions (HEIs) are interested in the rate and quality of students' attendance, for financial or administrative reasons, but also for the quality of undergraduates. Student absenteeism is a problem in universities, for example in medical education (Sharmin et al., 2017). As in face-to-face education, the absenteeism is a significant problem in online education, especially in HEIs. Mokhtari, Nikzad, Mokhtari, Sabour, Hosseini (2021) says online education is a proper solution for reducing absenteeism in lecture classes, and the online presence of students is critical for authentic and effective instruction.

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But what does *attendance* mean in an online context, as was imposed worldwide by COVID 19 breakdown? According with Federal Student Aid Handbook, some acceptable indications of attendance in an online course can be: student submission of an academic assignment; student submission of an exam; documented student participation in an interactive tutorial or computer-assisted instruction; a posting by the student showing the student's participation in an online study group that is assigned by the institution; a posting by the student in a discussion forum showing the student's participation in an online discussion about academic matters; an email from the student or other documentation showing that the student-initiated contact with a faculty member to ask a question about an academic subject studied in the course. (https://teaching.resources.osu.edu/keep-teaching/attendance-online-classes). The same document underlies that is not *attendance* "in a distance education context, documenting that a student has logged into an online class is not sufficient, by itself, to demonstrate academic attendance by the student" (Federal Student Aid Handbook, 2016, p. 886).

University students' attendance is often associated with other desirable academic behaviours such as engagement with the courses content, willingness for their academic success, and educational attainment (Moores, Birdi & Higson, 2019). Credé, Roch, and Kieszczynka (2010), in a meta-analysis find class attendance represents the most accurate predictor of academic achievement. Students' attendance significantly varied in relation with universities policies and expectation, but also depending on institutional or individual standards: some teachers award grades for a good rate of attendance; in some classes students' attendance is mandatory. In another meta-analysis on the relationship between students' attendance and academic performance (Crede et al., 2010), the authors find that those with high performance have also very good attendance and students with lowest mark have most likely very poor attendance.

Weijers, Ganushchak, Ouwehand & de Koning (2022) says class attendance is equally important in face-to-face and online education (Nieuwoudt, 2020), there are specific challenges related to attending online classes. For example, for an online class, it is easier for students to pretend to be present and to not login into the online class altogether, and it is more difficult to enforce class attendance compared to physical classes (Archambault et al., 2013). During the COVID-19 pandemic, online class attendance has become even more challenging and teachers have reported a significant drop in class attendance (Meeter et al., 2020). For all these reasons, creating and using digital tools for monitoring online attendance and for effective instruction of the students are very useful.

2. The Webex Usage Report Generated Weekly by the Teacher

Since the beginning of the COVID 19 pandemic stage one, in Romania the first case was declared on February 26, 2020, the companies that had online audio-video communication applications in their product portfolio made their product available free of charge to educational institutions. One of these companies is CISCO, which has in its portfolio the Webex application that the teachers from the "Alexandru Ioan Cuza" University of Iasi use for distance teaching in most of the distance face-to-face teaching scenarios. Of course, exists other popular apps as Classroom Attendance Tracker, in G-suite, that offer a tool for schools to take student attendance when remote learning, an add-on to google sheets (https://workspace.google.com/marketplace/app/classroom_attendance_tracker/993028068285).

As we have shown in the introductory part, attendance at classes, in many cases, is necessary for students to achieve the skills or the competencies required by teachers through assessments and to adequately respond to the requirements of future jobs that they will get after graduation. The presence in the classroom was often done by building a list of full names and counting at the beginning of each hour the students in the classroom to check if their number to match the number of students on the list. This system avoids the loss of time when the teacher read aloud the catalogue every hour and check if students are present. Also, this system depends on the observation process that the teacher must do during the course hour in which him observe the students faces and their position in the classroom. The process is based on the fact that the position in the classroom did not change during the course hours, any change in this situation becoming a source for reiteration of the attendance list through the reading of the names from the class catalogue. In the online environment, however, the number of attendances is permanently displayed by the application but the faces cannot all fit on a monitor or if they fit, they are very small and not always of high video quality, depending of course on the devices used and the network's upload/download speed. Displaying all the time the participants names or making print-screen with the list of participants is again a problem. This is because when a student enters after making the print-screen of participants this procedure must be resumed and the teaching/evaluating process must be interrupted.

In the case of the Webex application, this software provides a usage report for each meeting from the last 3 months. The usage report generated by Webex application is shown in figure 1.

All sessions in Romania Time (Bucharest, GMT+02:00)																				
Session detail for 'Sistem de rapoarte generat de aplicatia Webex':																				
Participant	Audio Type	Name	Email	Date	Invited	Registered	Start time	End time	Duration	Company	Title	Phone Nur	Address 1	Address 2	City	State/Prov	Zip/Postal	Country/re	Network jc
1		X Test	xtest.testx	3/5/2021	No	N/A	2:28 PM	3:17 PM	49 mins										External
2	VoIP	X Test	xtest.testx	3/5/2021			2:28 PM	3:16 PM	49 mins										
3		y Test	ytest.testy	3/5/2021	No	N/A	3:04 PM	3:16 PM	13 mins										External
4	VoIP	y Test	ytest.testy	3/5/2021			3:04 PM	3:16 PM	13 mins										
5		z Test	ztest.testz	3/5/2021	Yes	N/A	2:59 PM	3:16 PM	17 mins										External
6	VoIP	z Test	ztest.testz	3/5/2021			2:59 PM	3:16 PM	17 mins										

Figure 1. Activity Report Generated by Cisco Webex Online Software Opened With Microsoft Excel

In the report header we distinguish the name of the meeting, the time zone after which the time was noted in the table and then in an order the meeting participants. The rows with participants contain the participant name, email address, time of login, time of disconnection and minutes counting the time between login time at the meeting and the moment of disconnection from the meeting.

This activity report file can be downloaded directly from the website uaic.webex.com by the teachers of the "Alexandru Ioan Cuza" University of Iasi, if they want to. They could download at least one file for each of the teaching/learning meetings organized with students.

```
SessionDetailReport20210307112051.csv - Notepad
File Edit Format View Help
"All sessions in Romania Time (Bucharest, GMT+02:00)"
"Session detail for 'Sistem de rapoarte generat de aplicatia Webex':"
Participant  Audio Type  Name  Email  Date  Invited Registered  Start time  End time  Duration  Company Title  Phone Number  Address 1  Address 2  City  State/Province  Zip/Postal Code Country/region  Network joined from:
1          X Test  xtest.testx@emaildetest.ro  3/5/2021  No   N/A  2:28 pm 3:17 pm 49 mins  External
2   VoIP   X Test  xtest.testx@emaildetest.ro  3/5/2021            2:28 pm 3:16 pm 49 mins
3          y Test  ytest.testy@emaildetest.ro  3/5/2021  No   N/A  3:04 pm 3:16 pm 13 mins  External
4   VoIP   y Test  ytest.testy@emaildetest.ro  3/5/2021            3:04 pm 3:16 pm 13 mins
5          z Test  ztest.testz@emaildetest.ro  3/5/2021  Yes  N/A  2:59 pm 3:16 pm 17 mins  External
6   VoIP   z Test  ztest.testz@emaildetest.ro  3/5/2021            2:59 pm 3:16 pm 17 mins
```

Figure 2. Activity Report Generated by Webex Online Software Opened with Notepad

Starting from the information that the report provides and studying the structure of the CSV file (figure 2) that contains this report, but which they read in bytes, the authors built an algorithm who parse several such files and centralize the information in a presences catalogue for the virtual meetings of the students with their teachers.

3. The designed algorithm

The block diagram of the algorithm is represented in figure 3. It is mostly a linear algorithm who parses a single file and at the end if the teacher adds another file then the algorithm makes a repetition of the entire linear part, but adding the new information in the destination file, the presences catalogue. The simplicity of the entire software is a good thing but involves some limitations. One of them is that the source file must not be altered in any way, neither the name, nor the content. The authors have done some tests and discovered few modifications which are acceptable by the algorithm but they also strongly recommend at this point to not do any modification to the original Webex report. Also, it is a limitation regarding the delimiter symbol for field and for row. The software works with the "comma" symbol as delimiter of fields in a single row and with a specific byte's value as delimiter for each row.

The algorithm can be implemented in several ways, using databases to store information or using lists of files to integrate at any time upon request. Our working model is based on lists of files integrated on demand. Storing the files provided by the client would require more storage space than the authors had available for this project. Because of this they choose to rewrite the partial files and to delete the files already interpreted by the algorithm once the data is collected from them. At the same time, they mention that this software makes only a presence catalogue so that the student's presence can be more easily identified by the teacher for a longer period of time. For this reason, the authors strongly recommend to the teacher to keep also the files generated from Webex software because they remain the evidence of the student's attendance at classes.

The working model the authors used combines some variables initialized by any server automatically when the client-server relationship is first established and concepts from object-oriented programming. For the correct manipulation of data, we have built a class who define objects with one single property and to whom we apply three methods. Those methods will manage the object's properties. That class includes a method of retrieving data from uploaded CSV files and, with that data, to populate the *fields* property. That class also includes two methods of generating content for the user's interface.

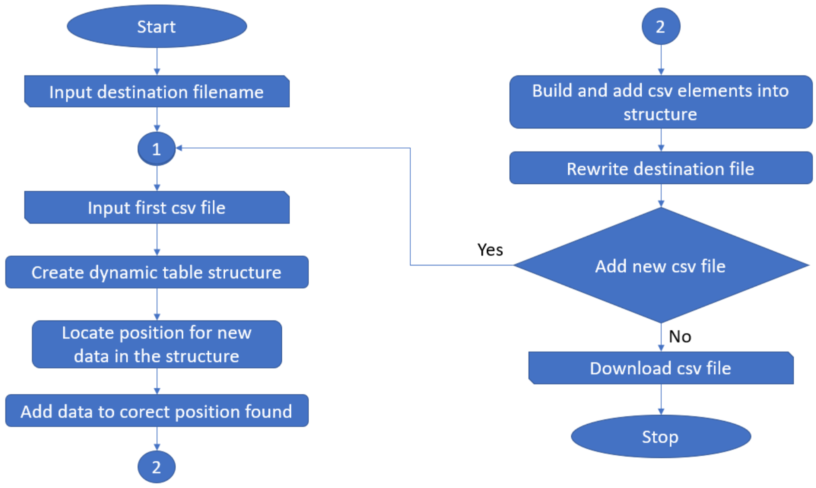

Figure 3. Software Block Scheme

File management verification is made with the help of SESSION variable. Because this is used in a work session is useful because it eliminates many of the situations when information is accidentally doubled or when same file is uploaded repeatedly. The file management section identify that a filename already exists in the SESSION variable that keep this information, means that was already uploaded and stop the parsing algorithm to gather again the data from that file. If doesn't identify the name as a duplicate than the algorithm writes the filename in that SESSION variable and then allow the parser to grab data.

The user interface includes a form for submitting a name for the resulting file and for uploading one of the source files. After the first source file was sent to the server the same interface will also include an area for accessing the results in two available formats: the CSV file for download when a link is clicked, and the web interface for displaying data in table style. The information shown in the user web interface will be increasingly developed as more source files are uploaded for the parser.

The application uses the PHP as writing language for backend part of the program and provides a simple client interface in HTML as writing language for frontend part. As we already mentioned the backend part of the application is built as a php class, made by ourselves. The *csv_builder* class has the following structure:

- the array type property named „fields”
- the methods:
  - *„loadwebexcsv”*
  - *„t_show”*
  - *„build_csv”*

Uploading any CSV file through the application interface to the server, after the name of the file is checked to avoid repetitions, allows the *loadwebexcsv* method to check if the file can be correctly parsed, to interpret the information in it by browsing and collecting useful data for the centralizer and to fill in the *fields* property with this information. At the same time, the name of the parsed file is added to the SESSION variable. As we mentioned already this variable is the one used to avoid repeated sending errors.

The information in the *fields* property is first structured after the values from the *E-mail* column (fig. 1). The first step in the algorithm evolution is to store the value from the *Name* column (fig. 1) corresponding to the e-mail value. Then the authors create an array structure with date information as key, and with the numerical values corresponding to the minutes of participation in each video meeting as value (fig. 1). For each new CSV file uploaded, the data stored in the *fields* property for any participant to video meeting are increased with the new date/time information.

Each time when the user interface is regenerate on the screen in the Internet browser window, on the right is shown an HTML tag as the reference to the CSV file generated using the *build_csv* method and ready for download. At the same time, the same information from the *fields* property, this time in HTML format generated with the *t_show* method, are also included in the user interface presented in the browser and could be checked by the teacher in any moment.

4. The results as CSV file

For the following example the authors used 3 CSV report files generated from the Webex application and downloaded locally. The contents of the newest of them is represented in figures 1 and 2. The contents of the other two source files are shown in figure 4.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
3	Participant	Audio Type	Name	Email	Date	Invited	Registered	Start time	End time	Duration	Company	Title	Phone Nur	Address 1	Address 2	City	State/Prov	Zip/Postal	Country/re	Network joined from:	
4	1		X Test	xtest.testx	3/3/2021	No	N/A	9:49 AM	10:36 AM	48 mins										External	
5	2	VoIP	X Test	xtest.testx	3/3/2021			9:49 AM	10:36 AM	48 mins											
6	3		y Test	ytest.testy	3/3/2021	No	N/A	10:02 AM	10:35 AM	33 mins										External	
7	4	VoIP	y Test	ytest.testy	3/3/2021			10:02 AM	10:35 AM	33 mins											
8	5		z Test	ztest.testz	3/3/2021	No	N/A	10:02 AM	10:35 AM	34 mins										External	
9	6	VoIP	z Test	ztest.testz	3/3/2021			10:02 AM	10:35 AM	34 mins											
10	7		m Test	mtest.test	3/3/2021	No	N/A	10:05 AM	10:35 AM	31 mins										External	
11	8	VoIP	m Test	mtest.test	3/3/2021			10:05 AM	10:35 AM	31 mins											
12	9		n Test	ntest.testr	3/3/2021	No	N/A	10:01 AM	10:36 AM	35 mins										External	
13	10	VoIP	n Test	ntest.testr	3/3/2021			10:01 AM	10:36 AM	35 mins											

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
3	Participant	Audio Type	Name	Email	Date	Invited	Registered	Start time	End time	Duration	Company	Title	Phone Nur	Address 1	Address 2	City	State/Prov	Zip/Postal	Country/re	Network joined from:	
4	1		y Test	ytest.testy	2/25/2021	No	N/A	2:07 PM	2:41 PM	34 mins										External	
5	2	VoIP	y Test	ytest.testy	2/25/2021			2:07 PM	2:41 PM	34 mins											
6	3		X Test	xtest.testx	2/25/2021	No	N/A	1:44 PM	2:41 PM	58 mins										External	
7	4	VoIP	X Test	xtest.testx	2/25/2021			1:44 PM	2:41 PM	58 mins											
8	5		h Test	htest.testh	2/25/2021	No	N/A	1:56 PM	2:41 PM	45 mins										External	
9	6	VoIP	h Test	htest.testh	2/25/2021			1:56 PM	2:41 PM	45 mins											
10	7		z Test	ztest.testz	2/25/2021	No	N/A	1:58 PM	2:41 PM	43 mins										External	
11	8	VoIP	z Test	ztest.testz	2/25/2021			1:58 PM	2:41 PM	43 mins											
12	9		n Test	ntest.testr	2/25/2021	No	N/A	2:01 PM	2:41 PM	40 mins										External	
13	10	VoIP	n Test	ntest.testr	2/25/2021			2:01 PM	2:41 PM	40 mins											
14	11		m Test	mtest.test	2/25/2021	No	N/A	1:46 PM	2:41 PM	56 mins										External	
15	12	VoIP	m Test	mtest.test	2/25/2021			1:46 PM	2:41 PM	56 mins											

Figure 4. The other two CSV files opened in Microsoft Excel

After the successive upload of source files using the file upload form, which is to be found in the first rows of the user web interface, the result is shown as HTML table (fig. 5). In the first row are the column headings which show the date of the meeting but in the order in which the files are uploaded. In the first column are arranged the names of the participants. They are shown in the order in which they are identified in the files. In the rest of the columns the user could identify in which days the participant was present at the online presentation and how many minutes has participated in the video meetings.

Participant	2/25/2021	3/3/2021	3/5/2021
y Test	34	33	13
X Test	58	48	49
h Test	45		
z Test	43	34	17
n Test	40	35	
m Test	56	31	

Figure 5. The result table

The user find also empty spaces in table. If the fields have no number of minutes inside, it means that the corresponding name on the horizontal row containing that field did not participate with the same email or did not participate at all at the video meeting in the corresponding day on the vertical column that contains that field.

In the user interface, at the top right is now the download button of the resulting CSV file. It contains enough elements to be viewed correctly in the version of Excel 2019 (fig. 6).

Centralizator prezenta			
Participant	25.2.2021	3.3.2021	5.3.2021
y Test	34	33	13
X Test	58	48	49
h Test	45		
z Test	43	34	17
n Test	40	35	
m Test	56	31	

Figure 6. The result CSV file opened with Excel 2019

5. The Conclusions

The utility of this application is generated by the output file which can be downloaded from the application interface for the attendance catalogue for several video meetings with over 150-200 participants each. In the described situation the manual centralization of the information from several files would be difficult. The ingenious realization of the algorithm is revealed especially by the easy usage, by the file's quick parsing method and by the speed in which the reports are generated in both tabular forms. The resulting file is in a simple CSV format that can be opened with any spreadsheet read application. For older versions of Excel applications, it is necessary to use configuration tools for the correct opening of the resulting files. On the Excel 2019 application, which the authors tested, the visualization of the content of the resulting file is done correctly.

The application was available at: dppd.psih.uaic.ro/apps.dppd/ centralizator_prezenta/. It was the first version of the application and it is in the stage to be developed in the second version with a more friendly user interface which will include advanced elements for information's security. At the same time, the csv_builder class will be developed on request with new methods. The authors already think of two improvements: one to sort the columns by first row values (ascending after the calendar data) and one to sort the rows by the participant's names column. New information could be taken in the result file from the sources file. The authors could fill in the result tables with information such as video meeting name taken from the source CSV files if this name is the same in all uploaded files. Also, the authors could complete the resulting tables with one new column where to calculate the entire amount of minutes of participation or with the average amount of minutes of participation on total meetings or both.

The idea and the work for developing this application, all carried out voluntarily, belong to the authors of this article.

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Virtual learning simulator of a flexible manufacturing line using Petri NET toolbox

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Abstract: *Several intelligent tutoring systems and e-learning platforms developed in the last decade in engineering domains (such as automotive, industrial robotics, manufacturing, energy, electrical engineering, computer engineering, electronics, oil and gas engineering, chemical engineering) integrate various software tools that facilitate the student learning process by studying simulations of some real-world applications. Examples of such tools applied in the manufacturing education are: different types of Petri Nets (including coloured Petri Nets), different toolboxes from Matlab, AnyLogic and FlexSim. Moreover, artificial intelligence provides methods and techniques that can significantly improve the performance of developed simulations. The paper presents a simulator developed using Petri NET toolbox in scope of representing the process of a manufacturing line for better understanding of the correlation between the theoretical control and the behaviour of the system. It tackles in a different way the learning process addressed to students to a more practical view of the control algorithm.*

Keywords: Manufacturing education, Learning process, Control algorithm, System behaviour.

1. Introduction

The manufacturing area has undergone significant changes in the past few years, being impacted by both globalisation and technological enhancement. The increase in product demand and the need for product availability on the market at any time has determined the development of new manufacturing strategies based on the Industry 4.0 vision and going straight towards supply chain digitalisation (Grobelna & Karatkevich, 2021). Artificial intelligence (AI) based approaches have shifted the manufacturing strategies towards the fourth industrial revolution, considered as Industry 4.0 strategies. The AI-based strategies in manufacturing offer many advantages as improving decision-making, productivity and system

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efficiency. Besides the advantages that this strategy offers, the implementation of AI-based approaches in the supply chain is still limited due to employees' knowledge and digital skills (Jamwal et al., 2022). The aim is to pass from traditional manufacturing to smart manufacturing, more efficient and customer focused. To reach this goal, it is mandatory to deeply understand the supply chain flow starting from planning of production and finishing with logistics, to have a clear vision on the entire process. For the future engineers that will work in manufacturing, it is important to facilitate the manufacturing learning process from the university. It is the best period, having fresh in mind the theoretical part (for students from different fields of study: automation, electromechanics, environmental, etc.) it will be much easier to understand the correlation between the theoretical control and the behaviour of the system by studying virtual simulations of some real-world applications such as a simulation of a flexible production line.

The paper is organised as follows. Chapter 2 presents briefly the general concepts of the manufacturing process, a short presentation of the reviewed literature and the production line overview. The methodology that was followed for the simulator development as well as the simulator itself are described in chapter 3. The final chapter concludes the paper and points out future works.

2. Flexible production line

2.1. General concepts

A flexible manufacturing system can be schematically defined as a system that receives as input data regarding the raw material required for final product, data of system status predefined parameters needed to trigger the production, human resources and as a result of the process, this data is transformed in output data (final product/ services) (Morosan, 2013).

A manufacturing system is flexible if it has the ability to be automatically changed to produce a different number of parts. At the end of the operation, the machine tools are automatically prepared for the next part (Sokmai & Ganea, 2010).

The main purpose is to provide the necessary flexibility of the equipment needed to complete the technological process in the defined parameters in order to obtain the planned production. Different equipment of the manufacturing line can produce a part of the final product/ piece (Javaid et al., 2022). For possible changes of product, the system can adapt to the new configurations of the required model (Mahmood et al., 2017).

2.2. Literature review

In the past years, it was observed an increase in interest in using Petri Net in analysing, exploring, and modelling flexible manufacturing lines. All the published studies have proven the capability to cover a wide range of teaching goals for the

Petri net-based approaches to flexible production systems (Grobelna & Karatkevich, 2021).

In (Drighiciu & Cismaru, 2013), the model of a flexible production line for bottling water is illustrated in Petri Nets, showing the entire dynamic system in different conditions.

A Petri Nets topology is used as a modelling tool to develop simulation models for studying the behaviour of the flexible manufacturing systems illustrated in a case study, demonstrating the advantages in using Petri Net as a tool for increasing the system productivity in (Maurya & Jayswal, 2015).

Furthermore, this paper focuses on developing a simulator with the scope of showing the basic concepts of a bottling production line for students understanding the manufacturing process, stages of production, the importance of each department in the production cycle and how the systems can be enhanced.

2.3. Production line structure overview

For the simulator development, we will use as a case study a flexible beverage bottling production line. The line consists of 5 main workstations, each having multiple sub-workstations.

The line is capable of producing different product types, from various flavours to all kinds of packaging sizes and formats at different production speed.

The production flow starts with the production schedule, indicating the product type and flavour. Based on this information, the production cycle is triggered. First are the raw material allocation for syrup preparation, consisting in mixing the beverage main ingredients at the settled quality parameters indicated by the recipe. Next, the syrup will be transferred to the filling area where the supplied empty containers will be filled and the cap will be applied. At this moment, the containers will pass to the packaging stage, where they will be labelled, and the pack and pallet formed. This will finish the production cycle.

After each production, the line will start the change over and a new product type will be scheduled for production. In figure 1 is presented the structure of the production line.

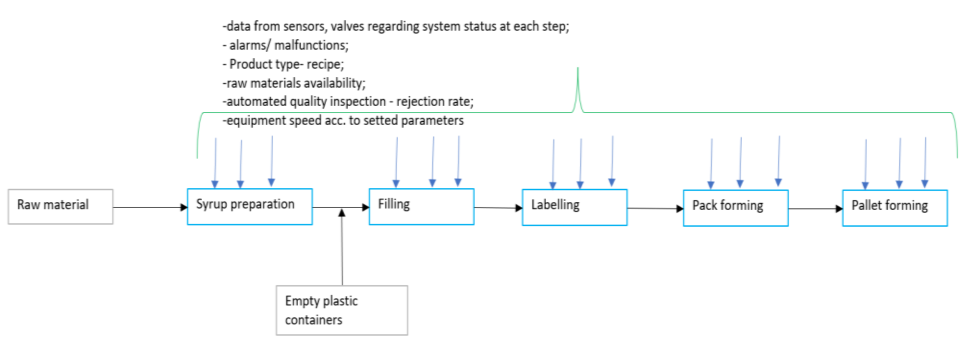

Figure 1. The production line structure

3. Production line simulator

3.1. Petri net modelling

Petri Net is a modelling tool that offers graphic and executable techniques for analysing dynamic and concurrent discrete event systems (Mireles et al., 2006).

A typical Petri Net can be defined as a 5-tuple (P, T, F, w, M0), where:
P = {P1, ..., Pm} is a finite set of places;
T = {t1, ..., tn} is a finite set of transitions;
F $\subseteq (P \times T) \cup (P \times T)$ is a set of arcs;
$w: F \rightarrow \{1, 2, ...\}$ is a weight function;
$M0: P \rightarrow \{0, 1, 2, ...\}$ is the initial marking;
with $(P \cap T) = \emptyset$ and $(P \cup T) \neq \emptyset$ (Murata, 1989).

In a PN model, states are associated to places and marks (also called tokens), and events to transitions. A transition t is said to be enabled if each input place *Pi* Î *·t* is marked with at least *w(Pi, t)* tokens, where *w(Pi, t)* is the weight of the arc between *Pi* and *t*. Once enabled, a transition will fire when its associated event occurs. Transition *t*, *w(Pi, t)* tokens are removed from each input place *Pi* and *w(t, Po)* tokens are added to each output place *Po* $\in$ *t·*. Here, *·t* and *t·* are the sets of input and output places of transition t (Murata, 1989).

In this paper, the graphical part of the PN will be used in order to represent the production line. We will use circles in order to represent places, rectangles to represent transitions, dots represent tokens and arrows represent the arcs, with weights above (Raposo et al., 2000).

3.3. Flexible production line simulator in PN

Based on the production line structure overview, it was developed the PN representation of the main workstation.

In figure 2 is presented the Petri Net model of a bottling production line. The Petri Net of the bottling production line can be defined by the 6-tuple (P, T, t, F, w, M0) where:

- the set of places P are:
  P={m1,m18,m17,m19,m4,m3,m8,m9,m10,m11,m12,m13,m14,m15}
- the set of transitions T are:
  T={T1,T2,T3,T4,T5,T6,T7,T8,T9,T10}
- the set of arc F are:

F={(m18,T1),(m19,T1),(m8,T4),(m5,T2),(m6,T3),(m7,T4),(m9,T5),(m10,T6),(m11,T7),(m12,T8),(m13,T9),(m14,T10)}

- the weight function is defined as follows:
  w(m18,T1)=1
  w (m19,T1)=1

w (m8,T4)=1
w (m5,T2)=1
w (m6,T3)=1
w (m7,T4)=1
w (m9,T5)=1
w(m10,T6)=0.98
w(m11,T7)=12
w (m12,T8)=64
w (m13,T9)=1
w (m14,T10)=1

- the initial state:

M0=[1 0 1 0 1 0 0 0 0 0 0 0 0 0]

Only the places m1, m4 and m 17 have tokens in the initial state and represent the raw materials input of the line.

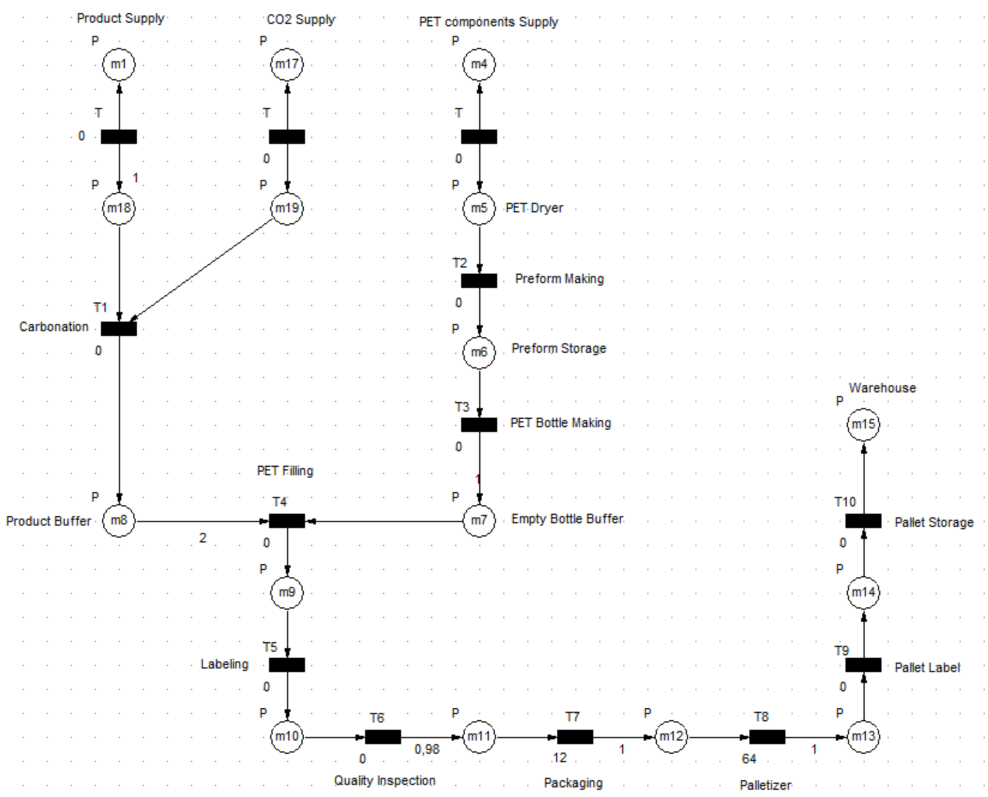

Figure 2. Petri Net representation of bottling production line

The weight of the transition (m10,T6) is 0.98 because 2% of the bottles are rejected by the automated quality inspection due to the defect in the filling or labelling process. The weight of the transition (m11,T7) represents the number of bottles needed to form a pack, in this case is 12 and for the transition (m12,T8) the weight is 64 because 64 packs are needed to form a pallet of product.

The first transition, T1, is represented by the Carbonation process that mix Product with CO2 according to the carbonation chemical reaction:

$$H_2O + CO_2 \rightleftarrows H_2CO_3$$

Figure 3. Carbonation chemical reaction

In order to avoid the bottleneck of the process, the product is not going directly to PET filling, instead is going to a Product Buffer represented by the state M8.

In parallel with the Carbonation process, the PET forming stream starts with the PET components that feed the Preform Making machine represented by the transition T2. After the transition T2, is fired the preforms goes to state M6 that represents the storing buffer of the preforms that feeds the PET making machine represented by the transition T3.

After transition T3 is fired, the empty bottle is formed and is ready for the filling process. Here is the point of merging the streams in the transition T4, PET filling. After the bottle filling process is finished, on the bottle is applied a label, transition T5 and the bottle goes to quality inspection.

After the transition T6 is fired, a part of the bottles will be rejected due to faults in the filling or the labelling process. The good bottles are transferred to the pack forming machine, presented by the transition T7 that forms a package of 12 bottles.

The packages go to the palletiser machine represented by the transition T8 that forms the pallet with 64 packages.

The pallet is labelled with the production date after the transition T9 is fired and in transition T10 is transported to the warehouse.

In conclusion, using the Petri Net, a virtual learning simulator is developed using the graphical technique, depicting the main steps of the product cycle during manufacturing.

4. Conclusions

This paper presented a virtual learning simulator developed on a case study of a flexible production line that will help and guide students in understanding the manufacturing process. The usage of the Petri Net tool as a methodology for developing this learning material makes it easier to understand and offers many options in analysing the system efficiency and increasing productivity.

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e-Dubba: a Learning Platform for Sumerian Exposing Cuneiform Signs as Text

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Abstract: *A wide variety of computer-assisted language learning systems have been developed for English and other living languages such as French, Chinese or Japanese. Comparatively, few systems, if any, have been developed for extinct languages, in particular for Sumerian. This language has the added difficulty for students to be written in cuneiform, a script in which a sign can have multiple readings and meanings and for which computer support is low. In this paper, we present e-Dubba, the prototype of a web-based learning platform that offers Sumerian courses in French. It is the first system of its kind to offer copy-paste-able cuneiform signs, which allows the reuse of them conveniently in other software applications or for communication. In addition, it integrates a dictionary that is capable of giving meaning and translation of words in the context in which they appear. Finally, the platform features learning analytics by logging user's page consultations and dictionary lookups. Teacher is provided with a page of its own to monitor progress.*

Keywords: Sumerian, CALL, smart dictionary, learning analytics.

1. Introduction

Numerous computer-assisted language learning (CALL) systems have been built for living languages (Gamper & Knapp, 2002). This paper lists software systems for English, Japanese, French, German, Spanish, Italian, Russian, Greek, Chinese, Arabic, Hebrew, Thai and Malay. There is however an imbalance in the representation of the languages, as most systems were developed to support the learning of English (14 platforms), Japanese (5) or French (4) or a combination (5) including one of those languages. That lack of language support diversity is hardly surprising given that most CALL publications emanate from the USA (30%), Taiwan (11%), UK (8%), and in a smaller percentage Canada, Australia and France (Gillespie, 2020).

Most world's languages, including the extinct ones, are thus lacking representation in the CALL landscape. One extinct language is the exception, classical Chinese, thanks to being studied as part of the school curriculum in China, Taiwan and Japan (Iino, 2002) and having a large population of speakers of a

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language (Standard Chinese) with which it shares its writing system. Consequently, there exist some digital learning systems for classical Chinese like the one presented by Wu & Chen (2018). On the other hand, languages written using the cuneiform script, that is Sumerian, Akkadian, Elamite, Hurrian, Urartian and Hittite (Daniels & Bright, 1996) has no educational electronic system developed for that we are aware of.

Sumerian, which is offered in dedicated classes or as part of a history curriculum in higher institutions around the world, sometimes remotely, have the added difficulty of being written with a logographic script called cuneiform (Cooper, 1996). As the offering is still quite limited, online software solutions have the potential to reach a larger public that wouldn't be able to learn the language presently. The cuneiform script has been integrated into the Unicode standard since version 5.0 (Andries, 2008) but the general electronic support (input methods, fonts, software support) is lacking. Moreover, learning materials even in digital form relies almost exclusively on transliterations or images of the characters instead of using text. This poses an obvious issue for learners, as no text-based educational application like a flashcard software can be used for reviewing the course content. Communication with teachers or other students is also impaired by the need to use an alphabetic transcription instead of the script itself.

In this paper we present e-Dubba (*Edubba* means «house from which the tablets are coming out» in Sumerian), a web-based platform for learning Sumerian containing learning material in French and embedding a dictionary. In addition to hosting course content and tracking learner progress as any other learning analytics (Clow, 2013) solution would do, it includes the following innovations: Sumerian characters as text and a dictionary that gives the exact translation of a word in the context in which it appears.

2. Pedagogical Problematic

Cuneiform, the script created and used by Sumerian, is a big hurdle for learners because of its logographic nature. A cuneiform sign can be used as a logogram (it then designates a *signified* and *signifier* pair as a whole), a phonogram that is used only for its phonetic value or as a determinative (Jagersma, 2010), that is a character that helps determining the semantic field of a word by prefixing or suffixing it. Like Chinese, words are not separated by visible boundaries. Those two properties of the writing system pose an evident pedagogical issue where the burden of guessing the value of a sign, as well as text segmentation, is left to the student.

The burdensome impact of the script on one's studies is multiple, for instance: more learning items to remember (both sign value and their meaning in addition to words of the language), difficulty to read a text without a dictionary, trouble or impossibility to input text on a computer and more a convoluted dictionary lookup process. Even the conventional transcriptions, which use letters with diacritics like ⟨ĝ⟩ and ⟨š⟩ are uneasy to input on a computer. Some of those aspects are shared with learners of Chinese and Japanese.

While there are digital dictionaries for both of these East-Asian languages which can be used using the native scripts and often with a romanization scheme (like hanyu pinyin for Chinese, or Hepburn romanization for Japanese), in Sumerian the reference dictionary is a paper dictionary, the *Manuel d'épigraphie Akkadienne* (Labat & Malbran-Labat, 1976). It contains cuneiform signs and words, their readings in Akkadian and Sumerian as well as their translations in French.

On the digital side, the ePSD (ePSD, 2022) dictionary in which an entry is presented in Figure 1 provides English translations but displays cuneiform signs as images instead of text. While this choice is understandable from an accessibility point of view, an option to display them as text is not present, despite the fact that the images of signs were clearly generated with the font *CuneiformComposite* used in the Unicode standard and by e-Dubba. In addition, it doesn't support lookup from Unicode characters.

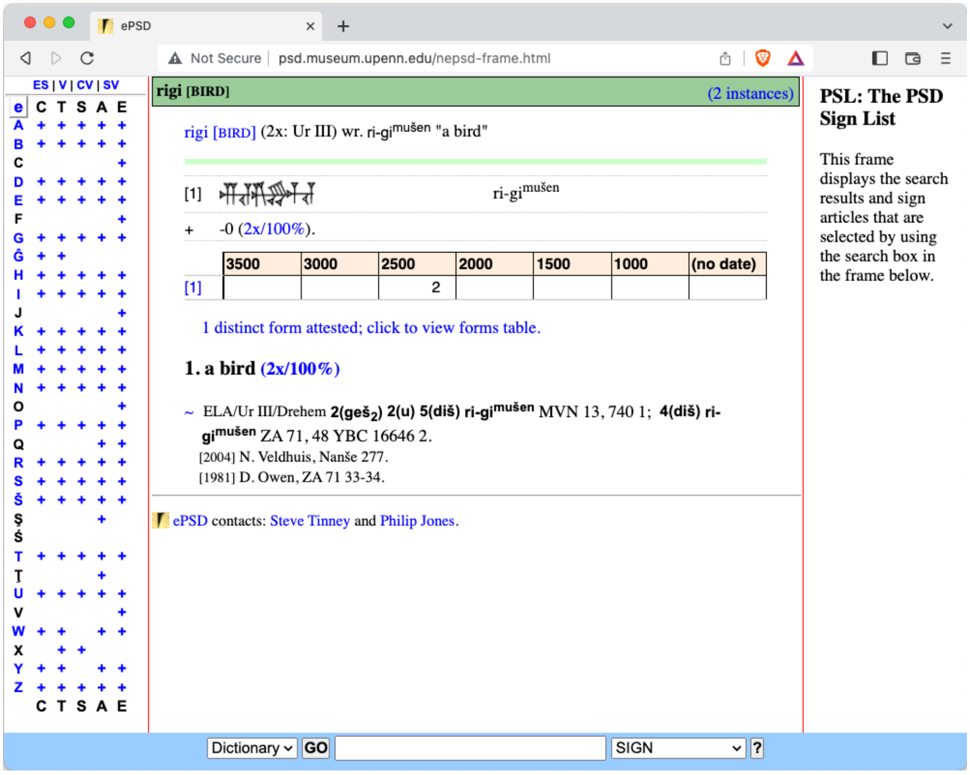

Figure 1. An entry in the ePSD dictionary

This situation motivated us to create a platform where: (1) cuneiform text is selectable so students can handle them as any other text on a computer and (2) create a Sumerian-French lexicon which is accessible directly within the pages of the course. Finally, logging capabilities (3) allow us to perform learning analytics. This benefits the teacher responsible for the class by monitoring the progress of the cohort of students. Dictionaries lookups are logged as well and students can track their individual progress.

3. E-Dubba Platform

3.1. Course Content

The content hosted by e-Dubba is based on the learning material of the first year of a university diploma offered by University of Strasbourg (France). This two-year diploma can be either taken on-site or remotely. Each semester is divided into 12 weeks, for which material is handed to students as PDF documents, in the case of remote students. The platform was developed with the remote students as primary users, and on-site students as secondary users. The learning material includes for each lesson a main lesson file, and depending on the week various exercises, an epigraphic document to translate and answer files to exercises of the previous week.

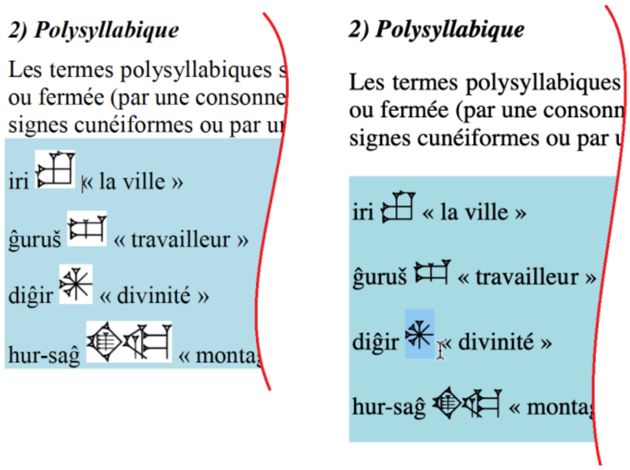

Figure 2. Original Learning Material (left), HTML Version (right)

The prototype of e-Dubba is built to host content of the main lessons. Five lessons have already been converted to HTML. A big difficulty of the task lies in the fact that in the original material cuneiform characters are images acquired from ePSD. Given the scarcity of resources containing cuneiform signs encoded with Unicode, some of those characters had to be manually searched in the Unicode standard table of characters (block U+12000). Figure 2 shows an extract of the original material (PDF) on the left with its HTML e-Dubba counterpart on the right.

It is visible on Figure 2 that the third Sumerian character (*diĝir*) is selected in the HTML version. This capability is an innovation in the landscape of Sumerian where even recent research works (Chiarcos et al., 2018; Punia & Schenk, 2020) seem to ignore the cuneiform characters themselves and relies on transcriptions exclusively. For pedagogical purpose, the issue caused by the lack of signs' glyph variation support in Unicode which is problematic for researchers is greatly counterbalanced by the educational affordances offered by those characters being accessible in text form. That way, they can inputted easily into flashcard software and can be used into written communication, for example when corresponding with the teacher responsible of the course.

3.2. Integrated Dictionary

All lessons on e-Dubba feature a dictionary panel on the right of the course content, formatted in HTML as described in Section 3.1. When a Sumerian word from the lesson is clicked, the data displayed in the dictionary panel is updated. Figure 3 is a screen capture of a lesson page. The yellow part of the dictionary contains information of the word or sign in the context in which it appears. Meaning that can appears in other contexts are listed in the red part.

