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14

Proceedings

of the 14th edition of Romanian International Conference for Education & Research

Innovations in Education and Research

29 - 30 OCT 2024 Cluj-Napoca

Coordonator: Alina-Cerasela Avram

București, 2024

ISBN 978-973-0-41349-6

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Published by: **Weik Press**

Desktop Publishing: Ioana Cristea

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The Role of Education in the Future AGI. A Study on the Balance of Education, Finance, and Social Welfare

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Abstract

According to the provisions set out in Objective 4 of the Agenda for Sustainable Development set up by the United Nations in September 2015 for the implementation of a fair and quality education, boundless by borders as a result of the adhesion of the states fully assumed for these objectives, the action plans must be vitalized and contextualized by the information crisis created by the pandemic, war, and artificial intelligence. These circumstances have instituted a global tension in education. While some companies are cushioning this tension through their investments in the specialization of employees, the solution to neutralize the global educational risk is the development of the public educational process per the worldwide objective. For future generations of professionals, educational practices must establish and develop contextualization and practice to meet the competence requirements required by AGI (artificial general intelligence) within enterprises. In AGI companies people use LLM (large language model) for evaluation and analysis and specialization involves competence for the profession's deontology and appropriate technical professional training. Thus, there is an established need

for an educational program that develops upskilling, a program with a double significance: the establishment of professional skills and the foundation of personality attributes for safe, ethical, and responsible professional practice.

The UN together with the OIM calls for a unitary educational system in principles and the implementation of an educational process based on scientific thinking and developed socio-emotional skills.

The general subject of this article examines to what extent education impacts social well-being and financial performance. The research aims to study the circumstantial conditional association between education, well-being, and economics and to highlight the impact of education on social welfare and the economy. The research is based on information capitalized in Eurostat, IMF, and OECD databases and starts from the status quo of the last 20 years, the analysis of this period notes an increasing rate of completion of the higher education cycle, but UNESCO statistics on skills acquired in reading and calculation affirms a decreasing rate of these. Going forward with the research, we observe the consequence in the employment rate for people who have graduated from an institution of higher education, much higher than the employment rate of primary or secondary education graduates, the Nordic countries being at the top of this ranking. This situation, however, generated an increasing unemployment rate in the analyzed period. This study researches how extent programs combat unemployment among young people aim to increase practical and social-emotional skills, analyzes the impact of investments in education and their effect on the economy, and the incidence of integrity and quality control of the educational process. Graphical representations and data analysis are performed in Microsoft Office.

Keywords: education, sustainability, artificial general intelligence, higher education, workforce, well-being.

JEL Classification: I20, I23, I24, I25, J01, J21, J24.

1. Introduction

"Education is the most powerful weapon you can use to change the world" (Nelson Mandela). The school in its early form, i.e. from the 9th to the 13th centuries, developed along two main

lines: religion and philosophy. In the organization of the terrestrial world, philosophers such as Xenophon of Elea affirmed that God is the absolute principle of all things. Anaxagoras, on the other hand, portrays God as the Universal Nous - the active and organizing thought that created minerals, plants, animals, and man. The rationalism of scholasticism is advanced by Plato's Dialectic as the basis for the innovative research of the new order that has God at its center (Ion Buga, 2021). Thus, education has meant since ancient times more than the accumulation of knowledge, but the shaping of a character, imprinting moral quality, harmonious development, elegance in behavior, and diplomacy in speech, all of which summed up a robust but skillful model of education (Iancu, 2019).

The chances of a world are determined by education, its territoriality, and the level of quality and equality of these services towards the learning of students. The gloomy scenarios project in the not-too-distant future a chasm regarding education and schooling opening for future generations. Therefore, education may become a privilege for the elite while for the poor, education will become completely inaccessible. Indeed, there is a huge potential for growth and development in education and training thanks to technology and artificial intelligence. The educational environment can benefit from structural transformations thanks to artificial intelligence that can solve inequality of learning, lack of resources, pollution, lack of educational programs, and shortage of teachers (UNESCO, 2021). The calls for investment, technology, and innovation are useful for the establishment and improvement of education plans and budgets for regions and countries that do not have the resources for such allocations.

The share of total public expenditure on education is made up of education expenditure per pupil, depending on the level of education and the source of funding. Africa, despite having one of the highest education expenditure ratios in GDP, has the highest number of out-of-school children in the Southern Hemisphere, and Africa also has the highest number of countries that do not have allocated sources of funding for science, technology, and innovation (Unesco Institute for Statistics, 2024). The high cost of education in the absence of investment and innovation jeopardizes evolution and development which is more important than income.

Nowadays education research is supported by more than 6 mil. papers on education realized in the last 50 years and among them more than 700.000 research on the quality of education. More

nearly 100,000 papers research the impact of artificial intelligence in education. Therefore, we can say that research on artificial intelligence is at its beginning, however, it is important to note the impact of research and innovation in increasing educational performance, it has given in a short period impressive skills and tools for efficiency and accuracy, for example ChatGPT.

A generally accepted view is emerging that innovation in education reflects the ability to experiment, share, and extend more so it reflects the ability to get fair value in an equitable and unbiased way. Innovation in research needs to happen at any scale, according to the UNESCO study of 2021 - Reimagining our Futures Together - more at the UN Summit in September 2024 the duty to support developing countries in their approach to investing in education is reiterated. The actions set, in the meetings held during the summit, emphasize ensuring measures for the implementation of early education and increasing skills while harnessing digital technologies (UN, 2024). Concerning the emerging centers of artificial intelligence, it reaffirms SDGs 4 and 5 set by the UN, according to which a strategy for maximum coverage of basic digital competencies among both teachers and students, while promoting intermediate and advanced digital competencies, should be implemented expeditiously (UN, 2024).

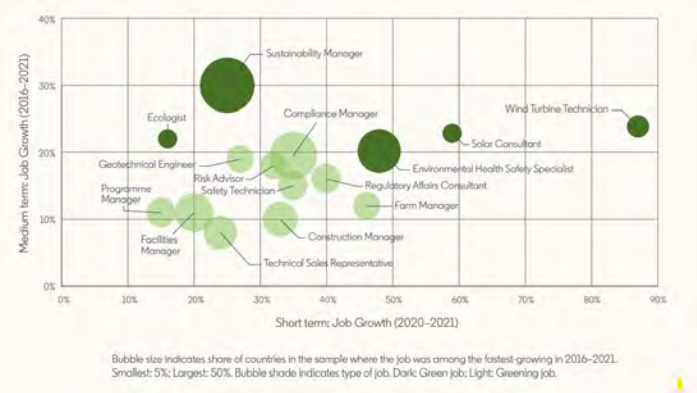
This study aims to contribute to the scientific field with research realized on the context influencing the qualitative factors of education. Respectively to perform an analysis of the causal link between the performance of research and innovation in the field of technology and the performance of the educational act present in the value chain. We also intend to analyze whether the consistency in investments and updating of teaching methodology has a positive effect on the educational level, manifested by the level of promotion, and the continuation of the learning process over a long period.

2. Literature Review

Whether because of the demands of the transition to a sustainable economy or the gargantuan challenges of artificial intelligence - the field of jobs is experiencing both opportunities and challenges. According to a study by LinkedIn, the demand for new skills outstrips the supply. But in this global context, new jobs are emerging, for example, sustainable development manager or energy auditor. More experience and green skills differentiate the labor market.

According to LinkedIn the US labor market ranks first in renewable energy, surpassing the Middle East. Moreover, as part of the transformation of the economy towards a sustainable economy, green financial products are being implemented, the management of which must be green and for which sustainable finance skills are required (LinkedIn Economic Graph, 2023).

Concerning green skills, dig into the status quo of competencies and attribute talent. In demand in all fields of activity, especially in emerging markets, talent is manifested through innovation in sustainable and environmentally sustainable actions. Another study conducted by LinkedIn Economic Graph exposes the situation that globally the share of green talent among workers with at least a bachelor's degree increased at an average annual rate of 11% between 2015 and 2021, compared to 9% among workers without a bachelor's degree for the same period (LinkedIn Economic Graph, 2022).



Source: Green Jobs, LinkedIn Economic Graph. Global Green Skills Report (2023).

On the implications of artificial intelligence for the expansion of the workforce and on the ecological transition of labor markets, the study conducted by Alexander et al for the IMF in July 2024 classifies sustainable and unsustainable jobs according to the nature of the tasks. Moreover, sustainable jobs are exposed to the demands of artificial intelligence and the advances it is making. Conversely, unsustainable jobs show minimal exposure to artificial intelligence, with manual labor predominating among them (Alexander et al., 2024). They study the future of the labor market with Pizzinelli's predecessor study investigating the uniformity of education, training, and work experience across jobs. According to him, occupations that require longer periods of professional development are better suited to incorporate AI knowledge, thus bringing complementary skills to job tasks (Pizzinelli, 2023) but are also more

resilient to these changes (TimeCO2, 2024). In response to the up-green skills requirements for the transition to a sustainable economy, MFI is a contributor to capacity building. In education, it continues to increase the number of its free online courses with more than 160,000 active learners participating, and to build sustainable financial solutions to support education (IMF, 2023).