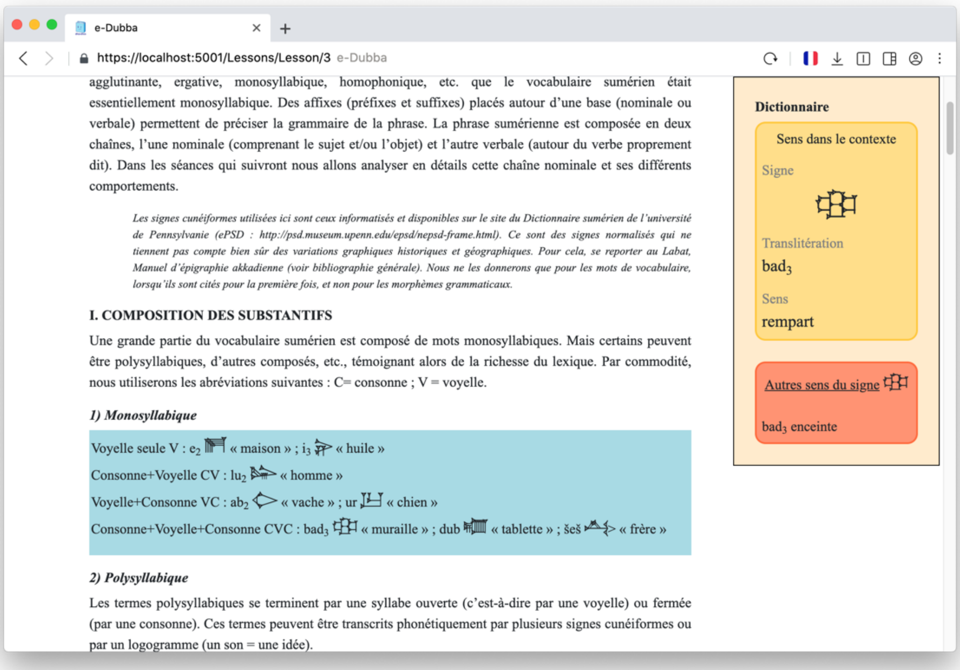

Figure 3. Lesson and Dictionary Panel

To provide the dictionary feature, we created a small Sumerian-French lexicon containing the signs, words and their values as used through the course formatted as a lexical network, using the methodology presented by (Lecailliez & Mangeot, 2018). As the script is logographic, we used special hyper-edges (see Figure 4, top) to encode information in a way that distinct meanings can be addressed by a unique id. Usage of hyper-edges allows to avoid the pitfalls of automated logographic character processing in linked data as explained in (Lecailliez, 2017). Figure 4 (top) shows a cuneiform sign (in black) with two meanings (shown in blue) with their respective transcriptions (red). Each of the hyper-edge links a character, its meaning and its transcription is associated with a unique id, shown in purple as a digit in the illustration. In the real dictionary GUID are used for the identity of edges and nodes of the lexical network.

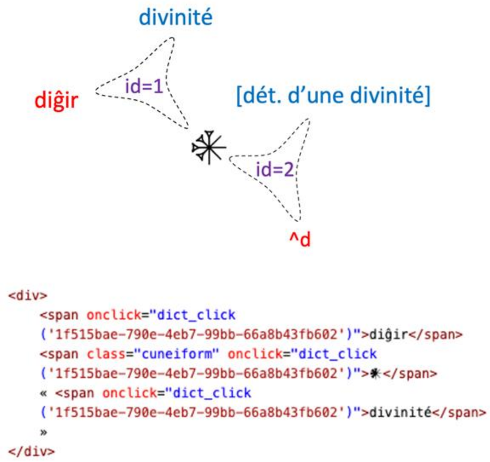

Figure 4. Hypergraph Modeling (top), HTML Encoding (bottom)

The bottom of the Figure 4 shows how the three parts (sign, meaning, transcription) are associated to each other in the HTML file of the lesson by linking the unique id (here *1f515bae-790e-4eb7-99bb-66a8b43fb602*) instead of the raw data itself. This method guarantees that when a click is performed on a word to query the dictionary, the data returned (here those associated with the meaning divinity) are the one expected in that context. Other meanings are displayed separately in a dedicated box of the dictionary.

3.3. Learning Analytics

A pedagogical problem common to courses taught online is that without analytics, the teaching staff doesn't know about the progression of students. The student itself might also be confused in where he stands in its learning.

For this reason, we integrated learning analytics into e-Dubba. After the user creates an account, he can log into the platform. Two user actions are automatically recorded by the system: pages that are browsed and dictionary queries performed by clicking on a Sumerian word in the text of a lesson. In comparison to the PDF version of the learning material, content is divided into more pages. This fine-grained division allows for more precise tracking of the student reading progression of the learning material. This could be reused for additional system features such as an integrated vocabulary review system, because repetition is one of the most important factors of vocabulary learning (Nation, 2017).

At this stage, the software components for dictionary lookup monitoring are implemented but visualization of progression as a student is not. So is the teacher page that should gather and present the reading progression of the student cohort, a simpler but similar in spirit of the dashboard presented in (Majumdar et al., 2019).

3.4. Possible Developments

The system currently focuses on the lesson material which is mostly in French with some Sumerian examples. Not included in the platform are exercises, most of which are translation homework's from a given Sumerian tablet. A possible and planned extension of the platform will be pages displaying the content of tablets in text form in addition to their photography. This would allow for additional features similar to those present in commercial online graded readers for Chinese that help readers to understand the text.

In particular, three types of information about a sign would be immediately relevant to the user: its pronunciation, translation and category (logogram, phonogram or determiner). The first two types of information are already present in the dictionary and the technique presented in Section 3.2 can be reused to provide contextual information of the words. The third information could be provided using a coloring scheme. The main difficulty lies in creating the text, which can be addressed using a web IME (input method). In addition, the integrated dictionary can be used to provide a provisional segmentation of a text thus removing the burden from the editor to manually segment the text and add most of the information pertaining to signs.

Finally, the platform can be adapted for other languages written using cuneiform script, such as Akkadian which is also offered remotely at the University of Strasbourg.

4. Conclusion

In this paper we presented e-Dubba, a web-based learning platform for French-speaking learners of Sumerian. The platform provides three main features which are innovative in the context of learning a language written using the cuneiform script. First, cuneiform signs are encoded using the Unicode standard making them easily paste-able into other applications. Secondly, we added a Sumerian-French dictionary to the system. By using it, learners don't have to rely on external systems for most of their vocabulary needs. In addition, it alleviates the complexities of the cuneiform script as used by Sumerian by providing the exact definitions of words and signs in the context in which they appear. Finally, a student can track its progression within the course thanks to the logging capabilities of the system. The teacher responsible for the course can monitor progression of the whole cohort of students.

The system is currently in development, with some of its features missing. When completed, it will be proposed to the students taking an online degree of Sumerian at University of Strasbourg for evaluation.

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Applied learning of artificial intelligence techniques by using the Gazebo simulator and Turtlebot3 multi-robot system

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Abstract: *Robotics became an important educational testing resource for different methods and techniques, especially from the artificial intelligence domain. Thus, either classical artificial intelligence methods (such as planning and scheduling methods, informed search strategies, knowledge based systems, intelligent agents and multi-agent systems) or computational intelligent methods (such as artificial neural networks, genetic algorithms, swarm intelligence and nature-inspired algorithms) have been applied in different real world or simulated systems that were developed by using educational robots (e.g. Khepera, Turtlebot, Pioneer, Nomad, LegoMindStorm). Various educational robot's simulation frameworks or integrated software tools have been developed so far (e.g. Webots, Gazebo, MiMicS, RoboNetSim). The paper focuses on some artificial intelligence techniques learned by using the Gazebo robot simulator and a Turtlebot3 multi-robot system. Details related to, for example, how is configured a multi-robot system, how is made the simulation of the multi-robot system are provided step by step in order to improve student learning process efficiency.*

Keywords: Educational robotics, Artificial intelligence techniques, Multi-robot system configuration, Robot simulator.

1. Introduction

The educational area has undergone significant changes in the past few years being impacted by Covid pandemic and technological enhancement, many courses being switched from traditional classes to online. The teachers adapt very quickly to these changes using online platforms to deliver the information needed, but the laboratories were the biggest problem. How can we move all the instrumentation and equipment's needed in online? How can we deliver to students the hand-on experience of a laboratory using an online approach?

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There are no simple answers to those questions. The only possibility is the development of virtual environments using simulator platforms and models for the equipment used in laboratory classes.

In this paper, we will present all the steps needed for creating a virtual learning environment for studying artificial intelligence using Gazebo simulator and Turtlebot 3 mobile robot. The simulating system will be developed using Robotic Operating System or ROS, an open-source platform dedicated to developing algorithms for robot's control. The advantage of using this platform is the fact that the methods developed in the simulator can be also used in a real multi-robot system.

Artificial intelligence is a fast-growing domain with vast applicability in many domains such as robotics, autonomous driving, economics and medicine. In the domain of mobile robots' artificial intelligence increases the capability of the robots to quickly adapt and explore unknown environments, make decisions and collaborate with other robots or humans.

The aim of this paper is to create an original method and to present the method of learning to students that want to start learning artificial intelligence, that can facilitate learning using a simulator in which the methods can be tested on a mobile robotic system.

Teaching artificial intelligence to students can be a challenging task but using a hand-on experience using a mobile robot such as Turtlebot 3 robot and Gazebo simulator could be a funny and easy to understand approach.

The paper is structured as follows: Section 2 presents a brief overview on multi-robot system modelling and simulation, the Section 3 presents the steps needed to install and configure the Gazebo simulator for simulating a Turtlebot 3 multi robot system and in Section 4 is presented a training scenario for artificial intelligence methods and some examples of methods to be used in the educational purpose. In the last section of the paper, we will present the conclusions and the future works.

2. Multi-robot system modelling: Case study Turtlebot 3 multi-robot system

In the past years, it was observed an increase in interest of using Gazebo and Petri Nets for simulating different environment for example in the paper (Kim et al., 2021) present a method for evaluating multi-robot formation control algorithms using a simulator developed in Gazebo or in the paper (Kloetzer et al., 2020) present a Petri Net simulation for path planning for robotic teams.

The modelling of a multi-robot system involves three main stages: design or choose a model for the multi-robot system, implement the model as a simulation and test it for various scenarios while doing model adaptation to the simulation results, and implement and test the final version of the model in a real-world multi-robot system.

Each stage tackles in detail the requirements related to robot coordination, robot communication and control and so on, according to the multi-robot system goal achievement (e.g. unknown environment exploration, autonomous driving or following a specific path in a very strict way inside a manufacturing plant). In this section, we will make a short overview on multi-robot system modelling and simulation.

From the variety of multi-robot systems models that were proposed in the literature, we mention three types: the multi-agent model, the Petri Nets based model (Stan & Oprea, 2020), and swarm intelligence-based model. A very short overview of some selected papers that use such models is made in this section.

Intelligent agents can easily model mobile robots due to their basic characteristics: autonomy, pro-activity, reactivity and social ability. Moreover, multi-agent systems which are systems composed of minimum two intelligent agents that have a common global goal and are embedded in a dynamic, usually, unknown environment, represent a straightforward model for multi-robot systems being distributed systems. Several research papers on modelling a multi-robot system as a multi-agent system were reported in the literature. For example (Calegari et al., 2020) in her systematic literature review point out that the agents and multi-agent systems (MAS) have been at the core of the design of intelligent systems since their very beginning, and their long-term connection with logic-based technologies, which characterised their early days, might open new ways to engineer explainable intelligent systems. We will take that point and we will extend further by giving new engineers the tools needed to develop the skills needed for creating intelligent systems.

For example, one of the challenging problems in mobile multi-robot systems is their control and coordination algorithm as is described in the paper (Ben-Gal et al., 2020) for large scale swarm systems or in (Stan, 2022) for small scale mobile robotic systems, the computational model of the system can be very hard to handle with a classical approach. The A.I. methods can be the solution for such systems, but almost all A.I. methods used for mobile robotics need advanced simulators and robot system models in order to do the training of the method in a medium close to the real environment.

For the simulator, we will use the Turtlebot3 Burger mobile robots. TurtleBot3 Burger is a small, affordable, programmable, ROS-based mobile robot for use in education, research, hobby, and product prototyping. The goal of TurtleBot3 developers is to dramatically reduce the size of the platform and lower the price without having to sacrifice its functionality and quality.

TurtleBot3's core technology is simultaneous localization and mapping (SLAM), making it the perfect choice for our application of developing and testing different A.I. methods into a simulated environment and to learn from results.

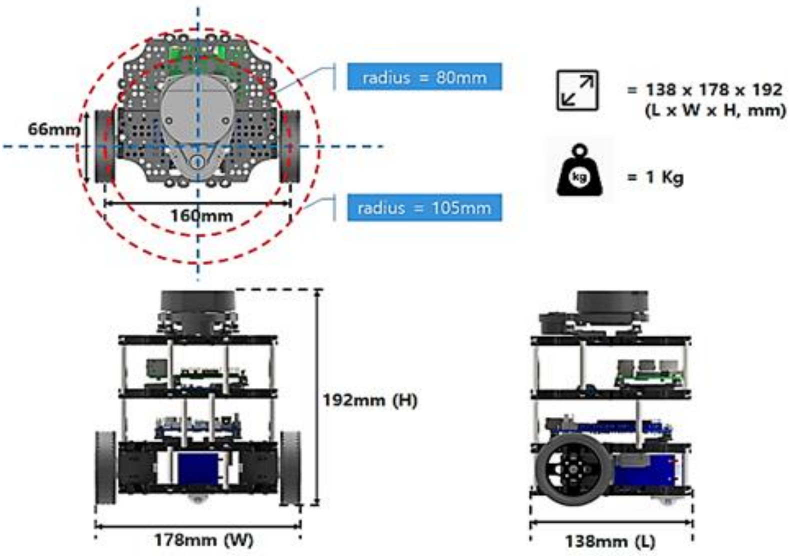

Figure 1. Turtlebot3 Burger robot specifications

In figure 1 is presented the Turtlebot3 Burger robot with the dimensional specifications. The system used in the simulator will be composed of three of these robots which can cooperate and communicate with each other in order to accomplish certain tasks.

For the modelling, we will consider the mathematical model of a 2 wheels mobile robot described in "Programming Robots with ROS" (Quigley et al., 2017) and the Turtlebot3 Burger model described in the paper the Turtlebot3 Burger model described in (Nica et al., 2021) as follows:

$$v_l = \frac{E_{lc} - E_{lp}}{T_e} * \frac{\pi}{180} \ (rad/sec) \quad (1)$$

$$v_r = \frac{E_{rc} - E_{rp}}{T_e} * \frac{\pi}{180} \ (rad/sec) \quad (2)$$

Where:

v_l- is the rotational speed of the left wheel

v_r- is the rotational speed of the right wheel

E_{lc}, E_{rc} - is the current value of the encoder of left/right wheel

E_{lp}, E_{rp}- is the previous value of the encoder of left/right wheel

Knowing that the radius of the Turtlebot3 Burger wheel is 65mm we can calculate the linear and angular speeds for our system:

$$V_l = v_l * 65 \text{ (m/sec)} \quad (3)$$
$$V_r = v_r * 65 \text{ (m/sec)} \quad (4)$$
$$\omega_k = \frac{V_r - V_l}{D} \text{ (rad/sec)} \quad (5)$$

Where: V_l, V_r- is linear speed of the left/right wheel and ω_k is the angular speed of the robot.

3. Install and configuration for Gazebo simulator

Gazebo is an open-source 3D simulator that provides realistic rendering of environments using high-performance physics engines such as ODE and Bullet. In that simulator we can model different types of mobile robots such as Turtlebot3, Khepera, etc and many types of sensors used alongside A.I. techniques such as laser range finders, cameras, Kinect, etc.

System requirements for Gazebo simulator are (source mathworks.com):

- Processor (CPU) - Quad core Intel® i5, or equivalent;
- Memory (RAM) – 4 GB or more;
- Graphics card(GPU) - Dedicated GPU with 1 GB or more graphics memory;
- Disk space – At least 20 GB free disk space.

For our example, it is also needed to install the Robotic Operating System (ROS) for the Turtlebot 3 Burger packages. Next in the paper, I'll present the installation procedure for booth ROS and Gazebo, bases on the documentation provided by the developer Robotis:

STEP 1: Install Ubuntu Ubuntu 16.04 LTS Desktop

STEP 2: Install ROS Kinetic

STEP 3: Install ROS Packages

STEP 4: Install Turtlebot packages and simulation packages from Robotis official documentation

STEP 5: Configure the env variables for Turtlebot 3 robot:

Modify the content of ~/.bashrc using nano or vi, the content is displayed in Figure 2.

```
export ROS_MASTER_URI=http://192.168.0.103:11311
export ROS_HOSTNAME=192.168.0.103
export TURTLEBOT3_MODEL=burger
```

Figure 2. Environment variables configuration for Ubuntu

For ROS_MASTER_URI and ROS_HOSTNAME use IP of the laptop/PC.
For the variable TURTLEBOT_MODEL use "burger".

STEP 6: Modify the ROS_MASTER_URI and HOSTNAME in ~/.bashrc

STEP 7: Install Tensorflow and Keras

1.Install Anaconda
2.Install ROS required packages
$ pip install msgpack argparse
$ pip install -U rosinstall empy defusedxml netifaces
3.Install Tensorflow
4.Install Keras

More information regarding the Turtlebot 3 packages can be found in documentation of the Turtlebot 3 from Robotis (Robotis e-Manual for Turtlebot 3-Open Robotics. https://emanual.robotis.com/).

Now, the Robot Operating System (ROS) and simulator Gazebo should be installed and configured to run the simulations for Turtlebot 3 multi-robot system. ROS together with Tensorflow permits the development of various A.I. algorithms in different languages such as Python, C or C++. Machine learning methods for robotic systems can be implemented and studied using the simulator Gazebo.

4. Training scenario for Artificial Intelligence methods using Gazebo simulator

The training scenario for the multi-robot system will be defined in Gazebo. We will use 4 different scenarios, with different grades of difficulties to train a Deep Q-learning method for environment exploration. On each step the simulator will generate a new objective location and the robots will try to reach that location.

The Deep Q-learning algorithm defines the learning rules for the intelligent agents using the next steps:

1. Initialize Q with a random value
2. For the current observation S select an action A with probability $\in$
$$A = arg_A max Q(S, A; \phi) \quad (6)$$
3. Execute action A, add reward R and store the next observation S'
4. Add experience (S,A,R,S') to experience vector
5. Take a sample of M experiences (S_i, A_i, R_i, S'_i) from experiences vector
6. If S'_i is the final state, set the value for the objective function y_i with R_i
$$y_i = R_i + \gamma max_{A'} Q_t(S'_i, A'; \phi_t) \quad (7)$$
7. Update Q by minimizing the values from experience vector
$$L = \frac{1}{M} \sum_{i=1}^{M} (y_i - Q(S_i, A_i; \phi))^2 \quad (8)$$
8. Update the value of $\in$ using the decay rate chosen

This is an example for one of the many artificial intelligence algorithms that can be applied in mobile robotics. Using these steps, we can implement in ROS, using C++ or Python, the control method for the simulated robot system.

Next, we will present in Gazebo the training arena for the algorithm using different difficulties. The four arenas presented in the simulation package provided by the Robotis and the complete documentation can be found in the official documentation on the Robotis website. The first one will be a 4x4 meters arena with walls and no objects for the first training scenario described in Figure 3.

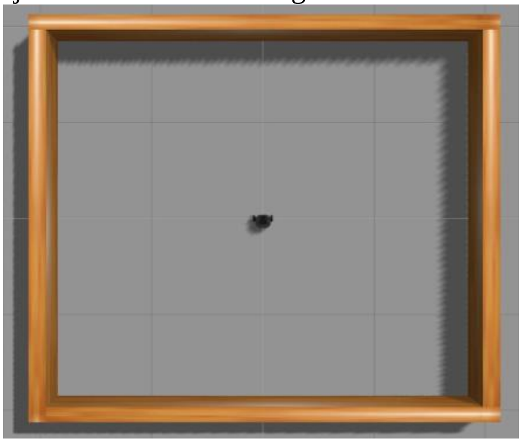

Figure 3. Training scenario 1 – no objects

The second scenario will have the same 4x4 meters map but this time with fixed round obstacles inside.

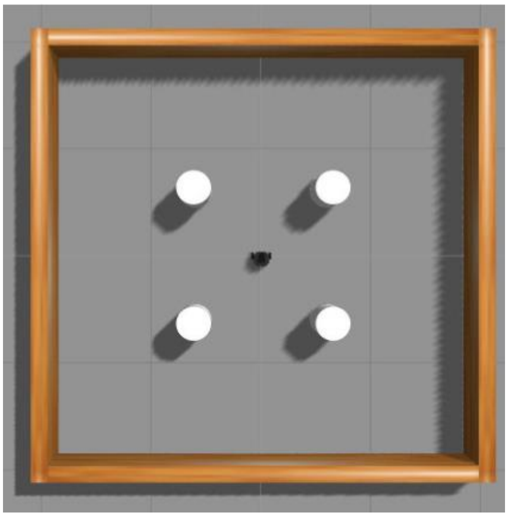

Figure 4. Training scenario 2 – fixed obstacles

As we can see in Figure 4, the robot start initial position is in the centre of the map and we have 4 fixed round objects inside. The objective location will be generated random on each step and the robot will try to reach that location without collide the obstacles.

Using the DNQ algorithm, in case of collision the robot will receive a big penalty and in case of reaching the objective the robot will receive a reward. By minimizing the experience vector, we will try to obtain the shortest path from initial location to the objective.

The next scenario will introduce the dynamical obstacles, represented by the same 4 round object, but this time the objects moves in a circular path.

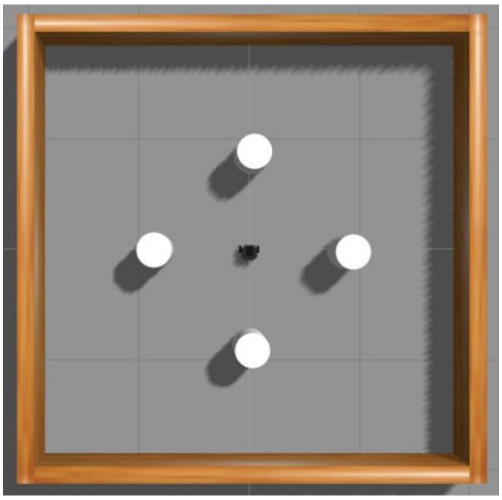

Figure 5. Training scenario 3 – moving obstacles

In Figure 5 we can see the obstacles and the robot's initial position. The rules are the same but now the training time for the DNQ algorithm will be longer due to the complexity introduced by the moving obstacles.

The last training scenario is the most difficult and simulates the real environment. The map this time is a maze type map with a wall inside and two random moving obstacles. The map is presented in Figure 6.

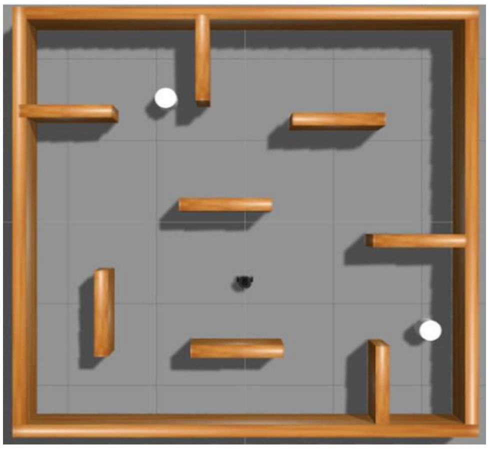

Figure 6. Training scenario 4 – maze with moving obstacles

5. Conclusion and Future Work

In conclusion, we can say that the virtual environment presented in this paper can be used for studying and developing artificial intelligence-based methods and can be tested using the Turtlebot 3 mobile robot system. ROS and Gazebo simulator offers good interoperability with new technologies used in AI such as Tensorflow and Keras and also offers the possibility to develop in many popular programming languages such as Python and C++.

As we have shown in the section 4, Gazebo offers the tools for creating a very detailed environment for training and testing machine learning methods with many pre-build libraries and objects to easily deploy objects or interactive agents such as the robot Turtlebot 3.

As further work, I intend to use this virtual environment to develop and study machine learning methods for environment exploration using a multi Turtlebot 3 robot system.

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Autonomous Digital Language Learning in Higher Education. The DIAL4U Erasmus+Project

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Abstract: *This paper aims at documenting some important aspects related to the process of teaching foreign languages in an online/hybrid university environment in Romania. The focus is on describing the online reality of foreign language instruction in Romania, sharing information on a series of observed challenges that language instructors and learners have had/need to focus on, and comparing and contrasting analysis of a selection of answers provided by teachers in Higher Education (HE) on various aspects connected to digital language instruction. The paper draws on theoretical research in the field of online/hybrid education, using the DIAL4U (Digital pedagogy to develop Autonomy, mediate and certify Lifewide and Lifelong Language Learning for (European) Universities) project to collect and analyse relevant data regarding the language instructors' perception on the use of digital apps and tools in the teaching process. Emphasis is also placed on how teachers acknowledge and use metacognitive and face management strategies as instruments of digital pedagogy. The research was based on a questionnaire which provided valuable qualitative and quantitative data. The results focus on the development of digital skills pre- and post-pandemic and preferences for certain resources, tools and apps, while also correlating these tendencies with metacognitive and pragmatic politeness strategies. The potential outcomes would be to identify creative solutions and design open educational resources to effectively teach online/hybrid language classes.*

Keywords: online/hybrid learning, learning foreign languages, Higher Education (HE), Open Educational Resources.

1. Introduction

Foreign language instruction in the online and hybrid higher education environment is rooted in the mediation of contents through language and digital apps and tools. Within the COVID-19 context, language instructors were urged to

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adapt their contents, methods and strategies to a new teaching scenario, in which digital pedagogy gained new dimensions and was reconfigured to accommodate learners' academic and emotional needs. Within the Romanian context, there were many challenges that occurred along the process ranging from limited technical support and training to redesigning academic content and the teaching-learning-assessment process. Additionally, an important challenge that had to be addressed was the lack of effective frameworks that encourage and support online learner engagement and academic achievement. Moreover, faulty communication among faculty members/departments (caused either by lack of uniformity in terms of used platforms and tools, by resistance to use and implement multimodal contents or by teachers of digital literacy) has also impeded on the online foreign language instruction process.

Attempting to respond to these challenges, various projects were conducted and DIAL4u (Digital pedagogy to develop Autonomy, mediate and certify Lifewide and Lifelong Language Learning for (European) Universities) is a good practice scenario, bringing together eight partner universities to provide tested solutions to online foreign language instruction. The aims of the project are to develop the digital culture of language teachers and their ability to use it for didactic purposes, to implement digital tools for language learning, to recognise and validate knowledge, skills and competences acquired in formal and non-formal contexts, and to motivate learners to use open educational resources in preparation for lifelong and lifewide learning.

The project was proposed in 2020 (and accepted in 2021) as a response to particular needs of higher education language instructors, who had identified a lack of structure in the framework of digital pedagogy in online foreign language instruction. Considering that online instruction was an immediate and temporary solution triggered by the COVID-19 context, the DIAL4U project sought to identify strategies and design digital content customised for new learning paths, foreseeing directions of instruction development for both online and hybrid scenarios.

The digital deliverables designed by the Babeș-Bolyai University team (in co-leadership with the Mikolo Romeris University in Lithuania) include a database on both formal and informal digital content for language learning mediation and online educational resources (metacognitive and online face management toolkits, glossary of apps and tools, teaching sequences showcasing the use of apps and tools and addressed to language instructors and students). The questionnaire addressed to language instructors represents a starting point catering for the needs analysis necessary for designing a set of creative solutions and OER that could provide a structured digital pedagogical framework for future technologically enhanced language instruction.

Having analysed the instructors' responses, we consider that providing a detailed guide of how various apps and tools that can be used in foreign language instruction constitutes a valid approach to digital pedagogy development and implementation in Higher Education (HE) Romanian institutions. At the same time, the needs analysis indicated a scarcity of background regarding useful strategies in the process, metacognitive and face management strategies being among the most significant mechanisms of promoting social and emotional learning and enabling teachers to facilitate autonomous learning.

The current paper aims to discuss the Romanian language instructors' perspective on the use of digital apps, correlating the online language instruction process with metacognitive and face management strategies with a focus on supporting and empowering learners. The theoretical framework covers aspects pertaining to Pedagogical Digital Competence (PDC) and the use of the Social and Emotional Learning framework in the support of language learning mediation. The following part presents the Methodology (purpose of the study, participants and procedure, research instruments and hypotheses) and is continued by a section which analyses and discusses the results and answers. The interpretation of results allows for some preliminary conclusions and sketches further directions of research.

2. Theoretical Framework

New technologies embedded in teaching foreign languages triggered the reconfiguration of the academic teaching content and led to the design of more interactive synchronous and asynchronous activities and to the increase in language learner autonomy. They also enabled language instructors to customise the strategies and methods by integrating digital apps and tools in the teaching, learning and self-assessment process. More than reshaping the academic content, language instructors were required to update their 21st-century skills, particularly since "digitalization has increasingly introduced a new dimension in teachers' pedagogical skills and competences which we have chosen to call Pedagogical Digital Competence (PDC)" (From, 2017: 43). The underlying argument is that pedagogical digital competence should be an integrated skill in all taught disciplines as digital competence has become a basic competence in all subjects and at all levels (Krumsvik, 2014). PDC should be thus a prerequisite for hybrid and face-to-face teaching in language instruction, meeting the learning needs of digital native students (see Prensky, 2001). Furthermore, PDC should be an integrated skill that must not be limited to the teaching framework generated by the COVID-19 crisis situation and that should be transferred to accommodate students' evolving identities in digitised society as "education cannot be detached from ICT" (Edelhauser, Lupu-Dima, 2020: 4).

The need for a tailored digital pedagogy in foreign language instruction stemmed from the reality in which language teachers, exposed to a plethora of apps, were in need of a specialised digital pedagogy background. In this respect, Zhu and Liu argue that "long-term integration of online teaching and learning into university curricula implies further attention to quality" (Zhu & Liu, 2020: 697), which emphasises the stringent requirement that language instructors master accurate PDC before delivering instructional content in a digital or hybrid framework. Additionally, the use of digital tools also facilitates the development of multiple literacies for both teachers and learners. As such, “in the online learning environment where digital resources are extensively used, teaching practice should acknowledge the different types of literacies: digital literacy, multimodal literacy, critical literacy and multicultural literacy” (Pop, 2020: 82-83).

Making use of the PDC also entails the accurate choice of language teaching resources (text, audio, audio-video, visual aids, interactive materials). At the beginning of the COVID-19 teaching crisis scenario, in Romania there was a practice of predominantly using text in a digital format or simply using the videoconference platform to enable communication with learners, which does not qualify as online teaching (Pedagogia Universitară în pandemia COVID, 2020). This also indicates an incongruency with the basic principles of digital pedagogy, which streamline an accurate use of digital technologies in collaborative and interactive academic tasks, design and production of digital content, selecting and tailoring content for specific teaching situations, and the involvement of students as active participants. In the same line of thought, the use of apps and tools in online language teaching should be made with suitable documentation regarding a digital pedagogy framework.

During COVID-19, a tendency to use apps that were available for free was noticed, even though some such apps were designed for primary and secondary education learners and for all the subjects included in the school curriculum (see also Zalat, Hamed, Bolbol, 2021; Grosseck, Holotescu, Andone, 2020; OECD, 2020). Moreover, most of these apps (Kahoot!, Quizizz, Quizlet, Learningsnacks, Wordwall) aim to gamify the teaching-learning process and gamified learning may well compensate for the lack of face-to-face interaction and add to the dimension of both collaborative learning and enable a positive competitive learning environment.

One aspect of online language instruction that became more stringent in the pandemic context was that language instructors assumed the role of facilitators, by coordinating students rather than the traditional method of assigning practical tasks in the form of fill-in-the-gaps, multiple choice, cloze or word formation exercises. Having experimented with various apps in different teaching scenarios (Kahoot for vocabulary practice, Quizlet for introducing and revising new concepts and terms, TedEd for reading and listening tasks etc.), language instructors explored the wider potential of apps and tools, by putting them into practice to facilitate autonomy for more empowered learners. With an increased role in language instruction, “learning autonomy represents the main ingredient in empowering students with the necessary tools and strategies to continue learning in other settings, non-formal or informal ones” (Cotoc & Pop, 2022: 119). In these new settings, language instructors take on the role of creating adequate learning contexts for specific activities, in which students can understand and acquire new content (grammar, vocabulary, concepts, theories), use it in skill-specific tasks, engage in self- and peer-assessment activities and produce digital learning content (presentations, posters, essays, storytelling). They also facilitate the use of digital cognition in the course of which “the scenes of knowledge construction are online platforms, where it is possible to form the most varied connections” and “the strategy of knowledge construction is problem-solving mediatized and facilitated by the educator” (Szőke-Milinte, 2021: 11).

In the framework of class interactivity as facilitated by the integration of apps and tools, the customisation of skill-specific tasks is dependent on the type of activity/skill, the affordances of the app and the instructor’s willingness to use new technologies and his/her digital literacy level. Regarding the type of activity/skill involved, receptive skills (reading and listening) allow for a wide range use of apps, but are quite limited in terms of interactivity among learners. On the other hand, for the productive skills (speaking and writing), apps enable interactivity and collaboration even more, creating a more resourceful learning context than in face-to-face instruction.

Social and Emotional Learning represents a useful framework against whose backdrop foreign language instruction may occur as it regulates language production, language proficiency, emotional intelligence and intercultural competence development. Online and hybrid learning environments have been blamed for being detrimental in terms of the emotional connection that is considered necessary particularly in the context of learning and teaching languages. While we acknowledge this downside, it is our stance that increased focus on metacognition training can improve online classes, helping students to stay more focused in class, to gain autonomy and responsibility for their own learning. Moreover, metacognitive strategies can improve exam performance and can be transferred to any subject or cognitive task.

The main metacognitive strategies we had in mind are planning (what learners do before the task), monitoring (what they do while solving the task) and self-evaluation (what happens after the task has been completed). During planning, students may ask themselves what they are required to do, what strategies they may use, but also more specific questions that depend on the particular task being addressed. During the monitoring stage, students may wonder if the strategy they are using is working, if they need to make any changes in terms of their approach. Last but not least, the self-evaluation stage is when students should ask themselves how they performed, what went well and what did not and what they may do in the future when confronted with similar tasks.

Metacognitive strategies are teachable (Hattie et al., 1996; Swanson et al., 1999; Dignath et al.,2008) and metacognitive training in language learning is necessary for instructors to empower learners to use strategies effectively and efficiently (Raoofi et al., 2014). Thus, it is relevant to highlight language instructors’ attitudes towards encouraging students to use metacognitive strategies in online classes.

Our study also acknowledges the role that pragmatic politeness plays in achieving a *quid pro quo* in communication that respects interactants' needs for autonomy, interdependence and collaboration. In Brown and Levinson's view, politeness is *universal and a highly rational phenomenon* (1987). Politeness is founded on linguistic and non-linguistic behaviour that is employed in interactions where Face Threatening Acts (FTAs) occur.

The rapport management theory (RMM) (Helen Spencer-Oatey, 2000 onwards) further and generously contributes to the politeness theory conceptualisations by focussing on the analysis of the relational aspect of social interaction and not just on the linguistic aspects that lead to polite strategies use. Focussing on relational management becomes an important pedagogical tool as the switch is moved onto a hearer-centred approach to politeness rather than a speaker-centred approach (Helen Spencer Oatey, 2015). Rapport management is crucial to academic foreign language instruction as the achievement of our interactional goals can only be executed through a collaborative *give and take*. The negotiation of meaning becomes a strive for consensus and engagement.

Moreover, anxiety is commonly researched in relation to its impact on students' motivation as it is a rather obvious psychological factor influencing students' oral discourse and speaking competences in foreign language instruction. The existing connection between effective foreign language production and anxiety has been analysed (Ely, 1986; Krashen, l985; MacIntyre, 1995) and Oflaz A. (2019) for example, details the effects of students' anxiety, their shyness level and adopted language learning strategies on their speaking skills and overall academic achievement.

3. Methodology

3.1. Purpose of the Study

The purpose of the study is to explore the attitude of Romanian foreign language instructors towards the use of digital tools and apps in the framework of digital pedagogy and to identify possible patterns in their approach regarding metacognitive and online politeness.

3.2. Participants and Procedure

A number of 104 participants were involved in the research. The majority were female (94.6%), 5.2 % were male, and 0.2% did not mention gender. The mean age was 34.55 (SD = 9.43). The study used the survey research method and collected both quantitative and qualitative data. The data were collected via Google Forms targeting the timeframe spring 2020-autumn 2021, given that the timespan accounts for two milestones in the online language instruction context in Romania. On the one hand, 2020 represented the moment of the abrupt transition to exclusively online teaching and learning scenarios, in which neither instructors, nor learners had any consistent and structured digital pedagogy knowledge. On the other hand, the end of 2021 marked the moment when instructors had already gained sufficient experience in online instruction patterns to acknowledge particular needs for reconfiguration of content, strategies and methods.

The participants completed the questionnaire in approximately 30 minutes. Participation was voluntary and the participants were informed about the confidentiality of any sensitive information and they granted their informed consent. The quantitative data obtained were statistically analysed using IBM SPSS ™ software, and since the research instrument that we used is not standardised, we used a cut-off point of -1/+1 mean standard deviation performed with Visual Binning in SPSS for setting the cut-off points. The qualitative data were processed using content analysis under certain categories.

3.3. Research Instruments

The participants were asked to fill in a survey containing 56 items designed to assess language instructors' backgrounds and perceptions regarding: the demographic characteristics, the use of tools and apps, the level of digital pedagogy skills, the use of metacognitive strategies, and the student/teacher online face management. The majority of the items were designed on a 5 point Likert scale, where 1 represented *strongly disagree* and 5 *strongly agree,* but also as dichotomic and open questions. To identify the internal consistency of the survey, we have calculated Cronbach's Alpha = .85. Therefore, taking into consideration the value of Cronbach's Alpha, our research instrument is relevant and consistent.

3.4. Research Hypotheses

Our study targeted the following research hypotheses:

1. There is a significant increase in the development of HE instructors' digital skills from the beginning of the pandemic until the moment when the questionnaire was completed;
2. Language instructors customised their activities using resources and apps according to their instructional goals;
3. Higher education language instructors limit the emphasis on metacognitive and face management strategies to encourage more autonomy and engagement.

4. Results and Discussion of Results

The analysis presents a selection of the data collected, placing findings in line with the research hypotheses, and aims to show the respondents' perception of the utility and didactic potential of apps and tools in online language instruction. Another aspect to be considered is the awareness that higher education language teachers have regarding metacognitive and face management strategies along the process of teaching, as well as the overview of how they embed these strategies in order to obtain learner autonomy.

Related to the Digital pedagogy and Digital apps and tools, two questions were selected so as to indicate the development of teachers' digital skills in the specific timeframe: *Q9. How do you assess your digital skills at the beginning of the pandemic?; Q10. How do you assess your digital skills now?* The responses were analysed and a comparison was drawn, showing that language instructors perceive a significant difference between the level of digital skills at the beginning of the pandemic (moment 1 - M1) and the level of digital skills at the moment when the questionnaire was applied (moment 2 - M2). A paired statistical data was performed and can be seen in Table 1 and Table 2 below.

Table 1. Paired Samples Test

	N	Mean	Std. Deviation	S.E. Mean
M1 → M2	104 → 104	3.13→3.78	.78 →.59	.08 →.06

Table 2. Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	S. E. Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
M1 → M2	-.64	.59	.06	-.76	-.53	-11.14	103	.000

It has been found that **a significant difference** *(t* = -11.14, *df* = 103, *p* = 0.000) was perceived between the level of digital skills at the beginning of the pandemic (M = 3.13, SD = 0.78) and the survey completion timestamp (M = 3.78, SD = 0.59). This means that the instructors consider that the pandemic positively influenced the development of language instructors' digital skills, due to the fact that they had to use digital platforms and apps. While other studies show there is effectiveness regarding the design of online courses and the facilitation of students' learning while using digital tools (Ma et al., 2021), as a multi-tool teaching-learning system (Andronache, 2022), our study focuses on instructors' perceived gain in digital skills within the context of PDC.

When asked about the extent to which teachers used particular resources to develop learners' language competence (*12. How much do you use the following types of resources to develop learners' language competence in the foreign language that you teach?),* respondents could opt for multiple resources in their answers. The majority indicated a preference for text and audio, 90 respondents choosing text (textbooks, literature etc. in hard copy/ digital resources) and 84 choosing audio resources. Audio-video resources (films, animations, videos, TED Talks etc.) were selected by 80 respondents, whereas visual aids (Power-Point, Prezi etc.) were selected by 69 responses. The least used resources were interactive materials (Wordwall, Nearpod, PearDeck etc.), with 41 responses (see Figure 1 below).

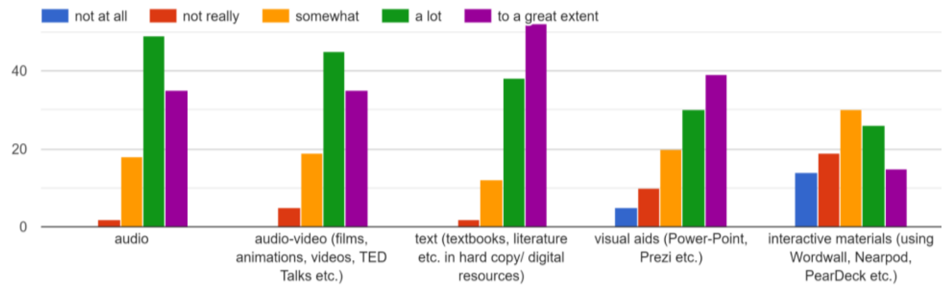

Figure 1. Most Used Resources for Digital Language Teaching

The results show that despite the increased availability of digital technologies, text and audio still represent the main resources used by language instructions. Teachers relied on what they already know in terms of pedagogical approach and the electronic versions (pdf/doc/docx) of textbooks/coursebooks/ handouts/images/PowerPoint presentations. The adaptation of the academic content to the new resources requires digital skills, digital cognition, PDC, and time which were readily available at the moment when teaching was fully transferred. For example, by sending a text-based resource, using a video-conferencing tool mainly for unidirectional transmission of the content or sending a recorded lecture in an audio-video format, the principles of PDC were not covered. Regardless of the age and teaching experience of the respondents, the choice of interactive materials was last on the list of preferences even if they were the most suitable means to ensure learner autonomy, interactivity, peer and self-assessment and even if they could have been complementary to visual aids, text and audio. A mirroring perception was identified in another study conducted among language learners, who "indicated a strong preference for the video conferences (synchronous meetings) (70.4 % first-year respondents and 90 % third-year respondents). This stands as proof for the fact that even if learning apps are useful tools, they need to be complemented by human agency and interaction" (Cotoc, Pop, 2022: 130).

Regarding the use of resources in foreign language classes, the answers to Q14 *How much do you use the following resources in your classes?* provided a top of most and least used resources. Language instructors referred to Online dictionaries, Kahoot!, Whiteboard, Liveworksheets, Quizizz as the most popular and frequently used digital resources, whereas the top least used resources are: iCivics (102 respondents), Chatterpix (101 respondents), Wallwisher (101 respondents) and Intothebook (100 respondents), Minecraft (99 respondents).

Findings regarding the top five most used resources show that only two of the specified digital resources (Kahoot! and Quizizz) encapsulate the gamification and interactive dimension, whereas the other resources are simply the electronic version of dictionaries (Online dictionaries), boards (online Whiteboard) and handouts (Liveworksheets).”Through gamified assessment there are various opportunities for students to learn collaboratively, to use peer-assessment as a pedagogical tool and respectively to increase motivation along autonomous learning” (Albert, Mudure-Iacob, 2021: 8197) We consider that the predominant choice, Online dictionaries, constitutes an unexpected outcome as such dictionaries are online repositories that do not have interactive features and that do not activate digital cognition either. Likewise, the majority of these resources are usually employed in the teaching and practice of vocabulary, indicating that many language instructors focused mainly on developing vocabulary micro-skills to the detriment of other language skills. In contrast, the top least-used resources show a tendency to avoid gamification (iCivics and Minecraft) in the language instruction process and use the apps which are more popular and which were presented in online trainings and webinars. Some of the indicated resources might have had a more popular alternative that was used by teachers: Padlet instead of Wallwisher, for example.