In the transition towards a sustainable economy, the emerging character and characteristics of the activity are supported by scientific studies, research, and academic papers (Regulation (EU) 2023/2772 regarding sustainable reporting). In these circumstances, accurate forecasts of academic performance provide benefits and predictability for students, teachers, policymakers, institutions, and businesses (Asselmanetal et al, 2023). These predictions can improve both academic performance and the objective performance of value chain stakeholders (Hakkal, Lahcen, 2024). However, once artificial intelligence has been formalized (including through the European Commission's AI Act establishing harmonized rules on artificial intelligence in Regulation (EU) 2024/1689, the question of the ethics and integrity of its use arises. According to the study by Lee et. al., there is an acceptance among universities to use it to explain concepts and to provide some ideas before the design of the work (Lee et.al., 2024). Moreover, learning in virtual reality is considered an efficient technique mainly in gaining experience and less in acquiring pedagogical information - for example, in training courses conducted for pilots to conduct training classes (Jongbloed et. al., 2024), however complementary studies reveal that to accomplish a high level of knowledge and contextualization requires personal study (Squires, Rigby, 2024). Even better, another study reveals that contextual knowledge analysis is a growing requirement among employers, academia, and research (Brianza et. al, 2024). But to evaluate contextualized information as an applicable science in research and practice, Brianza reveals that factors such as social, epistemic, and technological resources influence the outcomes of contextualized expertise (Brianza et. al., 2022). Moreover, science-gained expertise (Berliner, 2001) capitalizes on contextual information (Hatano, 1986) and although this is a desired and pursued strategy in both academia and business, information exchange still reflects a major gap between theory and practice and the contextual approach is insufficiently addressed for practitioners to establish meaningful connections between theory and practice (Ripple et. al.,

2018). The efficiency of contextualization that validates informational conductivity is realized through self-regulated metacognitive learning (Dahri, 2024) respectively through the mobilization and updating of techniques (Jianget et. al. 2016) that converge to increased efficiency of contextualization processes (Flavell, 1976). This is because awareness involves one's thinking and understanding (Lai, 2011). Also, in self-regulation (Dent, 2016) practitioners evaluate their knowledge and gaps and take actions to improve them (Boekaerts, 1999). The emergence of large language models (LLMs) is encouraging to improve self-regulation (Joublin, 2023) and develop critical thinking (Khan, 2023). Thus, LLM provides possible response options (Khan, 2023) that develop the informational event horizon (Winter, 2023). Other studies reveal the importance of LLM in SRL (self-regulated learning) (Wang, 2023). Also from the AI side, tools are being developed that improve self-learning. The Technology Acceptance Model (TAM) (Bagozzi, 1989) assesses and improves individual education (Li, 2023) and professional competencies (Al-Rahmi, 2019). Moreover, as we also showed from the studies conducted for the IMF, the disparity must always be assessed when analyzing the success of implementing an LLM tool (Herrmann, Weigert, 2024) and more so in the self-learning process (SRL) a human-computer disparity must always be assessed (Wang, Liu, 2023).

3. Methodology

The literature review to examine the scientific literature corresponding to the research topic was carried out by querying a sample of papers covering the literature published between 2023-2024, considering the emerging topic of the paper, we considered relevant the studies conducted in the last 2 years. To conduct the search and screening procedure we queried the *Web of Science* (WOS) database. The database was queried according to the keywords "Education", "High education", and "Artificial Intelligence". After extracting the papers, we formatted two databases and bibliometric analyzed them in the *Vos Viewer* program. The bibliometric analysis terms were extracted from the fields "Title" and "Abstract". A total of 1,452 papers were analyzed.

To capitalize on the informational focus of the analyzed studies, we performed examinations on the following queries:

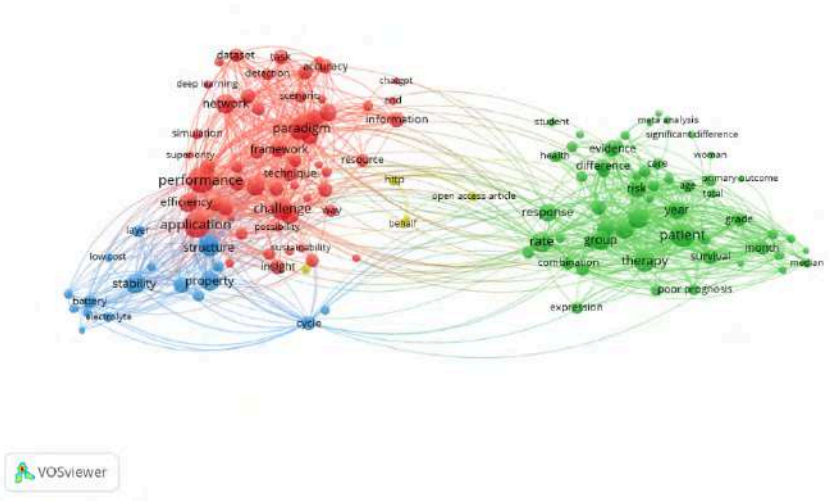
3.1 Area of events of artificial intelligence in education.

3.2 Differential impact between accuracy and performance on education using artificial intelligence.

For items 3.1 and 3.2 the representations obtained in *Vos Viewer* are investigated with statistical data represented in a tabular construct analyzed correlatively with the representations from the bibliometric analysis.

4. Results and Discussions

In this section, we present the results of the systematic review in the same order as in the previous methods section. We start with a brief overview of the sample resulting from the search and screening. We then present the results obtained for each of the points established in the previous section. The bibliographic coupling group in Panel A (Lim et. al., 2024) reveals immersive information that radiates to peripheral centers signaling either independent centers or specialized domains. However, the 3 cluster centers (red, blue, and green) show homogeneous formations characterized by interdependence. The obtained bibliometric result reveals the economic environment actions involving similar characteristics concerning artificial intelligence-augmented education.



Panel A. The artificial intelligence trend in education

3.1 Artificial intelligence events in education - investments in technology and higher education

The consolidation of the specialized literature with statistical data is realized according to the data reported by the UNESCO - Institute for Statistics in the period 2016-2022, so before the interval 2023-2024 (the period for the research carried out on the specialized literature) so we can say that the results of bibliometric research are the consequence of the research actions carried out with innovation and technology developed in the period 2016-2022. Therefore, the investments in innovation, science, and technology representing the number of professionals involved in the conception or creation of new information are presented in **Table 1** - Researchers per million inhabitants (FTE). The study reveals the top 5 places: Australia, New Zealand, North America, Europe, and Oceania.

	Sustainable Development Goal Regions	Researchers per million inhabitants (FTE)
1	Australia and New Zealand	28,810
2	North America and Western Europe	26,736
3	Northern America	25,601
4	Europe and Northern America	22,914
5	Europe	21,582

Table 1. Researchers per million inhabitants (FTE)
Source: Authors' research from the UNESCO - Institute for Statistics database

On the other hand, even if the bibliometric analysis reveals an increased density between education and technology, the statistical data differentially expose the expenditure in education from the expenditure in technology, respectively investments, from the data analysis the top 5 countries that rank in the top of public expenditure on tertiary education, from the data reported by UNESCO - Institute for Statistics for the period 2017 - 2023, are Sierra Leone, Denmark, Bolivia, Norway and Barbados according to **Table 2** - Government expenditure on tertiary education as a percentage of GDP (%).

	Country	2017	2018	2019	2020	2021	2022	2023	Total
1	Sierra Leone	2.75	3.24	2.99	3.58	3.35	2.70	2.10	20.71
2	Denmark	2.39	2.38	2.41	2.41	2.37			11.96
3	Bolivia	1.88	1.81	1.86	1.95	1.78	1.66		10.94
4	Norway	2.09	2.06	2.13	2.31	1.91			10.52
5	Barbados	1.24	1.39	1.18	1.42	1.72	1.47	1.27	9.70

Table 2. Government expenditure on tertiary education as a percentage of GDP (%)
Source: Authors' research from the UNESCO - Institute for Statistics database

The analysis shows that even though Africa ranks 19th out of the 29 regions reported by the UNESCO - Institute for Statistics, according to **Figure 1** - SDGs by region, it ranks first in the country rankings for tertiary education.

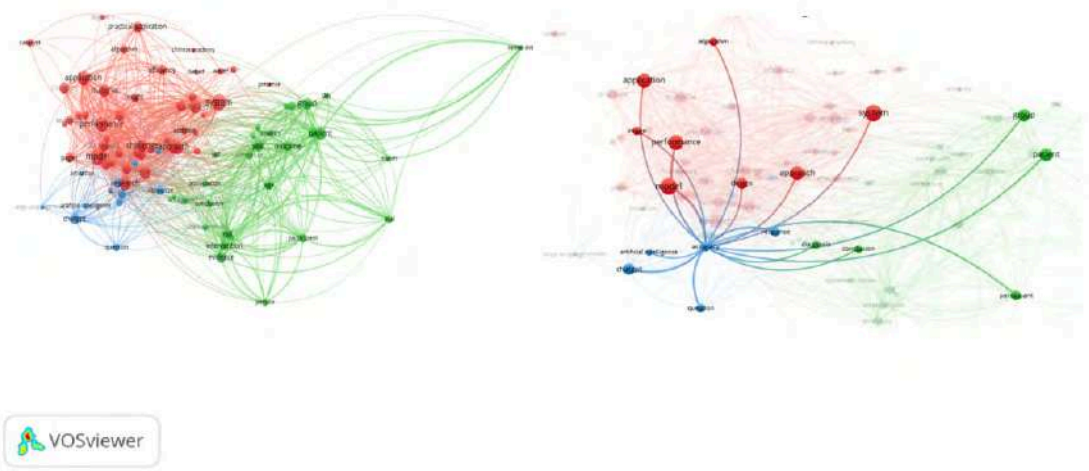
Tabel 1 - Researchers per million inhabitants (FTE)