When asked about what type of apps and tools can enable students to connect more interactively in class, *Q18. Are there any particular apps/tools you think that enable students to connect more interactively to the course/ you? Can you mention 1-3 examples?*, respondents referred to various popular apps which are included in the word cloud that can be seen in Figure 2 below. We notice that these apps can be categorised into: interactive gamified quizzes (Kahoot!, Quizizz), poll-creator tools (Mentimeter, Slido), escape room apps (Genial.ly, Google Forms), community building and networking platforms (Padlet, Flipgrid, Miro) and competitive environment-oriented apps (Nearpod, Quizlet). Taking the example of Liveworksheets, which merely provides the online alternative to a handout, the degree of interactivity of some of these apps is however debatable.

Figure 2. Apps/Tools that Enable Interactivity

When asked about the extent to which apps were used to develop learners' language competence (*Q11. How much do you use apps to develop learners' language competence?)*, 36.5% of respondents said they used them in more than half of their classes and 26.9% in almost all of their classes. Using the Pearson Correlation ($r = 0.70$, $p < 0.05$) to analyse Q11 and Q30 (*How much do you encourage students to use metacognitive strategies in online foreign language classes?*), it is shown that teachers who use apps in online classes tend to encourage students to use metacognitive strategies.

Another interesting finding is that teachers who feel anxiety in the context of teaching online, tend not to encourage the use of metacognitive strategies, as shown by the Pearson Correlation ($r=-0.68$, $p<0.05$) of Q39 (*Have you felt communication related anxiety when teaching online?*) with Q30 (*How much do you encourage students to use metacognitive strategies in online foreign language classes?*).

Q39 (*Have you felt communication-related anxiety when teaching online?*) and Q40 (*If you felt communication-related anxiety when teaching online was: a. student-related; b. teaching style related; c. technical aspects related*? detail the existence of anxiety in online teaching of foreign languages as perceived by language instructors. 64.4% of the Romanian respondents (104 answers in all) stated that they had experienced anxiety in their online teaching whereas 35.6% answered this question negatively failing to identify anxiety as a relevant variable.

Consequently, when asked to highlight the reasons behind the perceived anxiety, the respondents' answers (78 answers) have been categorised as follows: 39 answers (50%) have identified student-related reasons, 25 answers (32.1%) have revealed that their anxiety is related to their teaching style whereas 55 answers (70.5%) connect their perceived anxiety as being inadvertently connected to technical aspects.

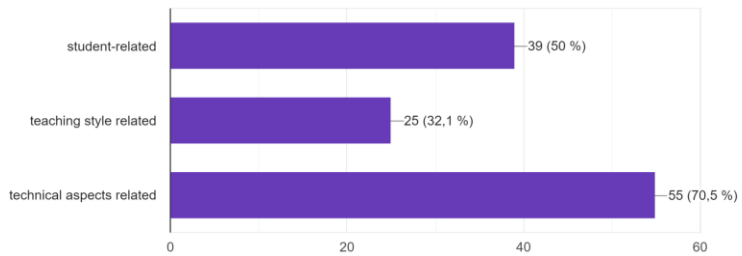

Figure 3. Anxiety-related Reasons when Teaching Online

Issues such as a valid Internet connection, access to online/hybrid resources, operational command of video conferencing platforms and various purpose-built apps as well as digital literacy skills may all be included under technical issues identified as conducive to instructors' anxiety in foreign language academic instruction.

The study has also focused on the existing correlation between the level of digital skills and the instructors' perceived anxiety when teaching online (a lack of a very high correlation). Nevertheless, we have identified a rather significant negative correlation between the level of digital skills at the beginning of the pandemic ($r = -.15$, $p < .05$), the level of digital skills upon completion timestamp ($r = -.15$, $p < .05$) and anxiety level perceived by the teachers. Thus, we may conclude that the lower the level of instructors' digital skills, the higher the experienced anxiety. Despite the challenges of such a dynamic context, our study has succeeded in analysing language instructors' perception of the usefulness of apps and tools in academic instruction, as well as the necessity of implementing metacognitive and politeness strategies that facilitate autonomous learning, relational collaboration and redefine the pedagogical framework in Romanian HE.

The core of our research has been articulated around three hypotheses that have resulted in different degrees of validation, contributing to a valuable snapshot of the Romanian HE context of digital pedagogy. Our first hypothesis (*1. There is a significant increase in the development of HE instructors' digital skills from the beginning of the pandemic until the moment when the questionnaire was completed*) regarding HE instructors' digital skills has been validated as our data show that the COVID-19 context triggered an increased awareness and consistent use of digital skills from the beginning of the pandemic until the moment when the questionnaire was completed. In what concerns the second hypothesis (*2. Language instructors customised their activities using resources and apps according to their instructional goals*), partial validation was obtained. Our study concludes that such tailoring is context and time-bound: instructors' willingness to integrate and develop apps and tools in the instruction, to apply their digital skills to content, urgency generated by the rapid switch to online instruction, time constraints, lack of standardised codes of good practice. The results obtained validated the third hypothesis to a certain extent *(3. HE language instructors limit the emphasis on metacognitive and face management strategies to encourage more autonomy and engagement*). Foreign language instructors are insufficiently aware of the benefits metacognitive strategies and online politeness strategies pose in online teaching scenarios.

5. Conclusions and Further Directions

The present study aimed at analysing foreign language instructors' perception regarding the online teaching and learning of academic content to identify the newly-emerged needs that language instructors have. It is also the purpose of this study to recommend future developments related to training and lifewide learning, which may be consequently implemented into a coherent pedagogical digital competence framework. The added value consists of the activation of digital cognition to support the metacognitive and face management strategies as PDC tools in language instruction.

Our contention is that academic instruction in Romania is in its formative stages in what concerns the effective and full use of apps and digital resources, whereas metacognitive and politeness awareness on the part of instructors is in need of attentive consideration. In our study, we have observed the need to provide controlled and verified support in the form of comprehensive glossaries that go beyond a simple enumeration and include pedagogical guidance and implementation suggestions, toolkits that regulate the implementation of metacognitive and politeness strategies for the benefit of instructors and learners alike.

There is a high value in delegating responsibility for students to create their own digital content (their own Kahoot, Quizlet, Padlets etc.) as OERs and as instances of digital cognitions. The added value in this type of student-centred tasks and self-reflection could be conducive to implementing filtering mechanisms that could support foreign language instruction.

There is a need for creating a considerate teaching and learning digital framework that includes emphasis on metacognition and pragmatic politeness.

Since metacognition has long been recognized as a key factor in any type of learning, it is no longer a question of whether teachers should be training students to use metacognitive strategies, but a matter of how to do so effectively. Future research should focus on how to embed metacognition training into curricula. Additionally, politeness and face management strategies are to be tapped into in the foreign language class and we suggest that HE instructors may start from raising students' awareness as to what significant benefits politeness encompasses, practising politeness strategies in communicative activities as well as enabling learners to create and maintain their own e-face in online exchanges by protecting both their own face needs and the interlocutors' face wants and needs.

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Section 3

Disrupting Education with Emerging Technologies

Experiment My Shape. E-learning in 3D Virtual Environments for Design and Architecture

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Abstract: *The period of the Covid pandemic has posed a significant challenge to education in visual arts, such as interior design or architecture, where subjects such as "spatial organisation" and the shape of objects are not well suited for online discussions. The solution that the present multidisciplinary team found during its research work was to immerse teachers and students under the form of digital avatars in a 3D virtual environment, designed according to a research theme, e.g. Early Modernism Design. Within the virtual space a lesson can be taught about the 3D real shape of the historical objects, like the Bauhaus furniture. The Virtual Learning Environment (VLE) was implemented on the Mozilla Hubs 3D online platform and was named "Experiment my shape!". The 3D models of the pieces of furniture were imported from Sketchfab, one of the most used online libraries of 3D models. After experimenting with this virtual environment for online teaching at the Interior Design MA level of the National University of Arts Bucharest, teachers and students recognized its pedagogical efficiency and recommended it as an effective e-learning tool for students in Design and Architecture.*

Keywords: Virtual Learning Environment (VLE), interior design, 3D models, visual perception, Mozilla Hubs.

1. Introduction

The period of the pandemic and associated restrictions led the authors to seek alternative ways of teaching and learning for the interior design and history of design at the National University of Arts (UNA Bucharest), some of the difficult subjects to be discussed online being those of the real shape of the objects. Online

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3D virtual environments were considered as a viable alternative, considering the previous experience of the authors (Stefan, 2012; Gheorghiu & Stefan, 2018; Gheorghiu & Stefan, 2019; Motaianu, 2021; Stefan & Motaianu, 2022) as well as the specifics of design classes that require visualisation and analysis in 3D space.

In addition, in the post-pandemic period, distance learning is no longer an exception, but a reality that must be taken into account. Therefore, online solutions must be developed even in non-pandemic conditions to benefit from technological advancements in the field of online 3D platforms and "metaverses" ("universe of universes") (Dionisio et al., 2013; Park & Kim, 2022). These platforms present an essential feature to be used in multi-user distant learning, namely the simultaneous presence of a large number of participants without a decrease in performance. On the other hand, several authoring tools and online repositories of 3D objects, available free or under the Creative Commons licence, are currently available. In recent decades, Virtual Learning Environments (VLEs) have been used extensively in distance learning. Several research works have discussed the affordances of VLEs (de Freitas, 2008; Annetta et al., 2010).

The online 2D environments, such as Google Meet (2022), are still viable and used within the hybrid learning/teaching model but have proven to be limited in their capacity to support visual arts education.

For the “Objects-Spaces-Cultures” class regarding design objects/pieces and decorative art, in which access is difficult, or even impossible, to the objects that must be studied, the present multidisciplinary team proposed an innovative solution using Mozilla Hubs (2022), a free, web-based 3D platform, to create a Virtual Learning Environment (VLE) for teaching and learning purposes.

The VLE (named "Experiment my shape!") is one within which a lesson can be taught about the shape of virtual objects that copy authentic ones, and also a personal study can be performed by students by experiencing in 3D the real shape of the historical objects, such as the Bauhaus furniture.

For the first experimental stage, the multidisciplinary team proposed a virtual space to be used both as a meeting place for the teachers and students, and as a space for displaying the pedagogical material, by placing historical furniture objects, in this case, objects created within the Bauhaus School, as well as explanatory materials, such as texts and posters. This virtual space was taken from the collection of predefined 3D scenes, offered by Mozilla Hubs, and edited with the help of the Mozilla Spoke editor, so as to create an architectural space that respects the architectural principles specific to the Modern period of the third decade of the 20th century.

The expected benefits were firstly the observation and analysis in 3D of the objects that are the subject of teaching/learning, and secondly, the interactivity and communication facilities, through which students could ask questions or formulate a personal opinion.

The paper sections will present the following:

- The authors' description of the research work in relation to similar work and domain status;
- An analysis of the learning affordances that can be leveraged using Mozilla Hubs;
- The detailed implementation of the "Experiment my shape!" VLE;
- The presentation of the results of a demonstration and survey conducted with students.

The paper will conclude with lessons learned and future research.

2. Research Background

2.1. Current Online 3D Platforms

Current online 3D platforms that can be used to develop immersive virtual worlds can be categorised as legacy platforms (González et al., 2013), such as SecondLife and OpenSimulator, as game engines such as Unity3D, and modern platforms, such as Mozilla Hubs.

OpenSimulator (2022) is an open-source, free, 3D multi-user platform, which allows easy content creation and user communication, and is recommended for building online virtual worlds and communities. Despite the numerous virtual worlds hosted, including virtual universities (González et al., 2013), in terms of usability and ease of access, OpenSimulator has several limitations, such as the requirement to be accessed using a client application.

Unity3D (2022) supports advanced 3D capabilities, such as 3D simulations, Virtual Reality (VR), Augmented Reality (AR) or Mixed Reality (MR) scenarios, animations and cinematics. Unity3D requires programming skills, which recommends it for the development of games and complex educational projects.

Mozilla Hubs is a multi-user, open-source platform (2022) which benefits from increased performance due to the inclusion of modern technologies, such as WebVR and WebXR, directly in the web browser. It does not require the installation of any additional software and it is optimised for the Firefox browser. Mozilla Hubs is customisable for different purposes, and at the current stage of development, it is offered for usage at no-cost. The Mozilla Hubs platform can be accessed from different devices, including VR headsets.

For specific purposes, it is worth mentioning platforms such as Artsteps (2022) or Kunstmatrix (2022), which offer hosting for virtual exhibition-type projects.

State-of-the-art level of current technologies, including Artificial Intelligence (AI), are the "digital twins" which can be defined as virtual representations of the real environments, with the purpose of supporting high-qualified activities, training or virtual simulations (Park & Kim, 2022; Microsoft Mesh, 2022).

2.2. Virtual Learning Environments

Virtual worlds are “crafted places inside computers that are designed to accommodate large numbers of people” (Castronova, 2005). A 3D virtual world is “a synchronous, persistent network of people, represented. as avatars, facilitated by networked computers” (Bell, 2008). A 3D virtual world (3DVW) is defined as “a computer-simulated electronic 3D virtual environment that users can explore, inhabit, communicate, and interact with via avatars, which are graphical representations of the users” (Ghanbarzadeh et al., 2014).

A 3D Virtual Learning Environment (VLE) is a virtual world designed for educational purposes (Loureiro & Bettencourt, 2014). In Dalgarno & Mark (2008) affordances of the VLEs such as experiential learning, contextualization, collaborative learning, intrinsic motivation and user engagement, are discussed.

Specific benefits that are expected from teaching and learning within the designed VLEs are the provision of an active and authentic learning process (González et al., 2013), to support the “development of imagination and spatial analysis” (Gheorghiu & Stefan, 2015), “opportunities to explore, create, imagine, collaborate, role play, interact, socialise, learn, and experience events in a safe and vivid manner, and they can also be linked to the real world and other Web resources and services in a variety of scenarios” (Ghanbarzadeh et al., 2014).

The experience of architecture students studying in VLE are discussed in Vecchia et al. (2009) and Myung et al. (2022).

2.3. VLE on Mozilla Hubs Platform

Virtual worlds for educational purposes need to satisfy both technical and environmental design requirements, as well as the creation of pedagogical content.

In the case of the current research, it was necessary that all these requirements be fulfilled through the effort of the research team, i.e. so as not to require IT operations or financial support from the University. In order to achieve the desired objective, databases with 3D design objects, such as Sketchfab (2022), were explored. These databases currently contain a limited number of authentic objects, but new digital objects can be added following a 3D scanning. One such object, for example, a Guéridon table, was scanned by a doctoral student from UNA, and uploaded to Sketchfab for the theory class mentioned above.

Mozilla Hubs offers satisfactory performance for wide use, but also possibilities to customise the content or the way to use the platform, such as "kits to create […] custom spaces, powerful avatar and identity options, integrations with existing communications tools" (MozillaLab, 2022). In this sense, Mozilla Hubs provides "VR chatrooms" within its virtual spatial "hub", that can be accessed individually via a link and can also be interconnected within the hub, via links, to facilitate the navigation. Furthermore, for optimal performances, a cloud-based version of Mozilla Hubs using Amazon Web Services (AWS) is also provided.

Social affordances are also important assets provided by Mozilla Hubs, such as communication, sharing content and collaborative work.

3. Implementation of the "Experiment my shape!" VLE

Mozilla Hubs is a platform for hosting predefined or customised 3D spaces and to support communication in mixed reality (MozillaLab, 2022). Users can select a 3D scene from a set of predefined spaces, that usually need a customization that can be performed in the Mozilla free web-based graphic editor, Spoke (2022). In addition to the Elements Kit, Spoke has a built-in 3D digital object database from Sketchfab platform, one of the most used online libraries of 3D models (Sketchfab, 2022). The 3D scenes need to be uploaded into Mozilla Hubs to create a corresponding "chatroom".

3.1. The Virtual Space

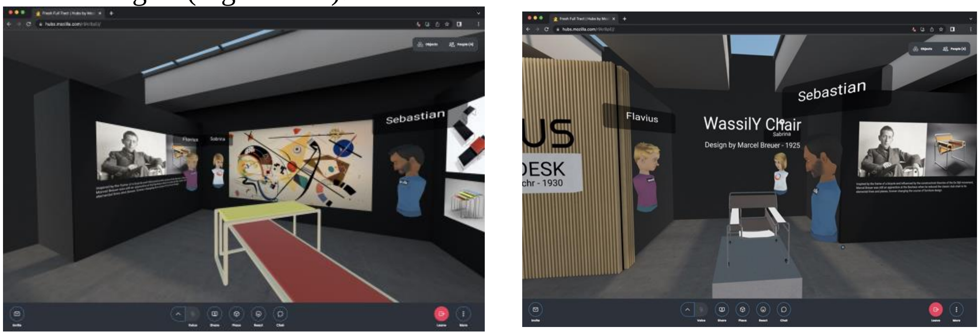
In the case of the "Experiment my shape!" VLE, a predefined virtual space was selected and customised using Mozilla Spoke editor. The customization consisted in the preparation of the virtual space to be suitable for the design class, respectively to accommodate the placement in the virtual space of some objects specific to Bauhaus design along with documentation and design posters made during the 1920s.

For the space dedicated to Bauhaus design, four design objects were selected, including three pieces of furniture: the Wassily Chair and the Laccio Tables designed by Marcel Breuer in the 1920s, a Bauhaus Desk, designed by Petr Vichr in the 1930s and a chess set designed by Josef Hartwig in 1924 (MOMA Museum, 2022). All the 3D models of those objects were imported in Spoke from the Sketchfab database.

The resulting virtual space was uploaded to Mozilla Hubs, which generated a URL address (UNA "Experiment My Shape!", 2022) (Figure 1).

Figure 1. The Entrance into UNA "Experiment My Shape!" Virtual Space

The objects were positioned on pedestals and the placement in space was done such that it allows the avatars to move around them and view the objects from different angles (Figures 2-3).



Figures 2-3. Students Moving Around the Object

3.2. The Learning Objectives

The perception of forms (Arnheim, 1964) is a mental process that was put to the test in the case of distance visual education.

Even before the pandemic, the prints of design objects, as well as the exhibition in art and design museums around the world, did not allow an integral experience of the shapes of the objects, these being presented in 2D or exhibited in a manner that did not allow a holistic, integral experience of the shapes. Therefore, the ability to experiment the shapes of things in three dimensions would allow students from the first years from the design or architecture institutes, a clear understanding of the volumes of objects and of the construction method, and consequently would allow the rapid development of good volumetric perceptions of the objects in the built space.

From the Mozilla Spoke editor's collection of predefined virtual spaces, a simple and empty space was selected and customised in order to observe the architectural principles specific to the Modern period of the third decade of the 20th century.

The virtual space for the presentation of the objects was designed as a space for experimenting with the shape of objects, but also to be able to provide documentation and information to help a better understanding of the culture that generated the design objects.

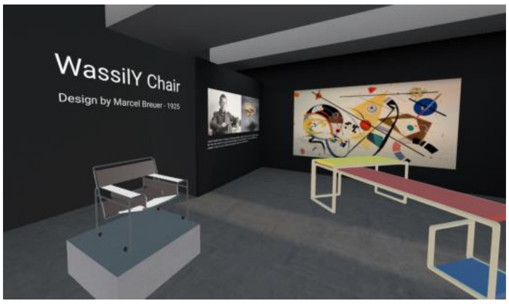
Teachers and students, in the form of avatars, can access this space, where they can interact with digital objects. Not being able to experience in the real world the original design objects from the Bauhaus movement, the students can thus experience in the virtual environment the shape of objects in a much easier way than in reality and thus understand the complexity of their forms.

4. Experimentation of the "Experiment my shape!" VLE

An online seminar was organised within the "Experiment my shape!" VLE with a group of students. Two of the authors described the history and functions of the objects, while the students experimented with these objects in space, from different personal perspectives, and studied the teaching class support content, digitally exhibited on the walls.

4.1. The Online Design Class

During the class, the students entered the virtual environment where they had the opportunity to move around the objects, in order to perceive their size and their shapes (Figures 4-5).



Figures 4-5. Students Analysing Objects and Communicating Opinions

4.2. The Research Survey

For the VLE evaluation "Experiment My Shape!" five students responded to a questionnaire with answers based on a 5-point Likert scale:

Evaluate the VLE "utility": a) to what extent did the VLE help you achieve the learning objectives for the "Objects-Spaces-Cultures" seminar? (5- Extremely; 4-Very much; 3- Moderately; 2-Slightly; 1-Not at all). The results: 20%-Extremely; 73%-Very much; 7%- Moderately; 0%-Slightly; 0%-Not at all.

Evaluate the VLE "usability": to what extent was the VLE easy to use? (5-Extremely; 4-Very much; 3- Moderately; 2-Slightly; 1-Not at all); If not: c) what problems did you encounter? The results: 55%- Extremely; 35%-Very much; 10%-Moderately; 0%-Slightly; 0%-Not at all. Students reported some technical problems regarding the lags of the environment.

Rate the VLE design quality by giving a general assessment as follows: 5 – Excellent; 4- Above Average; 3-Average; 2-Below Average; 1-Very Poor. The results: 80% – Excellent; 8% - Above Average; 2%-Average; 0%-Below Average; 0%-Very Poor.

5. Conclusions and Next Research

The results of the survey showed that the experience with the three-dimensional objects in the virtual space allowed a correct perception of the shapes, the students being able to remember the proportions and details of the experienced objects. The interaction between teachers, students and the 3D objects, as well as the information displayed on the walls of the virtual architectural space, created a learning environment whose effectiveness was verified on the occasion of the semester examination.

The process of presenting objects continues to have some limitations, due to the current level of Mozilla Hubs technology. Although the Spoke editor allows the placement of certain 3D objects from the Sketchfab platform, in most instances it does not place them with the textures that generate their volume, nor does it apply the ambient light from the space. Because objects that have complex shapes (containing a large number of polygons) are most often imported without textures, they are viewed schematically. Also importing multiple objects into the Spoke editor makes it difficult to export the space to Mozilla Hubs. Importing complex 3D objects directly into the Hubs space currently presents the same limitations as in the Spoke editor. It is expected that the platform will be improved in the future.

Future research intends to expand the 3D database with many decorative objects from different historical periods, which will be scanned or imported as 3D models and transferred into different virtual spaces necessary for future classes. The focus will also be on creating more complex virtual spaces, in which the spatial organisation of objects in different historical periods can be studied, allowing the students to experience them together with their coordinators.

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Automatic detection of ripe fruits with Python – an interactive learning activity with cross-disciplinary approach

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Abstract: *Automatic fruit harvesting addresses several issues, which can be considered as an independent computer science project, among them being the correct detection of a ripe fruit. The main focus of this article is to describe a project which derives from the detection of a ripe fruit and which is used within an interdisciplinary learning activity. The learning activity is intended for but not restricted to coding courses (like Coding with Patience) at high school and bachelor degree. We describe the original algorithms used for detecting the fruit, its level of ripeness according to its colour, and its dimensions. As the image is taken in RGB format, the colour recognition algorithm deals with the levels of red, green and blue of the image, but these levels are dependent on an optimal lighting of the scene, which is achieved using a hardware solution. The algorithms are calibrated to identify red and yellow fruits and with proper adjustments they can be extended to other types of ripe fruits (e.g., oranges, lemons, red apples, peaches, etc.). The detection is performed using a camera module attached to a Raspberry Pi 3B+ system and the image analysis is performed with Python.*

Keywords: Colour recognition, Interdisciplinary learning, Computer vision, Python.

1. Introduction

In the framework of the 21st century competencies required from the students, scientific skills include "the ability to use and handle technological tools and machines as well as scientific data to achieve a goal" (Partnership for 21st Century, 2009). In addition, more and more of the modern occupations require IT or ICT skills.

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But while IT is a very attractive domain on the labour market, the national school curricula do not always meet the requirements of the IT companies. Moreover, most of the concepts taught in school are presented purely from a theoretical point of view, lacking a connection to real-life situations. Among the consequences of this state-of-fact is the lack of interest of the students toward studying the curricula. If students fail to get a satisfactory answer to the question “Where will I use this knowledge?”, they are more likely to abandon study.

Interdisciplinary learning has been proven to be effective in improving students’ motivation, creativity and efficacy (Kuo et al., 2019). From this point of view, using robotics as a tool for computer science curricula is the logical sequel, as shown by Arlegui et al. (2008).

During the first decades of the 21st century, e-learning systems have seen an important advance, correlating the curricula with new technologies, such ICT (Maris et al, 2018). The COVID-19 pandemics further emphasised the importance of virtual learning environments as means of continuing education – either as synchronous or asynchronous learning.

The objective of this paper is to describe a learning activity connected with a real-life situation, which can be used either during physical or virtual classes by students and educators. For now, this activity is used locally, in Timisoara, during the Coding with Patience sessions, but it will be available online in the near future. The Coding with Patience sessions (Patrut et al., 2020), being a non-formal learning environment, are appropriate for interdisciplinary and blended learning and provide the circumstances for acquiring the ICT skills required by the society of the 21st century.

One of the emerging fields of computer science is computer vision. A phase of computer vision which has many applications in real-life is object recognition. Object recognition can be performed either by identifying the shape of the object, either by identifying its colour, or by identifying both characteristics. According to Xu et al. (2020), object recognition requires a low- and mid-level processing degree, which can be used appropriately in mid-level learning activities. But a correct identification of a ripe fruit (Halstead et al., 2018; Wan et al., 2018) is an essential tool for harvesting robots. Hence, computer vision is appropriate not only as a modern learning subject on its own, but also as a resource for interdisciplinary and even non-formal learning.

2. Planning the learning activity

2.1. Prerequisites

In order to attend this activity, a student must have basic knowledge of Python – either Python 2 or Python 3 (Python, 2020). If Python is not installed on the students’ computer, we recommend a portable version that can be downloaded from portablepython.com (Portable Python, 2022) and which can be used on older operating systems (like Windows XP and Windows 7).

For the final stages of the learning activity, a Raspberry Pi 3B+ system (Raspberry Pi, 2019) endowed with a camera module (Raspberry Pi Camera, 2019) is needed.

2.2. Objectives and competencies to be developed

The objectives of the learning activity are:

- Apply formal programming concepts (lists / arrays, matrices, loops, conditional statements, functions, data types) in real-life situations;
- Manipulate images (open, store, crop, apply colour filters);
- Identify appropriate characteristics for ripe fruits: colour, shape;
- Use a camera module in order to perform image recognition.

These objectives correspond to hard skills and competencies which are expected to be developed during computer sciences and robotics classes.

In addition, by completing this learning activity, the students will acquire the following soft competencies: curiosity, patience, problem solving, time management, accountability.

2.3. Materials and equipment

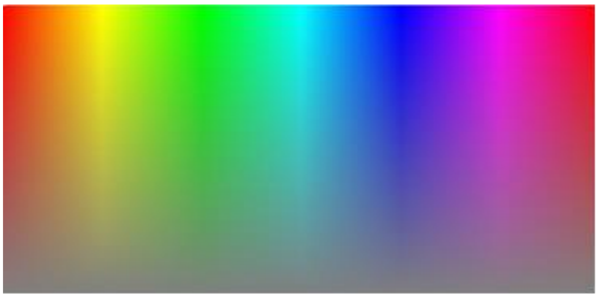

Figure 1. Colour spectrum (retrieved from standard Microsoft Office applications)

During the learning activity, the following materials will be used:

- Computers;
- Raspberry Pi endowed with a camera module;
- Python compiler (IDLE) and particularly the OpenCV (OpenCV- Python, 2022);
- Colour spectrum. A good colour spectrum is the one retrieved from the Microsoft Office applications (e.g., MS Paint, MS PowerPoint, as shown in Figure 1);
- Different images with ripe fruits (tomatoes, oranges, bell peppers).

2.4. Algorithms

In the following, we describe 3 of the algorithms used during the learning activity: an algorithm used to identify a ripe fruit on a plant (which is used to enhance critical thinking of the learners), a colour filter algorithm which is tested during the lessons for red and yellow fruits and which is actually implemented by the learners and an algorithm for identifying the geometrical limits of an object, which is implemented during the learning activity.

The algorithm for identifying ripe fruits, used by a harvesting robot, was presented by Maris et al. (2021) and it will be briefly described here:

- Start at the beginning of a lane between two rows of tomato plants
- Detect a plant
- Detect a ripe tomato:
    - Take a picture
    - Get picture parameters
    - Detect the colour of each pixel in the picture
    - Apply colour filter
    - Detect the parameters of the ripe tomato
- Grip the tomato
- Pluck the tomato from the plant
- Put the tomato in an adjoining basket
- Return to the plant and start over
- If no more ripe tomatoes are detected, find the following plant in the row and start over

The algorithm for identifying a colour (the colour filter algorithm) is:

- Open the picture
- Get image parameters (width, height)
- Initialize x=0, y=0
- While x<width and y<height
- Read the colour of the pixel (x,y) in (R,G,B) format
- If the colour condition is met
    - Colour the pixel in a certain colour (e.g., red, yellow, orange)
- Else
    - Colour the pixel in black
- Save the image

The algorithm for identifying the geometrical limits of a certain region of an image is briefly described here:

- Open the picture
- Get image parameters (width, height)
- While 0<x<width and 0<y<height
    - Determine the longest array L of pixels (horizontally) that has the colour C and its starting point x0

    - Determine the longest array H of pixels (vertically) that has the colour C and its starting point y0
- Return the geometrical limits of the object: (x0,y0) x (x0+L,y0+H)

3. Implementing the learning activity

3.1. Succession of lessons

The learning activity consists in a succession of 5 lessons, whose scenario will be presented briefly in the following. The total time needed to complete this learning activity is about 10 hours on average.

Lesson 1: How does a harvesting robot work. What does a harvesting robot need to know in order to harvest the appropriate ripe fruits.

The harvesting process is presented through movies and images of a real-life harvesting robot prototype. The students are encouraged to deduce the algorithm of identifying ripe fruits (as described above).

After figuring out the outlines of the algorithms used by the harvesting robot, the goals of the learning activity are stated, together with the succession of lessons, expected outcomes and assessment method.

Lesson 2: Images and colours. Storing an image. Cropping an image.

The students learn about the storage of an image as an array on the form [x,y,B,G,R], where x and y are the coordinates of a pixel (0<=x<=width, 0<=y<=height) and R (red), G (green), B (blue) define the colour of the pixel (0<=R,G,B<=255).

The students will create a simple program in Python which displays the width and height of an image and the colour of a certain pixel inside the image.

In order to crop an image, a new array is created, in which there will be stored only the values [x,y,R,G,B] for which x1<=x<=x2 and y1<=y<=y2 (possibly by replacing x with x-x1 and y with y-y1).

Lesson 3: Images and their colour. Applying a colour filter.

Different ripe fruits have different colours. Usually, the colour of a ripe fruit is red, orange or yellow. "Pure" reds are coded as [B,G,R]=[0,0,255], "pure" yellows are coded as [B,G,R]=[0,255,255] and "pure" oranges are coded as [B,G,R]=[0,165,255].

However, the colour of a ripe fruit is not always a "pure" colour. Hence, instead of "pure" colours, the colour filter should retain colour shades. Moreover, different varieties of the same species may have different colours for the ripe fruit (e.g., red tomatoes, orange tomatoes, yellow tomatoes, red peppers, orange peppers, yellow peppers, green peppers).

Hence, one cannot identify ripe fruits using a general colour-detection algorithm and should always specify the colours and shades that apply for a certain variety of fruits.

The colour condition for red shades we used during the learning activity is:

red>120 and red-green > 30 and red-blue > 30

By applying the red shade colour filter to the colour spectrum, the result presented in Figure 2 is achieved.

Figure 2. Red shades obtained from the red filter condition

For yellow shades, the colour condition used during the learning activity is:

(blue<110 and red > 130 and green > 130) or (blue<90 and red <200 and red-green>20)

By applying the yellow colour filter to the colour spectrum, the following results are achieved (Figure 3).

Figure 3. Yellow shades obtained from the yellow filter condition

Lesson 4: Identifying a ripe tomato and a ripe bell pepper. Characteristics of a ripe fruit.

For picking ripe red tomatoes, an efficient colour filter should retain different red shades. For picking ripe yellow peppers, the colour filter should retain different yellow shades.

By applying the red colour filter to various tomato fruits, results similar to Figure 4 are obtained. The quality of the filtered image depends on the sharpness of the initial image. Further, the sharpness of the initial image depends on the illumination of the scene, which, on the real-life prototype of a harvesting robot, is enhanced by the headlights mounted on the robot.

Figure 4. Ripe tomato detection (applied on an image retrieved from the internet)

In real-life situations (e.g., greenhouses), the colour filters we use during the learning activity identify correctly the ripe fruits from the background (Figure 5, Figure 6). However, students should experiment and adapt the colour filters according to their needs.

Figure 5. Red tomato detection (applied on images retrieved from the internet)

Figure 6. Yellow pepper detection (applied on images retrieved from the internet)

In order to detect a ripe fruit, first a rectangle is draw around the filtered image of the fruit. This permits to evaluate the dimensions of the fruit, compared with the average dimensions of a ripe fruit from the harvested variety.

Lesson 5: Identify a ripe fruit from a real-time picture.

The real-time picture uses images taken by a camera attached to the Raspberry Pi system.

For the real-life prototype of a harvesting system, the fruits are detected by analysing the images taken by a camera attached to the robotic arm. For learning purposes, it is sufficient to use a system which detects pictures of fruits (Figure 7).

The settings used by the camera are: ISO 200, image brightness 60, contrast 30, image dimension (resolution) 320x240 pixels. ISO 200 corresponds to a well-lit environment, which is provided by the headlights attached to the robot. The value for brightness should be an integer between 0 and 100, with the default 50. The value for contrast should be an integer between -100 and +100, with the default value 0. By modifying the brightness and the contrast of the camera sensor, the images become clearer.

The students should experiment with different conditions for brightness and contrast in order to calibrate the camera module and to obtain accurate information about the objects in the image.

Figure 7. Experimental stand for detecting ripe fruits

3.2. Outcomes of the learning activity

The outcomes of the learning activity are:

- Deduction of the operating algorithm for a harvesting robot
- Image manipulation
- Applying a colour filter
- Deduction of algorithms for identifying a ripe fruit (tomato, orange, bell pepper, etc.)
- Integrating a camera module with a Raspberry Pi in order to produce a simple functional image recognition system

3.3. Assessment of learning

For now, the learning process is assessed by using a checklist. Students get help in order to perform the tasks and each of them advances in his/her own time.

The progress of students is recorded on a scale from 1 to 5 (where 1 = minimal competencies gained, 3 = average competencies gained and 5 = maximal competencies gained) from 3 points of view:

- progress in algorithmics
- progress in coding (Python)
- progress in using a microcomputer and camera system (Raspberry Pi + camera module)

In order to pass the learning activities, the students should get at least 2 average marks.

In addition to the checklist, a **self-assessment of learning** is performed at the end of each lesson. The questions that students are requested to answer are:

- What have I learned today?
- What went well?
- What went wrong?
- What do I need to pay attention to in the future?
- What is my overall impression on the activities performed today?

4. Conclusions

Starting from the need to improve the quality of the learning process, by adapting it to the realities of the 21st century, various solutions were identified, such as: designing interdisciplinary learning activities, using real-life outcomes to describe the learning outputs, using e-learning as a more efficient learning environment, using robotics as a tool for increasing the students' learning motivation.

This paper presents an interdisciplinary learning activity based on the vision system of a harvesting robot. During 5 lessons (on average, 10 hours of studying), students learn to code with Python, to manipulate images, to think critically, to devise their own algorithms for ripe fruit recognition and to use the camera module of a Raspberry Pi system.

The skills gained by the students are both hard and soft and contribute to build a sound background to 21st century life.

The learning is assessed both from the point of view of the educator and the student. While the educator can issue a certificate for the completion of the learning activity, the self-assessment process refers to the way in which the student relates to the activities.

Further work in this domain involves the creation of a fully virtual environment for this learning activity and also the use of robotics for more interdisciplinary learning activities related to mathematics, physics, computer science, earth sciences.

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Social networks-based alt-metrics and the unethical use of AI

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Abstract: *A thorny issue in the research community, especially in the last decade, is the criteria for career advancement. In Romania and internationally, the indicators specific to academic promotion have been radically modified over the years. Their permanent refinement has been natural because research activity has changed radically, for instance, in terms of the way partnerships are formed and organised. Moreover, research data are made available and distributed openly, and the valorisation of scientific results in the form of articles and/or patents is actively encouraged. The world has continued to change, and the need to remove barriers to accessing research results is increasingly being questioned, with open science being a topic encouraged by policymakers. This new paradigm impacts the sphere of value indicators of research, and the subject of alt-metrics, i.e., alternative ways of measuring the quality of research, has also become a topic of interest. Many current proposals for considering research impact in line with the specificities of the contemporary world are derived from measuring interactions on social networks, which may or may not be dedicated to research activity. In this paper, we aim to explore the possibility of introducing sociometric alternatives that include indicators based on metrics specific to social networks in the context of evolving artificial intelligence (AI) technologies, which may influence the field in unethical ways. Therefore, we will identify and present how AI can influence alt-metrics, especially those based on social network activity such as Twitter, and explore the possibilities for detecting such actions, especially with bot identification.*

Keywords: alt-metrics, social networks, ethics, social bots.

1. Introduction

The problem of evaluating the impact of research carried out in a world of unlimited access to the latest scientific discoveries and of technologies capable of assuming important roles in the research team is a thorny issue. In recent decades, this has been achieved according to a series of quantitative indicators based mainly on the researcher's ability to access scientific publications with recognized prestige

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in the academic world (Bazelay, 2010, Gingras, 2016, Gutiérrez-Salcedo, Martínez, Moral-Munoz, Herrera-Viedma & Cobo, 2018).

But information and communication technologies drove the change of the world, and access to information became an increasingly valued variable in any community, even more so in the scientific one, where access to scientific novelty is a guarantee that one's own results have the particle of originality. That is why, researchers are increasingly aware that research results should not be restricted to a small, elitist number of people with access to scientific publications, but that they should be available to the general public. The implementation of this principle gave rise to the emergence of new concepts such as citizen science, civic science, crowd-sourced science, participatory monitoring (Fraisl, Campbell & See, 2020, Wehn & Almomani, 2019) and so on, which, in summary, designate a category of scientific research carried out by the nonprofessional scientists.

Making research data accessible is not an easy process, but a marked by a whole series of difficulties one, resulting from the inertia of traditional research management, the habits of financing access to specialised journals, from fears regarding data sharing and assuming intellectual ownership or from fears determined by the possibility that the data provided will be misinterpreted (Biagioli & Lippman, 2020, Bornmann, Tekles, Zhang & Ye, 2019, De Rijcke & Rushforth, 2015). Still, all these are problems that must be solved, because open science is an unstoppable phenomenon, a result of nowadays world.

In this paper, we analyse the main classical ways of evaluating research results based on traditional indicators and then review the considerations that have led to the emergence of a new generation of metrics that attempt to encompass new ways of communicating and using research results that are based on online tools such as social networks. This new category of metrics called alt-metrics has, besides obvious advantages, several risks that need to be taken into account to ensure their integrity and relevance. In particular, the current problems related to the proliferation of fake news and online misinformation make alt-metrics susceptible to targeted manipulation campaigns, especially in the case of scientific works that may have a significant social, economic or political impact. In this regard, we will present a series of results of studies that have highlighted such campaigns of manipulation of public opinion using social media and AI-based tools such as conversational agents. Thus, due to the use of AI tools in an unethical way to amplify or create false narratives to influence an individual, the issue of identifying and eliminating these software agents becomes essential to preserve the usefulness of alt-metrics.

2. Evaluation of research quality and alt-metrics

Traditional research quality metrics are evaluating each type of research object (researcher, research organisation or a country) based on indices such as the number of publications, citations, appearances in bibliometric databases (Web of

Science, Scopus, Google Scholar), on the basis of which additional scientometric indicators were built, especially for articles (Journal Impact Factor – JIF, Eigenfactor, CiteScore (Elsevier, 2016), SJR, SNIP,) and for authors (h-index (Hirsch, 2005), g-index, i10-index).

Although traditional methods of evaluating research are extremely widespread and used in many countries of the world (Gutiérrez-Salcedo, Martínez, Moral-Munoz, Herrera-Viedma & Cobo, 2018) they have received a series of criticisms from the research community. Each index has been evaluated from different points of view. For example, it was considered unfair to equate the impact of the journal with the impact of its articles (DORA, 2012) or incorrect for the H-index do not consider older but perhaps still very relevant works of senior researchers.

Thus, it was noted that traditional indicators to evaluate research are insufficient or irrelevant when comparing research objects having different characteristics or which are emerged in different scientific areas (Lesenciuc, 2012). Many critics referred to traditional indicators that assess research as a correlation of some data that is easy to collect, not a real and strong indicator of the quality of research (Bazeley, 2010). Currently, voices saying that the evaluation of research is based on a small but easily measurable number of metrics (such as publications, citations and the level of contracted funding) are more and more frequent, while elements at least as important are less used (peer review, contribution to the development of the research infrastructure, design of policies in the field, involvement in mentoring, supporting activities of other researchers to advance in their careers or assuming the role of reviewer or editor) (Moher et al., 2018, 27).

These considerations led to the emergence of a new generation of metrics, which are based on the understanding that science made accessible for everybody is impossible to be evaluated through the lens of a single category of metrics specific for times when only elites had access. Therefore, a multidimensional set of indicators are needed especially focused on the link between the product of research and its author, but also on the receptivity of society as a whole to new scientific perspectives. These metrics should reflect the evolution over time of interest in the topics under discussion. They are designed to evaluate research and also to support open science by 1. Monitoring scientific systems towards transparency at any level and 2. Measuring performance in order to reward individual or group research activities.

Several approaches to official regulate this subject took place in the last decade, suggesting the novelty and effervescence of this concern:

- Alt-metrics Manifesto 2010 led to the birth of alt-metrics through the already well-known phrase *'No one can read everything. We rely on filters to make sense of the scholarly literature, but the narrow, traditional filters are being swamped. However, the growth of new, online scholarly tools allows us to make new filters; these alt-metrics reflect the broad, rapid impact of scholarship in this burgeoning* *ecosystem. We call for more tools and research based on alt-metrics*.' (Priem & Hemminger, 2010);

- The San Francisco Declaration on Research Assessment (DORA, 2012) calls for the assessment of research by its merits and not by using journal impact factors (signed by 156 countries, over 21300 individual signatories and organisations by 2022);
- Science in Transition (2013, https://scienceintransition.nl/english) argue for evaluating research from the perspective of societal impact, not strictly from bibliometric point of view;
- The Leiden Manifesto (2015, http://www.leidenmanifesto.org/) proposed a set of 10 principles for the use of quantitative indicators for research evaluation (Hicks et al., 2015);
- The Metric Tide (2015, 2022) evaluates the role of metrics in the evaluation and management of research in the UK, which also includes recommendations for a responsible metric (Wilsdon et al., 2015);
- Next-generation metrics: responsible metrics and evaluation for open science (2017) (Wilsdon et al., 2017);
- Science Europe Study on Research Assessment Practices (2020, https://www.scienceeurope.org/our-resources/science-europe-study-on-research-assessment-practices/) which aims to optimise the quality of research by adjusting its framework.

Thus, new concepts such as alt-metrics and usage indicators have appeared in the discourse of specialists and aims to cover the area not evaluated by traditional research indicators, based to the greatest extent on social media (e.g., Twitter, ResearchGate, Mendeley), on the principle of quantifying the number of distributions, likes, followers, posts, mentions and comments (Wilsdon et al., 2017, 9-10). These metrics have the advantage of being able to constantly measure an ever-changing digital environment - while new platforms may emerge (e.g., Loop, WhatsApp, Kudos) and old ones may fall into obsolescence (e.g., MySpace, even Facebook), alt-metric principles can be used further with new inputs.