	Sustainable Development Goal Regions	Researchers per million inhabitants (FTE)
1	Australia and New Zealand	28,810
2	North America and Western Europe	26,736
3	Northern America	25,601
4	Europe and Northern America	22,914
5	Europe	21,582
6	Oceania	20,457
7	World	15,157
8	Central and Eastern Europe	13,236
9	Eastern Asia	11,834
10	Small Island Developing States	10,519
11	East Asia and the Pacific	9,946
12	Eastern and South-Eastern Asia	9,742
13	Latin America and the Caribbean	7,244
14	Upper middle income countries	7,108
15	Central Asia	6,449
16	Western Asia	6,296
17	Northern Africa and Western Asia	5,427
18	South-Eastern Asia	4,744
19	Northern Africa	4,431
20	Middle income countries	4,365
21	Arab States	3,533
22	Lower middle income countries	1,853
23	Central and Southern Asia	1,781
24	South and West Asia	1,745
25	Southern Asia	1,745
26	Sub-Saharan Africa	1,160
27	Low income countries	1,039
28	Landlocked Developing Countries	974
29	Least Developed Countries	428

Figure 1. SDGs by regions

Source: Authors' research from the UNESCO - Institute for Statistics database

3.2 The differential impact between accuracy and performance on education using artificial intelligence



Panel B. Resources and expected outcomes on school life expectancy

The determined factors analyzed in this cluster are the duration of the teaching process and we also considered relevant to analyze the number of teachers in higher education schools. The bibliographic coupling group in **Panel B** determines current as well as future trends. The bibliometric survey reveals current characteristics converging to the event horizon line. This may signify its potential in the future (Damar, 2021) constituted by a natural diversification or from the interaction with specific emerging factors that will drive future research toward new investigative environments.

From the bibliometric analysis, depicted in **Panel B**, the resolution applied on the first image reveals that one of the poles of education is the accuracy from which performance results, the image on the right side of **Panel B**.

For this reason, we decided to analyze the extent to which accuracy is supported in academia. **Table 3** shows the number of teachers involved in the higher education system. Thus, according to the data reported by the UNESCO - Institute for Statistics for the period 2017-2023, the top ten countries with the highest number of professors in the higher education system are shown in **Table 3**.

	Country	2017	2018	2019	2020	2021	2022	2023	Total
1	India	1,365,786	1,388,732	1,416,299	1,503,156	1,551,070	1,599,812	1,664,172	10,489,027
2	Japan	560,123	560,964	560,352	563,364	561,558	561,141		3,367,502
3	Germany	407,132	416,241	456,041	457,457	472,418	484,301		2,693,589
4	Brazil	445,514	448,533	472,012	439,269	438,364	442,095		2,685,787
5	Mexico	387,391	397,142		386,881	401,367	483,868		2,056,649
6	United States of America	1,581,424							1,581,424
7	Republic of Korea	219,598	220,797	211,090	216,295	222,134	226,248		1,316,162
8	Russian Federation	597,067	539,144						1,136,211
9	United Kingdom	156,295	161,145	217,004	192,027	193,011	200,310		1,119,792
10	Spain	167,063	171,869	175,759	175,019	179,661	186,592		1,055,963

Table 3. Teachers in tertiary education programs, both sexes (number)

Source: Authors' research from the UNESCO - Institute for Statistics database

Next, we found it necessary to analyze what is the school life expectancy related to the number of years of schooling that a person can receive during his/her lifetime. Given the importance of implementing a strategy that contains an early schooling program for the child, we consider that the expected lifetime schooling experience is closely related to accuracy and performance. **Table 4** shows the top 10 countries that are at the beginning of the analysis of the expected

number of years of schooling, based on data reported by UNESCO - Institute for Statistics for the period 2017-2023.

	Country	2017	2018	2019	2020	2021	2022	2023	Total
1	Greece	6.17	6.47	6.68	6.72	7.08	7.69		40.81
2	Türkiye	5.74	6.00	6.12	6.22	6.47	6.45		36.99
3	China, Macao	3.75	3.67	3.74	3.93	4.45	5.25	5.97	30.76
4	Australia	5.26	4.91	5.20	5.14	5.19	4.94		30.64
5	China, Hong Kong	3.58	3.82	4.06	4.31	4.59	4.62	4.76	29.74
6	Argentina	4.49	4.56	4.75	4.95	5.34	5.34		29.42
7	Republic of Korea	4.57	4.53	4.53	4.61	4.70	4.80		27.75
8	Finland	4.32	4.33	4.37	4.41	4.59	4.77		26.80
9	Chile	4.38	4.40	4.39	4.22	4.49	4.60		26.48
10	Belarus	4.19	3.94	3.74	3.66	3.58	3.42	3.24	25.77

Table 4. School life expectancy, tertiary, both sexes (years)

Source: Authors' research from the UNESCO - Institute for Statistics database

Although our study analyzes the accuracy and performance gained because of the use of artificial intelligence, we observe that although Africa invests in education, Sierra Leone is the country with the highest percentage of GDP allocated to tertiary education. It ranks lower in terms of innovation and the number of researchers, presented in **Figure 1** - SGD by region, but also in terms of the hard aspect of schooling being ranked 103 out of 158 reported by the Institute for Statistics - UNESCO, also from the same analysis performed results in many countries of the African continent with 0 aspects in terms of hard schooling. The analysis shows that the main objective of education in the educational strategy is the completion of schooling and employment.

About the school life expectancy indicator, for some of the countries with the highest number of years of schooling presented in **Table 4**, we identify traceability in the field of research, as they report a high number of researchers in innovation and technology. This correspondence is

presented in **Table 5** Researchers per million inhabitants for countries with the highest School Life Expectancy.

	Country	2016	2017	2018	2019	2020	2021	2022	Total
1	Republic of Korea	7,056	7,451	7,914	8,323	8,615	9,082		48,440
2	Finland	6,544	6,732	6,873	7,246	7,549	7,871		42,814
3	China, Hong Kong	3,652	3,709	3,972	4,235	4,349	4,585	4,809	29,312
4	China, Macao	2,614	3,177	3,471	3,629	3,866	4,132	3,545	24,434
5	Greece	2,728	3,264	3,441	3,685	4,074	4,326		21,518
6	China	1,211	1,238	1,319	1,486	1,602	1,687		8,543
7	Argentina	1,261	1,212	1,227	1,232	1,256	1,284		7,472
8	Belarus					1,434	1,394	1,382	4,209
9	Chile	500	500	529	512	519			2,560
10	Australia and New Zealand	4,856	4,812	4,850	4,849	4,747	4,696		24.114

Table 5. Researchers per million inhabitants for countries with the highest School Life Expectancy

Source: Authors' research from the UNESCO - Institute for Statistics database

Of course, even if some countries such as Belarus, Chile, and Turkey report a high school life expectancy, we can say that it represents the annual school enrollment rate for the reported age and number of years of schooling.

From our analysis, the countries of Northern Europe, North America, and Australia, countries that report significant resources in innovation and technology, in terms of the number of researchers, report a high duration of school life. This means that the usefulness of the duration of schooling is capitalized without reaching a marginal rate. Australia shows a balanced relationship between the number of years of schooling and important resources in innovation and technology, through the number of researchers, contributes relevant to our study so through the analysis we can say that investment in education is quantified in the number of researchers - innovation and technologization and capitalization of human performance contributes to all sectors GDP and even to exports.

Also, the distribution of spending on education matters, for example India which has the highest number of teachers (according to the data in **Table 3**) this statistic remains an expenditure that does not transform into investment. Analyzing this result correlated with the length of school life, India reports 10.68 years, which can mean both the age at which schooling starts and the length of schooling life, in both cases the result is a condition for GDP formation and not for

investment. Because both in India and Africa education, especially higher education, is accessible only to an elite, and this is the reality in many countries of the world.

On the other hand analyzing the anticipated optimal school life expectancy for investment and technology, regions such as China, Korea, Australia, and Finland (according to the data in **Table 4**) reveal an average school life expectancy of 26 years, analyzing this indicator in correlation with the number of researchers these regions lead their ranking, so we can say that for a country to achieve a solid commitment to investment and technology it is necessary to increase the active school life expectancy.

Another significant aspect is territoriality, because if in one region investments in innovation and technology are concentrated in one place (and from our analysis, we can expose the case of Egypt for Africa) this is not a sustainable strategy for the whole region, mainly. The region in question remains deprived of the benefits and advantages of scalable investment actions throughout its territory and the strategy is not a successful one in the relations with the other regions involved either. Often such places turn into export hubs that devalue the place of belonging.

5. Conclusions

Our study emphasizes both the importance of research and innovation in artificial intelligence in a corroboratory way with the educational environment. We conclude that this level of education is effective if affiliated with an educational standard.

We also mention the importance and impact of the social system that influences the implementation of innovation in technology (Khan, 2023). Hence, technology innovation can be perceived negatively or positively depending on the environment in which it is intended to be implemented this fact not only affects the efficiency of implementation but also affects the social environment in which it can create disturbances, and revolts. We also assert the importance of communication regarding self-education and its transdisciplinary support. Another important aspect in ensuring success between education and artificial intelligence is the homogeneity of environments and information. In such scenarios the performance gets to be maximized through low rates of returns obtained with the assumption of sufficient time

allocated to study and research, thus aiming at a macro and a micro level performance. We also assume the importance of sufficient human resources to ensure global interconnectivity at the industry level (science, innovation, and technology).