An attempt to reconcile traditional bibliometric indicators with alt-metrics generated a new category of assessment indicators – usage indicators that aim to measure the attention a research object benefits from (Usage impact factor, Libcitation). Starting from the premise that a work read with interest is not always cited later, usage indicators use the number of downloads or views of a product. Open access publications provide information on usage (PLoS), some indicating the number of downloads and reads of an article (e.g. Springer Nature, IEEE, ACM, Elsevier's Science Direct in cooperation with Mendeley). More advantage of usage indicators relate with the possibility to use them also for non-traditional but modern publications such as blogs (Shema, Bar-Ilan & Thelwall, 2014), open software or data (Peters, Kraker, Lex, Gumpenberger & Gorraiz, 2016).

The importance of alt-metrics was also highlighted in order to promote and support the Open Science paradigm - a global movement that aims to improve the accessibility and reusability of research outputs by providing unrestricted access to research publications and data, engaging citizens in research activities, and using open resources in education or software development. In this regard, in 2016, a study was conducted in 13 EU countries on the implementation of the Open Science strategy according to the EU agenda (European Commission. Directorate General for Research and Innovation., 2018). The focus of the study was on the potential of alt-metrics (as an alternative to traditional metrics) to support the development of the Open Science domain, i.e., the possibility of using alt-metrics as an incentive or reward for researchers. In addition, the study addressed recommendations for implementing national policies to promote Open Science. For example, in Romania's case, the alignment with the European Open Science Cloud objectives was achieved through the establishment of the RO-NOSCI national initiative, supported by participation in the NI4OS-Europe consortium (Vevera et al., 2020).

There are a number of indisputable advantages of the introduction of metrics for evaluating scientific products in accordance with the specifics of the modern technological revolution, as the metrics of future should:

- Evaluate research products communicated in new format: blogs, open software and applications;
- Measure not only scientific influence, but also audience impact;
- Diversification of the criteria for career advancement, considering several new possible dimensions of the research career;
- Evaluate faster research objects from several different perspectives.

Despite the importance of the subject, as in the case of any innovation, this desired change of research evaluation is accompanied by a series of unclear elements and challenges that must be overcome, derived both from the infrastructure supporting the new metrics, as well as from the specifics of the data collection. For example, the fact that alt-metrics are based on social platforms, whose territorial distribution is uneven, represents an obstacle for the unitary evaluation of research products. On the other hand, the behaviour behind alt-metrics is also not fully understood, especially since the collection algorithms are the property of the providers, and the used standards are under construction.

3. Alt-metrics challenges and the unethical use of AI

A comprehensive review on the use of social media and alt-metrics in research work was conducted by Sugimoto et al. (2016), which provided a very detailed literature review on practices in the field, focusing on the role that certain online platforms play in research work and then in the dissemination of results, i.e., it highlighted the strengths but also the limitations of alt-metrics. An important aspect that should be highlighted refers to the non-homogeneity of the results obtained, which differ from study to study depending on the methodology used, but also due to the fact that each online platform has other indicators, as well as collection and processing methods so that the results obtained are difficult to generalise. For example, in their study, several social media platforms were analysed, such as those offering social networking services, social bookmarking, video, blogs, referral management, recommendations, and ratings, but since these services are constantly developing and introducing new facilities and features to users, it is expected that the results obtained will not be relevant in the near future due to the technological evolution of these platforms.

Nowadays, more and more researchers are using various online tools such as social media platforms, blogs, or reference management systems, i.e., using platforms such as Faculty of 1000, Mendeley, Twitter or Facebook to disseminate information that is relevant not only to the academic and research community but also to the general public. This has led to a significant increase in scientific papers' impact in areas as diverse as health, education, technology or the environment.

However, it is also necessary to consider the risks, i.e., the possible downsides that can arise when the data used are affected by a series of attacks designed to artificially increase or decrease the impact of a scientific result or an individual researcher. Even if there is no specific intention to influence the relevance score of an article, certain aspects related to certain biases or stereotypes may lead to a subjective alteration of alt-metrics. For example, Chapman et al. (2022) systematically examined how alt-metrics for approximately 10,000 articles that have been published in journals may be relevant to highlight outstanding or impactful results. A surprising finding of their study was that there was an unbalanced distribution of alt-metrics scores, i.e., most articles scored so low that they could not be considered relevant, and furthermore, for articles that scored well, it was obvious a gender bias - when the first author was male, there was a higher score than for an article that had a female first author.

Social networks can thus be seen as influencing the way in which certain works are promoted, i.e., ideas are amplified or moderated, but also currents of public opinion formed based on results that rely on scientific research. Thus, Priem et al. (2012) analysed 20,000 articles published in the Public Library of Science to compare various metrics associated with them in social media. Their study revealed that both citation counts and alt-metrics have some degree of correlation but need to be considered together to determine the full impact of academic output. For example, there is a moderate degree of correlation between Web of Science citations and Mendeley citations, but most alt-metrics show an impact that is not reflected by citation counts (i.e., some articles may have a very high number of reads or saves in a citation management system such as Mendeley but will not then also have a significant number of citations).

Also, as the use of social media platforms to promote scientific articles increases, it is important to note that, especially in the case of public-sensitive topics such as the COVID-19 pandemic, many articles were withdrawn.

Nevertheless, the degree of attention given to them was similar to those that remained published. Khan et al. (2022) analysed the website retractionwatch.com in relation to the articles that had the COVID-19 pandemic as their theme, i.e., they calculated the Altmetric Attention Scores (AAS) metric to highlight the role that social media plays in amplifying misinformation and manipulation. Thus, out of a total of 196 articles that were identified within the Retraction Watch website, 175 papers had an identifying DOI number, and of these, only 30 articles were pre-prints. Subsequently, after calculating the AAS score and eliminating publications with an incomplete score, 22 papers remained published but were retracted, yet were promoted and disseminated on social media, having a significant role in misinforming public opinion. Furthermore, it was observed that retracted articles receive significantly more attention online, especially in the case of the Twitter platform, which, together with Mendeley, was the most popular media for disseminating retracted articles.

Another aspect worth considering relates to how metrics extracted from different online platforms are collected and aggregated. For example, different methodologies are used to extract information and metrics data for each online platform, and respectively different tools are needed to aggregate alt-metrics. This issue was highlighted by Zahedi & Costas (2018), who studied discrepancies related to data and metrics published by several tools using different methodologies for accessing, collecting, processing or summarising metrics extracted from the online environment.

It is widely accepted that modern society relies on social media for the smooth functioning of interpersonal relationships or to share information or sustain debates on important issues that concern an individual, a group or a community. It is all the more important to ensure the accuracy and integrity of news sources or participants in social media interactions. Twitter is a platform that specialises in the sharing and disseminating information and is one of the primary media used by the academic community to promote research results. One of the main features of Twitter concerns the implementation and use of bots, i.e. software agents that can interact and participate in a conversation with a human individual just like an average person. These conversational agents can perform different tasks (e.g., generate content, initiate discussion topics and sustain a conversation).

Although the use of intelligent agents to support online activities such as user interaction and support or to provide information are use cases with obvious benefits, there is still a significant risk in using them for malicious purposes such as misinformation or influencing public opinion, as was the case in the 2016 US election (Bessi & Ferrara, 2016). This problem can be attributed to the unethical way in which Artificial Intelligence (AI) is used, i.e., exploiting stereotypes and social biases to exacerbate the polarisation of public opinion, radicalization of groups and generation of conflict. From this point of view, it is essential to study how software agents can be used to amplify fake news or to promote themes or viewpoints that aim to manipulate public opinion in an unethical way.

Consequently, it is becoming increasingly important that the activity of bots within Twitter can be monitored and analysed, i.e., tools are needed to detect software agents that aim to misinform or manipulate public opinion, including by disseminating specific scientific results online. This is particularly important, including the impact on metrics using social media data, i.e., how scientific work is promoted through alt-metrics. A review of detection methods for identifying bots as well as the datasets used to do so was conducted by Samper-Escalante et al. (2021). Bot identification requires both the design and implementation of efficient methods but then also the explanation of the decision to identify such a software agent. Kouvela et al. (2020) present a bot detection solution that integrates an ML framework that offers the possibility to explain the results obtained, and additionally, it includes the user's feedback. A dataset for training the detection algorithms is also provided, and the bot identification tool is made available as a web service.

Traditional bot detection methods use supervised machine learning algorithms, but this technique has several drawbacks as it cannot identify changes in real-time. In this regard, an adaptive method of characterizing users based on their behaviour was explored by Minnich et al. (2017). The technique is based on both the use of metadata and features related to the content of messages and connections within the count graph within the ensemble of unsupervised models that are trained for anomaly detection in a multi-dimensional space. The bot identification accuracy was evaluated to 90% from a learning sample of 15 bots.

Also related to the performance of detection algorithms, Fonseca Abreu et al. (2020) presented an evaluation of four bot classification methods using simple features related to a user's profile statistics, obtaining homogeneous results with a mean of 0.85 and a standard deviation of 0.18. Also, for multi-class classifiers, an AUC score of over 0.9 was obtained which provides higher confidence for detecting Twitter bots.

Particularly in the case of events that have major implications for society as a whole, such as presidential or parliamentary elections, referendums such as Brexit, riots or popular movements such as the Arab Spring or Occupy Wall Street, social media platforms have been instrumental in generating and supporting public participation. While at first, this involvement was natural and quite limited, as society gradually adapted and was even encouraged to use these new technologies, their maturity increased as well. Thus, the risk that social media could be used to manipulate public opinion and amplify disinformation campaigns has been widely acknowledged. In addition, due to the new technical facilities offered by social media platforms, such as the filtering and selection of the target population susceptible to a particular message or communication and to the possibility of integrating software applications or conversational agents into social networks, it has become increasingly evident that algorithmic-based manipulation techniques are compelling in influencing society at the individual level. In this regard, numerous studies have analysed this phenomenon, e.g., influencing the 2016 US elections (Bessi & Ferrara, 2016), the Brexit referendum campaign (Howard & Kollanyi, 2016) or other topics with societal implications such as climate change (Marlow et al., 2021).

4. Conclusions

Taking into account the current challenges related to the evaluation of the research activities, we have presented both traditional methods and the new metrics that rely on the use of data extracted from social networks, reference management tools, or other online platforms, so-called alt-metrics.

In a democratic system, civic involvement is fundamental to sustaining an open environment that encourages citizens to engage in public debate on important issues. In this respect, social media and social networks are the main avenues through which social and political issues are debated, narratives on issues of interest are created, and communities coordinate their online and offline activities. In the context of science which has become a public and open phenomenon, a review of the criteria that are the basis of the evaluation of research and researchers by identifying new ones is not only recommended but necessary considering the paradigmatic changes we are going through.

The increasing performance of machine learning methods and artificial intelligence may represent a problem that needs to be understood and solved to create the necessary framework for implementing metrics related to the research results evaluation.

In this paper we described the main landmarks of this new era of evaluating research, underlining a few examples in the area of unethical use of AI to influence alt-metrics.

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Bibliometric Analysis of Studies on Metaverse in Education

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Abstract: *Cyberspace has continued to expand due to increasing empirical explorations and the invention of novel technologies that have been constantly making significant modifications to how people interact with technologies. One of the significant outcomes of those empirical explorations and inventions is Metaverse, which is a virtual environment or a cyber-simulated setting where numerous users in remote physical places can interact or work simultaneously. The application of Metaverse in education has been growing over time due to technological innovations and the inability of existing studies to cover comprehensive bibliometric analysis of literature on the application of Metaverse in education to date automatically creates a research gap that needs to be filled. The peculiarity of this study is premised on the limitations of the existing bibliometric studies on the Metaverse. This study applied bibliometric analysis via science mapping with the aid of VOSviewer software for data analysis and dissection to provide a general idea about the current knowledge base on Metaverse in education. The exploration was based on the data generated from the Scopus database. Findings from this study show the journals with the most cited publications on Metaverse in education, their attributes, and the intellectual structures of knowledge, which are; i.) the impacts of Metaverse on education, ii.) Metaverse for remote education, iii.) application of Metaverse in medical and health education, iv.) Metaverse for improved learning, assessment, and engagement, v.) Metaverse for teacher education. The collaboration network between countries placed the US at the center with no country from Eastern Europe and Africa appearing on the network visualization and suggestions were made for further research directions.*

Keywords: Metaverse, Virtual Reality, Mixed Reality, Augmented Reality, Education.

1. Introduction

Cyberspace has continued to expand due to increasing empirical explorations and the invention of novel technologies that have been constantly making significant modifications to how people interact with technologies. One of the significant outcomes of those empirical explorations and inventions is Metaverse, and to even imagine that some of the leading Tech Chief Executive Officers such as Satya Nadella of Microsoft and Mark Zuckerberg of Facebook (now Meta) discourse about Metaverse as the future of the cyberspace provide another

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significant recognition of metaverse as a novel concept that has potential to dominate the cyberspace. The pioneer description of metaverse took place in a novel titled "Snow Crash" by Neal Stephenson in 1992 and this pioneering description became the concept applied in describing virtual worlds, 3D where people relate with one another and their environment devoid of the physical restrictions of the real world (Narin, 2021). Ondrejka (2004) also affirmed that Snow Crash, a science fiction novel by Neal Stephenson in 1992 presented the idea of metaverse to readers, describing a virtual setting that serves as an actual place to the users where these users relate by applying the tangible world as a metaphor, and interacts, carry out economic activities and were kept amused. Dionisio, III, and Gilbert (2013) refer to the virtual environment as the cyber-simulated settings where various users in remote physical places can relate to play or work in real-time. Benedikt (2008) claimed that CitySpace which was in operation between 1993-1996 was the first metaverse. Afterward, Narin (2021) recorded that several metaverses like Active Worlds by Schroeder, Huxor, & Smith (2001) and Thereby Makena Technologies came into existence. Narin (2021) went further to state that Second Life created in 2003 by Linden Lab was the most famous and it gave room for the emergence of web-based virtual worlds to game lovers.

The transition from a set of autonomous virtual environments to Metaverse or an integrated network of 3D virtual environments relies on the advancement in the areas of "scalability, interoperability, the ubiquity of access and identity, and immersive realism" (Dionisio et al., 2013, p. 1). Metaverse is not a novel concept in education because it has successfully become an attraction point for pedagogists for some years based on the fact that numerous scholars, educators, and researchers have deliberated the implications of the concept for teaching and learning (Tlili et al., 2022). To mention a few of these studies, the integration of Metaverse via the application of a virtual environment named "Second Life" into the learning management systems to improve the teaching and learning process was done through the work of Kemp and Livingstone (2006). Another study (Collins, 2008) put forward an argument on the possibility of Metaverse becoming the new space where people can gather and interact with demanding educational institutions to be prepared for its application for instructional purposes with a focus on the virtuality aspect of the concept. Schlemmer (2014) added that Metaverse provides communication and collaboration platforms via the avatar that replicates the sensitivity of presence. Table 1 below shows the existing literature on Metaverse from the bibliometric analysis perspective.

Table1. A summary of existing bibliometric reviews on Metaverse and their limitations

Author(s)	Study Title	Article Type	Limitations
Schmitt (2022)	Metaverse: Bibliometric Review, Building Blocks, and Implications for	Bibliometric Analysis	The bibliometric analysis was limited to studies on Metaverse from the context of Business,

	Business, Government, and Society		Government, and Society.
Tlili et al., (2022)	Is Metaverse in education a blessing or a curse: a combined content and bibliometric analysis	Bibliometric & Content Analysis.	Metaverse and education but the article could not answer bibliometric analysis questions extensively due to the integration of content analysis into the same study.
Chen & Zhang (2022)	Exploring Research Trends of Emerging Technologies in Health Metaverse: A Bibliometric Analysis	Bibliometric Analysis	The bibliometric analysis was limited to Metaverse from the context of medicine and healthcare.
Abbate et al., (2022)	A first bibliometric literature review on Metaverse	Bibliometric Analysis	The bibliometric analysis used a single keyword "Metaverse" for data collection.
Damar (2021)	Metaverse Shape of Your Life for Future: A bibliometric snapshot	Bibliometric Analysis	The bibliometric analysis used a single keyword "Metaverse" for data collection.
Tas & Bolat (2022)	Bibliometric mapping of Metaverse in education	Bibliometric Analysis	The bibliometric analysis used keywords related to Metaverse but excluded education and other keywords related to it from the search string.

The inability of existing studies to cover comprehensive bibliometric analysis of literature on the application of Metaverse in education to date automatically creates a research gap that needs to be filled. The peculiarity of this study is premised on the limitations of the existing bibliometric studies on the Metaverse. For instance, this study used keywords such as “mixed reality”, “extended reality” related to Metaverse, as against Damar (2021) and Abbate et al (2022) single keyword, in combination with other keywords such as “pedagogy”, “learning”, “teaching” related to education against Tas et al (2022) and Schmitt (2022) exclusion of keywords related to education. This study concentrated on only bibliometric analysis to provide answers to only bibliometric questions against Tlili et al. (2022) integration of content analysis questions. However, it is essential to note that this does not in any way or form translate to an attempt to garbage these existing studies but fill the research gaps in these studies. Thus, this current study will in no doubt serve as the pioneering effort to provide an all-inclusive bibliometric analysis of literature on the application of Metaverse in education, to establish significant advancement and trends in this academic domain. This study will recommend research prospect agenda within the horizon of Metaverse in education and as create an equilibrium point for both contemporary and the past on the use of Metaverse in education for researchers. Furthermore, this study will support Metaverse developers, policy-makers, and educators to come up with novel programs on the use of Metaverse for improved instructional results.

This bibliometric study was set up with the main goal of assessing the current state of studies on Metaverse in education, with the main importance on the intellectual structure, research trends, the nature of co-authorship between countries, and key concepts. The following bibliometric analysis questions were raised for the purpose of actualizing the above research objective:

1. What are the top journals that have published the most cited articles on Metaverse application in Education, and what are their attributes?
2. What are the leading concepts (i.e., keywords) that have been explored in Metaverse in education and how are they connected?
3. What is the intellectual structure of knowledge on Metaverse in education?
4. What is the co-authorship network between countries where articles on Metaverse in education were published?

2. Method

This study applied bibliometric analysis, which deals with procedures for retrieving and statistically examining quantifiable information in published research articles (Godin, 2006), and it also integrates both statistical and quantitative analysis to account for the distribution arrangements of the published studies on certain topics and from particular periods with the capability to provide valued insights to the academic discourse arena (Martí-Parreño, Méndez-Ibáñez, & Alonso-Arroyo, 2016). According to Moral-Muñoz, Herrera-Viedma, Santisteban-Espejo, and Cobo (2020), bibliometrics has grown into a significant tool for measuring and examining the output of researchers, the collaboration between higher institutions of learning, the impacts of public-owned science finance on domestic research and development. Data sourcing was conducted on the Scopus database covering title, abstract, and keywords with certain specifications such as document type and language, but there was no time limit. Several studies have supported the adoption of the Scopus database for bibliometric studies based on the wider coverage of the database (Zhu, & Liu, 2020; Kawuki, Yu, & Musa, 2020), although they are others with divergent submissions on the said coverage (Hedding & Breetzke, 2021; Tennant, 2020). Science mapping was applied in this study to provide a general idea about the current knowledge base on Metaverse in Education. According to Van der Veer Martens (2007), science mapping refers to a procedure for conducting a bibliometric exploration of research work and literature.

Science mapping refers to a technique for leading a bibliometric investigation of writing and academic work (Van DerVeer Martens, 2007). Chen (2017) added that science mapping research majorly comprises many mechanisms, particularly a group of scientific literature, metrics, a set of visual analytic and scientometric apparatuses, and pointers that are capable of recognizing possible significant arrays and styles, and principles of systematic modification than can lead the investigation and analysis of visualized intellectual configurations and vibrant arrangements. Science mapping has also been categorized as an interesting subdivision of bibliometric examination in which scholars endeavor to investigate and graphically show the associations among the different scientific knowledge as it advances and develops throughout the long term by Eck and Waltman (2014). Cobo, López-Herrera, Herrera-Viedma, and Herrera (2011) added that these associations can be examined by applying different units like author, institution, keyword, publication, country and journal, institution and country as the foundation for investigation.

The process of science mapping analysis can be largely illustrated in seven phases: data recovery, pre-processing, network extraction, standardization, mapping, analysis, and visual representation (Cobo et al., 2011). However, lots of these phases do not appear to be autonomous as they are done concurrently by the VOSviewer and other related software designed for the same purposes with a couple of clicks of the mouse. Moosa and Shareefa (2020) cited the instance of VOSviewer software's five stages of network extraction, standardization, mapping, analysis, and visual representation which are totally done instantaneously when the necessary boundaries are chosen as wanted. Thus, this study employed the science mapping method with the aid of VOSviewer software for data analysis and dissection.

2.1. Data Sourcing, Inclusion, and Exclusion Criteria

The data sourcing was done on the 8th of September, 2022, returning 674 articles based on certain specifications such as document type (i.e., journals, articles, with the exclusion of conference proceedings and book chapters) and language (i.e., English language) without time limitation for the identification phase. To have clear-cut and appropriate data, the following elimination criteria were adopted;

- *Incomplete Data:* Any text that does not have authors' names or missing information is excluded;
- *Peer Review:* Any text that does not go through the peer review process prior to the publication of such is excluded;

- *Title, Abstract, and Keywords:* Any article that any of the synonyms of Metaverse and Education does not appear in either the title, the abstract, or the keywords of the text is excluded.

After the screening and elimination phase based on the above benchmarks, 29 articles were eliminated from the initial number of articles, limiting the available number of articles to 645. Away from the data gotten from the Scopus database, information was collated from Scimago Journal Ranking in order to have adequate features of the eligible journals based on ranking.

3. Findings

3.1. Journals with the most Cited Publications on Metaverse in Education and their Attributes

Table 2 shows the summary of journals that have published the most cited research on the metaverse in education and their attributes. With an aggregate of 645 articles, only 20 journals have been able to publish articles with a minimum of 5 citations when a minimum of 5 publications was applied as the threshold. Virtual Reality has 12 publications with 127 citations and 10.58 citations per publication to become the leading journal with the highest number of documents and citations, followed by Applied Sciences (Switzerland) with 11 publications, 115 citations, and 10.45 citations per publication. For the summary purpose, the details of the 20 journals that met the thresholds are presented in Table 3. The results indicated that only 19 journals were ranked by ScimagoJR, where 13 journals have Q1, 5 journals have Q2, and 1 journal has Q3 to complete the 19 journals ranked by ScimagoJR while the remaining 1 journal was unranked. According to Table 2, all the ScimagoJR ranked Q1 and Q2 journals have SNIP that is higher than one except Q3 with 0.35 as the lowest-ranked journal. Of all the journals with the highest citation, only three journals with the names “World Neurosurgery”, “Medical Science Educator”, and “International Journal of Computer Assisted Radiology and Surgery” came from the medical/health education domain. Five journals with the same “Computers and Education”, “Education and Information Technologies”, “Education sciences”, “Information and Learning Science”, and “International Journal of Emerging Technologies in Learning” came from the application of IT in the education domain journals while remaining are from chemical science, engineering, etc.

3.2. The Leading Concepts that have been explored on Metaverse in education and their connection

This study examines the co-occurrence of keywords that covered the keywords allocated by authors with a threshold of 10 as the minimum occurrence of a keyword and the findings are presented in Figure 1.

Table 2. Overview of topmost journals with most-cited publications and their attributes

Journal Name	TP	TC	CPP	CiteScore	SNIP[a]	SJR[b]
Applied Sciences (Switzerland)	11	115	10.45	3.7	1.03	0.51, Q2
Computers and Education	6	559	93.16	19.8	5.21	3.67, Q1
Computers and Graphics (Pergamon)	8	423	52.87	5.3	1.07	0.93, Q1
Education and Information Technologies	6	37	6.16	6.6	2.12	1.05, Q1
Education sciences	5	13	2.6	2.9	1.31	0.51, Q2
Electronics (Switzerland)	5	12	2.4	3.7	1.01	0.59, Q2
Frontiers in Virtual Reality	7	8	1.14	N/A	N/A	N/A
IEEE Access	13	111	8.53	6.7	1.32	0.92, Q1
IEEE Transactions on Visualization and Computer Graphics	10	78	7.8	11.4	2.43	1.75, Q1
Information and Learning Science	6	12	2	3.9	1.56	0.68, Q1
International Journal of Computer Assisted Radiology and Surgery	6	58	9.66	5.8	1.397	1.0, Q1
International Journal of Emerging Technologies in Learning	8	45	5.62	3.8	1.41	0.63, Q1
Journal of Chemical Education	5	79	15.8	4.8	1.25	0.50, Q2
Journal of Universal Computer Science	6	117	19.5	2.7	0.71	0.39, Q2
Medical Science Educator	6	21	3.5	0.9	0.35	0.22, Q3
Multimedia Tools and Applications	6	30	5	5.3	1.05	0.71, Q1
Research in Learning Technology	14	140	10	4.8	1.33	0.77, Q1
Sustainability	8	56	7	5.0	1.31	0.66, Q1
Virtual Reality	12	127	10.58	7.8	2.63	1.01, Q1
World Neurosurgery	6	58	9.66	3.6	1.1	0.69, Q1

TP = Total Publication, TC = Total Citations, CPP = Citation Per Publications, SNIP = Source Normalized Impact Per Paper, SJR = Scimago Journal Ranking, [a] Figures for 2021 from SCOPUS, [b] Figures for 2021 from ScimagoJR

According to the findings, the key concepts entrenched in all the articles can be plotted into five clusters and the most substantial keywords based on cluster size are “virtual reality”, “education”, “mixed reality”, “hololens”, and “mobile learning”. The most frequent keyword in Cluster 1 (i.e., Red) is “virtual reality” out of the 7 keywords that made up the entire cluster and it appeared 21 times.

Other keywords in this cluster based on appearance are “augmented reality” appearing 20 times, “extended reality” appearing 14 times, and “metaverse” appearing 14 times, while “machine learning” and “deep learning” had 9 and 7 appearances respectively. From Cluster 2, the most frequent keyword in this cluster (i.e., Green) is “education” out of the 7 keywords that made up the entire cluster and it has a 15-occurrence rate to also retain the first spot in the aggregate number of keywords in the cluster. “Learning” shared a similar occurrence rate with “education” in Cluster but with a weaker link strength compared to “education”. The third cluster (i.e., Blue) has “mixed reality” out of the entire 4 keywords that made up the cluster as the most frequent keyword with a 20-occurrences rate, followed by “covid-19”, “science education”, and “embodied learning” claiming 11, 7, and 6 occurrence rates respectively. “E-learning” competed with “hololens” by sharing a similar occurrence rate of 9 in Cluster 4 (i.e., Yellow), but “hololens” claimed the top spot in the cluster with a stronger link strength of 30 compared to 24 for “e-learning”. “Virtual worlds” is the least leading concept of the entire 3 keywords that made up the entire Cluster 4. Cluster 5 (i.e., Purple) has “mobile learning” as the only keyword that made up the cluster with stronger links to other keywords like “mixed reality”, “augmented reality”, “virtual reality”, “medical education”, and “simulation”.

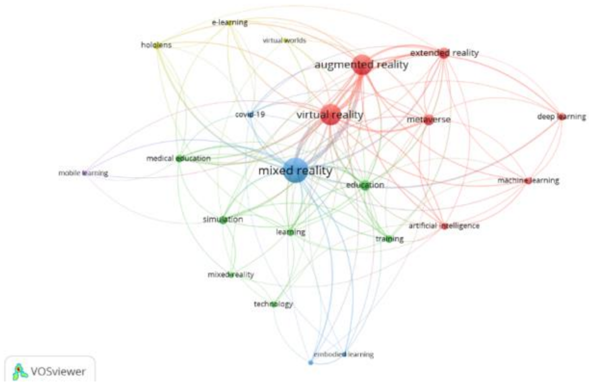

Figure 1. Co-occurrence mapping of the leading concepts.
Note: A least possible occurrence of 10 was used for the keywords whereby 22 of the 1942 keywords met the threshold

3.3. The Intellectual Structure of Publications on Metaverse in education

This study conducted a co-citation network analysis of authors cited to ascertain the intellectual structure of the knowledge base as indicated in Figure 2.

The results from Figure 2 indicated that the intellectual structure of knowledge of articles published on Metaverse in education has 5 divergent bodies of knowledge; i.) the general impacts of Metaverse on education (Cluster 1 in Red), ii.) Metaverse for remote education (Cluster 2 in Green), iii.) Metaverse in medical and health education (Cluster 3 in Blue), iv.) Metaverse for improved learning, assessment, and engagement (Cluster 4 in Yellow) and v.) Metaverse for teacher education (Cluster 5 in Purple). Thus, these five clusters are regarded as the main themes of studies conducted on Metaverse in education respectively.

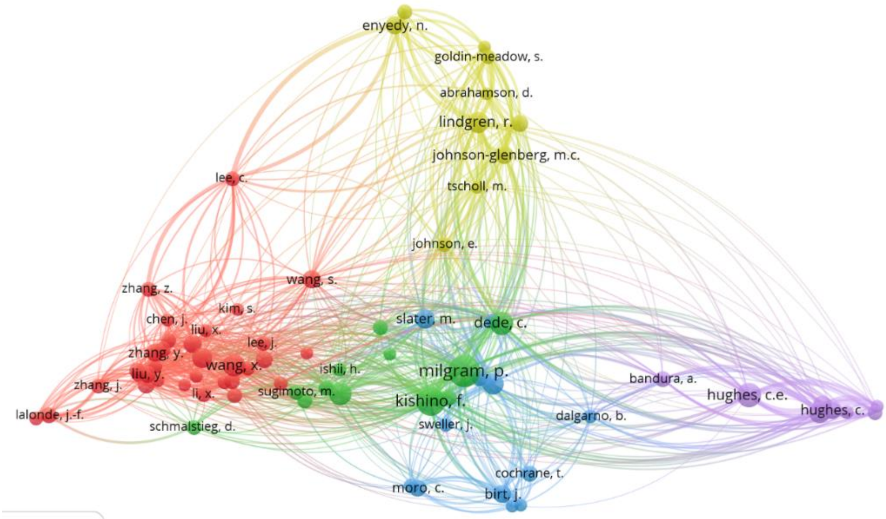

Figure 2. Co-citation network of publications on Metaverse in education.
Note: Using full counting, a threshold of 30 citations per article was adopted for the purpose of having a clearer interpretation of the co-citation network for establishing the intellectual structure. The network was only established for 75 authors out of the 42,787 authors

Considering published articles in the first theme, (i.e., the general impacts of Metaverse on education) the most extremely co-cited authors are "Wang, X." with 88 citation weight and 680 total link strength, followed by "Wang, J.", with 72 citation weight and 769 total link strength. The leading co-cited authors as far as the second theme (i.e., Metaverse for remote education) are concerned, are "Milgram, P." with 180 citation weight and 1696 total link strength, "Dede, C." with 103 citation weight and 1104 total link strengths, etc., The two leading co-cited authors as far as the third theme (i.e., Metaverse in medical and health education) are concerned, are "Mayer, R.E." with 82 citation weight and 1080 total link strength and "Moro, C." with 51 citation weight and 415 total link strength. Other authors on this theme include Bailenson, J. N., Birt, J., Cochrane, T., Cook, D. A., etc. The two leading co-cited authors as far as the fourth theme (i.e., Metaverse for improved learning, assessment, and engagement) are concerned, are "Lindgren, R." with 85 citation weight and 1407 total link strength and "Johnson-

Glenberg, M.C." with 61 citation weight and 1069 total link strength. Other authors on this theme include Abrahamson, D., Alibali, M. W., Birchfield, D., etc. The two leading co-cited authors as far as the fifth theme (i.e., Metaverse for teacher education) are concerned, are "Hughes, C.E." with 106 citation weight and 1234 total link strength and "Dieker, L.A." with 79 citation weight and 1114 total link strength. Other authors on this theme include Hynes, M.C., Straub, C., etc.

3.4. The Collaboration Network between Countries

Co-authorship analysis was conducted on the aggregate number of articles under investigation to ascertain the collaboration network between countries as indicated in Figure 3. As shown in Figure 3, the results indicated that the collaboration network between countries where articles on Metaverse in education were published has three alliance groups. Cluster 2 in Green with the United States leading the likes of Australia, Japan, New Zealand, and South Korea in the group. Cluster 1 is in Red with the United Kingdom leading countries like Brazil, France, Germany, Greece, Italy, Malaysia, Netherlands, Spain, and Taiwan in the group. Cluster 3 is in Blue with China leading the likes of India, Canada, and Singapore. From Figure 3, every collaboration network centered around the United States with 199 publications. China from cluster 3 has 53 publications, followed by the United Kingdom in cluster 1 with 48 publications, and Australia which belongs to the same cluster as the United States has 44 with three publications.

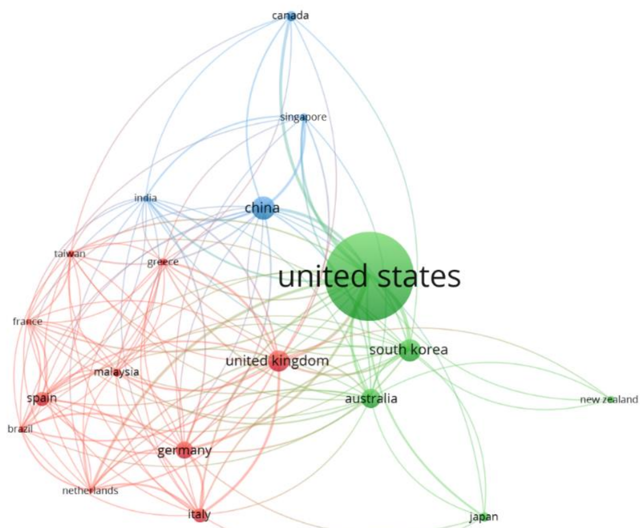

Figure 3. Collaboration network between countries. Note: Using full counting, a threshold of 10 publications per country was adopted for the purpose of having a clearer interpretation of the collaboration network. Only 19 countries met the threshold out of the 89 countries

This result indicated that collaboration between the United States and other countries is at its peak without any visible alliance from Eastern European countries and Africa appearing on the co-authorship network visualization.

4. Discussion

The findings of the study indicated that from the 20 journals that published the most cited articles on the application of Metaverse in education, 1 journal was not ranked at all, 13 journals have Q1, 5 journals have Q2, and 1 journal has Q3 to complete the 19 journals ranked by ScimagoJR. According to Eck et al. (2014), SNIP evaluates the average citation per article in a particular journal as a portion of the citation potential of the same journal in the particular topic area. Thus, when the SNIP score of a particular journal is higher than one, it is an indication that the average citation per paper in that journal is higher compared to the citation potential of the journal in its area of concentration (Björk & Solomon, 2014; Moosa et al., 2020). The SNIP scores in Table 3 indicated that only 17 journals out of the 20 top journals with the most cited papers have significant citation impacts in their area of concentration.

HoloLens happens to be the odd key concept from the leading five key concepts because the remaining 4 key concepts are general concepts connected with Metaverse in education while HoloLens is just a device captured under mixed reality. HoloLens is a mixed reality device with holographic processing that blends effortlessly with both the virtual world and the real world, advanced optics, and several sensors. Virtual reality and mixed reality are both related to education and mobile learning based on their application for the customary mode of teaching and learning, blended or hybrid education, and remote education. Away from co-citation network interpretation, it is essential to note that there is a close association between three divergent bodies of knowledge (i.e., the general impacts of Metaverse on education, Metaverse for remote education, and Metaverse in medical and health education), while the remaining two clusters (i.e., Metaverse for improved learning, assessment, and engagement, and Metaverse for teacher education) distant themselves from the first three as indicated on the bibliometric coupling map. Another major point of attraction to the co-occurrence mapping of the leading concepts showed “Covid-19” with 11 occurrence rates and this can be attached to the dependency of education during the Covid-19 pandemic on e-learning that integrated Metaverse. From the collaboration network between countries, it is evident that the United States has the highest number of collaborations, followed by China which belongs to the same cluster as the aforementioned, then the United Kingdom from cluster 1, Australia, and Germany. This implies that the United States is at the center of collaboration network between countries because it has a collaboration network with the other two clusters that appeared on the collaboration map.

5. Conclusions

This study conducted a bibliometric analysis of articles on the application of Metaverse in education without time limitation. Citations of articles were analyzed to ascertain the most cited articles, the journals that published those articles, and the features of those journals, the leading concepts that have been explored were presented using the keywords, the intellectual structure of knowledge, and the collaboration network between countries where articles on the application of Metaverse in education were published was established. The SNIP scores indicated that only 17 journals out of the 20 top journals with the most cited papers have significant citation impacts in their area of concentration, making it recommendable that scholars should consider journal metrics that will include SNIP and quartile rank in order to publish in journals that have significant citation impacts in their area of concentration. From the intellectual structure mapping, five divergent groups were discovered, the first group covered the general impacts of Metaverse on education, the second group covered Metaverse for remote education, the third group covered Metaverse in medical and health education, the fourth group covered Metaverse for improved learning, assessment, and engagement, and the fifth group covered Metaverse for teacher education. This might aid future scholars in comprehending the existence of five bodies of knowledge in the application of Metaverse in education. The result indicated that collaboration between the United States and other countries is at its peak without any visible alliance from Eastern European countries and Africa appearing on the co-authorship network visualization. Since no African and Eastern European countries appeared on the collaboration map, this gives a clear indication that researchers from Africa and Eastern Europe need to collaborate more across the globe in order to have global visibility and impacts on Metaverse and education. It is recommended to explore the potential of applying Metaverse in special education as assistive technology, the affordability of Metaverse tools by educators and learners in both developed and developing countries, and the issue of equity and accessibility with respect to the application of Metaverse in education.

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Collaborative Digital Textbooks: Theoretical Framework and Development Tools

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Abstract: *A Collaborative Digital Textbook (CDTb) is a complex digital learning resource and an intrinsic component of an e-learning environment. Developing collaborative digital textbooks performs a fresh approach to the e-textbooks field, putting the emphasis on personalised textbooks for learners. A collaborative digital textbook integrates different technologies, tools, and architecture, as well as the practice of various learning scenarios based on the authors' creativity and visions. It is a shared process of developing a digital textbook that includes the potential to expand e-books' usefulness in teaching.*

This study presents insights into the theoretical framework and the development tools of collaborative digital textbooks by reviewing scientific studies and cases, and analyses the authors' views on this topic. The work also examines different factors that influence the development of these types of e-textbooks in the frame of proper applications. Further, the research will require in-depth future studies on exploring the pedagogical design of collaborative digital textbooks.

Keywords: Collaborative Digital Textbook, Framework of Collaborative Digital Textbook, Development of Collaborative Digital Textbooks.

1. Introduction

As information technology and learning tools advance, we talk more and more often about the chances of using digital possibilities to improve educational processes and services. We think digital textbooks represent a particular segment of this field.

There are approximately two decades of the evolution and expanded implementation of digital textbooks in developed countries, which began during the promotion of multimedia interactive learning resources and the integration of information and communication technologies into teaching [MEC RM, 2015]. So far, there is not either a rate of a constant process of the application of digital textbooks in education or standards regarding digital textbook types described in

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specialised publications. Besides, we did not identify free tools for developing interactive personalised e-textbooks.

It is obvious the digital textbook is more advanced than a traditional printed textbook, as it could incorporate and use multimedia, collaboration and interactive learning features [Roberts et al., 2021]. We highlight particularly the usefulness of digital textbooks in classrooms through their interactive features that form a vital component of digital textbooks. The interactive content keeps students engaged and motivated, making learning more comprehensible. Besides, they make it possible to personalise student learning and select the most appropriate subject for each topic as often as needed. Also, we should draw the attention of both students and teachers to the following attractive experiences, like interactive activities, 3D images, diagrams, notes, incorporated educational applications, tutorials, appropriate references, and others. Another distinctive feature is that e-textbooks are more flexible, and we can constantly develop educational content. Using a good eBook builder, teachers can prepare customised educational content and, thus, provide a student-centred method in classrooms.

Contemporary didactic practices that combine blended learning, problem-based learning, or another type of student-centred approach, as well as 21st-century learning skills, contribute to informed training, well-prepared students and future competitive citizens in the modern workplace. The following statements could sum up the pedagogical characteristics of e-textbooks (Chiriac, 2016):

- e-textbooks involve instruction in meaningful environments that guide students to discover, collaborate, and share content;
- e-textbooks offer a lively and active learning approach, which leads to effective communication between the cognitive contents and the students, challenging them to learn;
- e-textbooks encourage know-how, comprehension, and critical analysis, and adapt to the student's learning rhythm.

In these conditions, we investigate tools that offer innovative and relevant features in creating interactive content necessary to ensure the development of students' skills and abilities.

1.1. Meanings of Collaborative Digital Textbooks

Seeking a broad and meaningful explanation of what a Collaborative Digital Textbook is, we will first introduce what a digital textbook is. We discover that the investigations regarding collaborative digital textbooks are preliminary and few to introduce some definitions of them or more precise meanings, though there is a substantial quantity of research on digital textbooks optimised with interactive features.

Chen et al. (2012) mentioned "eTextbook was a special kind of eBook developed according to curriculum standards, which meets the students' reading habits, facilitates organising learning activities, and presents its contents in accordance with paper book styles".

As stated by Embong et al. (2012) referring to some practical functions, e-books as textbooks in the classroom "allow students and teachers of the school to search for word definitions, bookmark pages, highlight text, and type notes", and […] "should offer various presentations of information and activities […], automate some feedbacks for students, provide scaffolds or flexible supports suitable for students' learning process, and ensure sustainable resources of knowledge".

In similar terms, by digital textbook/e-textbook we signify a structured interpretation of a subject/module/unit in digital format elaborated under the curriculum, whose content could combine various media like text, graphics, audio sequences, video, hyperlinks, interactive exercises, and other proper information.

Based on our findings, we can say that the term "collaborative" is practised in "the collaborative digital textbooks" syntagma when developing digital textbooks in collaboration, and/or digital textbooks include collaborative tools.

Thus, Weiskott (2017) experimented with a new pedagogical tool called "Collaborative Digital Textbooks" by building an intellectual resource (website) and inviting students to contribute through research, writing, design, and publishing new pages on the site. We determined that the website collaboration model in textbook elaboration was introduced in 2008 when the Flexbook authoring platform appeared on the IT market (https://www.ck12.org/fbbrowse/). Hill (2010) mentioned that the model of digital textbooks that uses a web-based collaborative model, called flexbook, includes open educational resources, and enables teachers to customise and produce their textbooks.

A newer interpretation of collaborative digital textbooks was proposed by Grönlund et al. (2017) in their article, in which they stated that collaborative digital textbooks "are developing from being books in pdf format to becoming collaborative digital environments where teachers and students can communicate, engage in feedback and discussions, share and manipulate materials, test knowledge, and monitor results".

In the following, we identify that Kempe & Grönlund (2019) introduce Collaborative Digital Text Books as "emerging artefacts in Swedish schools, combining the quality assured content of the traditional paper and digital textbooks with affordances for multimodal representation of knowledge, differentiated instruction, communication, collaboration, documentation and with varying learning activities". These new artifacts, as described by the authors, contain exercises, navigation mechanisms, marking and text annotation, explication of notions, tools for communication like chat rooms, wikis, tools for documentation and teacher feedback from exercises, can also include serious games, and tools that support the administrative concern for the teacher (ibid.). We can conclude that Kempe and Grönlund present the "collaborative" meaning of digital textbooks in case of digital material covering the entire curriculum in a digital book includes collaborative tools.