6. Future Research

Future research can be done in areas such as technological infrastructure in support of artificial intelligence or behavioral modeling of education using artificial intelligence. This paper represents a small analysis of the importance of education in the research and innovation process of artificial intelligence, the collaborative way in which these steps should be done, and how the studies can advance to other research contributing to this topic.

Acknowledgment

The author of this paper is grateful for the coordinating team's contribution, advice, and guidance.

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The Benefits of Using Technology to Optimize Student Learning in the Classroom

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Abstract

The use of technology in teaching practice is contemplated as a necessity facing the adaptation to the current needs of society. The purpose of this research highlights the benefits of using technology in education and to optimize students' learning in the classroom. The study emphasizes the results of a recent research accomplished survey Likert-scale. The participants in the research are 150 students from the secondary education institution in Buzau. The results obtained by analyzing the responses of the subjects included in our sample have shown that a group of students have the same opinions regarding the benefits of using technology in the classroom.

Keywords: ICT, education, motivation, classroom, learning.

1. Introduction

In this article we present practical approaches to the question of the benefits of technologies in education, in learning of the students. Improving the quality of the education process and the

skills developed in students are two interrelated desires of the current society in the field of education. Today, more and more teachers are using technology to improve the quality of teaching and help students learn more actively. Educational technologies provide flexible learning opportunities. Research shows that online activities offer learners some flexibility in terms of time, place and pace. Technology has transformed the teaching and learning environment.

2. Literature Review

Based on the literature review and from a pedagogical perspective, technology allows students to take control of their learning, reflect on practice, and establish the context that allows them to handle new learning situations.

The use of technologies in education is becoming a new form of communication with students, and teachers can use these new tools for different purposes. We now live in a digital age and today's learners have different needs. Learning doesn't just take place in the classroom, but outside of it as well. In present, technology has transformed the teaching and learning environment. Educational technologies offer flexible learning opportunities. Research affirms that online courses provide learners with some flexibility in terms of time, place and pace.

Today, the digital age is considered one which we need to embrace. Technology in education opens a huge world of possibilities as to how we convey, share, and engage with students presenting different ideas, facts and theories.

The challenges facing teachers today are complex and diverse. Its performance has been rethinking based on educational models focused on student learning, which also demand substantial changes in the academic-administrative organization of education institutions.

According to Amutha (2020) ICT are influencing all aspects of life. There is no doubt that ICT brings a massive change in the field of education also, it makes the teaching- learning process effective and interesting.

Educational technologies offer flexible learning opportunities. Research affirms that online courses provide learners with some flexibility in terms of time, place and pace (Gedera et al., 2015).

Using technology and educational platforms in teaching activities can enhance learning. In the classroom, motivation drives many behaviors and it is important to understand the role of the ICT in an educational environment (Cocea, M. & Weibelzahl, S. 2006).

Innovative technologies not only have the potential to evolve pedagogical practice, but also completely transform entire learning environments. When technology is leveraged with a very strategic vision and change management plan, the results can be revolutionary (Groff, 2014, p. 8).

Technology is most effective when there is a holistic strategy to integrate digital and no digital resources; the school's infrastructure needs to facilitate the use of the technology being introduced.

A series of educational phenomena such as "synchronous and asynchronous interactions in virtual and mixed learning environments, learning management platforms and tools, digital educational resources, the educational use of different applications and digital tools, virtual assistants for learning and teaching, digital skills of teaching staff, educational policies and specific programs" (Istrate O., 2022, p.3) determined the emergence and rapid development of a new, interdisciplinary field of study called *digital pedagogy.*

3. Methodology

3.1. Objectives of the research

This study investigates the role of technology in engaging students to learn effectively and explores their attitudes toward using technology in the classroom. At the same time, this article aims to develop useful suggestions for educators, students and teachers in schools to actively involve students in the didactic activity, thus improving the quality of education. This study was conducted at a secondary education institution in Buzău, with 150 students who answered the questionnaire with items that concerned their attitude towards the technology used in the classroom.

3.2. Research sample

In order to know how the attitudes of students regarding the use of technology in the classroom, and thus detect the main benefits but also difficulties that students may have in their studies in

general, was designed Questionnaire as a technique data collection information and they were asked questions: *To what extent do you consider digital technologies to be effective in the activities? Digital technologies support the effective development of course content? How well do digital technologies support collaborative learning? What benefits do you think you have had from your teachers' use of digital technologies?*

A total number of 106 students answered the questionnaire.

In total, 15 closed Lickert type questions or with pre-formulated answers were asked. For multiple-choice questions, respondents could add other answer options, thus completing and enriching the collected data:

- *What are the ways of integrating digital technologies within the lessons/courses? Please fill in as many options as possible in addition to those already listed (e-mail, online groups, chat, educational platforms, other situations).*
- *What are the digital platforms used in the lessons/courses? Please fill in with other variants used in addition to those already listed (Moodle, Adservio, Google Suite, Socrative, Other…).*
- *What is your preferred way of teaching the lesson/course? (direct teaching, face-to-face, interactive; Direct teaching, face-to-face with visual support; distance teaching, via the Internet, synchronous; distance teaching, via the Internet, asynchronous; other).*
- *What disadvantages have resulted for you from the use of digital technologies in the lessons/courses? (difficulty managing time; too much attention paid to technology; violation of privacy, cyber bullying behaviors; ignorance of cyber security rules; other.*

In what follows, we present a more detailed description of the sample structure: by age, the majority of respondents, 49.1%, are between 18-19 years old (see **Figure 1**).

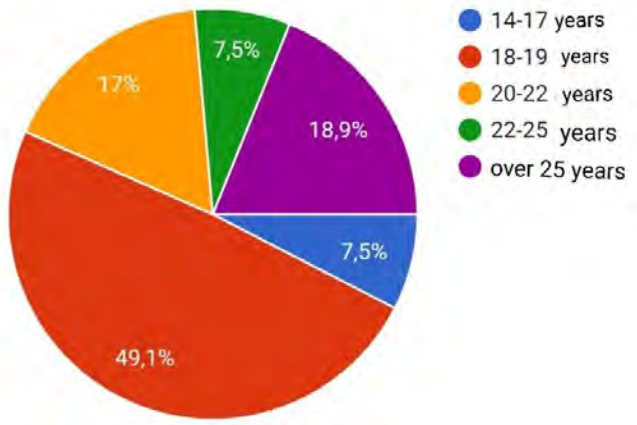

Figure 1. Distribution of population by age

3.2. Procedure

The procedure followed to obtain the data was the written application of the questionnaire, sent to the students by email (Google Forms).

4. Results and Discussions

The results obtained by analyzing the responses of the subjects included in our sample have shown that a group of students have the same opinions regarding the benefits of using technology in the classroom.

The respondents' preference for the use of digital technology in teaching activities (*To what extent do you consider that digital technologies are effective in teaching activities?)* is expressed in a relatively high percentage: strongly agree -5- 69 (65,1%) and agree-4-28 (26,4%) (see **Figure 2**).

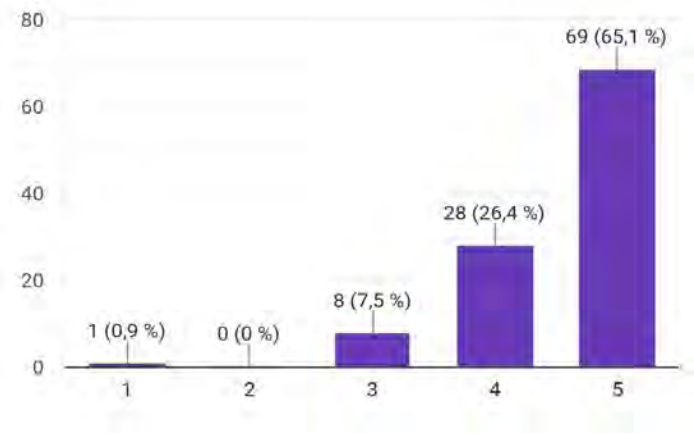

Figure 2. Graphic of responses students

Contrary to students' desire or perception of digital technology being used in teaching activities, its actual use, according to students and students, is much lower, 13.2% (strongly agree) and 28,3% (agree) (see **Figure 3**). From here, one of the clear directions for optimizing the didactic process can be formulated, through the use of digital technology on a larger scale by at least 25% compared to how it is currently used.

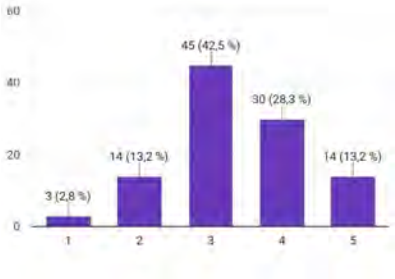

Figure 3. Graphic of responses students

Also, another important factor is students' commitment to learning and using an online environment and the ability to share their own creations with other students by providing constructive feedback.

In an overwhelming proportion (45% - to a very large extent and 45% - to a large extent), the respondents believe that digital technologies help them to better understand the learning

content. Digital technologies support the effective development of course content (see **Figure 4**).

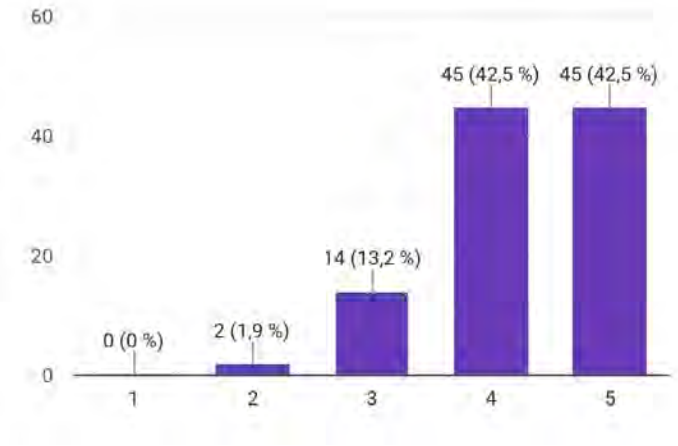

Figure 4. Graphic responses of subjects

I noticed how well digital technologies support collaborative learning (see **Figure 5**).

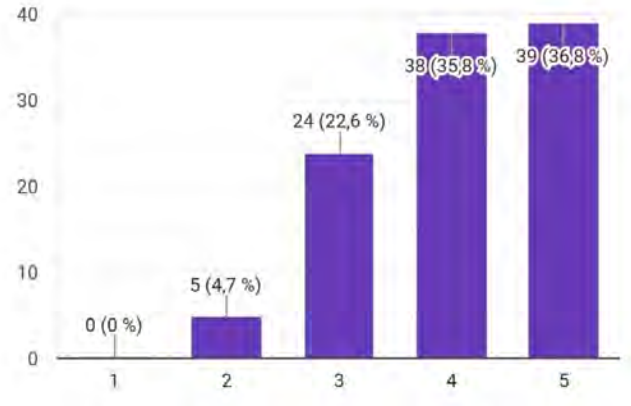

Figure 5. Graphic responses of subjects
(*digital technologies support collaborative learning*)

The use of technologies in education is becoming a new form of communication with students, and teachers can use these new tools for different purposes. Also, another important factor is students' commitment to learning and using an online environment and the ability to share their own creations with other classmates by providing constructive feedback.

Depending on the students' opinions about the benefits of using digital technologies in teaching activities (*What benefits do you think you have had from your teachers' use of digital technologies?)*, teachers build working alternatives. In this sense, the respondents highlighted a number of benefits:

- their active involvement in activities
- development of digital skills;
- quick access to information;
- differentiating the learning activity and personalizing it according to one's own pace and interest;
- access to varied and quality resources;
- autonomous learning;
- access to recorded lessons;
- effective collaboration in groups.

As we have noted from data collection the students are motivated by the atmosphere during classes the use technology. The climate is established through some hours motivating and attractiveness by applying modern working methods (in groups, guided discussions, debates, use of the new technology, forum and the classroom). The climate needs to at the same time be relaxed and captivating, and the teacher to manifest enthusiasm and passion.

It should also be noted that no respondent denied their role in facilitating learning, which demonstrates, once again, the role of learning anchors that digital technologies fulfill for students. These results in other concrete measures to improve the school's offer:

- the material and financial investment in the substantial digital training of teachers in the stage of initial and continuous training;
- creation of the formal, supporting curriculum in a digital version,
- encouraging teachers to work in interdisciplinary teams to create relevant curriculum for students, in accordance with the future requirements of education, society and direct and indirect beneficiaries;
- permanent digital modernization of school facilities;

- the collaboration of educational institutions with institutions capable of creating digital curriculum or the creation of much stronger IT departments at the level of schools and faculties.

The data analysis indicates the use of technology in the classroom to offer support for understanding content courses, optimize learning and provide increased motivation for continuing didactical activities.

5. Conclusions

The study's conclusions show that technology has had a significant impact on engaging students in the educational process, increasing motivation for learning and facilitating teamwork. Incorporating problem-based learning, collaborative learning, experiments, and the use of technology, allows for greater interaction and the opportunity for students to practice newly acquired skills and knowledge. ”Accessibility and customization, increased motivation and engagement, collaborative learning, development of essential digital skills, digital learning and flexibility, effective assessment and monitoring, access to experiential learning through VR (virtual reality) and AR (augmented reality) technology” (ChatGPT, Personal communication, september 28, 2024) are the ways in which digital technologies supports the development of relevant skills for the future and the improvement of students' academic performance. Although it investigates students, the study is addressed to teachers who need vision, scientific perspectives on the education of the future in order to build meaningful educational actions.

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The Positive Effects of the Coronavirus Pandemic on Marine Higher Education

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Abstract

The study aims to analyze the positive effects, deriving from the pandemic situation, on the marine higher education in "Mircea cel Bătrân" Naval Academy, by examining the degree of satisfaction of students and teachers on the educational process carried out during the two pandemic academic years. The analysis was carried out in three main directions: the use of ICT technologies and didactic resources in the education process, the qualitative evaluation of teaching and evaluation methods in e-learning, and the communication and relationship methods between students, teachers, and institutional management. The results allow the identification of new development directions and trends in marine higher education, which respond to current and future challenges, to improve the quality of marine education.

Keywords: marine higher education, education process, e-learning, online.

1. Introduction

No education system is perfect. Each type of education has its advantages and disadvantages. The evaluation of each education system is necessary to identify which of the features of these systems best fit the didactic objectives specific to each university and the social environment in which they operate.

The coronavirus pandemic has radically changed the social environment causing all forms of education to quickly adapt to a virtual social environment (Dietrich, 2024). With the advancement of information and communication technologies and the adoption of various forms of synchronous and asynchronous e-learning, such as online, blended, and hybrid learning (Lup & Mitrea, 2020), all participants in the educational process—including teachers, students, and institutional management—needed to adjust to these changes (Lup & Mitrea, 2020).

Thus, the actors participating in the education process (teachers, students/students, and institutional management) had to adapt to the new form of education, by adapting the curriculum content and didactic resources, implementing new teaching/learning and evaluation methods, as well as new methods of communication and relationship (Ionescu & Vrăsmaș, 2024). The evaluation of educational systems is crucial to identify the most suitable characteristics for each university. The coronavirus pandemic forced rapid adaptation to a virtual environment, including at the "Mircea cel Bătrân" Naval Academy (MBNA) a representative marine higher education institution, where education was conducted online in 2019-2020 and hybrid in 2020-2021.

The study analyzes the degree of satisfaction of MBNA students and teachers, as part of marine higher education, on the educational process carried out during the two years of the pandemic, with an emphasis on the positive effects. Evaluative research specifically targets information technologies, the educational resources utilized, the e-learning process, the qualitative assessment of teaching and evaluation methods, and the communication and relationship dynamics between students and teachers, as well as between students and institutional management.

2. Methodology

The target group under analysis consists of military and civilian students from all forms of education and full professors within MBNA, a marine higher education institution. Thus, the participants in this study in the academic year 2019-2020 were 320 students out of a total of 1793 enrolled students, and 27 teachers out of a total of 58 tenured teachers, and in the academic year 2020-2021 were 390 students out of a total of 1899 enrolled students and 24 teachers out of a total of 58 tenured teachers (Avram & Coșofreț, 2020).

To validate the collected data, from the point of view of statistical research, the minimum sample required/reported to the population under study was identified by calculation for a tolerated error of +/-5% and a confidence interval of 95% (Coșofreț & Kaiter, 2022) (Gârboan, 2007). Thus, for the 2019-2020 academic year, the minimum validation sample is 317 respondents, and for the 2020-2021 academic year, the minimum study validation sample is 320 respondents. Therefore, the study samples fall within the convenience of statistical research (Renovater, 2024).

Data analyzed in the study were collected during the two academic years, between May 25 - June 16, 2020 and between April 27 and June 7, 2021, through the opinion survey method, the survey technique being the electronic survey. The survey tool used for data collection was the anonymous questionnaire built with the help of the Google Forms program. The collected data was stratified into two respondent categories: teachers and students. The analysis of this data employed the following statistical methods:

- the percentage reporting method, for presenting the frequency of use of applications or didactic activities;
- simple ANOVA variance (dispersion) analysis method, to identify the intensity with which the respondents perceived the effects of the current situation on the teaching process, or on themselves.

To analyze the effects of an independent variable, Likert scales were used, with several steps of comparison. The comparative data analyzed were: the number of respondents, the mean and the standard deviation, the value of the F ratio (F-Fisher test) for testing the differences between

two groups and the Bonferroni t-test, for testing the differences between the means of the compared groups.

3. Results and Discussions

The use of forms of education that take place in the virtual environment requires didactic support based on information and communication technology.

For the educational process to run smoothly in the virtual environment, the cumulative fulfillment of the following requirements is necessary:

- a stable and high-speed Internet connection;
- high-performance hardware devices;
- stable platforms and communication methods;
- digital didactic resources for each subject in the curriculum;
- technical and pedagogical support;
- competences and digital skills of the actors of the education process.

3.1.Internet connection benchmarking

The existence of an Internet connection is a main condition for e-learning. A permanent and high-speed Internet connection is necessary for the teaching and evaluation processes to run smoothly in the virtual environment. The percentage comparative analysis for the two academic years regarding the type of Internet connection used by both categories of respondents is presented in **Figure 1**.