In figure 1, we recapitulate and graphically present connections between the collaborative e-textbooks' meanings and interpretations based on collaboration elements and how these could help us understand the use of CDTb in education.

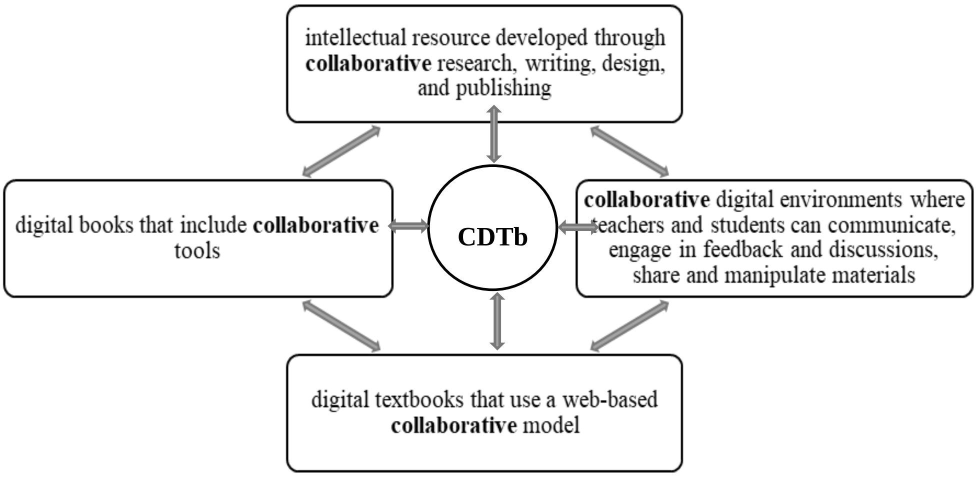

Figure 1. Collaborative Digital Textbooks: meanings and interpretations

2. Collaborative Digital Textbook Framework

The above differentiations, illustrated in figure 1, having in common a 'collaborative' topic, are made to centre the reader's attention on the usefulness of collaborative digital textbooks and how they could be developed and implemented in education. Each statement handles an aspect of the collaborative work and shows the conditions of the collaborative digital textbooks' involvement in the entire curriculum content. Also, these statements could suggest us the dimensions of Collaborative Digital Textbook Framework that should be considered when plan, produce and implement a CDTb, which are described below:

- *Key Features*. The key characteristics commonly realised for collaborative e-textbooks include the function to build interactive exercises and multimedia, navigate and search through the text, take notes or make annotations, insert hyperlinks, and also allow teachers and students to print information, and download the book to their computer or mobile devices. Considering pedagogical principles by applying interactive strategies (collaborative project creation, learning by doing, problem-based learning) we could complement the use of CDTb learning resources in a classroom, thus contributing to collaborative education.
- *CDTb types and formats*. E-textbooks differ in type and Lee et al. (2012) proposed three categories of e-textbooks: web-based systems, reading software, and dedicated devices. In this case, the accessibility

and usability of e-textbooks are specified. We read the content of digital textbooks in various format including *pdf*, *epub*, *html* or *exe* files;
- *The structure of the working team to develop a CDTb*. A successful e-textbook implementation relies on the mutual interconnection between members of a well-organised working team in developing learning resources for digital textbooks. The contributions of the expert team engaged in developing various components of the digital textbook are vital to get qualitative learning resources. As a whole, the team must include subject authors, researchers, programmers, designers, teaching staff, and other specialists involved with the development, distribution and use of e-textbooks and learning resources. This process is a collaborative one;
- *CDTb Builders*. Building upon our experience of developing e-textbooks, we recommend taking into consideration the following aspects to design and develop customised collaborative learning resources for an e-textbook, namely: the importing of various types of data, creating navigation, links, comments, developing/editing of learning objects, the assessment, intuitive access, interactivity, and other relevant characteristics. According to Grönlund et al. (2017), tools serving various purposes in developing e-textbooks could be structured as presentation aids, tools for working with texts, tools for communication, and teacher tools.

Any design of a CDTb for teaching and learning activities specifies the perspective of how to teach knowledge. We notice many software applications help us create and present information or phenomenon using different formats, thus contributing to understanding that information (text, images, simulations, etc.). Also, users' professional skills are constantly increasing as soon as new tools appear, which determines the development of new alternative content for modern learning resources. The fundamental role and diversity of tools for building e-textbooks for all levels of learning bring us to a newer standard of digital textbooks, which is rectified within the context of improvements in education. Many software packages offer adequate facilities to build e-textbooks, which could contain various types and tools of information representations mentioned above. However, using those tools combined in an application differs from using them separately in multiple digital environments. That's why a specialised cooperative team in developing e-textbooks is better than separated developers. From this point of view, the development of digital textbooks becomes cooperative, positive, and innovative, which supports both a collaborative digital textbooks framework and establishes a partnership between the curriculum and new tools in developing digital textbooks.

3. CDTb and collaborative tools

In what follows, we discuss the abilities of some e-textbook builders to ensure the expectations of the teachers and students regarding the collaborative features of e-textbooks.

The study investigates some examples of e-textbooks builders that offer tools to produce ‘collaboration’ through web technologies or enriched tools for learning context.

One of the powerful tools focused on a web-based collaborative model is *FlexBook* open authoring platform developed by the CK-12 Foundation (screen capture, figure 2).

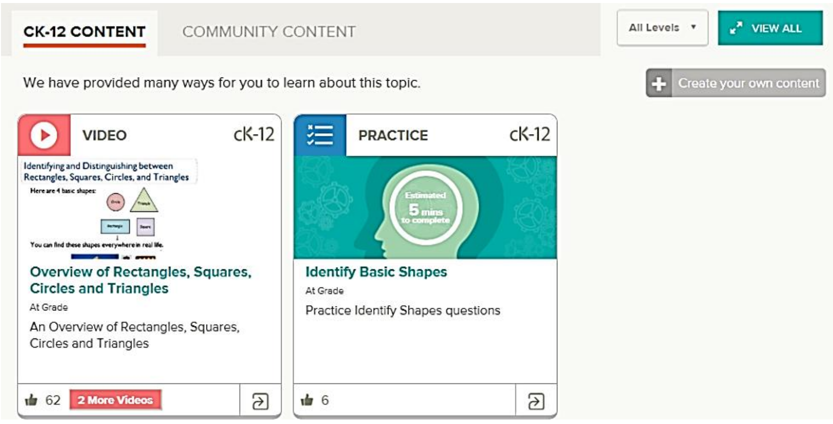

Figure 2. Example of flexbook: Math, Grade 1-5, Geometry, Identify basic shapes (source: https://www.ck12.org/c/elementary-math-grade-2/identify-basic-shapes/)

According to the mission of flexbooks and CK-12 concepts (https://www.ck12.org/) they are made to be flexible, engaging and educational, and can customise online textbooks to fit learners' learning styles, regions, languages, or levels of skill. Every teacher can create a flexbook from scratch (could contain reading, videos, images, simulations, flashcards, study guides, assessments etc.), and to begin he/she needs to have a CK-12 account. A user could form a group (teachers, community) to develop learning material in collaboration, thus multiple flexbook editors can work under a single account, as stated by CK-12 Foundation Blog. Also, the collaboration could occur over multiple CK-12 accounts. Each team member can work on a separate piece of a flexbook. Then, the group leader will organise a collection of customised content developed by the team members.

French e-textbooks, *manuels numeriques,* are another example of CDTb (https://www.lelivrescolaire.fr/) (figure 3). The process of creating textbooks is opened up and expanded to all teachers who have the opportunity to participate, interacting with hundreds of other colleagues, which makes it possible to create content tailored for classrooms.

Figure 3. Manuel numeriques. Sciences numériques et technologie (source: https://www.lelivrescolaire.fr/page/36959000)

3.1. Case description and research

For several years our research is focused on e-textbook builder *MDIRConstructor 2.0* (Balmuș, 2020) (within the national research project "Development and implementation of interactive digital textbooks in pre-university education"), which has incorporated tools to develop personalised digital textbooks, namely:

- hypertext (semantic links between content sequences);
- multimedia integration: simulations, didactic films, interactive animation, audio clips;
- integrating complex learning activities and educational games;
- online access (downloading, completing some tasks in cooperation, sending the solution to some work tasks, etc.).

Developing any educational application by MDIRConstructor 2.0 is a process of a collaborative working of a team that includes at least a course teacher, a programmer, and a tester (teacher, student). The developed e-textbooks through MDIRConstructor 2.0 require a particular educational pdf file (scanned traditional book, auxiliary educational materials, and others).

The next screen capture, figure 4, represents an example of adding a link from YouTube resources (menu PersonalResources/ResursePersonale, SelectTypeOfResource/Alege tipul de resursa, InternetLinks).

As it could be seen in figure 5, there are numerous tools available to help teachers to add various types of learning resources (audio, video, PowerPoint presentations, images, documents, vocabulary and grammar exercises, choose the correct option, complete the gaps, sentence formation, word transformation, matching, true/false, crosswords, executable applications elaborated in integrated development environments, and many others).

The advantages of this builder stand in the possibility of personalising digital textbooks. Any teacher can develop didactic materials from personal experience and point of view, aiming for an innovative style of getting new knowledge.

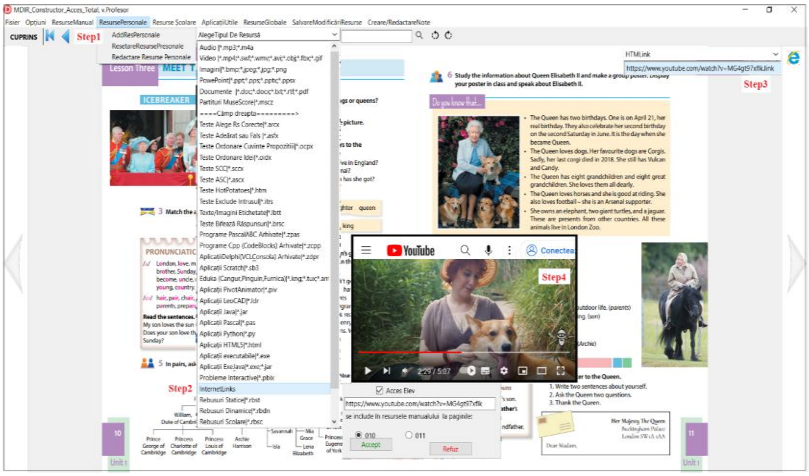

Figure 4. Adding a video link

In the figure 5 we present a screen capture of the *MDIRConstructor* e-textbook: 4 steps of the elaboration of the "Select the Correct Answer" application. At the first three steps we access and open the menu (/ResourceCreation/Creare resurse, Text/Immages/Labels-Texte/Imagini Etichetate) and create the educational application (TexteEtichetateCreator). In the last step, the teacher integrates the elaborated application in the e-textbook. Accessing and finding the solutions could be a collaborative activity as well.

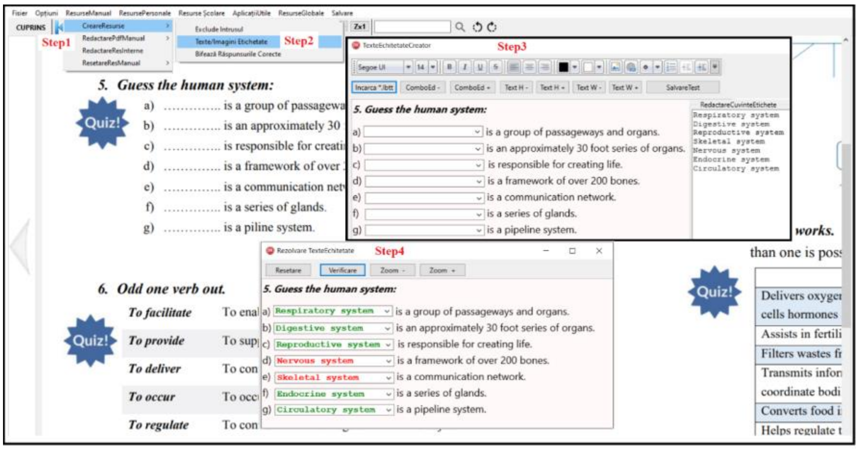

Figure 5. Creating the "Select the Correct Answer" application

Barriers

Despite the advantages of any categories of e-textbooks, including collaborative, immersive, and interactive features, several barriers prevail regarding the implementation of digital textbooks in education in the Republic of Moldova. In our opinion, they are:

- lack of a national policy regarding e-textbooks;
- lack of an e-textbook market, which success depends on the government's support and stakeholders (content publishers, teachers, and students);
- the necessity to endorse the e-Textbook implementation at the governmental level;
- the necessity to adopt e-textbook standards for authors, publishers, schools, teachers, students, and the community;
- lack of free builders to develop complex learning resources and e-textbooks.

Discussions

This work displayed some findings about collaborative digital textbooks, which have elaborated from pdf format books in interactive, dynamic and collective digital learning environments. The important point is the possibilities for interactivity and collaboration within CDTb. The result of the collaboration is proved by the possibility to interact with teachers through some tools, built/shared learning resources and documents.

The lack of digital e-textbooks in the national schools may awaken the involvement of the Moldavian government. Implementing e-textbooks in Moldavian education could start by reassembling traditional textbooks and providing educational content with digital tools. Establishing a national project in a coordinated group of university and pre-university teachers, stakeholders, and target groups centring entirely on the elaboration and adoption of digital textbooks is necessary to experience the highest impact in this field. Furthermore, we need to spread out teachers' professional growth in developing digital resources and promote the utilisation of innovative pedagogical strategies. At the university level, a web-based textbook is more practical than a traditional printed book. Here, it is relevant to encourage a university platform that offers valuable teaching-learning experiences.

4. Conclusions

As stated, there are several interpretations and meanings of collaborative digital textbooks. We can say in conclusion that a CDTb represents a collaborative digital educational resource developed through the joint involvement of a group of teachers and IT staff, where teachers and students can cooperate, engage in feedback and discussions, and share materials. Modern e-textbook web-based builders use a cooperative working model that includes the possibilities of connection between members of a collaborative team.

The tools of the MDIRConstructor software, introduced as a case study, allow the development and insertion of various types of learning resources and share educational resources. The most common functionalities of collaboration are the links of connection with web pages, completing tasks in group, and using teachers' tools to elaborate learning activities within e-textbook. At present, the transition to a digital representation of educational resources is analysed as an educational change regarding innovative learning strategies.

Acknowledgement

Referring to international and national experiences, the authors present a theoretical research about the practices and importance of Collaborative Digital Textbooks in education and tools that could help developers create Collaborative Digital Textbooks. We carry out this investigation within the national research project "Development and implementation of interactive digital textbooks in pre-university education" (The State Program 2020-2023, Republic of Moldova, nr. 20.80009.0807.25)(https://ancd.gov.md/sites/default/files/document/attachments/Rezumate%20proiecte%20site.pdf).

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Learning by Wikipedia's NPOV principle: an online dynamic experience

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Abstract: *Wikipedia projects are available in many languages and they contribute to learning programs by using digital content and peer learning practices. The Neutral Point of View (NPOV) is a fundamental principle of Wikipedia. As such, it is influencing the on-boarding process for new editors and the quality of contributed articles. The authors have been training new editors for Wikipedia in Romanian and coordinating a research project inquiring about NPOV within Wikipedia and its learning community.*

This article is an exploratory study on better understanding the process of learning about NPOV practices and its potential to create learning and teaching opportunities. The authors will present a literature review documenting the learning approaches within Wikimedia projects that contribute to more balanced and comprehensive Wikipedia texts from the NPOV perspective. Looking at the relation between the community of editors and the quality of NPOV editing, the authors will focus on the Romanian Wikipedia project. They will map the NPOV tagged Wikipedia articles and start a discussion about the online group dynamics and learning contexts for editors. The analysis will look at how the size and diversity of a Wikipedia community contributes to improved articles adhering to the NPOV.

Keywords: Wikipedia, Neutral Point of View, Online learning, Online communities, learning with Wikipedia, Teaching with Wikipedia.

1. Introduction

The global Wikipedia project is unique in its approach and goals. An online encyclopaedia edited by volunteers, it is now "both the largest and most widely used encyclopaedia in history" (McDowell & Vetter, 2021). Moreover, the project, available in 329 languages, is kept alive and developed continuously by a community of volunteer contributors (Wikipedia, 2022a). All the contributors go through a process of learning about the project and how to contribute to it and then contribute to it based on their available time and interest. This makes Wikipedia

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not only a resource for learning but also a learning platform for anyone interested in developing digital skills, critical thinking, and documentation abilities.

Wikimedia Education is a project that was developed precisely to promote Wikipedia as a learning tool and project. Among the abilities and knowledge recognized as being enhanced by contributing to Wikipedia are: reading, writing, critical thinking, information literacy, literature review, collaboration, community of practice, citation, copyright, coding, online etiquette, and online citizenship (Wikimedia, 2022). Multiple teaching projects, curricula and analyses have already looked at the impact contributing to Wikipedia can have for the learning process of children, young adults or seniors (Brailas et al., 2015; Johansson & Lindberg, 2019; Vetter & Moroz, 2019). The connection between learning processes and programs and Wikipedia, even though recognized, is underused especially in smaller Wikipedia projects like the Romanian language one.

This article is presenting the initial phases of an exploratory study that looks at the potential the ro.wikipedia.org project (WikiRo) can have for supporting learning and teaching processes in formal but also informal learning settings.

1.1. Context

As new editors are constantly joining Wikipedia projects around the world (in October 2022, the number of registered editors was over 44.4 million), their process of learning and adhering to the norms of Wikipedia communities in various languages takes some effort and time. The Wikimedia Foundation and affiliated organisations encourage the participation of new editors through campaigns, activities, but also courses. One direction of activity is training librarians, primarily from public libraries, to edit Wikipedia articles on local history (Vershbow, 2022).

Wikimedians of Romania and Moldova User Group (WMROMD) is an affiliated group of the Wikimedia Foundation. Since 2017 WMROMD organises the #1lib1ref (one librarian, one reference) campaign in Romania; thus, librarians became a group of potential new users for editing WikiRo. Previously, the user groups that were trained and encouraged to contribute to WikiRo were mainly students and professors (Popovici, 2022). For a couple of years, the #1lib1ref events were organised following the method used in similar events around the world (Wikipedia, 2022b) and did not gather many new users. The approach changed in 2019 when WMROMD, in partnership with Goethe Institute Bucharest and the National Library of Romania, organised an editing workshop for public librarians. The invited guest was Antje Theise from the Hamburg University Library and she presented how her university library was benefiting from connecting history, research, and digitization library projects to Wikimedia projects (Theise, 2017). Wikipedia and other Wikimedia projects (like Wikimedia Commons or Wikidata) can bring visibility to the information held by libraries. In the process of contributing to Wikipedia, Theise suggested there is great potential for librarians to contribute to more informed and educated communities. The workshop was followed by two regional one-day trainings of public librarians in

Arges and Galati counties. The participants identified ways in which they could promote their communities' local history, while the WMROMD organisers observed the need for a more sustained learning process to empower librarians to fully contribute to Wikipedia.

The 2020 pandemic forced the WMROMD to stop physical training events. At the request of libraries, WMROMD started to offer online courses for librarians from Arges and Brasov counties. The interest to support online learning became central for volunteers from WikiRo. The results of the 2020 online training were significant given the time and efforts invested (Wikimedia, 2021).

Encouraged by these results, WMROMD members started to look for other online learning opportunities. The Learning Circle methodology implemented through an Erasmus project in Romania was the opportunity to revise how new editors could onboard the Wikipedia project. Learning Circle is a methodology for adult learning that is built upon peer learning and regular meetings of the group invested in learning together (Makowska & Koszowska, 2020). Peer2Peer University is empowering learning circles around the world and hosted two rounds of Learning Circles on editing WikiRo. In 2020-2021 Claudia Serbanuta developed an online course for learning how to edit Wikipedia and facilitated the Learning Circles on this topic for 23 public librarians, that created 10 new pages, improved 156 pages, and uploaded over 400 media files.

The results were encouraging but in the process of requesting feedback and discussing what made editing Wikipedia hard, the participants –besides understanding that time commitment for adult learning is mandatory, that digital skills need to also be developed when learning Wikipedia–, confessed that The Neutral Point of View (NPOV), one of the core principles of Wikipedia, was difficult to understand and implement. The ability to author articles that respect the NPOV standard might seem like a Wikipedia-only skill but if we look closely at what NPOV requires (neutrality, ability to distinguish between facts and opinions, presentation of the different points of view regarding a subject, a neutral tone etc.) we see that NPOV adherence is a fundamental ability for anyone. Writing almost any high-school level or higher essay requires (at least partially) some sort of NPOV-related skills. Moreover, mastering these abilities is relevant in a world in which individuals are subjected to false information on a regular basis. That is why NPOV training has potential to contribute to educational tools, and we have chosen to focus our study on NPOV status in Romanian Wikipedia. This will inform on constructing better country-specific NPOV training tools and programs.

Starting from the learning experiences organised in the past few years for that community, the authors, supported by a grant from the Wikipedia Foundation, are looking for new ways of engaging and learning online. This article includes a literature review on learning through editing Wikipedia and an analysis of the literature for learning about one of the five core principles of Wikipedia, The Neutral Point of View (NPOV), in projects in English.

1.2. Methodology

This exploratory study focuses on looking at the community of contributors to the Wikipedia project in Romanian language and identifying ways to better equip new editors to become contributors to this project. The literature review on how Wikipedia is used in learning contexts and the role NPOV has in facilitating or making it hard for new editors to learn and contribute to this project is mostly based on English speaking communities. The exploratory study is looking at the dynamic of the community of editors from WikiRo.

The creation of free content on Wikipedia is supported through discussions that take place on talk pages throughout the project. In fact, in the case of WikiRo, the total number of pages for articles is less than the number of pages where discussion takes place. The clarifications related to the content on the main article, the suggestions of improvement as well as the disputes are documented on these talk pages. For this exploratory phase of our study, we started mapping the community actions in addressing the ways in which the NPOV was dealt with.

We started with the list of articles marked by the community as disputable with respect to the NPOV guidelines (Categorie: Dispute PDVN - Wikipedia). We excluded several articles that had no identifiable NPOV problem in the talk section and then took a close look at each article's talk page. This initial analysis allows us to map the types of conflicts NPOV creates and that will help future work on what is missing from the learning to edit perspective.

The article will conclude with this initial analysis and suggest ways to continue analysing but also plan for learning to edit Wikipedia in more effective ways.

2. The NPOV and the learning opportunities

When talking with librarians engaged in learning to edit Wikipedia during the 2021 Learning circles WMROMD sessions, the facilitator observed the efforts they were making in keeping a neutral tone and allowing multiple perspectives on a topic to be presented and linked to proper documentation in Wikipedia articles. Librarians were confused about the position they were expected to take as Wikimedians, as that neutral tone and approach was not something practised often in their everyday work. This made the authors interested in exploring how NPOV was understood by new Wikipedia editors, and what type of experiences related to NPOV tagging and improving articles existed already within the community of WikiRo editors.

Wikipedia has been the subject of numerous scientific studies, some focusing on its accuracy as an Encyclopaedic project (Giles, 2005), others using it as a corpus of data for diverse types of studies (Gleim et al., 2006). In fact, a search using the term Wikipedia in the Web of Science Core Collection (similarly in Scopus) resulted in over 6000 results (as of 24 October 2022). However, the number of results for articles analysing the NPOV in Wikipedia declines dramatically.

The Web of Science Core Collection search yields between 28 (if using both "Wikipedia" and "Neutral Point of View" as topic) and 14 items (if using "NPOV" as an added topic). Scopus offers two items when adding "NPOV" as a keyword and four results when searching with "Neutral Point of View"). These articles fall under one of the following categories: articles that offer a general description of NPOV (Pavalanathan et al., 2018), articles that analyse different biases (Koerner, 2019), and articles that analyse linguistic differences between Wikipedia editions (Góngora-Goloubintseff, 2020).

O'Neill (2017), in her discussion with Irish Wikimedians, presents the view of practitioners as Oliver Moran, who believes that, while the neutral point of view should always be paid attention to, the focus of editors should remain on information being accurate and verifiable. Matei & Dobrescu (2011, p. 41) argue that in the policies that the Wikipedia community adheres to, there is a degree of ambiguity that, even though normal for "the pluralist and non-hierarchical values of the culture that brought Wikipedia to life", contribute to a way of solving conflicts related to meaning (like NPOV conflicts) in ambiguous ways. So, the dynamic between information and ambiguous solutions is accompanying NPOV discussions on Wikipedia.

Bias is another element very present in language used in Wikipedia and related to the NPOV principle. As Kackie Koerner (2019) states: "Bias can appear in many areas like Wikipedia's policies, practices, content, and participation.". Given the large corpus of data Wikipedia produces, the ways to research biases are also suitable for quantitative data analysis. Hube & Fetahu (2018, p. 1785) propose a semi-automatic approach to detect biased statements in Wikipedia. Focusing on language bias, they constructed a bias word lexicon in English, and used it to accurately identify biased statements in Wikipedia.

The research on NPOV is focused on identifying biased language but also on finding ways to improve the quality of articles. A core role in this process is played by the Wikipedia editors whose work can be made better through discussions, training, and shared good practices. A result that illustrates the complexity of this process was obtained by Pavalanathan et al (2018) as they were analysing articles and talk pages tagged by NPOV in English Wikipedia. Once a talk was started after identifying biased language on a page the content on that page improved as the biased language was addressed by various editors. However, for individual editors who used biased language, there was no meaningful change in how they used the language in a way that would improve their contributions. The list of "words to watch" and dedicated lexicons used were helpful in identifying improvement of content after NPOV marking and discussions but they were not as successful in helping editors better internalise the need for unbiased and factual information required by the NPOV Wikipedia pillar.

Another way of looking at how Wikipedia articles can be improved is by applying theories from software and crowd contributions. Linus's Law –"given enough eyeballs, all bugs are shallow" (Raymond, 1998)– is used primarily in the software world to imply that progress in locating a problem is improved through a larger number of contributors. This law has also been used in relation to Wikipedia's NPOV by Greenstein & Zhu (2016), while analysing a corpus of texts from the English Wikipedia. This article tries to verify the hypothesis that (1) a larger number of contributions and contributors to a NPOV article leads to a better article from a NPOV perspective and (2) a more diverse base of contributors would lead to better NPOV. The authors only find evidence for hypothesis (1) at best and no support for hypothesis (2).

While identifying the NPOV non-compliant articles in Wikipedia is of interest to researchers and the editing community, what needs more attention is how we can help editors fully adhere to the requirements of NPOV in each language. This can happen through learning and having access to quality learning materials.

3. Learning within the WikiRo community

The WMROMD group continues to train new editors in 2022-2023 through the "Editing Wikipedia Together" program, supported by Wikimedia Foundation through the Wikimedia Community Fund. The authors' research interest shifted towards understanding how new editors can be helped to work and improve their writing and editing skills to be able to put NPOV guidelines into practice. This exploratory study takes the experiences and observations from larger communities, like the English Wikipedia, and looks at ways to apply and learn in a Romanian language context. As a starting point, this article presents observations on the NPOV tagged pages and discussions in WikiRo. This will help with seeing what arguments and instruments are used for improving the content, what is the dynamic and the drive for making these changes, and whether we can contribute to the learning processes for new users. As editing Wikipedia is also a learning experience, editing WikiRo has the potential to help Romanian language editors improve their skills and editing abilities.

3.1. Data gathering and analysis

The marking of articles as non-NPOV-compliant is done by members of the community observing that some content in articles is not respecting the NPOV requirements; once an article is marked, it is automatically added to the list of NPOV - marked articles. WikiRo had, on the date of our data collection (11 October 2022), 157 NPOV-marked articles out of over 430.000 articles in total. When searching the Discussion pages, we found that 19 articles lacked any discussion and 24 lacked any NPOV-related discussion. Furthermore, seven articles were not real NPOV articles but Wikipedia articles related to principle. This brings the total of actual NPOV-related articles down to 107 as seen in Figure 1 NPOV - marked articles.

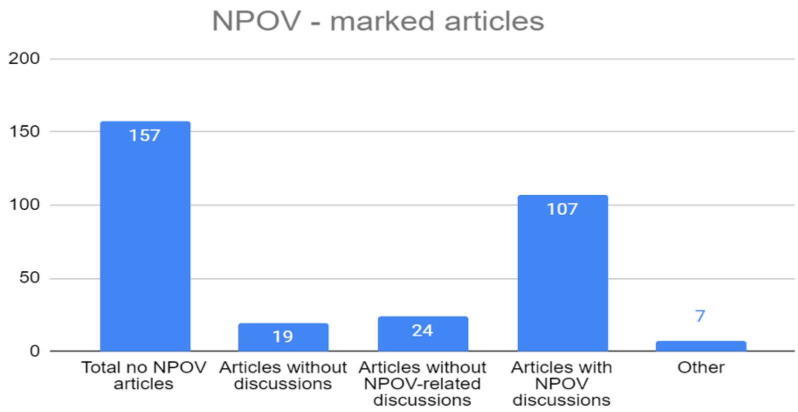

Figure 1. NPOV marked articles

The total number of NPOV-related contributions (initial conversation starter and replies) in the 107 articles is 572, or about 5.34 per article. This average, however, is extremely skewed: 121 articles have at most five contributions leaving only 29 with over five contributions, as seen in Figure 2 Contributions per article. Most articles have either zero or one contribution (43 each) and the top discussed article has 62 contributions. Only 17 articles have at least ten contributions and even in that case not all contributions are part of one actual continuous debate but sometimes part of several small dialogues or even monologues.

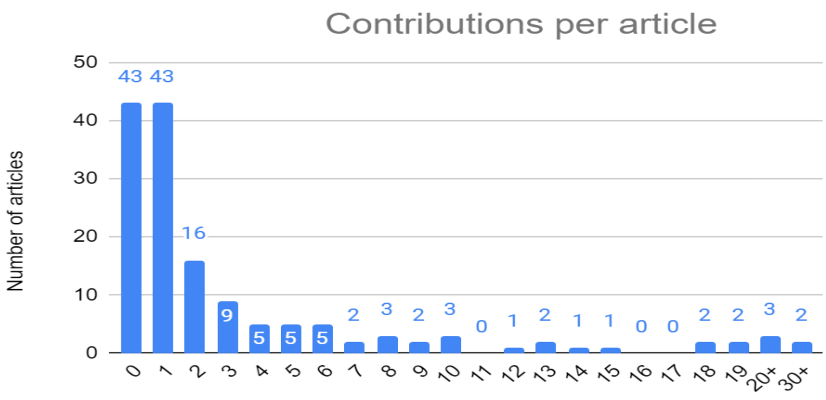

Figure 2. Contributions per article

So, the NPOV was more like a final mark given by a more experienced Wikimedian to an article than an invitation to a debate. Certain topics ignited more active debates. The dynamics of these discussions was more like a series of angry replies from fixed positions than actual debates with logical arguments, responses, and a civilised tone. A constant problem was, in many cases, the continuous usage of sources that lacked verifiability by some editors (even after being informed about the verifiability issues of their sources by other Wikipedia editors). This kind of issues arose not only in the case of anonymous users but also in the case of registered users that had previous experience editing Wikipedia and should have been, in theory, able to identify and use reliable sources. Another issue encountered in our analysis is the usage of Wikipedia as a publicity instrument, both by companies and individuals. These articles are easily identifiable by the language used (highly positive) or, as was the case in a politician's Wikipedia page, by the fact that the creation and editing of the page was done by a single person that had no previous (and has had none since) Wiki edits.

From a topic perspective, when considering only the articles with at least ten contributions to the Talk page, the data shows that subjects such as Politics and History are conducive to lengthier discussions, as shown in Figure 3 *Contributions per topic*, having a total of 228 contributions out of the total 572 contributions among all topics and from all the articles (regardless of how many contributions the article had). This accentuates the skewed perspective and clearly indicates not only the appetite for discussion on certain topics (a handful of articles) but also the lack of any proper discussion in the case of most articles. However, lengthy discussions do not necessarily translate into fruitful debates - as evidenced by the presence of political and historical subjects in the Wikipedia NPOV list.

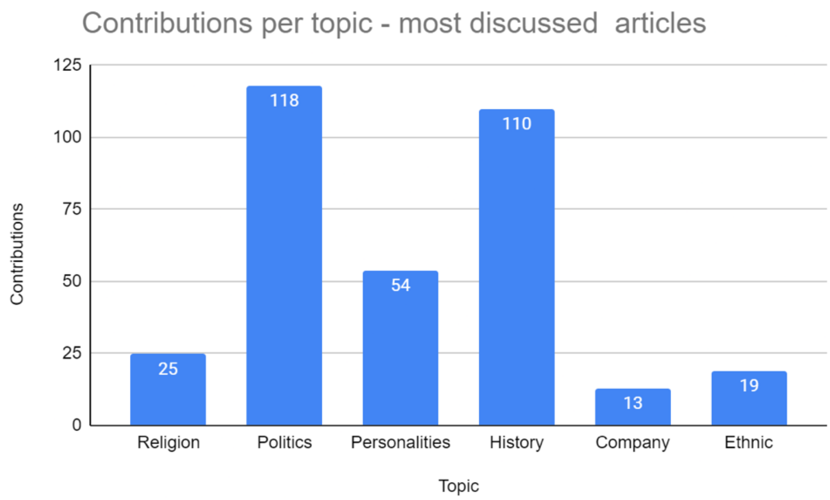

Figure 3. Contributions per topic

When considering Linus's Law, we observe that even the topics that ignited significantly longer discussions (20 plus replies) lacked a substantial number of contributors (most had under ten), besides lacking the number of contributions to the discussion (only five had over 20 contributions). This reality makes unattainable any attempt to extract a relationship between the NPOV and number of contributions/contributors in the manner proposed by Greenstein and Zhu (2016), based on the lack of a statistically significant population size.

4. Discussion

Learning cannot happen without interaction, and this is also true in the community of Wikipedia editors. By design, the Wikipedia community is based on interaction, and learning is an important part of being an editor - regardless of language and size of the project. The quality of the content in a community-based project like Wikipedia is not the responsibility of a few but of everyone involved. As such, learning is a dynamic process dependent on the community (its componence, practices, objectives and dynamics). As we have seen in the literature, the potential of using Wikipedia articles and selected corpuses to investigate community practices has a great potential in helping paint a more complete picture of the editing community.

In the Romanian-speaking community of Wikipedia editors the learning process is based on individual motivation and perseverance but until now it is unclear how much of it is also influenced by other members of the community and to what degree these influences are positive or negative. The mapping of the NPOV tagged articles, the discussion they created and the editing history is only the beginning of this analysis.

4.1. NPOV as co-learning process

Working on a Wikipedia article is a shared process, involving both learning and sharing knowledge. The peer-to-peer learning method used in Learning circles by WMROMD facilitators to induce new editors produces reasonable results. This method might also be useful for editors interested in improving their skills in relation to the NPOV. However, this assumes that people are ready to recognize their need to better their skills as they agree to participate in a learning program. This assumption needs to be verified through future interviews.

NPOV tagging is done by one editor and it signals a need for improvement of the quality of the content. The signal is sent to the whole community, not only the main contributor of that article so there is a potential of co-editors joining in the improvement process however the analysis did not yield any obvious signs in this direction. The small number of participants in discussions is a sign that there are even fewer people willing to contribute to NPOV improvements. More editors could mean more chances of people engaging and contributing to better content, more people present and active in the learning process.

Pavalanathan and her colleagues observed that editors who used biased language, even after discussing the issues and, with the help of the community, improved the articles, did not change their approach right away (Pavalanathan et al., 2018). In smaller communities like the Romanian speaking community of editors, this change is even harder as the size of the community limits the availability of peer-to-peer learning opportunities.

4.2. Limitations

This study's limitations ensue from the size of the NPOV contributing community in WikiRo. Although the small number of discussions related to the NPOV articles makes applying an instrument such as Linus's Law inefficient, it also points towards the first step for a better NPOV standard in the WikiRo community: involving more editors in the discussions, thus ensuring, if not a more diverse community from the start, at least a greater possibility of attaining such a community in the long term, as a small community of contributors (as is the case in the NPOV interested community) has a smaller probability of a diversity of points of view.

4.3. Future investigations

Wikipedia is "de facto global reference of a dynamic knowledge" (Graham, 2011, p. 269) and the references that document the diversity of cultures in this world come from Wikipedia editors around the world. WikiRo is developed by a small community of volunteers but to develop it needs support. And this can come only from better understanding the community of learners. Understanding and helping with addressing the NPOV requirement in this community can open the door for more effective peer to peer learning practices and community development. The authors plan to inquire about this issue and interview editors about their NPOV related practices.

Because NPOV is a principle that benefits (at least in theory) from a larger number of participants, the low activity in WikiRo regarding NPOV makes attaining different perspectives less likely and thus reduces the chances of fruitful NPOV talks. Of course, the number of contributors is, by no means, a sufficient condition for attaining NPOV but it does seem to be a necessary basis on which to build a possible, future, neutral status of Wikipedia articles. Therefore, we consider that a first step in our future work regarding NPOV Wikipedia should be focused on trying to get more Wikipedia editors involved in the neutrality-principle discussions.

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Section 4

Online Group Dynamics and Non-Technological Dimensions of Digital Learning

Supervised Machine Learning: A Brief Introduction

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Abstract: *Machine learning is being employed more and more in psychological research, and it can enhance our knowledge of how to categorise, anticipate, and treat psychosomatic illnesses and the negative health effects that go along with them. Machine learning provides new resources to address problems for which conventional statistical techniques are inadequate. One of the jobs that intelligent algorithms perform most commonly is supervised classification. The most accurate prediction algorithm is determined according to the data set, the number of situations, and the parameters. This article discusses numerous Supervised Machine Learning (ML) different classifiers, equates numerous supervised learning algorithms, and specifies the most effective classification method. This article offers a broad overview of machine learning with a particular emphasis on supervised learning. We present several popular supervised learning techniques. Therefore, we can argue that supervised predictive machine learning needs machine learning procedures that are detailed, correct, and have a low mistake percentage.*

Keywords: Machine learning, Supervised machine learning, Classifiers, Data mining methods.

1. Introduction

Among the computer engineering subfields with the quickest growth has broad-ranging implications is machine learning. The most effective forecasting tool is machine learning. We can predict the economy, wind power, wind speed, and other variables using machine learning, which is one of the greatest significant research areas for academics (Seemant, 2022). It speaks about the automatic recognition of significant data structures. Giving algorithms the capability to learn and adjust is a goal of machine learning techniques. Data analysis is the primary important use of machine learning (ML), which has many other uses as well. When doing investigations or even when attempting to build correlations among several aspects, people are frequently susceptible to errors (Kotsiantis, 2007). Employing the correct learning approaches is thinkable to improve numerous discoveries since the conjoining of machine learning and data science. Data mining besides machine

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learning has progressed significantly as a consequence of the advancement of intelligence besides nanostructures, which flashed attention to the discovery of hidden patterns in information to make worth. A comprehensive discipline with a complex analytical basis and very strong techniques has been shaped and concluded the merger of statistics, machine learning, statistical inference, and then computation.

A classification of machine learning techniques is created according to the purpose of the method. An output-to-input relationship is produced through supervised learning. Machine learning algorithms have occasionally advanced due to extraordinary information extraction. These have prompted the use of several supervised and unsupervised machine learning techniques. Identification issues commonly require supervised learning since people frequently want computers to acquire a custom categorization (Ayodele, 2010).

Data science, pattern matching, and machine learning all depend on categorization. So, its groups data according to previously previous data, it is a method of supervised learning. By integrating the characteristics and extracting trends similar to every category from training examples, every test instance's category is determined. There are two stages to classification. To assess the method's effectiveness and accuracy, a categorization technique is performed on the training sample first, as well as the derived structure is then tested vs a tagged testing dataset. Content categorization, spam detection, image processing, fraud prevention, attrition analytics, risk assessment, energy forecast, and more uses of categorization exist (Tiwari and Ling, 2021). The goal of supervised learning is to improve target class algorithms by using prediction information. Beyond that, in circumstances when the quantities of the prediction features are available, however the meaning of the target class is uncertain, a secondary classification is employed to apply classifiers to testing data. The labels in the categorization specify the category to which the training dataset corresponds. In regression, on the other hand, the label is a true solution that correlates to the sample (Dridi, 2021).

The categorization of algorithms for supervised learning is covered in the next section. In the third section, we continue our investigation of machine learning method elements. The usage of supervised machine learning classification methods was discussed in the fourth unit. The fifth segment discusses the difficulties and possible futures. Finally, the sixth section's conclusion.

2. The Categorization of Algorithms for Supervised Learning

Below are some of the important supervised machine-learning techniques that focus mostly on categorization.

2.1. Naïve Bayes (NB)

This is a BN just with single parents and multiple offspring, with the kid connections assuming a high level of autonomy. If such a premise is correct, these classifiers will improve more quickly than discriminative methods. Trained with

NB consumes lower computational effort. In contrast to Neural Networks and SVMs, there are no free variables to configure, thus considerably simplifying NB (Kuncheva, 2006). This delivers probabilities, making it easier to employ NB in a wide range of situations. It does not relevant whenever the relationships among characteristics must be considered (Islam et al., 2007). The ML Naïve Bayes technique is employed in the classification of academic subjects wherein database examples are distinguished based on a specified characteristic (Genoud et al., 2020). The method is essentially probabilistic and also is founded on the Naïve Bayes (Ahmad et al., 2020).

2.2. Bayesian Network (BN)

The Bayesian Network (BN) is just a graph method that depicts the probable correlations between groups of variables. Bayesian networks are among the most common statistical learning techniques. When contrast to decision trees and other neural networks, the greatest fascinating distinguishing of BNs is certainly the aptitude to take into consideration preceding data on a specific issue regarding the structural correlations between its elements (Kotsiantis, 2007). One limitation of BN algorithms is they are not ideal for samples with a large number of characteristics. The applicability of Bayesian networks to decipherable machine learning and optimization by showing implementations in neurology, engineering, and biotechnology that encompass a broad range of machine learning as well as optimization challenges (Mihaljevic et al., 2021).

2.3. Support Vector Machine (SVM)

This is a difficult procedure, yet it has a high level of precision. It moreover prohibits conceptual promises about overfitting from being made. These could even function because if a given dataset is not linear in the basic feature set when you employ the right kernels. These were rooted in the concept of reducing the distance between the hyper-plane and the closest sampling position (Mehra and Gupta, 2013). The amount of elements does not affect intricacy. It can generalise well and is resistant to high-dimensional datasets. However, the training pace is slower, and effectiveness is dependent on parameter selection (Caruana and Niculescu, 2006). With linear SVM, the variables are termed p-dimensional since they may be divided by the number of p-1 surfaces called hyperplanes (Kaur and Kumari, 2022). As a result, the lines split the set of boundary then information spaces between the datasets for the regression otherwise classification learning job.

2.4. Logistic Regression (LR)

Whenever the dependent or targeted variables are bidirectional, this approach is used. In such a particular method, logistic regression tends to say in which the border between the categories occurs and also specifies the classification probability dependent on distances from the border. Whenever the set of data is bigger, this advances faster toward the extremities (0 and 1). Such probabilistic claims elevate logistic regression above the level of a simple classifier. It provides greater, higher accurate predictions and might be fitted in a different method; however, such powerful forecasts may be incorrect (Caruana and Niculescu, 2006).