Figure 1. Comparative percentage analysis, by university year, of respondents' answers regarding the type of internet connection used.
used.

An improvement in the internet connection in the academic year 2020-2021 compared to the previous year can be observed in both categories of respondents, with an increase in the permanent high-speed internet connection (for students by 7.64% and for teachers by 17.65%). This can be attributed to the recognition of the internet's crucial role in the effective functioning of the virtual educational process. The marine higher education institution expanded the campus Wi-Fi network in the second academic year, while students upgraded their internet subscriptions.

3.2. Benchmarking the use of hardware tools

The primary hardware tools utilized by teachers and students for conducting the educational process in a virtual environment include desktop computers, laptops, notebooks, tablets, and mobile phones/smartphones. The comparative analysis regarding the degree of use of hardware tools is presented in **Figure 2**.

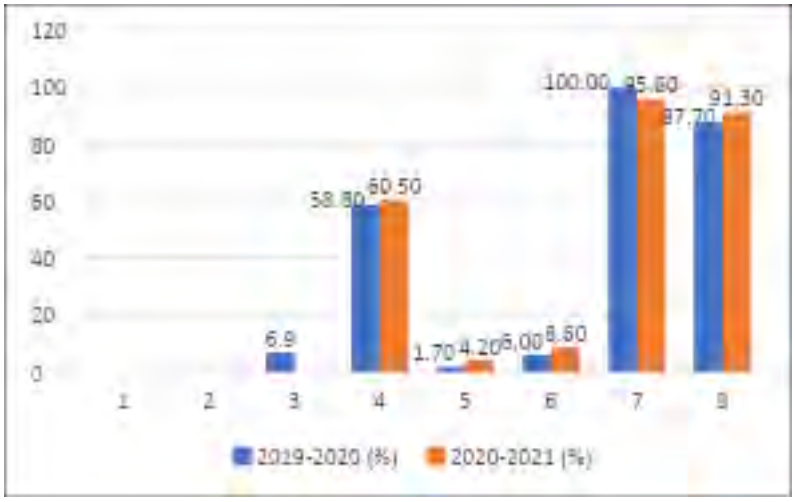

Figure 2. Comparative analysis by university year regarding the use of hardware tools by respondents

From the figure, it can be seen that, among the communication hardware devices analyzed, the computer is the most used due to its hardware performance, storage capacity, installation of

communication and teaching software tools, teaching materials in digital format, augmented reality applications, and virtual reality applications, as well as due to its seamless operation. In the 2020-2021 academic year, there was a 3.6% increase in computer usage among student respondents, replacing the use of phones. This shift is attributed to the institution's initiative to provide laptops to military students and the recognition by civilian students that computers are the most suitable tool for virtual learning. Additionally, there was a 2.5% increase in tablet usage among teachers, replacing the use of computers and phones (from 6.9% to 0%). This change is due to the university supplying high-performance tablets to the teachers.

3.3. Comparative analysis regarding the use of digital communication platforms

To support specific educational activities in the virtual environment, various software platforms for synchronous and asynchronous online communication are essential. These platforms facilitate synchronous online meetings between teachers and students, as well as asynchronous activities through the implementation of a Learning Management System (LMS). The LMS encompasses recording the training process, test results, and access to all educational materials. For conducting virtual classes, specific videoconferencing platforms like Webex or Big Blue Button (used with Moodle) are utilized. Additionally, numerous free synchronous and asynchronous communication platforms, such as email, Skype, WhatsApp, and Facebook Messenger, enable information exchange between teachers and students. At the onset of the pandemic, MBNA, a significant marine higher education institution, had an e-learning platform for video conferences with an integrated LMS and an institutional email platform. **Table 1** presents a comparative analysis of the usage levels of digital communication tools. This analysis was conducted using the Bonferroni t-test and by comparing the Likert scale means of responses from the two categories of respondents. The Likert scale ranged from 1 to 4, where 1 indicates "never," 2 indicates "once a week or less," 3 indicates "once every few days," and 4 indicates "daily."

Software tools	University years	Students					Teachers	F	Significant differences *
		Average	Year I N=86 N=128	Year II N=61 N=108	Year III N=40 N=68	Year VI N=112 N=85	N=27 N=24		
ADL platform	2019-2020	3.737	3.820	3.767	3.732	3.630	3.625	1.032	No

	2020-2021	3,735	3,870	3,676	3,790	3,720	3,735	1,043	No
E-mail	2019-2020	3.506	3.477	3.508	3.575	3.438	3.778	1.544	No
	2020-2021	3,180	3,240	2,971	3,130	3,370	3,180	2,335	No
Videoconference (Google Meets, Microsoft Teams,.....)	2019-2020	3.067	3.151	2.885	3.450	3.098	2,923	4.568	III>II;III > T; I < T
	2020-2021	2,923	3,110	2,490	3,160	3,100	2,478	8,338	T<III,IV; II<III
Audio and chat communication	2019-2020	2.991	3.023	2.984	2.975	2.920	3.222	0.439	No
	2020-2021	2,676	2,940	2,529	2,440	2,670	2,348	1,080	No
Open educational resources and digital content	2019-2020	3.052	2.814	3.295	3.325	3.125	2.556	5.083	III > T; I > T; > I; IV > T
	2020-2021	2,348	1,191	2,714	1,778	3,820	2,957	1,716	I<T; VI>T

* Significant differences identified using the Bonferroni t test.

Table 1. Software tools used for conducting educational activities were analyzed in relation to respondents from the two academic years, with responses measured on a scale from 1 to 4

From the analysis of the results, it can be seen that the e-learning platform of the university remains, in the academic year 2020-2021, the most used software tool with a daily usage regime for both categories of respondents. Also, a slight regression is observed regarding the degree of use of other types of platforms for video conferences, as well as email and other platforms for audio and chat communication. This improvement can be attributed to the enhancement of the advanced distance learning platform during the 2020-2021 academic year, particularly through the development of the learning management system.

3.4. Analysis of the use of digital teaching resources by the respondents

Synchronous online teaching differs from traditional face-to-face instruction, necessitating the adaptation of teaching resources and methods for the online environment. Although online teaching resources must cover the same content as face-to-face teaching, they should be tailored to the discipline's specifics using visual and multimedia support. These can include collaborative presentations (Google), dynamic presentations (Prezi), interactive presentations (Mentimeter), PowerPoint presentations with quizzes, videos, and interactive materials, virtual laboratories, and process simulations.

The term "Digital didactic resources" used in the study is a generic one, which represents the software tools used by respondents to carry out teaching/learning and evaluation activities in the virtual environment. The way to integrate digital didactic resources into didactic activities depends to a great extent on the digital and pedagogical skills of teachers and their creativity in the educational design of learning resources and activities (Grosseck & Craciun, 2020).

The choice or combination of various applications is determined by the teacher's teaching philosophy – their perspective on teaching, learning, and assessment; the presentation and structural requirements of the discipline taught; the skills and abilities needed to be developed in students; and the ability and competence of the teacher to identify and integrate different digital educational resources into the teaching process in the virtual environment.

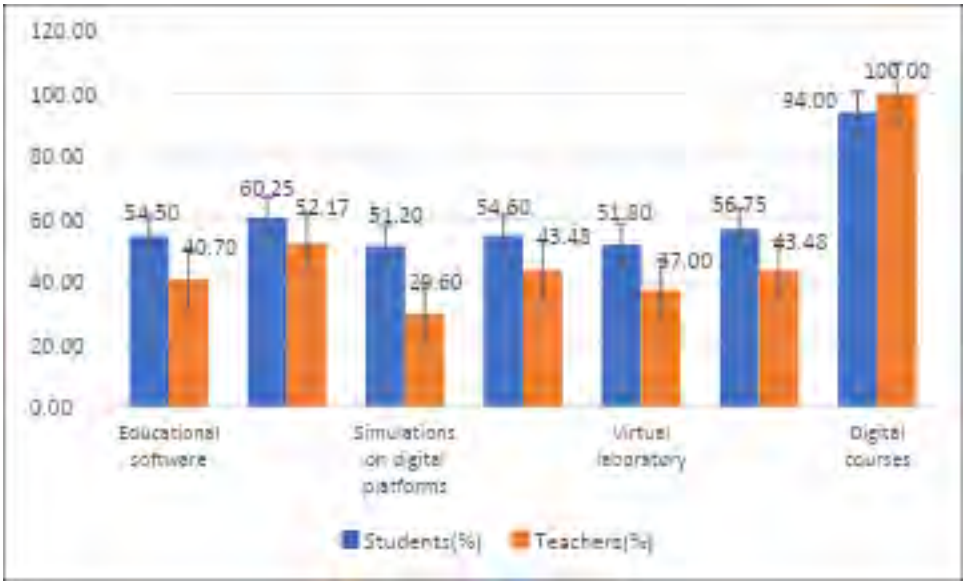

Figure 3. Comparative analysis by university year regarding the degree of use of digital didactic resources by respondents

From **Figure 3**, a significant increase in the use of specialized digital teaching resources can be observed by both categories of respondents in the academic year 2020-2021. Thus, in addition to using courses in digital format, teachers used approximately 11% more educational software, approximately 13% more simulations on professional platforms, and approximately 6% more virtual laboratories. This can be attributed to the teachers' increased experience and digital skills in teaching and assessing subjects in the virtual environment compared to the previous

academic year, as well as the additional time they had to prepare courses for the 2020-2021 academic year.

3.5. Analysis of evaluation activities in the virtual environment

The shift from face-to-face education to a virtual environment necessitated the adaptation of assessment methods for educational activities, while maintaining the specific assessment requirements for each discipline. According to specialized literature, the advantages of virtual environment evaluations include (Vișan, 2021):

- reduction of costs, efforts, and time needed by teachers in relation to classical assessment. Specialized assessment applications on the platforms have the ability to share tests quickly and securely online. This reduces the costs and time of printing exam questions, simplifies the task of teachers in manually collecting and correcting students' answers, and sharing their results.
- streamlining the administration of evaluations. Through specialized applications, the results of the evaluations can be centralized, the results obtained by each student can be tracked over time, and they can facilitate the easy retrieval of response scripts at the request of students or teachers;
- automatic evaluation of answers, thus reducing human error. By defining an answer evaluation algorithm in the software, the results are provided instantly after the test is completed, thus eliminating the human errors of the teachers;
- options for adding comments and feedback for the pupil/student reference.

As the main disadvantages of online assessment, it can mention:

- allocating a long time and a greater workload in developing the tests;
- lack of knowledge on the part of teachers to use assessment applications;
- complexity in developing the test. The teacher must create specifications associating taxonomic cognitive levels (knowledge and understanding, application, and reasoning) that are adapted to the respective discipline; • low and average complexity of the assessed learning outcomes;
- probability of guessing the answer;

- ambiguities that may arise from careless test design.

The study periods also overlapped with the assessment activities (colloquiums, exams), so that the study participants were able to express their point of view, knowingly, regarding the assessment methods that can be implemented in education in the virtual environment.

The methods of evaluation of the didactic activities subject to the survey of both categories of respondents were: grid test, oral evaluation, online oral presentation of reports. The reporting of these evaluation methods was carried out by the respondents according to the type of teaching activities, namely for: courses, seminars, and laboratories.

The comparative analysis of responses from the two academic years regarding assessment methods suitable for the virtual environment shows that there are no significant differences in students' use of online grid tests between the two years, as illustrated in **Figure 4**. However, among teaching staff, there was a decrease of approximately 12% in the use of this method for course evaluations in the 2020-2021 academic year compared to the previous year. Conversely, the same academic year saw an increase of about 8% in the use of online tests for evaluating laboratory activities.

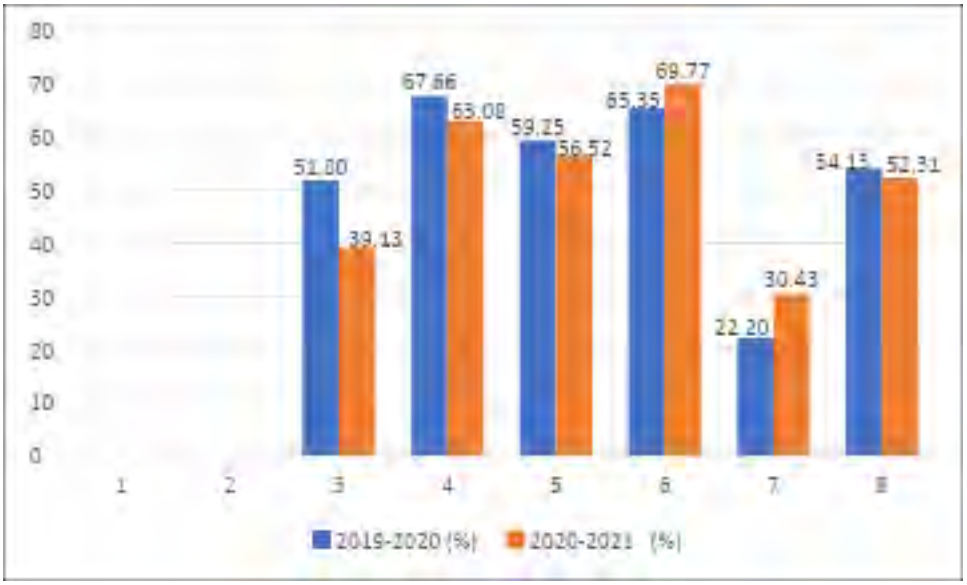

Figure 4. Comparative analysis by university year regarding the degree of use of the online grid test in the evaluation of didactic activities

3.6. Comparative analysis, by university years, of the advantages of didactic activities in the virtual environment from the teachers' perspective

From the analysis of teachers' answers over the two academic years regarding the advantages of education in the virtual environment, significant differences were observed for "Online education is useful for facilitating students' learning" (a reduction of approximately 0.4 in the average of answers in the academic year 2020-2021, compared to the average of the answers from the year 2019-2020).

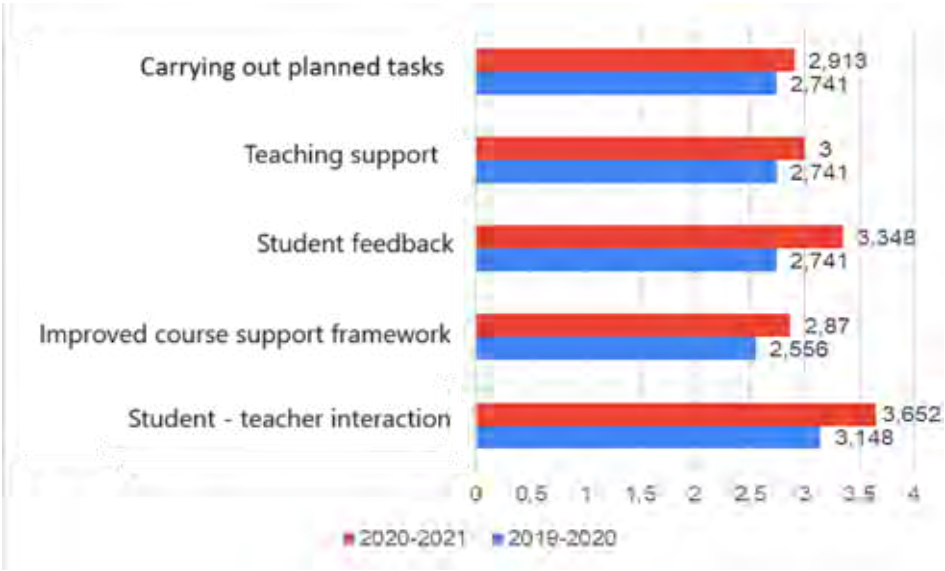

Figure 5. Averages of teachers' answers on the advantages of learning in the virtual environment - comparative analysis, by university years

Concerning the answers to "the digital skills acquired during this period are useful acquisitions for the subsequent didactic activity" (an increase of approximately 0.9% in the average of the answers in the academic year 2020-2021, in relation to the average of the answers from the previous year).

Regarding the limitations of virtual education from the teachers' perspective, the average responses over the two academic years are compared in **Figure 5**. Significant differences were noted in the statement "limitation of feedback received from students," with an increase of approximately 0.6 in the 2020-2021 academic year, indicating a reduction in these limitations due to improved communication methods between teachers and students. Similarly, there was an increase of about 0.5 in the average responses for the 2020-2021 academic year concerning the limitation of interaction between teaching staff and students.

4. Conclusions

Disruption of "traditional" courses caused by the emergence of the coronavirus pandemic has led to the closure of schools and universities globally, including marine higher institutions.

This generated, in the first phase, significant difficulties and challenges in the teaching-learning process. However, in retrospect, these changes also produced beneficial effects on the educational process. Here are some of these positive effects:

The need to move quickly to online education has accelerated the adoption of digital technology in the educational process. Educational institutions have implemented and continue to develop digital platforms and tools, and teachers and students have developed their digital skills through their use. Today, these digital technologies have become an integral part of the process of delivering and receiving educational knowledge. Thus, in MBNA, a marine higher education institution, the Wi-Fi network was developed, laptops and tablets were purchased for teachers and military students, the university's e-learning platform was developed, interactive whiteboards were purchased in each lecture hall and seminar, the electronic catalog was implemented, digital platforms and software for teaching and research laboratories were purchased, and the learning management system (LMS) was improved, etc.

The experience of online education has paved the way for the adoption of a hybrid teaching/assessment model that combines elements of online and classroom teaching. This model offers more flexibility for students and can better meet their individual needs. Currently, cadetship students on transport ships can access teaching resources, access courses, and communicate with teachers to complete certain teaching tasks, etc.

During the pandemic, online educational resources such as open online courses (MOOCs), virtual conferences, and digital libraries have developed and diversified. This expanded access to educational resources can help equalize learning opportunities and facilitate continued education in diverse contexts.

Online learning and virtual collaboration have enabled a greater exchange of ideas and knowledge internationally. Students and teachers had the opportunity to participate in online events and collaborate with colleagues from around the world, contributing to the globalization

of education. For example, nowadays, many international conferences are organized in the online and/or hybrid environment.

Students who had to navigate the online environment developed organizational, time management, and self-regulation skills. These skills are essential in lifelong learning and in today's rapidly changing context. MBNA, like marine higher education institution, has begun to provide more resources and support for managing stress and pressures, recognizing the importance of balance between academic and personal life.

It is important to note that these beneficial effects do not negate the overall impact of the pandemic on education and that many students and teachers have faced significant challenges during this time. Adapting to the changes brought about by the pandemic has been a complex and ongoing process.