Logistic regression is a frequently used technique in applied statistics in addition to discrete data processing. Logistic regression is a type of linear interpolation. LR is a powerful classifier among supervised machine learning techniques. It is an expansion of basic regression models that, when implemented in a database, expresses the likelihood of occurrence or probability of failure of a certain example (Uddin et al., 2019).

2.5. Decision Trees (DT) and Random Forests (RF)

DTs are simple to understand and describe, and they can readily manage relationships among components. Because it is non-parametric, aberrations do not affect the method, allowing it to handle linearly inseparable information. Several good techniques were ID3, and CART based on various dividing parameters like Gini Coefficient, Gain Ratio, & Info Gain (Rokach, 2005). Decision trees could deal with a variety of information, including incomplete data and redundant features, and also have significant adaptation abilities. They are also resistant to disturbance and deliver excellent results for a comparatively small computation time. Furthermore, dealing with processing high-dimensional data utilising DTs is tricky. However the computing time is short, and it takes a long time to grow the tree. This employs a split-and-rule strategy that works effectively when there are few hugely important traits yet is not so effective when there are numerous intricate interconnections. Issues spread via trees, becoming a severe issue as the number of classes grows (Xhemali et al., 2009). Tree of Decision the ML technique is utilized to split the learning process, and the tree is built by splitting the database into lesser units until every division is spotless as well as unadulterated, then data classification is determined by the kind of data (Muhammad and Haruna et al., 2020). Whenever the tree is properly formed, the cutting procedure is employed to eliminate the noise from the database (Muhammad, Islam, Usman, and Ayon, 2020).

RF is an ensemble approach that works through training several decision trees and providing the classes with the highest consensus across all trees in the ensembles (Lorena et al., 2011). When it reaches the training phase, it generates a vast amount of trees as well as a forest of decision trees (Hasan et al., 2018). Several classification tasks are won by RFs, who are generally somewhat clear of SVMs. These have quick, modular, and noise-resistant, don't really over fit, and thus are simple to comprehend and display without a setting to handle. Therefore, as the amount of trees increases, the algorithms become too sluggish to forecast in actual time. Recommends a floods catastrophe robustness assessment system based on RF to address the fuzziness of robustness assessments (Liu, 2020).

2.6. K-Nearest Neighbour (KNN)

It's a supervised classifier that does not use parameters. It provides the category of the closest before labelled specimen to an unidentified sampling site. The criterion is unaffected by the sampling elements' combined distributions and categories. It is ideal with multi-modal interfaces in addition to situations in which an element can have multiple identifiers. It is a simplistic and inefficient approach to learning. Furthermore, the effectiveness is contingent on selecting a suitable ‘K’ quantity. Apart from computationally intensive approaches such as cross-validation, there isn't a methodical process that must choose ‘K’. Because all information should be examined, performance fluctuates with quantity (Pernkopf, 2005).

High precision effectiveness is provided by machine learning methods like the K-Nearest Neighbour models. K-Nearest Neighbour is among the machine-learning techniques used to improve mammography diagnostic performance (Khorshid and Abdulazeez, 2021).

2.7. Neural Networks (NN)

These were computing systems that use the neural architecture, comprehensive suite, and learning capacity of the human mind often at small sizes. This strategy is useful for issues with non-linear and highly dynamic connections. ANN mimics the tasks and functions of the human mind, which are identified as networks, which are scientifically documented by way of before mentioned to as artificial neurons. The neurons connect as well as transfer info and data between themselves in the type of 0s and 1s or mixtures, but every neuron is assigned a certain weight that specifies its activities and roles in the network (Kaur and Kumari, 2022). NNs are a potent alternative to traditional approaches, which are frequently constrained by stringent requirements of normalcy, regression, parameter independence, and so forth. Whereas a NN can record numerous different types of relationships, it permits the user to quickly and effortlessly represent occurrences that would otherwise be challenging or challenging to describe. Back Propagation Neural Networks (BPNN), Probabilistic Neural Networks (PNN), and other versions are classed according to the technique used to train the network.

The perceptron represents the most basic version of NN, utilized for the categorization of linearly separable sequences. This is made up of a single neuron having weights that have been modified. Because of the availability of unlabelled data, training is expensive and unworkable. Its most commonly utilized NN classification is a Multi-Layer Perceptron, which can simulate complicated tasks and is resistant to extraneous inputs and disturbance (Zhou, 2004).

3. Machine Learning Method Elements

Supervised machine learning methods are useful in a wide range of fields (Setiono, 2000). In principle, SVMs or neural networks outperform while working with multidimensional and continuous information. While working on identified, logic-based algorithms generally accomplish superiority. A high sample size is compulsory for neural network models and SVMs to attain maximum predictive performance, while NB might need a smaller dataset.

There's a really strong consensus that K-NN is particularly subtle to unlabelled data; this trait could be addressed via the method's operation. Furthermore, the existence of unlabelled data might make neural network training ineffective, if not impossible. Many decision tree techniques are inadequate for applications requiring diagonal division. Whenever there is multicollinearity as well as a nonlinear association among the input and output characteristics, ANNs and SVMs work effectively.

NB involves minimal internal storage for together the training and classification phases: the rigorous minimum is the RAM required to record the previous and consequent probability. Its elementary KNN method requires a significant amount of memory throughout the training stage, besides its implementation area is at least as large as its training space. Furthermore, while rules methods can indeed be utilised as progressive classifiers, Naïve Bayes (NB and KNN) can. Missing data are inherently resistant to Naïve Bayes classifiers because they are completely disregarded in computing probability and so have no influence on the concluding result.

Furthermore, Decision Trees and NB typically had varying operating characteristics; while one is exceedingly efficient, the other is not, and conversely. On the opposite, decision trees and rules analysers work similarly. SVM and ANN share comparable functionality. Over whole samples, no individual learning system can reliably outclass others. Diverse data sets having various varieties of variables and the number of incidences define the sort of technique which will work efficiently.

One of the key kinds of ML is supervised learning. It entails training the models using labelled data and then testing them with unlabelled data. It is also separated under classification and regression jobs. Several supervised learning methods have been projected through the last era. From fraudulent activities to knowledge discovery, through analysis of heart illness to the discovery of cancer, supervised learning is working in an extensive range of circumstances.

4. Usage of Supervised Machine Learning Classification Methods

Table I depicts the methodology, specific applications, and the benefits and drawbacks of supervised machine learning.

Table I

Methods	**Specific Application**	**Benefits**	**Drawbacks**
Neural Network	Image categorization	Focuses on non-linear or dynamic connections that are not constrained to	Leisurely to train on average, effectiveness is dependent on the size of

		presumptions of linearity, normalcy, or variables independent. Resistant to unnecessary and noisy inputs.	the hidden layer and the model parameters set, and is difficult to comprehend.
K-NN	Calculation of density, Geometric computing	Suitable with multi-modal groups, regardless of the sampling distributions and categorization.	Low effectiveness, which is reliant on selecting a suitable value of k, is harmed by noises and unnecessary characteristics, and effectiveness fluctuates with data volume.
Decision Tree	Drug testing, Welding precision, Sensing from a distance	Anti-parametric, manages characteristic relationships, could manage the linearly inseparable information, could manage a range of data, incomplete data, and duplicated characteristics, is disturbance resistant, and provides great effectiveness for a very minimal computation complexity.	Hard to cope with high-dimensional information, might quickly over fit, requires a long time to construct the trees, could not handle dynamic interaction, faults spread across trees, and information fragmentation issues.
SVM	Text categorization	High precision, prevents overfitting, variable kernel choice for non-linearity, precision, and effectiveness were independent of information size, and strong classification performance.	Complicated, the training pace is slow, and effectiveness is depending on parameter estimation.
Random Forest	Object recognition, to locate a cluster of individuals, Microarray data segmentation	Quick, flexible, and noise-resistant, it gives a description and presentation of its results without requiring any settings.	Because as the quantity of trees rises, the method gradually decreases.
Bayesian Network	Documents categorization, Clinical imaging equipment	Capability to understand an issue in terms of the architectural link between predictions, training requires lesser computing time, and also no free variables must be set.	Performance degrades as dataset size increases, and it cannot handle high-dimensional information.

Logistic Regres-sion	The amount of damage, kinds of collisions	Because the outcome is understood as probabilities, this can manage non-linearity, interaction effects, and strength factors.	Multicollinearity occurs when a huge sample size is used to get reliable outcomes.

5. Difficulties and Possible Futures

Measurement inaccuracy is a significant difficulty in constructing effective machine-learning techniques. Whenever the input is not accurately collected in the research dataset owing to malfunctioning equipment, participants give misleading info due to poor recollection or sensitivity problems, or errors occur in coding data, measuring mistakes appears. A forecast will only be meaningful if it is founded on accurate measures, and the amount of information used to generate it must be carefully considered a supermodel. There are numerous statistical strategies for minimising the effect of estimation errors, such as using endogenous latent construct measures, Bayesian methods (Hubbard, 2018), and others. Exterior validation is a second essential difficulty. This topic overlaps significantly with relevant problems in psychology science about repetition and durability (Tackett et al., 2017). A 3rd problem is the computing complexity in addition to the effectiveness of several machine learning approaches, particularly when dealing with huge datasets. While technological advancements might relieve some worries about cognitive efficiency, there is a significant carbon impact connected with employing extremely big cloud computing services (Strubell et al., 2019). Furthermore, there is also the possibility of little additional performance as compared to previous methodologies, therefore machine learning could be unsuitable or inefficient for particular data formats (Christodoulov et al., 2019). Furthermore, even if the additional effectiveness over conventional methods is significant, it could not be statistically important. Unusual results, like mortality rates, are frequently forecasted with poor good predicted results, also when machine learning is used (Belsher et al., 2019).

In (Brazdil et al., 2003), supplied a comprehensive array of data as well as statistical measurements for a collection. Upon ahead a profound grip on every technique's advantages besides weaknesses, the selection of uniting two or maybe more methods to solve a specific issue must be studied. The area is to use the advantages of one method to compensate for the limitations of some other. Since we only desire the greatest classification performance available, it may be challenging or unbearable to locate a single classifier that works similarly to a solid ensemble of predictors. Machine learning methods like SVM, NB, and RF may provide excellent quality besides precision irrespective of the no. of characteristics and information instances.

6. Conclusion

Investigators should be deliberate in assessing whether machine learning is indeed the correct path for their study topic of interest, in addition to being prudent in using and interpreting such extremely configurable methodologies. Wherever appropriate, analyses employing machine learning techniques must make comparisons to that of conventional statistical methodologies, which may operate comparably but are considerably better subject to interpretation. Additional analysis is also required to establish whether measurement inaccuracy impacts different machine learning techniques and to devise methods to harmonise metrics to facilitate external validation better possible. If solutions for addressing these issues are found, machine learning can dramatically enhance our capacity to comprehend and then forecast their accompanying negative repercussions.

This report looks towards the most widely utilised supervised machine learning technique for categorization. The goal was to create a detailed assessment of the important principles, highlighting the benefits and drawbacks of the different methods. Based on the analysis, each machine learning method depends on the field of implementation, and no single method is preferable in every situation. The nature of the issue and the data provided influence the choice of an acceptable method. The accuracy can be enhanced by selecting two or more suitable algorithms and forming an ensemble.

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Reinventing the EU Studies Curriculum for the Digital Era

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Abstract: *Considering current labour market trends, an International Relations and European Studies curriculum might seem too theoretical. Students often wonder what they will become once they graduate, but this question is worthy of the 20th century, while the faculty should prepare them for the 21st century. Digital skills are a significant part of 21st century skills and they are not only hard skills. In this sense, the underlying assumption is that individuals require digital skills training to properly engage in society and to function on a competitive labour market.*

This paper discusses the need to update the EU studies curricula for the digital era by integrating training within the framework of the Digital Competence Framework 2.2. Methodologically, this paper analyses a case study of academic subjects taught within the International Relations and European Studies curriculum. First, the paper details the Digital Competence Framework 2.2 and the role of the EU in digital policies. Then, it focuses on presenting the Internet in international affairs syllabus and its correspondence with the Digital Competence Framework. Finally, it discusses the labour market implications for such a horizontal and vertical approach to digital skills training.

Keywords: digital skills, European Union, future of work, European Studies.

1. Introduction

The European Commission has designated the year 2023 the European Year of Skills, based on the acknowledgment that a *workforce with the right skills* is a "crucial factor underpinning the current and future competitiveness of our social market economy" (European Commission, 2022c). Having the right set of skills is not necessary only for the workforce, but it is crucial for the proper working of our democracies. In her State of the Union address, the President of the European Commission highlighted the reasons behind this initiative, such as a shortage of low-skilled and high-skilled staff alike, lack of cooperation with the companies, or the need to match the offers with people's aspirations (Ursula von der Leyen, 2022). At the same time, the speech addressed the threats to our democracies,

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stemming from disinformation and the malicious use of technologies (Ursula von der Leyen, 2022). In fact, the Commission has addressed this topic quite a lot, aiming to create a value-based digital space in the European Union, where democratic values and principles are respected. Hence, there are two avenues by which digital skills are relevant for the digital era in the European Union. The first is their relevance for the labour market. The second is their significance for the health and safety of our societies and democracies.

In the current digital era and economic circumstances, matching skills with the requirements of the labour market is crucial and universities play a significant role in this balance with more or less success (Hotnews, 2022). At the same time, there are "stark differences" between Member States regarding the level of digital skills, as some states report figures below 50%, while others are much closer to the Digital Decade targets (European Commission, 2022a, 20). Digital skills are crucial both for the labour market and for exerting our rights and responsibilities for a democratic society. They are not only hard skills, but rather soft skills requiring a critical and balanced attitude towards the technologies we use in our daily lives. For this sense, they are not only the attributes of information and communication technology (ICT) training but require horizontal and vertical integration in other study programs.

The purpose of this paper is to investigate the potential for horizontal and vertical integration of digital skills training in a social science program. The underlying assumption is that individuals require digital skills training to properly engage in society and to function on a competitive labour market. In this sense, the European focus on digital skills, both regarding the labour market, but also for social and democratic participation will provide the backdrop of the analysis. The theoretical framework will focus on two aspects, a brief analysis of future work trends, as well as discussions regarding the digitalization of higher education institutions (HEIs). Indeed, this is where this research aims to intervene, namely to bridge the gap between the integration of digital technologies in HEIs and the usefulness of digital skills training for the world of work and the digital society. The literature focuses quite significantly on advanced digital skills and the need for universities to integrate digital technologies, such as automation and artificial intelligence to prepare students for the future of work (Ahmad, 2019). But this is just one side of the story, given that not all study programs train for advanced digital skills for the digital economy and Industry 4.0. Thus, this research paper focuses on the way a social science program can adapt to the requirements of the world of work, but also contribute to the cultivation of citizens aware of their digital rights and individuals that can use technology in a critical sense.

Methodologically, this paper analyses a case study of an academic subject taught within the International Relations and European Studies curriculum. After the literature review focused on digital skills and the future of work, it moves to empirical analysis, detailing the Digital Competence Framework 2.2 and the role of the EU in digital policies. The case study presents the *Internet in international* *affairs* syllabus and its correspondence with the Digital Competence Framework. The paper ends with a plea to extend this model and a brief discussion on the implications for the labour market.

2. HEIs, digital skills and the future of work

This section addresses the theoretical outlook regarding the future of work, thus aiming to conciliate this research with the research on the effects of digitalization of HEIs.

Firstly, analyses on the future of work tend to focus on the integration of technologies within companies and map out scenarios on the types of tasks that will be automated (Acemoglu and Restrepo, 2018; Zande et al., 2019). Acemoglu and Restrepo (2018) trace the way in which technologies will reduce the demand for labour, leading to more automation, but end up maintaining an optimistic perspective, concluding that automation will create new types of tasks in the workplace and will require new skills. This scenario puts the pressures on HEIs to stay on top of the curve, but the literature looks more towards entities, such as labour agencies or companies and their role in upskilling and reskilling (Bernhard Schmidpeter & Rudolf Winter-Ebmer, 2021). In this scenario, possessing digital skills and understanding how different technologies work are basic requirements for the labour market, given that upskilling and reskilling can take place within the company.

Secondly, the future of work entails another significant trend, namely *platformisation*, defined as "the penetration of infrastructures, economic processes and governmental frameworks of digital platforms in different economic sectors and spheres of life, as well as the reorganization of cultural practices and imaginations around these platforms" (Poell, Nieborg, & Dijck, 2019). Looking at the labour market, platformisation changes traditional employer and employee relations, but it also requires from participants in such arrangements knowledge on algorithmic governance and on their digital rights. In the case of platformisation, skills are traded easily, but the autonomy of such workers is reliant upon their knowledge on the way in which such digital platforms function. Attempts to regulate platform work in the European Union have drawn upon this need, as a proposal for such a directive includes requirements on algorithmic management (European Commission, 2021b).

Thirdly, integration on the labour market, which is complicated by automation and other similar trends, requires a proper set of skills and HEIs play a significant role in this respect. Most of the literature on the digitalization of HEIs focuses on two perspectives, which mirror the horizontal and vertical integration of technologies in study programs. The first looks at the integration of digital tools to improve the teaching experience, a trend accelerated by the COVID-19 pandemic and discussed in the literature (Roy, Gruslin, & Poellhuber, 2020; Monteiro & Leite, 2021). The second concerns the need for HEIs to contribute to students' digital competences as tools for the labour market. Quantitative analyses reveal the need for universities to develop students' digital skills, based on needs analyses for various industries (Spada et al., 2022). Given the current focus on advanced digital skills, the literature also develops the concept of teaching factory, whose mission is to produce skilled workers (Mourtzis et al., 2018). Analyses emphasize the significance of achieving digital skills, not only for the world of work, but as prerequisites for thriving in a digital society (van Laar et al., 2017).

This research starts from the theoretical backdrop related to investigations into the world of future work, which require rethinking of skills training and attainment. HEIs have the mission of training such workers, but the world of work does not entail only technical and hard skills directly for the factory floor. This is where the research intervenes, by looking at how a social science program – International Relations and European Studies – can contextualize digital skills both within the logic of the program and with an eye on students' digital skills. This requires both a vertical and a horizontal integration in the curriculum and teaching methods, as the case study will reveal the correspondence between the topics approached and the Digital Competence Framework, a policy document of the European Commission aimed at measuring citizens' digital skills. In this research, such digital skills are the foundation for functioning and thriving in the digital society, both as citizens and as workers. The next section dives into the empirical research, by looking at the EU policy context that resulted in the Digital Competence Framework 2.2.

3. European Union and digital policies. Analysis of the Digital Competence Framework

The vision that the EU has taken on the digital space influences the definition and prioritization of digital skills. The EU has developed a vision of a *European digital society* that cherishes "solidarity, prosperity, and sustainability", it is "anchored in empowerment of its citizens and businesses, ensuring the security and resilience of its digital ecosystem and supply chains" (European Commission, 2021a). Citizens are empowered when their digital rights are respected and when they possess the necessary digital skills to properly engage with authorities and businesses. For this reason, the European Commission has put forward the European Declaration on Digital Rights and Principles with principles, such as: *a secure and trusted online environment*, *universal digital education and skills for people to take an active part in society and in democratic processes*, or *accessible and human-centric digital public services and administration* (European Commission, 2022b).

This soft law document illustrates the EU vision with regards to digital technologies, which O'Hara et al. (2021) deem the *Brussels Bourgeois Internet*. In this model, the individual has a fundamental right to privacy and autonomy, moral foundations should underpin the development of new technologies and legislation is put in place to safeguard these values. The individual is empowered in this model, but this cannot happen without transparency of these regulations, but also without a proper educational framework in place. Hence, digital competence plays a key role for the growth not only of a high-skilled labour force, but also for the exertion of proper citizenship.

As a matter of fact, digital competence has been listed as one of the life skills of the 21st century by the European Commission (Directorate-General for Education, 2019). Given the constant technological change, digital competence requires constant upgrading, and, as such, the Declaration includes a commitment to support the acquiring of digital skills necessary to participate "in the economy, society, and in democratic processes" and to allow for the opportunity "to adjust to the changes brought by digitalization of work through upskilling and reskilling" (European Commission, 2022b). The signatories of this Declaration have assumed this mission to prepare the conditions for Europeans to be empowered in the digital society and HEIs represent major players in this field.

In education, the Commission aims to achieve this vision with the pillars of the Digital Education Action Plan. The second pillar of the plan is aimed at "enhancing digital skills and competences for digital transformation", planning to pilot a Digital Skills Certificate by 2023 (European Commission, 2020). Indeed, standardization is a significant aspect for the assessment of knowledge, skills, and competences. Such a certificate thus becomes a means by which the individual is empowered to participate in the digital society and economy in a flexible manner. The assessment will be based under the Digital Competence Framework, meant to codify and standardize the necessary digital skills and competences for Europeans.

The initial version of the Framework was launched in 2013 and it has gone through several updates, which reflect the evolution and major debates related to the digital space. The current framework contains six major transversal areas, with usages in various life scenarios. Table 1 provides an overview with examples of abilities from each area.

Table 1. Digital Competence Framework 2.2 with examples from learning scenarios. Source: author's composition based on (Vuorikari, Kluzer, and Punie 2022)

Digital Competence Area	**Digital Competence**	**Example**
Information and data literacy	1.1. Browsing, searching, filtering data, information and digital content 1.2. Evaluating data, information and digital content 1.3. Managing data, information and digital content	• The ability to use keywords to refine search for specific literature • The ability to identify credible and reliable sources of information • The ability to recognize the existence of "filter bubbles" that reinforce existing views

Communication and collaboration	2.1. Interacting through digital technologies 2.2. Sharing through digital technologies 2.3. Engaging in citizenship through digital technologies 2.4. Collaborating through digital technologies 2.5. Netiquette 2.6. Managing digital identity	• The ability to use chat applications to organize class work • The ability to use the cloud to share materials or to solve cloud-related issues • The ability to create a public consultation for a social issue, using social media or blogs
Digital content creation	3.1. Developing digital content 3.2. Integrating and re-elaborating digital content 3.3. Copyright and licenses 3.4. Programming	• The ability to create and update an online presentation with interactive tools • The ability to correctly choose content that is copyright free for usage in an online and interactive presentation
Safety	4.1 Protecting devices 4.2. Protecting personal data and privacy 4.3. Protecting health and well-being 4.4. Protecting the environment	• The ability to protect one's accounts using a strong password and two-factor authentication • The ability to manage one's data on social media platforms • The ability to recognize and defence oneself against cyberbullying
Problem solving	5.1 Solving technical problems 5.2 Identifying needs and technological responses 5.3 Creatively using digital technologies 5.4. Identifying digital competence gaps	• The ability to adjust language settings for certain software • The ability to follow a massive open online course (MOOC) and to ask and/or answer questions

As observed in the table, the competence framework provides a sign of the times in terms of abilities and of concepts and major debates regarding the digital society. For instance, one specific ability is identifying filter bubbles, a significant debate in the age of social media. Showcasing this commitment towards the state of the art, the Digital Action Plan will update the Digital Competence Framework with competences and abilities related to AI (European Commission, 2020).

4. Case study

This section delves into the curricula and methods of one BA level course taught at the Department of International Relations and European Studies, University of Oradea, Romania. The course is entitled *Internet in International Affairs*, broadly focused on contextualizing current debates in international relations in the context of digital transformation. For this purpose, the course used *the Internet* as an umbrella term, as it delves into a variety of technologies that are based on the Internet. This analysis will provide a model to integrate digital skills training into the curricula of social science programs by developing specialized courses aimed at boosting students' digital skills necessary for their integration on the labour market. First, the structure and objectives of the courses, followed by a comparison of the activities and structure of the course to the Digital Competence Framework areas.

Table 2 presents a comparative overview of the two subjects.

Table 2. Overview of IIA at the BA in International Relations and European Studies. Source: author's composition based on the curriculum

Features of the course/seminar	**Internet in International Affairs (IIA) – course and seminar**
Allocation in the curriculum	Second year Bachelor's in International Relations (IR) and European Studies – taught in English and Romanian
Purpose of the course/seminar	Contextualizing current debates in international relations in the context of digital transformation
Learning outcomes	Students will be able to apply IR theories with regards to the digital space. Students will be able to identify and analyse the major changes to economy, society and politics due to digital transformation and digital technologies By the end of the semester, students will develop digital skills – in terms of the DigComp 2.2 framework
Number of courses/ seminars per semester	7 lectures and 7 seminars over the course of a 14-week semester. Each topic is addressed within 1 course and 1 seminar.
Course/seminar structure	1. Introduction to the topic. Globalization and ICTs 2. The emergence of the digital space. Digital space and international relations 3. The global digital economy 4. Foreign policy and digital technologies 5. EU digital policies 6. Social media –actors in international relations 7. The governance of the Internet. Who controls it?

Digital issues are analysed from an IR perspective. The seminars and the case studies focus on issues that directly affect the experience of students in the digital space, as students explore their own social media accounts so that they understand the business model of social media platforms. Practical exercises for students include testing their ability to recognize trolls or deep fake videos or the possibility to create social media content for political leaders in role-playing exercises (MIT Media Lab, 2022; Media Forensics Hub, 2020). Use of technology underpins all major hands-on activities in class. For more detail, Table 3 showcases the connection between the subjects and activities within the classes and the skills necessary for the digital society.

Table 3. Internet in International Affairs syllabus and its correspondence to the Digital Competence Framework. Source: own composition based on the curriculum and the Digital Competence Framework 2.2

Course and seminar subjects	**Digital Competence Framework 2.2 Area and Item**	**Activities and methods, and learning outcomes during the IIA course and seminar**
Introduction to the topic. Globalization and ICTs	**Information and data literacy** 1.1. Browsing, searching, filtering data, information and digital content 1.2. Evaluating data, information and digital content **Communication and collaboration** 2.2. Sharing through digital technologies	(Correspondence with 2.2) Students fill in an initial survey where they present how they use technologies daily (Correspondence with 1.1 and 1.2) Students research online the differences between the Third and the Fourth Industrial Revolution and trace major innovations
The emergence of the digital space. Digital space and international relations	**Problem solving** 5.1 Solving technical problems **Communication and collaboration** 2.2. Sharing through digital technologies	(Correspondence with 5.1.) Students learn the technical differences between the Internet and the World Wide Web (Correspondence with 2.2) Professor and students collaborate in a virtual canvas to discuss views of major IR theories on the digital space (realism, liberalism, constructivism)
The global digital economy	**Information and data literacy** 1.3 Managing data, information and digital content **Safety** 4.2. Protecting personal data and privacy	(Correspondence with 1.3) Students understand the business models of major tech platforms (Meta and Google) (Correspondence with 4.2) Assisted by the professor, students explore their social media accounts to discern the data driven business model and to do a privacy check-up
Foreign policy and digital technologies	**Information and data literacy** 1.1. Browsing, searching, filtering data, information and digital content **Digital content creation** 3.1. Developing digital content 3.2. Integrating and re-elaborating digital content	(Correspondence with 1.1) Students explore social media presences of states, political leaders, and international organizations (Correspondence with 3.1 and 3.2) Students engage in a role-playing exercise where they create posts for states, political leaders, or international organizations in a given situation

EU digital policies	**Digital content creation** 3.3. Copyright and licenses **Safety** 4.2. Protecting personal data and privacy **Problem solving** 5.4. Identifying digital competence gaps	(Correspondences with 3.3 and 4.2) Students learn about the major policies of the EU and resulting legislation – for instance – the Copyright directive and the General Data Protection Regulation (Correspondence with 5.4) Students use the Digital Skills Assessment Tool to assess their digital skills
Social media – actors in international relations	**Information and data literacy** 1.2. Browsing, searching, filtering data, information and digital content 1.3. Evaluating data, information and digital content **1.4.** Managing data, information and digital content **Problem solving** 5.2 Identifying needs and technological responses	(Correspondence with 1.2, 1.3, and 1.4) Students research major international political events triggered by social media and compare them (Correspondence with 5.2) Students use online tools to assess their preparedness to spot trolls and disinformation
The governance of the Internet. Who controls it?	**Problem solving** 5.2 Identifying needs and technological responses	(Correspondence with 5.2) students research Internet governance models and engage in a role playing exercise on to negotiate governance changes

Although not aligned perfectly with the progression of the DigComp 2.2 major areas, the case studies, discussions, student work, and methods help students understand the major debates related to the digital society. The main digital competence area explored in the classes is *information and data literacy* since students make use of online tools to search and evaluate information. They also engage in content creation and learn to use collaborative tools, such as Google Jamboard, and content creation tools, such as Mentimeter or Google Forms. Additionally, the content covered reinforces their knowledge on the digital space. Finally, many tasks are related to their problem-solving skills online, for instance, as they learn to understand where their digital competence gaps are.

At the beginning of the course, they answer an initial survey regarding their Internet usage and worries regarding technology. Social media, streaming, and messaging are the main activities in which students engage online, according to the most recent survey of students from the 2021/2022 academic year. The initial survey is anonymous and applied during the first class. The number of participating students is small (10-15), hence not statistically relevant. However, over a four-year timespan, activities and worries generally remain the same. When looking at the main fears and worries regarding technology for the same cohort of students, sample answers from students include the following:

- "Utilization of data against us, not enough privacy";

- "How easy it is to fall into an echo chamber where you become surrounded by yes-men and like minded people […] you become close-minded/manipulated";
- "Concerned with the status of privacy and anonymity of the individual on the Internet and with how technology and the Internet shape our perspective on certain events";
- "Concerned that I am not a pro in using it and have some troubles with it".

As evident from these answers, the students are concerned about their experiences as users in the digital space, from echo chambers to privacy concerns, even if they consider themselves frequent Internet users. Hence, they require contextualized debates on issues related to high politics, but which are subsequently transposed over their own experiences as Internet users.

5. Discussion

The case study presented a model for horizontal and vertical integration of digital issues in an International Relations and European Studies curriculum. Not only do students use digital technologies to research, collaborate, create content, or solve problems, but they also understand the major debates that stand behind the technologies that they use both educationally and recreationally. This feeds into the *Brussels Bourgeoise Internet* vision, as students are empowered in relation to technology since they become critical users and not passive adopters of technologies. This is where the syllabus contributes to the development of active and involved citizens that are concerned for their digital rights.

The implications for their integration into the labour market converge from multiple directions. Empowered users of digital technologies will know how to use them, but they will also be aware of their pitfalls. For instance, they will be able to understand the potential biases resulting from algorithmic processing and will not be too reliant on its results. As both employees and employers, they will understand and apply the data protection regulations and governance accordingly, becoming assets to companies. As the world becomes increasingly digital, politicians and organizations require well-prepared advisors who understand the digital space, and such a subject can become the starting point for further exploration and specialization.

6. Conclusion

This paper has provided a case study of one course integrated in the International Relations and European Studies curriculum, whose aim is to develop students' understanding of the socio-economic and political effects of technology, as well as to boost their digital skills by contextualizing major debates related to the digital space. The need for such a course stems from the growing importance of digital technologies in every area of society and economy and citizens have to be empowered. This feeds into the EU vision towards the digital society, a value-based space where digital transformation is human-centric.

The article focused not only on the use of technology in class, but also discussing the correspondence between the topics, activities, and methods used in class and their correspondence with the Digital Competence Framework with implications for students' future integration on a labour market marked by technological change. The analysis is focused and thus has several limitations. For instance, the analysis could benefit from a quantitative and statistically relevant analysis of students' online activities, as well as from extended interviews or surveys regarding their perceived level of digital skills before and after the class.

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Computational thinking enhancing socio-emotional learning by connecting the mind and the heart

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Abstract: *Our everyday activity involves problem solving. Very often, to solve them, we resort to all kinds of technological devices: phones, tablets, ATMs, etc. Devices are created and programmed by humans who have the ability to understand what can be transferred to non-human tools and how these tools can be programmed. Before tackling a problem, the problem itself must be first clearly understood.*

Computational thinking is what allows us to take a complex problem, understand it and solve it step-by-step. However, developing a skill is not the same as teaching a notion or concept. Every skill we want to cultivate is a process that requires exercise, practice, feedback and the ability to make adjustments. Therefore, in order to develop computational thinking skills for early ages it is mandatory for teachers of all subject areas to be confident and competent computational thinkers themselves.

Developing computational thinking skills should be done keeping in mind that humans are social beings, which means that schools must also be socio-emotional institutions, helping students to become both programmers and computational thinking savvy.

Keywords: Computational Thinking, Socio-Emotional Learning, Education, Pedagogy.

1. Introducing the Concepts: Computational Thinking and Socio-Emotional Learning

"Computational Thinking" (CT) is a concept that has gained popularity over recent years. Not so long ago, computing was seen as a skill possessed by specialists such as computer engineers, scientists, mathematicians, and people from similar disciplines. However, nowadays, regardless of age, everyone is expected to possess basic computing skills in line with the latest technological developments.

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The basic definition of CT was defined by Wing: solving problems, designing systems and understanding human behaviour by drawing on the concepts of computer science" (Wing, 2006).

According with the International Society for Technology in Education (ISTE) and Computer Science Teacher Association (CSTA) CT is described as "A problem-solving process that includes (but is not limited to) the following characteristics:

- *Formulating problems* in a way that enables us to use a computer and other tools to help solve them;
- *Logically organizing and analysing data*;
- Representing data through *abstractions* such as models and simulations;
- *Automating* solutions through algorithmic thinking (a series of ordered steps);
- Identifying, analysing, and implementing possible solutions with the goal of achieving the *most efficient and effective* combination of steps and resources;
- *Generalizing and transferring* this problem-solving process to a wide variety of problems". (ISTE & CSTA, 2011).

According to Early Code Consortium (Early Code Consortium, November 2022) Computational Thinking represents a set of four components as described below:

Problem Decomposition is a method for breaking down a complicated problem or system into smaller, more manageable parts. It is also known as the "Divide and Conquer" method. Problem decomposition enables children to evaluate the problem at hand and identify all the steps that are required to complete the task.

Pattern Recognition as the second component of computational thinking is a way to look for similarities or patterns within problems. It allows children to analyse similar objects or experiences and identify commonalities.

Abstraction is a method used to focus only on the essential information and to dismiss unnecessary details. In this way, it leads children to more understandable and straightforward solutions.

Algorithmic Thinking is a method used to develop an ordered steps solution to the problem, or the rules to follow in order to provide solutions.

On the other hand, regarding *socio-emotional learning* (SEL), *The Collaborative for Academic, Social, and Emotional Learning* (CASEL, 2022) defines it as an integral part of education and human development. SEL is the process through which all-young people and adults acquire and apply the knowledge, skills, and attitudes to develop healthy identities, manage emotions and achieve personal and collective goals, feel and show empathy for others, establish and maintain supportive relationships, and make responsible and caring decisions.

Each of the five socio-emotional learning components, once mastered, serve as cornerstones for success in both academic and personal life:

Self-awareness refers to being aware of one's own emotions and feelings and one's impact on others. This component includes the process of learning to stop, observe and articulate your own feelings, moods and energy levels.

Managing one's own resources is the ability to successfully regulate one's emotions, thoughts and behaviours in different situations. This competence is cultivated by looking for patterns and strategies that increase the level of self-control in stressful or difficult situations.

Social awareness is the recognition that each of us is different and that we need to empathize with others even if they come from different backgrounds and cultures.

Relationship skills represent the ability to establish and maintain healthy relationships with others, regardless of their background. Key aspects of managing and maintaining relationships are the ability to listen carefully and communicate clearly with others.

The process of making responsible decisions represents the ability to make constructive choices regarding personal behaviour and social interactions based on social norms and ethical standards.

Cultivating these SEL components helps children become balanced and wise members of their classroom and community. Ultimately, learning to know yourself and manage your emotional life leads to improved academic success and the development of positive relationships with other community members.

The challenge will be to apply the principles of SEL and at the same time use computational thinking.

2. From Theory to Practice: The Relationship Between Computational Thinking and Socio-Emotional Learning

In the previous chapter, we highlighted some essential aspects regarding the two concepts (CT and SEL). Although it may seem that CT has a lot to do with computers and informatics, in reality, we use computational thinking in our current activities, but we do not call it such. If we think of a simple action of buying some pharmaceutical products and food products, in order to accomplish the task we will have to take into account several variables and analyse them: the best route, list of products, necessary time, finding the best-stocked store, the budget, method of payment and so on.

The ability to transform a complex problem into a simple one is an ability that many of us have already developed. In the presented context, computational thinking is present in the planning part and following the plan is similar to a programming activity.

If computational thinking is one of the key skills throughout life that we develop unconsciously then the socio-emotional development of children is a skill that is better to be taught. We must prepare children and young people to become wise, responsible and empathetic adults, although children learn to understand and manage their own emotions, unconsciously, in the family environment. Later, once school starts, we cannot expect all this emotional baggage to be left at the entrance. Teachers have an important role in identifying each vulnerable situation and have to be aware of the implications of socio-emotional realities on the learning process.

2.1. SEL in Romanian Educational System

Romania has placed a strong emphasis on children's social-emotional development in the past ten years, especially on issues regarding better emotion management in the sense of achieving a much-desired wellness or wellbeing state. The results of these efforts can be seen in the nationwide school curricula for the second grade (ages 8-9) where the subject of *Personal Development* is taught and the one for the fifth grade (ages 11-12) where the subject of *Counselling and Personal Development* is taught.

The interest for SEL is increasing in the Romanian educational system as the number of initiatives promoting SEL, at macro and micro level. Most of these are projects that raise awareness on socio-emotional learning and offer training to teachers while other initiatives are organised at national level and generate more deep change in adopting SEL in a policy framework at national level. In the past years, socio-emotional learning and student well-being have become priorities, especially due to the pandemic context. One relevant action was the publication of a guide for school counsellors on "*Programs and counselling activities for the development of students; socio-emotional competencies*", with three components (for primary, secondary and tertiary education) and specific examples of activities, programs for developing SE competencies. More than 70 examples and activities are organised on five dimensions of social and emotional learning.

The values promoted in the Romanian educational system are an integral part of the response that education offers to the challenges of the contemporary world. These values equally reflect the culture and spirituality of the Romanian people and are meant to guide the management of personal life (health, fulfilment and personal development), to promote a sustainable lifestyle, oriented towards success, active citizenship, social inclusion, entrepreneurship and integration into the labour market.

2.2. SEL and CT through Future Teachers' Eyes

In the Romanian Educational Law 68th Article, the eight domains for the key competencies that determine the students' training profile are mentioned. The 3rd and 4th paragraphs refer to primary education, ICT and the preparatory class:

(3) ICT is an optional subject for students from 1st to 4th grades and is a compulsory subject in middle and high school education.

(4) The curriculum for the preparatory class (before 1st grade) aims at physical, socio-emotional development, cognitive development of language and communication, as well as the development of skills and attitudes in learning,

while ensuring the bridges to the development of the 8 key competences (LEN 1/2011).

In order to establish a baseline in students' degree of familiarity with the concepts of CT and SEL, we wanted to create an overview of the way in which the two concepts are defined from their perspective, and of the way in which they establish the connection between the two concepts.

The target group consists of students enrolled in the first year at Pedagogy of Pre - School and Primary Education - bachelor programme, at the University of Bucharest, Faculty of Psychology and Educational Sciences. The survey took place during the first month of the first semester of the academic year 2022-2023, during the *Information and Communication Technology* course. A number of 71 students took part in the survey and 67 of them do not currently work in the educational system.

The results showed a decreased level of knowledge on CT and SEL concepts: 41 respondents were not familiar with the CT concept and 57 respondents never have heard of SEL. Their responses were surprisingly taking into account that the values promoted in the Romanian educational system are an integral part of the response that education offers to the challenges of the contemporary world. These values equally reflect the culture and spirituality of the Romanian people and are meant to guide the management of personal life (health, fulfilment and personal development), to promote a sustainable lifestyle, oriented towards success, active citizenship, social inclusion, entrepreneurship and integration into the labour market.

In the previously mentioned survey, students were also asked to describe the concepts, in order to see their understanding on the terms. Most of the descriptions were incomplete or irrelevant. Only to mention a few for SEL - "*For me this concept represents a learning related to the social environment and emotions."; "Learning by empathizing with various social cases."; and CT - "I perceive the concept of computational thinking as an innovative source of technological learning."; "A set of skills based on computer science concepts to which is added a range of mental tools.*".

Other answers were more specific and proved a better knowledge on the field, but the number of such answers was very small.

As a result, the teachers were asked to apply the new methods developed during projects aimed at developing both computational thinking and socio-emotional learning skills.

3. European Initiatives in Introducing CT and SEL at the University of Bucharest

Within the University of Bucharest, the Faculty of Psychology and Educational Sciences, starting from 2018, projects aimed at both computational thinking and socio-emotional learning took place.

EARLYCODE - Developing Teaching Materials for Preschool Teaching Undergraduates on Computational Thinking and Introduction to Coding (2018-1-TRO1-KA203-058832) is an European project, having the main aim of up-skilling preschool teaching undergraduates on Computational Thinking and Coding Education and equipping them to inspire and teach children computational thinking principals utilizing effective, innovative and engaging methods.

The project intended to improve capacity within the education sector to provide high quality computational thinking teaching at preschool level in the partner countries. The project specifically targeted higher education students studying to become preschool teachers.

EARLYCODE project focused on developing teaching materials for Preschool Education undergraduates, lecturers and preschool teachers on computational thinking and introduction to coding.

The project's consortium consisted of public and private organizations from five countries: Turkey, Romania, UK, Italy and Latvia. The intellectual outputs are available in all partner countries' languages, including Romanian.

COMPUSEL - "Computational Thinking in Enhancing Primary Students' Social and Emotional Learning Skills" (2021-1-TR01-KA220-SCH-000031609) is a new project, framed at KA220 School Education – Collaboration Partnerships that aims to improve the SEL Skills of primary students and training primary school teachers for this purpose. It will develop a curriculum and digital stories including examples of different social and emotional challenges that will be discussed and seek solutions together with primary school teachers to foster self-awareness, self-management, social awareness, relationship or responsible decision-making.

The first main target group of the project practice will be a total of 100 primary school teachers in the partner countries. These teachers will be involved in the project practice actively through seminars, workshops and training activities (piloting). The second main target group of the project consists of 100 primary school students attending public schools (associated partners) in the partner countries and will be trained during the piloting. 17 teacher educators (lecturers/trainers) are another target group of the project.

4. Conclusions

Social-emotional learning is an important asset for the harmonious development of children, and interest in the subject is constantly growing at the macro level. There are many ongoing development initiatives, projects and courses that address the topic by emphasizing the need to use appropriate teaching methods to develop social-emotional learning.

Combining social-emotional learning and computational thinking can be an innovative way to teach children how to handle different life situations from a different perspective, which includes analysing problems, identifying similarities with other experiences and identifying commonalities, retaining essential information and developing rules to follow to find solutions.

Teachers need to be familiar with these concepts and have access not only to literature, but also to practice, receive support and appropriate materials to be able to organize lessons that include social-emotional learning and computational thinking. With proper training, teachers can identify common problem situations in their classrooms and discuss with children using computational thinking components that allow children to find their own solutions to specific problems.

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Following the Line from Blocks Programming to Robotics

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Abstract: *Computational thinking has developed into one of the basic abilities to be achieved during childhood, and not only. Industry 4.0, on the other hand, requires a set of basic skills that can be linked with computational thinking. Although many of the concepts involved in both computational thinking and Industry 4.0 are difficult to be achieved by using a traditional learning path, there are alternatives, especially for young learners, to get started and advance with computational thinking, and get accustomed with some of the new skills required by the new industrial revolution. There are numerous means to acquire such capabilities, supported by formal and non-formal frameworks of education, and assumed by different types of organizations. We focus our paper on an educational path from the youngest learners to teenage programmers, in the context of CoderDojo non-formal educational activities.*

Keywords: Blocks-based programming, Computational thinking, Robotics, Scratch, K-9 education.

1. Introduction

Computational thinking was first introduced in 2006 by J. Wing as "a universally applicable attitude and skill set everyone would be eager to learn and use" to be added to the basic set of abilities on top of which every child should build their education (Wing, 2006). Since then, numerous contributions emphasizing the different aspects of computational thinking can be counted. While computation-like thinking is not something new for the youngsters, who have become familiar with some basic skills through various building/board games, elementary mathematics, or even easy science experiments, computational thinking can develop over these skills, among others, towards a set of analytical thinking capabilities. The society is rapidly advancing with Industry 4.0, which in a rather simplistic definition can be viewed as an "application of the IoT, cloud computing, cyber-physical systems (CPS), and cognitive computing into the manufacturing and service environment." In this context, computational thinking is a "vital skill for

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empowering employees to address problems critically and systematically. (Chong & Wong, 2019).

Many approaches to introducing computational thinking among the youngest exist, many of which are built on habits acquired in their early experiences (e.g., brick buildings or the easy-to-follow board games). There are different block programming approaches, which address the curiosity of young programmers, such as Scratch Jr or Lego Education WeDo, as introductory tools (Papadakis et. al., 2016; Pinto-Llorente et. al., 2016) and Scratch, VEXcode, Robot C, or Lego Education (Mindstorms) EV3, for some advanced notions and transition to robotics (Ko, 2013; Roscoe et al., 2014; Zhang & Nouri, 2019). As (Hsu et. al., 2019) mention, computational thinking has marked a turnpoint in different tech-based educational initiatives across the world. The introduction of computational thinking in the different fields of education allows the realization of the ambition "to prepare the younger generations for the opportunities and challenges of the future economy where computing permeates virtually every aspect of society. (Hsu et. al., 2019).

Not for profit initiatives play an important role in attracting the attention on the importance of computational thinking for the young generations and, without any constraints in their implementation means, they can afford innovative approaches towards achieving some of the objectives of computation thinking. Such initiatives include CoderDojo, "a global movement of free, volunteer-led, community-based programming clubs for young people", with a focus on "peer learning, youth mentoring and self-led learning", or the "Științescu Fund", a program to support several community foundations to create and manage local funds "to encourage innovative ideas that can make sciences more attractive for secondary education students and that can be applied with support from the community." The content of our paper is based on the experience gained by implementing activities within local CoderDojo implementations, as well as the experience gained by implementing some of the Științescu community-funded projects, with a specific focus on the learning path for the young attendees through the various blocks-based programming languages, a plethora of tools, with a unique goal: achieving and improving the computational thinking abilities of the young learners.

2. Background Information for Block-Based Programming

2.1. Block-Based Languages

Blocks-based languages offer a simple and intuitive approach to programming, usually not linked with previous programming experiences. With the different categories of block types, the user has the ability to construct applications by simply "snapping" those blocks that match each other, an ability that is based on the experience of brick building toys. Apparently, such a programming language is rather simple, with limited possibilities to build complex programs. Many block-based programming languages currently exist, since the initial version of Scratch was publicly made available, in 2007, with the ambition to improve the "digital fluency". "Digital fluency" includes "designing, creating, and remixing, not just browsing, chatting, and interacting", (Resnick et al., 2009) and it is broader than the "digital literacy", offering the opportunity for learners to "self-select from a range of tools to achieve outcomes, and navigate collaborative".

The block-languages considered in our study cover different characteristics:

Age: Scratch Jr or Lego WeDO for the youngest programmers, aged 6-8; Scratch or Lego EV3 for young learners, aged 8-12; Scratch with advanced features, Snap! (a Scratch spin-off, an extended reimplementation of the language, offering advanced options to "build your own blocks"), or VEX-based approaches for young and teenage programmers;

Approach: programming by playing (Scratch Jr and Lego WeDo), programming by exploration and experimenting (Scratch, Snap!, EV3 or VEXCode), programming by robot experiments (WeDo, EV3, VEXCode, Robot C, also Scratch/Snap! with appropriate extensions);

Interaction: sprite-based, in Scratch Jr, Scratch or Snap!, robot-oriented in Lego-centered or VEX-centered initiatives;

Expressivity: simple interactions in Scratch Jr or Lego WeDO; programming basics and/or advanced programming concepts in Scratch, Snap!, EV3 or VEX-based/ Robot C.

With such a variety of options, Scratch-based approaches can be used to gain basic skills, complemented by advanced elements introduced by the introduction of the different robot-specific devices and sensors.

2.2. Programming Basics

Despite its rather simple appearance and seemingly rudimentary support for data types, the different block-based programming languages abound with less expected features, thus offering a different perspective to the apprentice programmer compared to the traditional means used for first steps in programming. Visual programming approaches like Scratch focus their attention rather on the application logic, instead of the syntactic aspects of the language (Malan & Leitner, 2007), emphasizing that the focus is on the final outcome, not on the particularities of those building blocks. In such a simplification, "programmatic constructs are represented as puzzle pieces that only fit together if syntactically appropriate", offering the means to intuitively discover the basic structures of programs. In fact, according to (Malan & Leitner, 2007), the transition to a high-level programming language was easier for first-time programmers when they developed prior experiences with a visual-programming environment. The development of many block-based languages is based on the triplet "low-floor/high-ceiling/wide-walls", being thus easy to get started, covering various types of users, while offering the opportunity to create complex projects (Jatzlau & Romeike, 2018; Resnick et. al., 2009).

Some of the core concepts and capabilities for block-based programming languages are briefly presented next. However, more details can be found in (Jatzlau & Romeike, 2018), while (Fagerlund et. al., 2020) offer a clear overview of computational thinking concepts, and their mapping onto Scratch-based environments.

Program flow: the ability to manually control the execution path of a program, with the possibility to pause the application, interact with the sprite or robot/device, observe and correct their behavior. (Zhang & Nouri, 2019).

Sensing: the capability of the controlled objects (sprites or robots/devices) to interact with their environment or with the user/programmer, detect and report various information. The relevant computation skills covered include events or coordination /synchronization (Zhang & Nouri, 2019).

Weak data type: the low-floor paradigm cannot be achieved with the data type constraints. Even in a simplified form, this can offer an introduction to the variables / initialization skills for computational thinking (Zhang & Nouri, 2019).

Delayed execution of code: this an interesting capability offered by blocks-based languages, avoiding the application to run too fast.

Drag and drop: in contrast with text languages, all blocks-based languages offer a drag-n-drop support, the programmer will build the application by selecting blocks that fit with the target one.

Block shapes: there are many characteristics blocks can have, and their shape is one of the essential characteristics.

With the different block characteristics (color, shape, induced semantics, domain of use), it is not a difficult task to gradually introduce proper programming-like attitudes to the youngest learners and, consistently, maintain and develop even more programming abilities on top of these. Moreover, as current approaches included in EV3 Mindstorms or VEXCode are fully compatible with Scratch, there will be an easy transition from the young learners to a more advanced user.

2.3. Advanced Features in Block-Based Languages

The core concepts for block-based programming languages were discussed in (Jatzlau & Romeike, 2018), and include broadcasting, sensing, prototyping, event-driven programming, weak data types, or delayed execution of code. At the same time, some of the advanced concepts considered in (Hermans & Aivaloglou, 2017) are events, coordination, parallelism, together with the rather traditional ones, like conditionals, loops, operators, procedures, etc. We will offer an overview of some of the unexpected concepts offered by the blocks-based languages used in our approaches.

Concurrency: multi-threading is an interesting feature of Scratch, which allows students to get accustomed with concurrent programming concepts by the means of sprite (the main abstractions from the language) control. As it was presented in (Meerbaum-Salant et. al., 2013), the concepts related with concurrency can be considered at two levels: “type 1 concurrency occurs when several sprites are executing scripts simultaneously, [...] type 2 concurrency occurs when a single sprite executes more than one script simultaneously". Also, there is a rather lightweight multi-threading mechanism, as the language is missing some of the high-level synchronization mechanisms. Instead, the language offers the complementary messaging system, which offers in turn some basic synchronization means. In fact, there's nothing to worry about race conditions, as the Scratch model was developed "by constraining where thread switches can occur. (Maloney et al., 2010).

In (Fatourou et al., 2018) the authors concluded that "learning tasks were built in a structured approach so that pupils incrementally build knowledge on concurrency issues [...] and not missing the fun of game design". Notice that in the case of some robot-based environments, explicit support for threads/tasks may be used, like in the case of VEX-based projects, when the text version of the coding environments is used.

Messaging and event processing are yet another surprising features of the various blocks-based programming environments. The broadcast-receive pattern is a central feature in Scratch inter-sprite communication, with a default asynchronous behavior, where a message is sent to all sprites capable of accepting it. Additionally, there is a synchronized flavor of this pattern, where the broadcaster will have to wait until all receiving sprites end their message-based processing. With the message passing implementation, the languages expose a rather complex concept through the easy-to-use interface for those who are starting to build their computational abilities. "The concept of message passing is quite complex, combining concurrency, synchronization, and the asymmetric roles of the sender and receiver." (Meerbaum-Salant, 2013).

Event processing is another important concept spanning across the different blocks-based environments, either sprite-based or robot-centered. Event processing can be linked with other capabilities exposed by those languages, like concurrency, messaging, user interactions, or sensing, and can be invoked in various ways: one sprite touching another, sprites touching specific colors, a distance or color sensor attached to a robot, and others.

Sensing: despite its intuitive look, sensing is not an easy concept for block-based programming languages. Sensing is used to describe both the capability of sprites to interact with some environments (touching other objects, distance to other sprites, etc.), or the ability of robotic constructs to interact with the real environment by the means of different sensors (such as distance, light, touch, etc.) The sensing capability can offer the necessary support for an autonomous behavior of the different objects (Jatzlau & Romeike, 2018). Sensing also involves event processing capabilities and may require existing concurrency/multi-tasking support. In order to access the sensing support, a hardware configuration may be needed.

3. Learning Alternatives

The emergence and implementation of the first CoderDojo clubs (dojos) represented an outstanding opportunity for a large number of young learners to get in touch with programming by various technologies. It was the place where two global initiatives intersected, as Scratch was one of the enabling technologies for CoderDojo, to provide an exciting experience to young learners. The local CoderDojo network involved an important number of volunteers, and even more young learners who regularly attended weekly workshops. More than half of them had no previous experience in programming, and almost 25% were enrolled in the first grades of primary school when they started the learning activities. The CoderDojo approach raised important challenges for the mentors, since most of them were IT specialists or students without any teaching background. A methodology for delivering the knowledge was needed such that no one is left behind, regardless of their background and, at the same time, to offer a successful approach for the numerous children that are about to begin reading.

Even if Scratch-based delivery of knowledge was the natural choice, given the success of the Scratch educational path as it was implemented by the CoderDojo Foundation, Scratch adoption was not an easy task, as few quality learning materials were available, and the workshop materials needed to be developed in the meantime. This allowed us to develop a core set of activities, and to complement them by the introduction of additional technologies through specific extensions (e.g., Lego WeDo in Scratch projects) or offer new experiences that were enabled by existing knowledge (like the development of EV3 or VEX IQ interactions).

3.1. Activity Organization

Regardless of the experience of the mentees ("wide-walls"), each workshop starts with a story and an example, which can easily be adapted to the preferences of each participant. By using such a beginner-friendly environment ("low-floor") for learning, users can rapidly visualize some results, and easily understand the effect produced by different commands. First workshops are meant for a smooth introduction into the programming environment, starting with games and stories that can be decomposed into simple steps that can be easily transformed into some sequence of action (the algorithm). Such an approach offers the means for an easy introduction to the identification of the flow of the action, and the analysis of the problem, eventually to support problem decomposition once the learner can better understand the process. As each child will further develop the project at their own pace, in the following workshops they will have the opportunity to reach the level of development appropriate for their level of knowledge and, finally, to present their achievements to the others. Periodically, the organization of major events is considered (local events, named MegaDojos, or the global Coolest Project events), bringing together children from different geographical areas, an opportunity suitable both for the presentation of projects made in previous workshops, and for introductory sessions for newcomers.

First time learners: Many of the first learners are K-5 students, some of them with minimal reading abilities. However, this is not a real difficulty in our approach, as we have the groups of color-coded blocks: blue for Motion, magenta for Sounds, yellow for Events, orange for Controls or green for Operators. Moreover, for these first-time learners we are using a set of Scratch cards, each of them presenting a simple command that will be executed as mentioned. The students are asked to change the different parameters, such that they understand the effects of essential command blocks for this stage: Motion, Looks, Sound and Events. Also, a continuous mentor-mentee relation is a must in order to guarantee a successful learning path. While each child will be happy to see that everything imagined quickly turns into reality, within games, animations or stories, together we are able to make the first steps towards computational thinking. The first-time learner will acquire some CT basic skills:

a) run their first applications, by making a connection between the green-flag and the corresponding yellow-hat block;
b) define a simple algorithm, by stacking a series of blocks, usually blue or purple, at their choice;
c) define a second sprite, and make it active by using the yellow green-flag block;
d) understand and change sprite properties, in a more sophisticated use;
e) for the advanced uses, introduce some decisions, by the corresponding orange if block, and have a basic understanding of some conditions (with the green boolean hexagonal blocks);
f) and, for the most advanced use at this level, play with some wait actions, eventually linked with some purple Looks blocks.

As most of these basic skills do not require a high level of knowledge, the entire learning process can be easily adapted to alternative languages: Scratch JR or Lego WeDo. Worth to mention that, while Lego WeDo can offer an appealing alternative to introductory workshops, it can also be the subject of some complex approaches, if integrated in a Scratch project. Depending on their age and level of understanding, the new learners stage can last up to 4 months. Most of them will be capable of changing their roles, from simple consumers to creators. It is a moment when they want to create their own games, stories, or art projects. They are able to advance to the next level, as there's a clear curiosity to check the use of multiple sprites/stages and increase the complexity of their projects (high-ceiling).

Young programmers: Once the first-time learner stage is over, many of the participating children will continue the block-based learning path. We consider that block-based languages offer enough opportunities, even when faced with new directions of development, as blocks-based environments can be used for Lego EV3 Mindstorms or VEX IQ projects, Raspberry Pi, or even offer some preliminary steps towards mobile application development, via AppInventor. Even if the activities are still under the umbrella of the weekly workshops, there is more freedom in the learning path for the young programmers. During this stage their curiosity is encouraged, with less interaction with adult mentors, but more interaction with other young programmers and young mentors (usually from the team of young programmers). The young programmers are encouraged to discover the language capabilities and, consequently, build new skills, through thematic projects. New approaches were made available (Lego WeDo/EV3 in Scratch installs, robots-based approaches, like VEX IQ, etc.) in order to offer even more possibilities to develop the new skills, allowing the young developers to create complex and interactive projects, exposing a higher level of CT abilities.

The young programmer will have the opportunity to acquire additional computation thinking skills, based on:

a) *creativity*, via pen tools, by replicating turtle graphics programming languages, adding graphic effects, animations and even arts to the projects;
b) *collaboration and interaction*, as they are encouraged to periodically present their projects, and participate in larger scale events;
c) *application flow*, with improved text inputs, written or spoken, exposing the story and improving the general interaction level of the project;
d) use some *advanced features* for mathematics (e.g., random numbers), variables and lists (storing, using and showing relevant information for their projects, e.g., time, scores, lives, items, essential in the case of a game);
e) *problem analysis and decomposition*, by defining their own blocks (procedures, for text-based languages), defining different scenes (stages) and/or characters (sprites);
f) *message passing and synchronization*, by defining messages and message handlers, as well as advanced interactions with the script;
g) *application control*, with the capability to use different loop blocks and fully exploit the if-then-else blocks.

Young programmers usually spend up to 6 months developing the full range of skills. At this stage their relationship with mentors is still very important, but only for introducing new notions and for the identification of structural or logical errors in application. Even if learning cards can be used during the first weeks, this type of information passing is rather replaced by an increased collaboration between attendees, especially when robots come into the scene.

Young developers: A significant number of participants will continue the activities in the workshops, either to further develop the applications made previously or to provide support to the freshmen. After their introductory year with Scratch-like approaches, they are either moving to different technologies, or continue to improve their knowledge with block-based languages and start their robotic adventure. Either way, they are going to improve their CT abilities, and develop really complex projects, usually as a team collaboration. The relationship between the young developers and mentors is more specialized now and directed to the new categories of devices (robotic brain, motors, sensors, etc.) and new categories of requirements for project development. Moreover, the young developers can get in touch with some advanced topics, e.g., related to Neural Networks, Artificial Intelligence and Machine Learning.

Their computational thinking abilities will reach maturity, for the age group they belong to, and most of their projects will exhibit those advanced skills:

a) capability of using the cloning, and control the behavior of cloned sprite;
b) possibility to start multiple stacks (scripts) as a response to various events;
c) fully control the messaging support offered by the language, and influence the behavior of other objects (sprites, backdrops) by messages;
d) understand and use the full range of control blocks;
e) use the full range of interactive blocks (such as Looks, Sound, Sensing);
f) use automation and debugging for applications, have the capability to identify simple structural or logical errors in scripts;
g) load external libraries of blocks for custom executions, or use other blocks-based languages (like WeDo/EV3 support in Scratch, the EV3 Mindstorms or VEX IQ environments);
h) investigate alternative approaches, such as the VEXCode or Robot C text-based editor, where fine tuning of blocks-based projects will be possible.

It is difficult to have an estimate of the time it takes for young developers to understand most advanced concepts of blocks-based language, given the fact that some of them are difficult for university students to understand. However, at this stage a good part of the efforts of young developers are oriented towards the development of competitive projects, which will be presented in local events (MegaDojo) or global (Coolest Projects).

3.2. Assessing Computational Thinking Abilities

Given the non-formal nature of educational activities in the context of CoderDojo, they will not include activities to assess the progress made by participants, the development of each following its own pace, without constraints (the “low-floor” paradigm). However, it is necessary to understand and identify when a certain level of maturity is reached for the language used. And assessing progress can be important to reach the “high-ceiling”: for preparing complex projects, participating and recognition of their progress at the local or global events as mentioned before. Several tools exist for assessing the computation thinking level achieved by a young learner, based on the content of his/her Scratch projects. The evaluation of a set of Scratch-based projects presented at one of the nation-wide dedicated events revealed the most difficult to achieve CT capabilities. The following information was extracted:

a) Most of the projects were of *Master* quality (a total of at least 17 points from the 7 categories): *Master* - 56.25 %, *Developer* - 31.25%, *Beginner* - 12.5%;
b) No project was able to reach the *Master* level for the *User interaction* chapter (usually by specific event/message handlers, little or no use of video/sound blocks);
c) There were difficulties in getting high score in the *Data representation* and *Abstraction* chapters (suggesting difficulties in understanding lists operations, or advanced sprite usage);
d) Most of the projects were able to get high scores at *Synchronization* and *Parallelism* (good command of events and messages handlers, as suggested by *User interaction*, including for sprites or backdrops; the ability to initiate several stacks or scripts at specific events).

4. Conclusion

After several years of activities, the educational approaches developed on top of the CoderDojo approach offer a set of necessary and complimentary activities for introducing programming and computational thinking abilities to the youngest learners. Additionally, a larger number of girl participants were counted during the implementation of these activities, as creative, collaborative coding activities and competitiveness were able to increase their motivation. In our work we presented the learning path adopted in local CoderDojo activities, in order to improve the skill level of young learners, from simple technology users to advanced content creators, a learning path which is failure-free, without any evaluation pressure. Despite its apparent simplicity, the approach used allows the customization of the learning path and the diversification of the tools used in the process of acquiring new knowledge. The different levels of activities also define the different levels of interaction with mentors or other young colleagues, offering as a side effect a certain level of independence in the development of future projects. One can estimate how each of the three levels was achieved by aligning projects to the different skill levels that are associated with computational thinking, thus providing indirect feedback to the implemented learning cycle!

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Development of Ultrasonic Device for High School Lab Activity

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Abstract: Using the methods of comparative analysis and those for the development of educational and technical means, a model of a device for obtaining ultrasonic characteristics is proposed. The comparative analysis showed that ultrasound measurement systems can be divided into three main groups: using an oscilloscope, using a Data Logger and stand-alone measurement systems. Summarized, the factors that affect measurement accuracy can be divided into two main groups - essential, which must be compensated for, and minor, which can be neglected. Pedagogical aspects in the development and use of ultrasound devices are reviewed. It has been found that they can be successfully used in project-based and problem-based learning. Multimedia learning can be successfully combined with game-based learning. A laboratory setup is proposed, in which, in addition to the ultrasound system, an oscilloscope is used. Despite the shortcomings of this configuration, it has the potential to be used in more than one academic discipline.

Keywords: Ultrasonic, Doppler, Lab activity, Quality assessment, Pedagogical approaches.

1. Introduction

Practical and laboratory exercises aim at learning new knowledge for students. With the development of science and technology, the requirements for the technical and technological means necessary to obtain this knowledge also increase (Georgieva et al., 2015).

Under European programs, experienced productions have been acquired in Bulgarian universities, mainly from producers in EU countries.

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In Bulgaria, there are long-standing traditions in training in the use of systems for the analysis of objects from various fields such as agrarian, food production and energetics.

For the effective use of laboratory experimental setups, there is a need to adapt them to the teaching methods in Bulgaria (Doncheva et al., 2018).

Pedagogical goals that can be fulfilled by the implementation of such technical means are related to familiarizing students with solving measurement and data analysis tasks for various objects of production. This is achieved by solving and implementing real tasks from industrial production.

According to a study by Batista et al. (2014) educators use mobile devices to a greater extent to deliver learning through mobile applications, video resource sharing and virtual learning environments.

Modern requirements in the production of food products are a prerequisite for directing scientific research to new and precise methods for measuring and managing technological processes in this area.

Ultrasonic techniques are an alternative to traditional measurement methods, as they can be used online, directly on the production line, they are non-destructive and have a potentially low cost of technical means for their implementation.

Ultrasound, which is essentially a mechanical wave, interacts with substances in food products. The variety of types of ultrasonic waves allows them to be used in different aspects.

The ultrasonic non-contact measurement method is suitable for the analysis of food products in the various stages of their production. Through this method, the recommendations for hygienic production can be met. The parameters of the ultrasonic signal correlate to a large extent with the physico-chemical and organoleptic indicators of food products.

One of the modern learning technologies with wide, even mass application, are multimedia technologies. Multimedia presentations are the main tool in them. Their meaning and purpose are: to illustrate the learning content; their content to be adopted quickly and effectively by the trainees; to maintain attention; content to be easily understood; to aid its memorization; to provoke the learner's activity.

The aim of this study is to propose an ultrasonic device that is appropriate for educational purposes. To solve this problem, next tasks have to be done:

- To propose a comparative analysis of existing ultrasound devices from the point of view of the technical principle of operation;
- To analyze the pedagogical aspects for their application in training;
- To propose an ultrasonic device suitable for e-learning and distance learning in this field.

2. Methods

In the present study, the method of comparative analysis was used. It is a process in which the measuring instruments studied are compared. It is a method by which it can be determined whether the results obtained in the study complement or improve those known from the available literature.

Benchmarking allows identifying good practices, prioritizing opportunities for improvement, and improving performance against learner expectations, as well as bypassing traditional change cycles. It also helps to choose a sufficiently accurate and efficient way of doing the activity, to study how lower costs can actually be achieved (Knippe, 2002).

The main problem that the authors of the available publications note is that it is necessary to look for ways to reduce the influence of factors that have a negative effect on measurements with ultrasonic sensors. Through such results, it will be possible to propose an ultrasonic system suitable for application directly on the production line, in real cheese production.

3. Types of the developed ultrasonic devices

Ultrasound measurement systems can be divided into three main groups: using an oscilloscope, using a Data Logger, and stand-alone measurement systems.

Table 1 shows the advantages and limitations of the more common ultrasonic characterization systems.

From the study of various systems for obtaining ultrasonic characteristics, sensor systems using an intermediate unit of an oscilloscope or a Data Logger have the advantage. The speed and resolution of analog-to-digital conversion and the number of discrete values of one measurement depend entirely on the capabilities of the intermediate measurement module. A common disadvantage of an oscilloscope and data logger system is that there is the possibility of noise being superimposed on the analog signal en route from the sensor module to the intermediate measurement module.

In the case of stand-alone sensor systems, the advantage is that they have the ability to work with ultrasonic sensors for different frequencies, through one sensor module. With them, the possibility of superimposing noise on the received analog signal is minimized. There is an opportunity to create a fully automatic measuring system and high mobility.

4. Factors that affect measurement with ultrasonic devices

In addition to the type of measurement system, obtaining ultrasonic characteristics is influenced by a number of factors. These factors are divided into two main groups - essential, which must be compensated for, and minor, which can be neglected.

Table 2 shows the factors affecting the measurement accuracy, the type of their influence and the literature sources in which they are analyzed.

Table 1. Comparative analysis of ultrasound systems

Type of the system	**Advantages**	**Limitations**	**Source**
System with oscilloscope and memory card	It is used independently without the need for a personal computer	An operator is needed to transfer the data	(May et al., 2000)
A system with a direct connection of an oscilloscope to a personal computer	A fully automatic measurement system can be implemented	Reducing mobility and increasing the cost of the system	(Benedito et al., 2001)
Measurement system with Data Logger	It can be used independently without the need for a personal computer	Reducing mobility and increasing the cost of the system	(Nowak, 2015)
Self-contained system for obtaining ultrasonic characteristics	All operations on receiving and pre-processing of measurement data should be performed in the sensor module	The cost of the measuring system depends on those of the personal computer and the measuring module	(Simeonov et al., 2009)

Table 2. Factors affecting measurement accuracy with ultrasonic sensors

Factor	**Main influence**	**Source**
Air temperature and humidity	Propagation speed of the ultrasound signal	(May et al., 2000)
Atmospheric pressure and gas composition of air	They can be neglected when measuring the same altitude	(Buckin, 2003)
Measuring distance	Operating frequency of ultrasonic sensors	(Ilarionov et al., 2010)
Measured material	The object of measurement must be located in the far zone of the ultrasonic emitter	(Nowak, 2015)
Reflection angle and distance	Angle of displacement of transducers and their dimensions	(Awad et al., 2012)

Factors affecting the accuracy of measurement can be divided into two main groups - essential, which must be compensated for, and minor, which can be neglected.

The temperature and humidity of the air affect the speed of propagation of the ultrasonic signal. They can be compensated after measuring their values and calculating a compensation equation.

At the same altitude, atmospheric pressure and gas composition of the air can be neglected.

When increasing the working distance to the measured object, it is necessary to choose a lower operating frequency of the ultrasonic sensors. This is also related to another factor – the transmitter's operating frequency.

The object of measurement must be located in the far zone of the ultrasonic emitter, where the wave can be assumed to be flat.

It is necessary that the angle at which the ultrasonic waves are reflected from the material, as well as the distance to it, should be such as to ensure their maximum perception on the working surface of the receiver. The measurement accuracy also depends on the angle of displacement of the transducers and their dimensions.

From the analysis of the factors affecting the accuracy of measurement by ultrasonic sensors, it is clear that humidity and air temperature have the greatest influence. Therefore, it is necessary to measure them periodically in order to make a correction and validation, by means of computational methods.

The measurement distance must also be selected correctly depending on the material to be measured as well as the frequency of the emitter. It is necessary to analyze the influence of these factors when indirectly determining the quality indicators of the studied products using ultrasonic characteristics.

5. Pedagogical approaches

In addition to the technical aspects, when developing laboratory equipment, it is necessary to take into account the pedagogical ones. The development and use of ultrasound devices allows for the use of project-based and problem-based learning. Multimedia learning can be successfully combined with game-based learning.

Table 3 presents the more commonly used pedagogical approaches in training to work with ultrasound devices. Through appropriate hardware and software, video clips, electronic textbooks and courses can be realized. A graphical representation of the ultrasound signal can be recorded for multiple objects. In this way, ultrasound data can be processed remotely, by students who have a computer and an Internet connection. Through online data processing and analysis tools, they can complete part of the exercises without having to be present in the school's laboratory.

6. Proposed laboratory device for ultrasonic measurement

After searching the available literature sources, a laboratory setup was developed for obtaining ultrasonic characteristics. The option with an oscilloscope connected to a personal computer is selected. Despite the many disadvantages and limitations of this configuration, it uses multiple measuring devices, making it suitable for educational activities. The laboratory setup can be used in educational disciplines related to electronics, embedded microprocessor systems, and express analysis of food products.

Figure 1 shows a general view and block diagram of the developed laboratory setup for obtaining ultrasonic characteristics of various products. Position (1) denotes the ultrasound system, which consists of a single-board microcomputer, an ultrasound sensor with receivers, and a transmitter. To compensate for the influence of ambient humidity and temperature, their measurement is carried out with a digital sensor for these environmental parameters. The ultrasound system is connected to an oscilloscope (2), through which the ultrasound signal is received and visualized. The oscilloscope is connected to a personal computer (3). The oscilloscope software visualizes and records the ultrasonic data for the measured samples (4).

A comparative analysis of the developed device was made with other devices described in the available literature.

Nowak (2015), proves that not all signs obtained from the ultrasound signal can be applied in the identification of specific characteristics of the studied objects, due to the lack of significant differences in their average values.

Table 3. Pedagogical approaches in teaching to work with ultrasonic apparatus and equipment

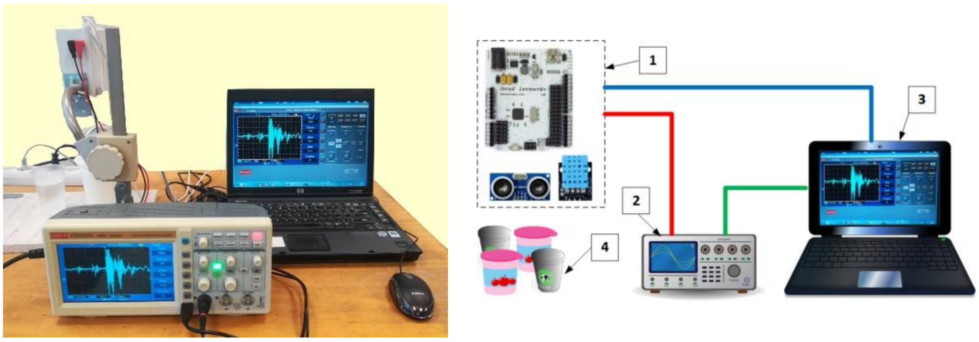
Approach	Description	Source
Project-based training	Project work is an interactive strategy for realizing the connection between students' theoretical knowledge and practical activity, for connecting learning with their real life and cognitive experience, for realizing full socialization and for orientation in the existing information environment as necessary competencies.	(Diawati et al., 2018)
Problem-based training	It offers opportunities for multiple interactions between the participants in the learning process, which in turn leads to the formation of skills for successfully dealing with life situations of different origins.	
Training through play	Appropriately introduced game method develops greater independence and activity in students, mediates the contact of	(Tee et al., 2019)

	Students with material culture, the acquisition of socially significant experience and provides a comprehensive approach to development.	
Multimedia-based training	Modern information technologies are used to ensure the learning process and innovative research. These are computer-based teaching, testing and assessment tools.	
Computer-simulation based training	Simulation training is associated with professional fields where there is zero tolerance for deviation from established standards. It helps to reduce errors and maintain a culture of safety in professions directly related to the development and protection of human life.	
Systematized approach	It represents a hierarchical approach, which is expressed in the mutual subordination of some elements to others. Structuring is manifested in the combination of components in subgroups, between which certain relationships are established.	(Shen et al., 2013)
A directed survey experiment	It represents conducting a scientific experiment in education. Revealing to students the methods of reaching knowledge, which are research and explanation.	(Kvittingen et al., 2016)
Method experiment	This is a special organization of the pedagogical activity of teachers and students with the aim of checking and substantiating previously developed theoretical assumptions or hypotheses.	
Method demonstration	Demonstration as a teaching method means showing objects or didactic materials, accompanied by descriptions and explanations, through which students receive information about the studied phenomena.	
Method – Workshop	The workshop allows students to work together and assess the work of other students or on tasks set by the teacher. There are multiple options for rating by different criteria.	(Bonjour et al., 2014)

This thesis was confirmed by Daskalov et al. (2019). According to the authors, representing the ultrasound characteristics by signs is a better option than using their raw data directly.

The presented schematic solution, algorithm, and test of the proposed non-contact ultrasonic measuring device overcome the shortcomings of the one proposed by Simeonov et al. (2009), from the point of view of its application for laboratory training, because the experimental set-up consists of several measuring devices – an oscilloscope, an ultrasound system, and a personal computer. For this reason, it can be used in more than one academic discipline.

What has been said so far is a prerequisite for the implementation of future research related to improving the performance of the proposed ultrasonic device, from the point of view of accurately determining the values of the characteristics of the investigated objects, in laboratory conditions and directly on the production line, as well as evaluating the possibility of predicting these parameters with ultrasound techniques.



a) General view b) Block-diagram

Figure 1. Laboratory set-up for ultrasonic measurements

7. Conclusion

In the present study, a comparative analysis of ultrasonic devices is made from the point of view of their principle of operation, the factors influencing the measurement with such technical means, as well as the pedagogical aspects related to their application as educational and technical means.

Using the methods of comparative analysis and those for the development of educational and technical means, a model of a device for obtaining ultrasonic characteristics is proposed.

The comparative analysis showed that ultrasound measurement systems can be divided into three main groups: using an oscilloscope, using a Data Logger, and stand-alone measurement systems.

It has been found that the factors that influence the accuracy of measurement with ultrasonic devices can be divided into two main groups - essential, which must be compensated for, and minor, which can be neglected.

Pedagogical aspects in the development and use of ultrasound devices are reviewed. It has been found that they can be successfully used in project-based and problem-based learning. Multimedia learning can be successfully combined with game-based learning.

As a result of the studies, a laboratory setup was proposed, in which, in addition to the ultrasound system, an oscilloscope is used. Despite the shortcomings of this configuration, it has the potential to be used in more than one academic discipline.

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Harnessing Auto-Generative Learning Objects in Serious Games

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Abstract: *The IT industry has a shortage problem regarding human resources. High economical projects are rejected due to the human resources shortage. Such practices affect the internal revenue and thus the national economy. Universities developed several solutions in this sense for a faster and better training of students. They developed distance learning programs, MOOCs, etc. The use of auto-generation learning objects (AGLOS) represents a solution in this sense since it has the potential to deliver online variable and dynamic e-learning content based on function compositions and random numbers. A gamification of such objects would motivate and enable students to improve their competences in the field of ITC.*

Keywords: e-learning, auto-generative learning objects, gamification, serious games, computer science disciplines, mobile applications.

1. Introduction

The migration of human resources from the Eastern Europe to the Western European countries puts a constant pressure on the local IT industry. By human resources we mean: software architects, software developers, embedded system developers, web developers, GNOC (global network operations centre) engineers, DevOps engineers, etc. Specifically, in the region around the city of Timişoara periodically, the number of IT specialists is diminished significantly, so the need for specialists becomes more severe affecting the region's development.

In this context, each year software companies reject high value projects because of human resources shortage. Other software companies which prospect the region are reluctant to invest in new subsidiaries to create new jobs for the citizens. In order to tackle this problem universities must train software engineering specialists better, faster and deliver them to the industry to increase regional

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companies' capability of accepting and developing more and larger software projects.

Companies employ students very early, sometimes in the second or third year of study in part time or full-time programs so their study time is quite limited. In this context arise the need for new learning ecosystems that are adapted to this issue where students are motivated more, can learn and exercise several learning objectives efficiently in their limited free time like: lunch breaks, while on / waiting for public transportation, while waiting in queues (e.g., in a bank to meet a teller employee) etc. By learning ecosystems, we understand a combination of technologies and resources that help individuals to learn in an environment.

On the other hand, students tend to be present more and more in online activities, they often use gadgets for information, entertainment (social networks) and also for learning by email, blogging, microblogging, wikis, polls, surveys, collaborative writing tools etc. Universities tend to cope with the increasing IT specialists demand coming from regional industry and benefit from the digitally enabled nature of students so they built several learning environments like: LMSs, MOOCs etc. The learning content offered to students in this environment is mostly static – the content of a learning object does not change.

In this context we propose a new learning ecosystem based on the composition of two concepts: AGLO (Chirila et al., 2015) and gamification (Huotary et al., 2012). Conceptually, we can define the gamified AGLO like:

GamifiedAGLO = AGLO ○ Game

The AGLO is a meta-model for generating dynamic e-learning content that enables several advantages over static learning content. An AGLO has embedded the functionality of a specific learning objective and with the help of the computer one can generate several examples, tests for better understanding and learning assessment. AGLOs are meant to be designed by tutors and to be used independently by students in online platforms.

Using AGLOs the student can benefit automatically from a virtually infinite number of examples when studying a learning objective. In this sense an ecosystem based on AGLOs could be considered a smart learning ecosystem. For example, in the context of IT disciplines when the structure of an array is studied using an AGLO the student can work on virtually an infinite number of memory mappings for that array, variable parameters are element size and array starting address: i) array of integers or floats where the array element has 4 bytes; ii) array of short integers where the array element has 2 bytes; iii) array of doubles where the array element has 8 bytes; iv) array of structures where the element can have an arbitrary size. In the regional automotive industry developers use untypical data types represented on 4, 12, 20 bytes; v) the starting address of the array in the memory is also random; vi) the computation of the array elements addresses can be learned in such an AGLO created context.

Gamification refers to using game design elements and principles (game mechanics) in non-game contexts in order to improve user engagement (Huotari et al., 2012). Several review researchers find that gamification brings positive effects for their users. We consider that in order to increase even more the attractiveness of AGLOs we can use several gamification techniques. Specifically, to our region, the target users for the gamified AGLOs are as follows. IT students in the first year of study may play gamified AGLOs because of their young age. On the other hand, the biggest dropout rate is found at the end of the first year 50-60% so we consider that such measures have some potential in at least limiting the size of this problem.

Another segment of the target users are the students and graduates from non-IT faculties that easily can be trained into IT because of their technical backgrounds and of their digital user experiences. In our region such students easily become software developers mostly in embedded systems of the automotive industry.

A different segment of potential target users are students from non-technical universities that need basic programming skills. The regional industry searches for such students and even started to develop informal schools for professional conversion. For example, in the regional automotive industry such students / graduates are employed as software testers.

A younger segment of target users are middle school and high school students who intend to learn the first steps in programming and want to follow a career in the IT field and to act in the regional industry.

The paper is structured as follows. In section 2 we analyse related works. In section 3 we present a short definition of AGLOs. Section 4 presents an AGLO example at work. Section 5 analyses several gamification ideas in the area of searching and sorting algorithms, while section 6 deals with gamification of trees and graphs algorithms. Section 7 describes the implementation of the current prototype. Section 8 reflects on the strengths and weaknesses of the approach. Section 9 concludes and sets future work.

2. Related Works

Generally, learning objects (LO) are considered deliverable learning content and have been under several standardisation processes (IEEE LTS, 2016). AGLOs may be considered as specialisations of GLOs which are used in several learning contexts. GLOs are pedagogical patterns that can be reused in several contexts (Boyle, 2003; Boyle, 2006; Jones at al., 2007) through instantiation. They are considered to be the second generation of learning objects (Boyle, 2006). The instantiation can be implemented by metaprogramming or other methods like manual content fulfilment. In (Boyle & Bradley, 2009) is presented a GLO maker tool that assists the creation and instantiation of GLOs using a graphical user interface.

(Chirila, 2013; Chirila, 2014) present an AGLO model used in primary and secondary schools e learning platforms. The model is based on a state machine, random values, interpreters etc. in order to generate a variable dialog where competences are developed in the context of a competence and skills system build.

(Chirila, 2014b; Chirila, 2015; Costea et al., 2018) present generative models of learning objects for computer science disciplines like data structures, algorithms and operating systems.

In (Damasevicius et al., 2008; Stuikys et al., 2013) are presented elaborated models (feature models and others) that generate GLOs operating LEGO robots in order to teach computer programming in a very intuitive manner.

In (Shorn, 2018) is presented an experiment about teaching computer programming based on team-based competitive games and individual competitive activities. The learning gains were positive but of small effect size and lack of statistical significance compared to the traditional approach.

In (Zhan et al., 2022) is described a meta-analysis on gamification in programming compiled from 21 empirical studies using cross-tabulation analysis. Several aspects were analysed like: students cognitive load, game types, reasoning strategies, gamification applications, teaching tools, pedagogical agents and programming types.

In (Mubin et al., 2020) is presented a gamification literature review in programming language learning. The study reveals that gamified solutions for website development programming languages should be developed.

ADL (ADL xAPI, 2016) researches infrastructures, environments and tools in the domain of serious games based on virtual reality and simulations. They contributed to web distributed games that train policy and procedure in the defence area. Other approaches developed by ADL in this sense are: i) game interactions to teaching environments; ii) maths and programming in a story line; iii) Virtual World Sandbox for simulations delivered and stored online.

3. The Basic Concepts of Auto-Generative Learning Objects

The AGLO model is based essentially on function composition and random numbers generation being able to deliver generated e-learning content embedded with interactivity and feedback. The development of free gaming frameworks running also on mobile phones, like Unreal Engine 4, Unity, etc. enables the creation of gamified AGLOs which can enhance even more the attractiveness of the e learning materials.

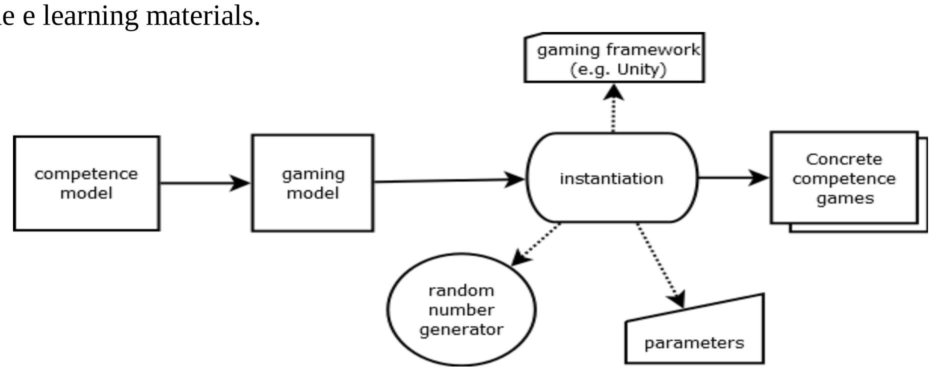

Figure 1. The AGLO Gamification Approach

In this paper we explore the first steps of creating AGLO models based on gamifications in order to increase the attractiveness of learning objects. Figure 1 presents the framework in which AGLO gamification will work. We start from a competence model which can be an informal description of the competences we want to achieve. Next, we design a generic gamification model which is instantiated based on random numbers, local parameters and animation facilities from different frameworks. Finally, after the instantiation we obtain a concrete playable gamification. Re-instantiating the model will produce different concrete gamification. The AGLO model (Chirila, 2015) is based on several sections like: i) name – the identification section, small descriptions, and other metadata can be set; ii) scenario – the symbols definition section using formulas and random numbers; iii) theory – a section for explaining theoretical fundamentals necessary to be accessed in order to perform actions in the other sections; iv) questions – a section where the questions are formulated based in symbols; v) answers – a sections where answers are assessed relating on precomputed symbols; vi) feedbacks – a section for explanations related to the previously asked questions and based on the computed symbols. The number of sections is not limited to the previously listed ones, only the symbols definition section is mandatory and other sections may or not depend on the defined symbols.

In this paper we want to add the advantages of gamification like status and achievements to the AGLO model in order to better motivate students to achieve their learning goals. The challenges of our approach are to make first steps towards the design of the gamification generic model in order to be able to apply it to different learning objectives from different disciplines. The first step of our research is to identify the gamification principles in concrete examples, namely searching, sorting and graph related algorithms.

4. AGLO Based Serious Games for Arrays

Revisiting the array memory mapping example from the first section we can enter in the anatomy of that AGLO where its functionality can be explained into details. Firstly, in the scenario section we define the model of the learning objective. In this AGLO the proposed learning objective is to learn the memory mapping of an array and to exercise the computation of the array's elements addresses. We imagine our model following the next strategy: i) to generate randomly a base memory address denoted by b; ii) to convert the memory address into hexadecimal representation sb; iii) to create an array of array elements sizes, for this example we propose to have [1,2,3,4,8,16] ; iv) to randomly select one on the sizes from the array using an index named id; v) to get the value from the sizes array d=tab[id]; vi) to generated a random index i; vii) to compute the result address of the array element r=b+i*d; viii) to convert the result address into hexadecimal representation sr. All these parameters will be defined as symbols in the context of an AGLO. The formalisms that implement the previously explained steps are:

```
<symbol name="b" type="integer">random(100,200,0); </symbol>
<symbol name="sb" type="string">(v("b")).toString(16); </symbol>
<symbol name="tab" type="array">[1,2,3,4,8,16]; </symbol>
<symbol name="id" type="integer">random(0,5,0); </symbol>
<symbol name="d" type="integer">v("tab")[v("id")]; </symbol>
<symbol name="i" type="integer">random(0,20,0);</symbol>
<symbol name="r" type="integer">v("b")+v("i")*v("d"); </symbol>
<symbol name="sr" type="string">(v("r")).toString(16); </symbol>
```

The implementation is a prototype in JavaScript with a few wrapper functions used to implement a simple running environment. The random(…) function is based on the Math.random(…) library function. The v(…) function is used to access the values of previously defined symbols in the dynamic of symbols definition. For example, symbol d uses previously set symbols tab and id, etc. The dynamic content shown the student is based in the following text pattern:

Given the memory address of the beginning of an array <value name="sb"/>h, knowing that the element size is of <value name="d"/> bytes, compute the element address at index <value name="i"/> from the array.

The generative content of the AGLO uses only 3 symbols sb, d and i. The correct answer was computed and can be compared to the student answer so points, medals, cups or other gaming mechanics can be awarded to the student.

Next, we show three different instantiations of the model:

#1

Given the memory address of the beginning of an array 10h, knowing that the element size is of 4 bytes, compute the element address at index 3 from the array.

#2

Given the memory address of the beginning of an array 22h, knowing that the element size is of 8 bytes, compute the element address at index 7 from the array.

#3

Given the memory address of the beginning of an array ACh, knowing that the element size is of 16 bytes, compute the element address at index 9 from the array.

5. AGLO Based Serious Games for Searching and Sorting Algorithms

In this section we will present a few ideas and principles for the gamification of basic computer science algorithms like searching and sorting. We consider that linear search and sentinel based linear search algorithms are quite trivial to gamify so we focused on other algorithms like simple sorting algorithms. In order to achieve the gamification effect, we will include the following dimensions: i) points – to model a score in the game economy, achieving correct algorithm steps will increase the score, while wrong actions will decrease the score; ii) badges – each passed algorithm gamification will be rewarded with a specific badge, they are be implemented as parameterized vector graphic images; iii) top performers board – this facility will be used for the promotion of competition between students, such boards could be created locally at school or university level or at national and international levels after the gamification are internationalised; iv) levels – the same gamification can be parameterized with the size of the problem, e.g., a sorting algorithm can be instantiated for 7, 15 and 25 elements representing different difficulty levels; v) unlocking higher levels – gamification of algorithms may have prerequisite relations between them, e.g., in order to access interpolation search algorithm gamification you must first fulfil the binary search algorithm gamification.

5.1. AGLO Serious Games for Binary Search Algorithm

For the binary search algorithm, we will consider for each step a set of actions to be executed by the player. Firstly, he needs to point the left and right boundaries of the array where the search is done. This can be implemented by dragging and dropping a set of parentheses like “[“ and “]” or other computer graphics sprite decorations at the right location. Secondly, he needs to points to the pivot element. This step can be implemented by dragging and dropping the "m" letter, or other sprite over the median element. Variations can be imagined at this step by allowing the player to set the pivot at his own will. Allowing the median to be at an index different than the median will possibly trigger more or less algorithm steps in the search. Thirdly, the player has to select the sub-array where the search should continue. This can be implemented by highlighting differently the two zones, to be able to click on one of them. Next, the player has to adjust the left boundary or the right boundary by moving the left or right parenthesis. Finally, he has to repeat the previous steps until the search is over. The total number of points are computed by adding each action point. The rewarding badge as a certified binary searcher may look like a military distinction with an inscription of the name of the algorithm inside. The top performers’ board will list the fastest players (total no of steps completed / total time). The levels can be achieved by setting the array length to 7, 15 and 25. The unlocking of higher levels after completing the binary search may involve revealing the gamification of interpolation search and quick sorting algorithm.

5.2. AGLO Based Serious Games for Sorting by Insertion Algorithm

The philosophy of the algorithm is to split the array into two parts sorted and unsorted and at each step to increase the size of the sorted part thus diminishing the size of the unsorted one. This philosophy can be visually implemented by using two different background colours for the two array zones. Firstly, the player will see the initial array with one element already sorted, belonging to the growing zone. Secondly, the player is invited to extract the first element from the unsorted zone.

Thirdly, the player will have to repeatedly move the greater elements one position to the right using the drag and drop technique. Optionally, the player could select all elements that have to be transposed and transpose them as a whole block. Fourthly, the player is invited to insert the extracted element at the right location between the other two elements. The steps are repeated until the array is sorted. The points are obtained for each element move. The rewarding badge for the sorting by insertion algorithm will be a decoration with one symbolic element to be inserted between the other two. On the top performers board will be the players which will make the largest number of correct moves. Levels can be created varying the number of elements in the array. The unlocking of higher levels may be related to the binary insertion sorting algorithm or any algorithms based on insertions.

6. AGLO Based Serious Games for Trees and Graph Data Structures

6.1. AGLO Based Serious Games for the Binary Tree Creation Algorithm

The gamification of the binary tree construction starts with displaying a random list of integers. Firstly, the player must set its root by dragging the first element from the list to the binary tree construction area. Secondly, the player must compare the next element in the list with the root, this can be implemented by positioning it on the left side or right side near the root. Thirdly, the player must attach the new element to the root on the left or on the right depending on the case. The points are obtained for each correct comparison and node placement. The granted badges will have miniature binary trees on them. The top performers' board will hold the names of the fastest and most accurate players of this gamification. The levels will be generated according to the numbers of nodes like: 7, 15 and 20. Regarding the unlocking of higher levels, we can trigger the release of the binary tree searching algorithm gamification. Similarly, a binary tree searching algorithm gamification can be imagined.

6.2. AGLO Based Serious Games for the Kruskal's Algorithm

In the preparation stage a weighted graph will be generated based on control parameters like: i) no of nodes; ii) number of edges; iii) degree; iv) minimum and maximum weight values. In the first stage of the gamified algorithm, we have a drag and drop episode where the player will sort the graph edges. The edges list will have the possibility of accepting other edges between two already existing ones. In the second stage the player will select and rebuild a greyed shape of the graph with the minimal edges avoiding cycles. The points are obtained for each action in the process of ordering and in the process of filling the graph without making cycles. The badge gained will depict the name of the author, namely Kruskal. The top performer's board will contain the fastest players playing with graphs having a great number of edges. The levels can be obtained by changing the parameter values with 5, 10 and 15 for the number of edges in order to increase difficulty. Regarding unlocking higher levels, we can unlock other minimum spanning tree algorithms like Prim's algorithm for example or other complex algorithms.

7. Web Application Implementation

The implementation is based on a rapid prototyping of a client web-based application. The code is written in JavaScript and runs on the client side, namely in browsers. The used libraries are JQuery and its drag and drop extension. Each algorithm implementation is based on a state machine with the unrolling of the execution steps. When the player acts according to the correct step then the number of points is increased. The common elements of the prototypes are the fact that all work with arrays, all need: i) element selection facilities; ii) inserting facilities and iii) elements swapping facilities (distant or neighbour). Dynamically, each phase is played in one virtual line and after its completion a new line is created so the player can see the progress of its actions and eventual error not to be repeated in the near future. The first two lines the player is assisted with indication and afterwards it is left to play alone. If errors occur then the assistance is set back on in order to help him understand the behaviour of the studied algorithm. When assisted the player will get no points. With xAPI each action can be stored in a standardised format for later analysis or publication. We consider that only the full completion of an algorithm gamification should be stored in the database and not each phase's result.

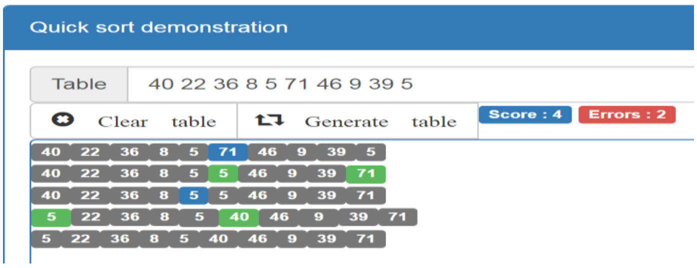

Figure 2. Gamification of Quicksort Algorithm

In Figure 2 we show a snapshot picture of the prototype where the student plays the gamification of the quick sorting algorithm. Using drag and drop, clicking, he will have: i) to select the first pivot; ii) to swap the pairs of elements around the first pivot; iii) to select the left pivot; iv) to swap the pairs of elements around the left pivot; v) to select the right pivot; vi) to swap the pairs of elements around the right pivot; vii) etc. For each correct move the score is increased and for each bad move the number of errors will grow. In this example the AGLO instance provided the learning context which is the input integer array. In this case it may seem trivial to generate a random integer array. But, for example, in the context of graphs the graph generation models from AGLOs are not trivial. The generation of a random graph involves several iterations for generating the nodes, the edges, the weights etc., which are features offered by AGLOs.

8. Conclusions and Future Work

In this paper we presented ideas towards the gamification of AGLOs dedicated to the learning of computer science basic algorithms. We imagined and experimented with several gamified AGLO models in this sense. Gamified AGLOs can embed not only variable text and variable images to form variable questions with attached answers and feedback but also gamification of concepts, namely data structure specific algorithms. The drawback of the approach stands in the complexity of the learning content which involves advanced knowledge of programming. Still some levels of abstraction can be set to favour accessibility e.g., a level controllable by parameters only accessible to non-programmer content authors. We consider that the union of benefits obtained by the proposed composition can help to train faster and better students benefiting from the advantages of both concepts, thus supporting regional development. As future work we intend to reuse and refine the AGLO gamification model to other computer science basic programming disciplines like Programming Techniques where the majority of universities have a large number of students they have to train, especially in the first years of study. Nevertheless, such LOs could be used in high school learning programs.

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The Quality of Teaching Comparison of Online and Face to Face Teaching Experiences

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Abstract: *With the increasing global competition, many countries have made changes in their education systems to adapt to world standards. Education quality has been a topic discussed by students, teachers, educational institutions and societies. Online education environments, which have increased with the pandemic, are compared with the traditional method, face-to-face education programs. It is important to determine the opinions of prospective teachers, who will shape education in the future, on the quality of online and face-to-face teaching. This study aims to examine factors affecting the quality of teaching. It aims to explore perceptions of student teachers about online teaching experiences from the voices of prospective teachers in order to determine future of education in terms of quality. 190 prospective teachers participated to the study. It is revealed that culture, learning environment, time and readiness are main factors to adapt learning. Most of the prospective teachers resist joining flexible learning environments. This study sheds a light on how prospective teachers enrich their professional development to make a bridge to future education.*

Keywords: online learning; prospective teachers, teacher education, quality.

1. Introduction

The Covid-19 outbreak has affected many sectors and of course education as well as health services. After the interruption of education due to the epidemic, 770 million people were affected by this situation (Zhong et al., 2020). With this global crisis, face-to-face education, which is the traditional method, was suspended and

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education moved to online education platforms. The students found themselves in a process they had perhaps never experienced before. After these changes, the differences, positive and negative aspects of online and face-to-face education started to be discussed.

Online education, which has developed with the changes in education with the renewal and development of science and technology, is used as an alternative to face-to-face learning (Yıkıcı et al., 2022). Online education has started to be talked about and researched more with the epidemic. Online education has been implemented through interactive tools and is shaped according to modern information and technological developments. This research is to determine the opinions of prospective teachers, who are important in education, on the comparison of face-to-face and online education. For this purpose, answers were sought for the following sub-problems;

1. What is the perception of prospective teachers about traditional learning teaching practices?
2. What is the perception of prospective teachers about online learning teaching practices?
3. What are the suggestions regarding the quality of teaching for the future?

1.1. Online Education

Online education: It is the learning done by the teacher and the student, although they are physically in different places (Telli & Altun, 2020). According to Parlak (2017), online education is learning where students are far from each other and there are learning resources in time and place.

Soykurt et. al. (2021), on the other hand, defines online learning as a planned learning method in which students and teachers teach in different ways, synchronously or asynchronously, online, without the physical presence of students.

Online education applications are divided into two as synchronous and asynchronous. Asynchronous training; It is a model where teachers and students do not share the process and the virtual environment at the same time, and the course content can be accessed at any time. Synchronous education, on the other hand, is an education model where teachers and students share the same virtual education environment on the internet at the same time and communicate with each other (Altınay et al. 2020). While asynchronous education is defined as the education in which the necessary documents for the lesson are shared with the student on the internet regardless of the place and time, there is no communication between the student and the teacher, synchronous education is defined as "the environments where the student and the teacher interact with each other in different places at the same time". Synchronous education provides some of the advantages of face-to-face education with opportunities such as providing communication, participation and follow-up and instant feedback (Midkiff & DaSilva, 2011).

Online education, due to financial situation; It has become a part of our lives due to epidemics, disasters and unforeseen reasons in the future. Its place in our lives is growing day by day. Granger and Bowman (2003) stated that the need for information in online education in the world is increasing day by day.

1.2. Differences between Online Education and Face-to-Face Education

The education system is always open to innovation in order to eliminate the problems and disruptions in the teaching process. In order to better meet the requirements of the age, technological development and education needs, the online education system has been implemented.

The traditional education system is mostly an education system built between four walls and conducted in narrow classrooms. In this context, in traditional education; Teachers have problems such as authoritarianism, raising externally controlled individuals, understanding each student's story in the same way, limited research opportunities and not finding enough time for repetition (Deveci, 2019). Although efforts are made to find solutions to these problems, they are not fully resolved, for example due to inequalities in education and infrastructure. Sun and Chen (2016) suggested that such problems can be solved through online education.

Although online learning has advantages over traditional learning or traditional learning over online learning, online learning is not an alternative to traditional learning. Online education exists to eliminate the deficiencies of face-to-face education. Instead of choosing any of them; It is emphasized that using these two methods together and planning them according to geographical conditions, student potential and teaching needs is much more beneficial in terms of learning (Balaman & Hanbay Tiryaki, 2020).

2. Methodology

In this study, the opinions of prospective teachers on the differences in face-to-face education and online education and their suggestions for increasing the quality of education for the future are presented.

Qualitative research method was used in this study. Qualitative research is defined as research in which qualitative data collection methods such as document analysis and interview and observation are used, and the qualitative process is followed in order to reveal events and perceptions in a natural environment in a holistic and realistic way (Yıldırım & Şimşek, 2018).

As a data collection tool, a semi-structured interview form was used within the scope of the research. In qualitative research, face-to-face interviews, document analysis and interview techniques are applied in order to obtain in-depth views during the data collection process (Legard et al., 2003). In the process of preparing the interview form of the research, the opinions of academicians who are experts in their fields were taken. Then the interview form was revised. Afterwards, a pilot study was conducted for the research and it was examined whether the questions were understandable and clear, and whether the answers were in line with the research purpose.

The qualitative study group of this research was conducted with 190 prospective teachers in the 2021-2022 academic year. Participants of the study were determined by a purposeful random sampling method. Purposeful random sampling is defined as the classification of systematic and randomly selected case samples in accordance with the purpose of the research (Marshall & Rossman, 2014).

Table 1. Distribution of Demographic Characteristics of the Participants

	n	%
Gender		
Female	108	%57
Male	82	%43
Age		
18-21	87	%46
22-25	64	%34
26-29	31	%16
30 and above	8	%4

The data collected by the interview technique were analyzed by the content analysis method. The answers given by the participants to the questions were categorized and divided into themes. Participant opinions were given directly. Opinions were expressed by coding in terms of the identity confidentiality of the participants.

3. Findings

3.1 The perception of the prospective teachers about traditional learning teaching practices

"What is the perception of prospective teachers about traditional learning teaching practices?" The answers given by the participants to the question are analyzed in Table 2.

Table 2. Participant views on teaching practices of traditional education

Categories	**Themes**		**Participants view Frequency Percentage** f	%
Advantages and disadvantages of teaching practices in traditional education	Advantages	Teacher and student interaction	98	26
		Practical training opportunity	43	12
		Classroom management	54	15
		Permanent learning	27	7
		Physical attendance and use	35	9

		of materials		
		Ease of communi-cation	89	24
		Providing immediate feedback	12	3
		Measurement and evaluation more objective	14	4
	Disadvantages	Limited accessibility	124	34
		Limited resource	87	23
		Time and place limitation	78	22
		peer bullying	26	7
		Not using different training methods	32	9
		Mediocrity	11	3

Advantages of teaching practices in traditional education, Teacher-student interaction (f98), Practical training opportunity (f43), Classroom management (f54), Permanence of learning (f27), Physical attendance and use of materials (f35), Ease of communication (f89), Providing immediate feedback (f12), Measurement and evaluation are expressed as more objective (f14). The disadvantages are listed as limited accessibility (f124), Limited resources (f87), Limitation of time and place (f78), Peer bullying (f26), Not using different education methods (f32), Ordinariness (f119). The answers given by the participants are as follows:

"It is easier to reach and communicate with the teacher in face-to-face education. The teacher can easily understand whether the student understands the subject or not. On the other hand, in face-to-face education, it is a disadvantage that there is no opportunity to access the lesson at any time and the resources are limited during the lesson." P11

"One of the leading differences of face-to-face education is that it is applied education and it provides permanent learning by using physical materials, for example, by making laboratory lessons more effective. However, peer bullying, which is increasing day by day in face-to-face education, has a negative effect." P32

"In face-to-face training, you can easily ask questions that come to your mind. Communication and interaction between teacher and student are provided more easily. This interaction supports social and academic development. The teacher knows his/her student and assessment and evaluation is done more objectively. As a disadvantage, students may have problems physically participating in the lesson. In addition, teachers' use of traditional methods can make the lesson monotonous." P74

3.2. The perception of the prospective teachers about online learning teaching practices

The research participants were asked "What is the perception of prospective teachers about online learning teaching practices?". The answers of the participants were gathered under 14 themes as advantages and disadvantages.

Table 3. Participant views on teaching practices of online education

Categories	**Themes**		**Participants view Frequency Percentage** f	%
Advantages and disadvantages of teaching applications in online education	Advantages	Orientation to research	94	19
		Ease of access to the course	190	40
		Technological knowledge development	77	16
		Unlimited resources	57	12
		More beneficial for health	21	4
		Learning how to access information	45	9
	Disadvantages	Communication difficulty	167	23
		Lack of equal educational opportunity	134	18
		Lack of motivation and adaptability	97	13
		Limited participation in class	89	12
		Infrastructure issues	110	15
		Lack of application	72	10
		lack of supervision	46	6
		Teacher's lack of knowledge	21	3

All of the participants stated that they could access online education without time and place limitations. Other answers of the participants about the disadvantages of online education Difficulty in communication (f167), Lack of equal educational opportunities (f134), Low motivation and adaptation (f97), Limited participation in the course (f89), Infrastructure problems (f110), Lack of implementation (f72), Lack of supervision (f46) and the teacher's lack of knowledge (f21). Opinions of the participants as the advantages of online education, Directing them to research (f94), Ease of accessing the course (f190), Technological knowledge development (f77), Unlimited resources (f57), More beneficial for health (f21), Learning how to access information (f45) has been revealed. The opinions of the participants are as follows:

"It is more difficult to get attention in online education. Student motivation is lower and students are more indifferent to the lesson. On the other hand, the most important advantage of online education is that there are no time and place restrictions and students can access the course whenever they want." P13

"Online education is more student-centered than face-to-face education. Continuous access to the course can be provided. It encourages the student to research and enables the development of their technological knowledge. But teachers' lack of knowledge and technology creates problems. It reduces the efficiency of the lessons." P73

"In online lessons, it is not understood whether the student is following the lesson or not. Most of the time the camera and microphones are turned off. Communication is limited and difficult. This makes it difficult to adapt to the lesson. It is important to provide access to information at any time, as there is no time and place limit." P118

3.3. The suggestions regarding the quality of teaching for the future

"What are the suggestions regarding the quality of teaching for the future?" The question was asked and the themes that emerged regarding the answers of the participants were examined in Table 4 below.

Table 4. Participant recommendations for the quality of education for the future

Themes	**Participants view Frequency Percentage**	
	f	**%**
Education model should be mutually supportive	178	34
It should be student centered	114	22
Teacher development should be provided	102	19
Permanent learning should be provided	89	17
Different measurement-evaluation methods should be applied	44	8
Total	527	100

Participant suggestions for the quality of education for the future are as follows: Education model should be mutually supportive (f178), Student-centered (f114), Teacher development should be provided (f102), Permanent learning should be ensured (f89), Different assessment-evaluation methods should be applied (f44). The statements of the participants are as follows:

"Although face-to-face and online education have different advantages and disadvantages, they should support each other. Lessons can be supported with different educational technologies in order to eliminate the disadvantages of face-to-face education. Likewise, in online education, courses can be supported by applied training." P60

"The main purpose of education is to provide permanent learning. Education should be student-centered and help students increase their knowledge and skills. In addition to traditional measurement and evaluation methods, methods that measure the knowledge and skills of different students should be applied." P75

"I think that the knowledge and skills of teachers should be improved in order to increase the quality of education. It has been observed that many teachers in the online education period do not have sufficient knowledge in this direction. Work needs to be done in this direction. Thus, student education can be provided as required by the age." P183

4. Conclusion

Every stage of online education is increasingly used in education. Online education/online learning, which has become an important part of our education life, has been an important subject of study by researchers (Lockee, 2021; Erol and Erol, 2020; Kilit & Güner, 2021). Especially the advantages and disadvantages of online education have been examined within the scope of many studies. In this research, it is aimed to reveal the advantages and disadvantages of face-to-face and online education as well as their suggestions for the quality of education in the future.

As a result of the research, the advantages of face-to-face education include teacher-student interaction and ease of communication, while there are practical lessons, use of materials, immediate feedback to students' questions, and more objective measurement and evaluation. Participants stated that the accessibility in face-to-face education is limited, the resources used are limited, the lessons are ordinary, time and place limitations, and peer bullying as a disadvantage.

When the participants were asked about the advantages and disadvantages of online education, all of the participants stated that it is an advantage to be accessible at any time without time and place limitations in online education. Although online education has disadvantages, it is expressed as an important advantage to have fast access to information and continuous access to education (Sezgin, 2021). In addition, other advantages include directing the student to research, helping to develop technological knowledge and skills, unlimited resources, learning access to information and being safer in terms of health. The disadvantages of online education are expressed as the lack of equal educational opportunities, low motivation and adaptation, infrastructure problems, lack of supervision and teachers' lack of sufficient knowledge. According to the research, it has been revealed that especially the internet infrastructure should be strengthened in order to carry out online education in a healthy way (Karasel et al., 2020).

Face-to-face education or online education are not superior to each other. It is important that education be integrated in order to be effective and efficient. For this reason, it is foreseen that clarification of the problems of education and reduction of these problems in the light of suggested solutions will contribute positively to the improvement of education quality, not to the development of education.

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Cybersecurity education in Romania - competitive advantage in the EU market

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Abstract: *Modern information and communication technologies have experienced significant development in recent years, with a major impact on every aspect of life: social, political, economic, and cultural. The development of cybercrime is also based on the revolutionary growth of technology. Education and courses provided at a national level are essential to prevent cyber attacks. Cybersecurity awareness and the need for cybersecurity specialists make a significant competitive advantage in the EU market. Therefore, it is crucial to know who the primary providers of cybersecurity education in Romania are and if there is room for improvement. Also, it is critical to understand who is seeking to acquire knowledge in this field and how the providers approach them. Thus, this paper presents both universities and private entities which provide at least one course focused on cybersecurity Moreover, it analyses Romania's attitude in a European environment toward this field and how and when its strategy will lead to a competitive advantage in the EU market.*

Keywords: Cybersecurity, cybersecurity education, online courses, education providers.

1. Introduction

Digital transformation dominates the agenda of businesses, governments, and consumers worldwide, with increasingly substantial sums invested in cloud computing, automation, databases, and artificial intelligence (AI) technologies in recent years to facilitate work and enhance the customer experience. It applies to medical emergencies, climate change, population ageing, or other future challenges because digital technologies represent the means of progress, enabling the world to move forward.

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The increasing use of the internet and cyber-based technologies has resulted from the fast expansion of information and communications technology (ICT) and the global digital transformation (Eriksson & Giacomello, 2022).

Nevertheless, accelerated digitalisation also brings challenges in terms of cybersecurity (Fischer-Hübner et al., 2021). Threats of this nature are increasingly numerous, and the risks are growing, which is why combating cybercrime requires collective societal responsibility (Ho et al., 2022) and tremendous coordination of forces at all levels. At the same time, people and organisations must use all the tools at their disposal – legal and technical measures, capacity building, and cooperation – to connect with each other and build trust.

The digital world has become an integral part of people's lives. All types of organisations, such as medical, financial, and educational institutions, use it to function effectively. Organisations use it to collect, process, store, and share large amounts of digital information. As more and more digital information is collected and shared, protecting this data becomes even more critical for national security and economic stability. And the tensions between data privacy, security, competition, and stability will continue to play out in the increasingly integrated global digital economy (Haksar et al., 2021).

Cybersecurity is described as the conjunction of technologies, individuals, systems, and functions working together to protect companies, networks, and people from digital theft, unauthorised access, attacks, damage, or disruptions in services (Bada et al., 2015). It is an ongoing effort to protect network systems and data from unauthorised use or attack. Protecting identity, data, and electronic devices is necessary. For organisations, the responsibility is divided by each employee to protect the entity's reputation, data, and customers. For states, when it comes to national security, the safety and well-being of citizens are at stake.

People spend more and more time online, and actions in this environment can affect their lives (European Parliament, 2020). Offline identity is who friends and family interact with daily at home, school, or work. They know personal information such as name, age, or address. Online identity is about who people are in cyberspace. Online identity is about how individuals present themselves to others online. Their online identity must provide limited information about them.

The necessity for education and training in this field prepares an organisation or individual confronted with an ever-changing security environment and the exponential growth of new IT & C technologies. Thus, Romania needs specialised courses in cybersecurity, which can always be a competitive advantage in the EU market.

The EU's actions to upskill the workforce, develop cybersecurity talents and invest in research and innovation are essential to protecting against cyber threats. The new cybersecurity strategy seeks to protect an international and open Internet while simultaneously providing safeguards not just to ensure security but also to protect European values and the fundamental rights of the citizen (European Commission, 2020).

The Revised Digital Education Action Plan aims to raise cybersecurity awareness both among individuals, focusing on children and young people, and organisations, particularly SMEs. Another objective is to promote women's participation in science, technology, engineering, and mathematics education and ICT jobs, upskilling, and reskilling in digital skills (European Commission, 2020).

Through the Digital Education Plan, the European Commission establishes two strategic priorities:

1. Fostering the development of a high-performing digital education ecosystem.
2. Enhancing digital skills and competences for the digital transformation.

Thus, Romania needs to ensure that there are enough highly-skilled specialists in cybersecurity ready to support and lead solutions to existing and potential challenges related to this field. But how well is Romania doing regarding cybersecurity? Are there sufficient universities educating students in this field? Or is cybersecurity an overlooked area?

2. What is cybersecurity

Cybersecurity is defined by the International Telecommunication Union (ITU) as „the collection of tools, policies, security concepts, security safeguards, guidelines, risk management approaches, actions, training, best practices, assurance and technologies that can be used to protect the cyber environment and organisation and user's assets" (ITU, 2008).

It refers to the way information, devices, and digital assets (personal data, accounts, files, photos, and even money) are protected.

People, small businesses, large companies, and public administration depend on IT systems constantly. These systems are increasingly complex, including a range of services interconnecting new and older elements.

Thus, numerous potential security vulnerabilities occur that did not exist before the emergence of the digital society. Cybersecurity is particularly significant, including how the elements of a computer system are protected against cyber attackers, who could access and use them for criminal purposes.

For individuals, cybersecurity attacks can lead to identity theft and identity extortion attempts, which can cause severe damage to the individual's life. People need their data and personal information to be protected. For example, when people connect to an application or fill in the card data when making a payment online. If these systems, networks, and infrastructures did not have the proper protection, the filled data could reach attackers. The same applies to organisations, which store enormous amounts of data, much of which is sensitive information.

According to Marsh Risk Resilience Report (Marsh, 2021), even if 45% of the organisations rated cyber risk as the most critical threat, only 18% of them state that they are highly prepared for it.

Moreover, within the tenth edition of the ENISA Threat Landscape report, there were identified the prime threats: ransomware, malware, social engineering, threats against data, threats against availability, Denial of Service, threats against availability: Internet threats, Disinformation – misinformation, and supply-chain attacks (ENISA, 2022).

Therefore, it is important to understand the **CIA triad, confidentiality, integrity, and availability,** as a guide to an entity's information security.

Confidentiality provides data protection by limiting access and encrypting authentication. Company policies should limit access to information to authorised personnel and ensure that only authorised individuals view this data. Data can be divided according to the information's level of security or sensitivity. For example, a Java developer should only have access to the personal information of some employees. In addition, employees should receive training to understand best practices for securing sensitive information to protect themselves and the company from attacks. Privacy protection methods include:

- Data encryption.
- User ID and password.
- Two-factor authentication.
- Reduced exposure of sensitive information.

Integrity ensures that information is correct and trustworthy. Integrity is the accuracy, consistency, and reliability of data throughout its entire life cycle. Data must be unchanged during transit and not modified by unauthorised entities. Permission levels assigned to files and user access control can prevent unauthorised infiltration. Version control can be used in order to avoid accidental changes by authorised users. Backups must be available to recover corrupted data, and checksum hashing can be used to verify data integrity during transfer.

Availability guarantees that data is accessible to authorised individuals. Maintaining equipment, performing hardware repairs, updating operating systems and software, and creating backups ensure network and data availability to authorised users. Following natural or manufactured disasters, there must also be plans for rapid data recovery. Security equipment or software, such as a firewall, protects against downtime caused by denial of service (DoS) attacks. Denial of service refers to the action by which a hacker tries to overload resources so that services are unavailable to users.

3. Cybersecurity culture in Romania

LAW no. 362 of December 28, 2018, establishes the legal and institutional framework, measures, and mechanisms necessary to provide a standard high level of security of networks and IT systems and to stimulate cooperation in the field (Romanian Parliament, 2018).

In this context, Romania has developed a cybersecurity culture regarding the security of networks and IT systems, with several cybersecurity awareness campaigns in place. These campaigns are conducted by Romanian institutions

(National Cyber Security Directorate, National Institute for Research and Development in Informatics, Romanian Intelligence Service, Romanian Police), non-governmental entities (The Romanian Association for Information Security Assurance (RAISA)), professional associations (The Romanian Association of Banks) or private companies (Microsoft, Bitdefender, Orange, RDS).

The Global Risks Report 2022 states that 95% of cybersecurity issues are traced to human error (World Economic Forum, 2022). Therefore, the human-generated risk as an IT&C infrastructures operator becomes a major one. This is because the threat has continuity. It starts with training and the actual perception of obligations, complying with the job description. Thus, the cybersecurity culture must be developed before beginning professional activity.

According to the Digital Economy and Society Index (DESI) 2022, Romania ranks 27th regarding the human capital dimension. Our country encounters a deficiency of fundamental digital skills; therefore, this applies to cybersecurity too. Less than a third of citizens have at least basic skills, and only one out of ten has above-basic digital skills. However, the proportion of ICT specialists is growing steadily, as per the graph below (Figure 1. Female ICT specialists). Also, in terms of female ICT specialists, Romania is above the EU average (19.1%), with 26% of the total ICT specialists (European Commission, 2022).

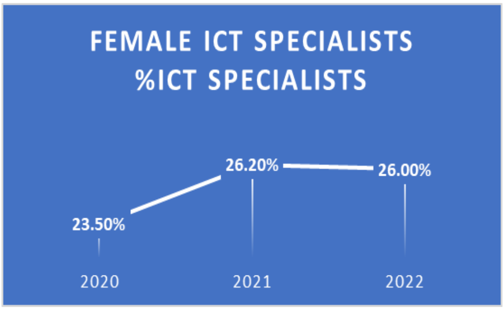

Figure 1. Female ICT Specialists

However, the future of Romania's cybersecurity culture should be brighter. Among the five objectives of strategic importance for 2022-2027, as defined within The Cyber Security Strategy of Romania, is a pragmatic public-private partnership between public administration authorities and institutions, private entities, academia, research, and citizens as a necessity since cyber-attacks target a large number and a broad spectrum of networks and computer systems (Romanian Government, 2021).

Within this objective, there are the following measures:

1. Running public awareness programs and raising the level of cyber security culture;
2. Development of educational programs in the field of cyber security;
3. Conducting professional training programs for those who carry out activities in the area of cybersecurity;

4. Developing and strengthening cybersecurity research and innovation;
5. Development of the national cybersecurity industry.

4. Cybersecurity in universities in Romania

Since technology will not stop developing, governments, businesses, organisations, and individuals are increasingly vulnerable to cybercrime. Anyone who lost money or vital information to hackers better appreciates cybersecurity experts. Therefore, cybersecurity specialists and information security analysts are essential in today's world. Thus, the need for experts to protect different entities' information is also growing.

Over eight years, Cybersecurity Ventures tracked the number of unfilled cybersecurity positions that grew by 350 percent, from one million in 2013 to 3.5 million in 2021. The cybersecurity skills gap settles for the first time in a decade. At the same time, they predicted the same number of jobs (3.5 million) in 2025 (Cybersecurity Ventures, 2022).

Nowadays, different programs and training courses are available, but only some graduates become cybersecurity experts after just 14 modules. This is why universities have adjusted their curriculum, in order to meet workforce needs.

Academic institutions have distinct approaches to cybersecurity education. Some universities are focused on specialising early, developing bachelor's courses. Others deliver master's programs and postgraduate courses, considering the need for a computer science background.

In this context, I conducted an analysis of the current state of the cybersecurity education provided by universities in Romania, from the perspective of bachelor's courses, master's programs and postgraduate courses.

During my research, I found universities that provide cybersecurity education all around Romania (Figure 2. Romania Cybersecurity Education Providers Map). Thus, there are **16 cities** where universities provide at least a security of information system course. In total, **27 universities** offer **14 master's programs** and **nine postgraduate courses**. Moreover, Ferdinand I Military Technical Academy has the Faculty of Information Systems and Cyber Security.

Figure 2. Romania Cybersecurity Education Providers Map

The universities' steps toward cybersecurity education should be taken into account. But there is also a need for a strategy to develop a unity of efforts in order to create a skilled workforce in this field.

Table 1 below shows the 27 universities and the various programs and courses they offer in order to educate students in Romania. Some universities only provide courses for different education levels – 15, but the other 13 provide entire programs (bachelor or master). The courses range from applications in the maritime area to cyber defence, e-business security, and data security in the www. Furthermore, the most common course is the Security of Information Systems, similar to the essential introduction to cybersecurity.

Table 1. Cybersecurity education providers in Romania

University	**Education level**	**Programs/courses**
Bucharest University of Economic Studies	Master	Program: IT&C Security Master - Cyber Security
Politehnica University of Bucharest	Bachelor, Master	Programs: Advanced Cybersecurity, Security of complex computer networks; Courses: Cybersecurity introduction, Cryptography introduction, Computer, and Network Security, Security of Information Systems
University of Bucharest	Bachelor, Master	Program: Security & Applied Logic; Course: Security of Information Systems
Ferdinand I Military Technical Academy	Bachelor, Postgraduate	Faculty of Information Systems and Cyber Security, Postgraduate courses: Cyber defense technologies, Cyber defense management, Planning cyber defense activities, Digital investigations
Technical University of Construction Bucharest	Bachelor	Course: Systems engineering
Titu Maiorescu University	Master	Program: Security of information systems and information networks
Spiru Haret University	Bachelor Master	Faculty of Engineering and Informatics, Course: Information Systems Security Modern Technologies in Information Systems Engineering (Master), Courses: DevSecOps Methodologies, Computer Networks Security, IT Security Management
Constanța Maritime University	Master	Courses: Cyber Security and Risk Management, Maritime Cyber Security and Autonomous Operations, Management Induction of Maritime Cyber Security, Cyber Warfare and Maritime Risks, Global Cyber Capabilities and Trends, Maritime Cybersecurity Law and Policy, Managing Maritime Cybersecurity Operations, Cyber

		Practitioner in Maritime Cybersecurity Simulation Lab, Risk Analysis and Compliance in Maritime Cybersecurity, Information Assurance
Ovidius University of Constanța	Master	Program: Cyber Security and Machine Learning
„Dunărea de Jos” University of Galați	Master	Program: Combating Cybercrime
Vasile Alecsandri University of Bacău	Postgraduate	Course: Cybersecurity
Technical University "Gheorghe Asachi" Iași	Master	Program: Cyberspace Security
Alexandru Ioan Cuza University of Iași	Bachelor	Course: Security of Information Systems
Ștefan cel Mare University of Suceava	Postgraduate	Courses: Fundamentals of Cyber Security, Information Systems Security, Cyber Security Incident Management
Petroleum-Gas University of Ploiești	Bachelor	Courses: Data security, Cryptography and information security
Henri Coandă Air Force Academy	Bachelor	Course: Cybersecurity
Transilvania University of Brașov	Master	Program: Cyber Security
University of Pitești	Master	Program: Advanced Techniques for Information Processing, Information security
University of Craiova	Bachelor	Courses: E-Business Security and Risk Management, Information Security
„Constantin Brâncuși” University of Târgu Jiu	Bachelor	Courses: Data security in the WWW, Data security in a network
Lucian Blaga University of Sibiu	Bachelor	Course: Information Systems Security
Technical University of Cluj-Napoca	Master	Program: Information and Computing System Security
Babeș-Bolyai University	Postgraduate	Course: Information Systems Security
Polytechnic University of Timișoara	Master	Program: Security of Information and Cyber Systems
West University of Timișoara	Bachelor, Master	Courses: Information Systems Auditing, Cryptography, Program: Cybersecurity
Vasile Goldiș” Western University of Arad	Bachelor	Course: Security of Information Systems
University of Oradea	Bachelor	Course: Security of Information Systems
Spiru Haret University	Postgraduate	Course: The audit and security of IT systems

We can conclude from Table 1 that in the bigger cities, where the cyber sector is more developed, the need for specialising students in cybersecurity is met more than in the small ones. Therefore, the most important cities in Romania also provide master's programs or even an entire faculty, as there is in Bucharest. Meanwhile, the small towns and the smaller universities still understand the need for specialists in this field, and they have started to provide students with introductory or postgraduate courses.

In the future, we can also expect smaller universities to provide master's programs or even an entire bachelor's program. Romania now knows the importance of cybersecurity specialists, so it has started to grow its own. Soon, they will be the professionals every entity is searching for.

Conducting this study was relevant to cybersecurity education in Romania, which still needs a curriculum and an integrated approach. Therefore, government and industry should closely collaborate with the universities to demand skills that future experts need to face a cyber-attack. Collaboration is required on all ends in order to create a competitive advantage for Romania in the EU market.

6. Cybersecurity courses in Romania

Cybersecurity is one of the most crucial matters impacting governments, organisations, companies, and customers. Every year, the number of cyberattacks, malware, data and identity theft, ransomware, and fraud continue to increase. Cybersecurity attacks are still expanding not only in the matter of vectors and numbers but also regarding their impact (ENISA, 2022). The positive side is that more people are curious to discover how to defend themselves and their organisations from cybercrime.

As an alternative to university programs, the shortest and easiest way to achieve cybersecurity competencies is through various courses on the market. Anyone can easily find these courses online by a quick search on every search engine.

For instance, using Google as a search engine, I have found **24 courses**, starting from one hour (after the war in Ukraine, Ascendia offered a free course for Romania and Moldova) to 120 hour-course. The price for these courses ranges from 50 euros to 2350 euros. The primary providers of this kind of education are the National Institute for Research and Development in Informatics, Info Academy Bucharest, CISCO, Ciseo, Teachbit.ro, Cyberstart, Factory 4.0, Computerland.ro, ITtrainings.ro, Skillab.ro, IT Level, DoIt Academy.

Each course has its requirements, syllabus, price, and target audience. Still, regardless of whether people want to enhance their cybersecurity knowledge for personal, professional, or academic purposes, they can find a suitable option online. Unfortunately, there are no standards regarding these courses, and not all providers can offer a diploma accredited by the National Qualifications Authority.

7. Conclusions

Cybersecurity is a constant effort to protect network systems and data from cyberattacks, malware, data and identity theft, ransomware, and fraud. Since people use technology increasingly, the demand for education in this field has grown exponentially.

Education and training in cybersecurity are essential for organisations and individuals facing various cyberattacks. Therefore, Romania is taking action to have specialised people in cybersecurity, a competitive advantage in the EU market.

Although there are no national standards, the state of cybersecurity education in our country is evolving, having universities and private entities as providers. Students can be educated in this field at the graduate and postgraduate levels, with only some universities requiring prior education.

Analysing the Cyber Security Strategy of Romania and its objective to create a pragmatic public-private partnership establishes the framework for developing education in this field.

Raising public awareness and designing new awareness campaigns leads to a better cybersecurity culture. The educational programs in this field will also help, especially if the Government applies standards. Professional training programs for those who carry out activities in the area of cybersecurity are needed since this is an ever-changing area. Funding for research and innovation is necessary to keep pace with the emerging challenges in the cyber environment. All these aspects will help develop the national cybersecurity industry and make a difference, leading to a competitive advantage in the EU market.

The next step should be to promote the 16 cities, 27 universities, 14 **master's** programs, and nine postgraduate courses. There is excellent potential for cybersecurity education in Romania, but it still needs to be adequately advertised. Many of the universities in this research are state universities; therefore, schooling is free, unlike the other 24 courses I have found online, which need payment.

The need for cybersecurity experts will still grow in our country, even if it has settled at a global level. Thus, Romania should take advantage of all the university programs to improve its DESI rank and cybersecurity culture.

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