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The Role of Discursive Genres in the Spread of Fake News: Visual Rhetoric, Cognitive Biases, and Cross-Platform Dynamics

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Abstract

This article investigates how discursive genres shape the propagation of fake news across social media platforms, focusing on persuasive and manipulative discourse mechanisms. By examining the role of polyphonic discourse, intertextuality, cognitive biases, and visual rhetoric (including memes and deep fakes), the paper explores how genre conventions adapt to different platforms, amplifying the reach and believability of misinformation. Case studies, including the "Plandemic" meme series and the deepfake of Mark Zuckerberg, highlight the powerful influence of emotionally charged and visually persuasive content. The analysis also addresses the cross-platform dissemination of narratives, illustrating how different genres contribute to creating a networked ecosystem of misinformation. By combining insights from Critical Discourse Analysis (CDA), intertextuality theory, and media studies, the article sheds light on the sophisticated tactics used to manipulate audiences and spread misinformation.

Keywords: Discursive Genres, Fake News, Polyphony, Persuasion, Digital Media Amplification.

1. Introduction

Contextualizing Fake News: The role of misinformation in contemporary society, particularly the rapid spread of fake news through digital platforms.

The Rise of Discursive Genres in Digital Media: An introduction to discursive genres and their ability to adapt to various online platforms (e.g., memes, videos, fake news articles, manipulated images).

Research Questions: How do different discursive genres influence the propagation of fake news? What role do visual rhetoric and cognitive biases play in this dissemination?

Discussing the problem of fake news spread on social media and the polyphonic discourse across different platforms is highly relevant in the context of education. Some of the main reasons refer to the fact that education plays a crucial role in developing students' ability to critically evaluate the information they consume, education systems having a responsibility to prepare students for active citizenship, focusing on developing communication skills that can enable them to engage with diverse viewpoints, encouraging constructive dialogue rather than polarization. We can't ignore the potential danger of fake news significantly altering educational patterns. The erosion of critical thinking skills might lead to the situation when our students struggle to differentiate between credible information and misinformation. Without proper training in critical thinking and media literacy, they may accept information at face value, leading to the erosion of their ability to critically evaluate sources, analyze arguments and form well-reasoned conclusions. The impact on knowledge foundations is obvious in this respect. Fake news can distort students' understanding of core subjects particularly history, science or politics. In this way they can develop a flawed understanding of the world. Another possible risk is the development of polarized thinking, with fake news often exploiting the emotional triggers, playing into biases, fears or ideologies. Social media algorithms can create echo chambers where students are exposed only to information that reinforces their preexisting beliefs. Instead of becoming open-minded, empathetic thinkers, they may develop rigid, extreme viewpoints. All of these potential dangers have the capacity to undermine the trust in institutions, leading to a generation that is cynical about learning, scientific reasoning and expertise. This could cause a shift toward anti-intellectualism, where students prioritize emotional narratives or unverified sources over reason and evidence. Without the proper tools to

filter and evaluate information they may be easily misled by false narratives, becoming less competent professionals and vulnerable citizens.

The key to counteracting this threat is integrating media literacy and critical thinking into the curricula, at all possible levels of education. The present article tries to contribute to our understanding of the evolving landscape of digital communication and the critical need for media literacy and responsible digital citizenship in the digital age. Furthermore, the article addresses the complex and dynamic nature of online texts, emphasizing their adaptability and the interplay of voices. By drawing parallels with traditional media we can further investigates how polyphony in online discourse shapes the construction of reality and public perception. We are facing a paradigm shift, when internet linguistics has incorporated sociolinguistics and computational aspects and we must address this challenge without delay.

Key Concepts:

- Discursive Genres – The specific forms of discourse, such as news articles, memes, and tweets, that structure the presentation of information and shape audience perception.
- Fake News – Misinformation deliberately crafted to deceive, often spread through both traditional and social media platforms.
- Polyphony – Mikhail Bakhtin's concept of multiple voices or perspectives in discourse, highlighting how fake news can embed diverse, often conflicting, viewpoints to manipulate understanding.
- Persuasion – The rhetorical strategies, including implicit and explicit argumentation, used in fake news to shape public opinion and influence decision-making.
- Digital Media Amplification – The role of social media platforms, algorithms, and the digital landscape in accelerating the dissemination and visibility of fake news across different genres.

Fake News can have a significant impact on all age categories, but especially on young people due to their reliance on social media and digital sources for news and information. Lewandowsky (et al., 2017) refers to an epistemic crisis- the "discourse does not try to establish a coherent model of reality, it aims at eroding trust in facts and reality". New generations come with a declining attention span and tendency to switch back and forth between different apps. It is said that Millennials seem to prefer to consume content, while GenZ to create content (over

60% of them using Tiktok). Much more, we are facing deepfake (created through different software and artificial intelligence). We already have a new verb - "to deepfake". From "truth" we, as a global community, have migrated to "post –truth"(which was word of the year 2016, according to Oxford Dictionary, which reflects what Ralph Keyes (2004) says – that "as intelligent beings we invented rational reasons for manipulating the truth".

Occurences of the word "fake" indicated by teenagers, in a survey conducted by me on 25 teenagers, aged 13-14, revealed the following cases: fake news; fake accounts (trolling in games); fake reviews; fake followers/likes; fake ID; fake apps; fake profiles, through "catfishing" – creating a fictional online persona). These multiple occurrences at such a young age suggest that young generations are exposed to the phenomenon more than we might think.

The language of chat, blogs, sites or forums, the one present on social media platforms, represents a new form of communication, neither spoken, nor written, a centaur like creature, maybe as potent as its original mythological source. Advantages come bundled with disadvantages, the openness of communication with a limitless number of people is accompanied by bad orthography or punctuation, extreme use of abbreviations, ambiguity, stylistic mistakes imitated and transmitted to others, due to limited linguistic competence or ignorance, but also the proliferation of disinformation and fake news.

2. Literature Review

The spread of fake news across digital platforms is not a random or isolated phenomenon but is deeply rooted in complex discourse practices and cognitive processes. The literature review consulted revealed that different genres contribute to fake news in unique ways. News articles often use sensationalist headlines and misleading data, while social media posts leverage hashtags and viral trends to gain traction. Memes, with their visual appeal and brevity, can distill complex misinformation into easily digestible content. Secondly, among the several key persuasive strategies we can include emotional manipulation, false equivalence, and appeals to authority. These mechanisms enhance the persuasive power of fake news by engaging readers' emotions and biases. The presence of multiple voices in fake news can enhance its perceived credibility. By presenting information from various sources or viewpoints, fake news can create

an illusion of balance and objectivity, making it more persuasive. Furthermore, the interplay between traditional and social media amplifies the spread of fake news. Traditional media often provides initial coverage that is later disseminated and distorted by social media platforms, creating a feedback loop that reinforces misinformation.

Intertextuality and Polyphonic Discourse - intertextuality, a concept developed by Julia Kristeva (1980) and expanded by Mikhail Bakhtin (1981) through his theory of polyphonic discourse, refers to the ways in which texts reference, quote, or build upon other texts to create meaning. In the digital age, intertextuality is central to the circulation of fake news, as misinformation often borrows credibility from legitimate sources or existing narratives to gain traction.

The Concept of Fake News: fake news can be seen as false or bad news, "fabricated" news, as opposed to true/good news. False reports are disguised as real. This is not a modern discovery, as the literature mentions the "yellow journalism" or "freak journalism" of the past. "Truth", "accuracy" and "objectivity" are cornerstones of journalism ethics. People presume that those who present a message have the purpose to inform (Griece, Schwarz, 2014 - the logic of communication). They need information but also meaning associated to it. Dis-information seems to have a greater power than information because it is more concentrated on its target audience, generating action, especially when based on social identities. (Murphy, F., Patnoe-Woodley, 2011). Claire Wardle, when speaking about fake news, distinguishes between: mis-information, dis-information, mal-information. Noam Chomsky argues that mainstream media is complicit in spreading fake news by promoting a narrow range of viewpoints, ignoring important facts.

The article "Digital false information at scale in the European Union" (2022) shows the distribution of research topics: Didactic 1%, Neuroscience & Psychology 4%, Health Care studies 9%, Communication and Media 12%, Social Science 15%, Computer science and Information studies 61%, only 3 out of 93 papers being from Romania.

Persuasion, argumentation and demonstration are all related to the process of conveying information, convincing others, establishing a point of view. Demonstration has no emotional and subjective dimension. In argumentation, subjectivity is reduced to a minimum. But in the case of persuasion, we have both logic and emotional appeal – resulting in an ambiguous term.

The persuasive power of discourse (political, media, advertising) is as important nowadays, as it always was. The "universal audience" of Perelman, in "The New Rhetoric" becomes a "particular audience" nowadays. Gross (Gross & Dearin, 2003) mentions that "speeches for the universal audience focus on the real (fact, truth, presumption), while those for a particular audience on the preferable (values)". When speaking about manipulation, Van Dijk (2006:360) says "manipulation…is a communicative and interactional practice…a manipulator exercises control over other people, usually against their will and best interest… such practice violates social norms. Manipulation not only involves power, but specifically abuse of power, … it is a form of illegitimate influence by means of discourse". Manipulation techniques include: the rumor, the misinformation, the intoxication, the propaganda.

Fake news typically aims to both persuade and manipulate its audience, spreading false or misleading information while presenting it as factual news. It seeks to influence people's beliefs, opinions, to shape public perception, by intentionally distorting facts, in order to generate web traffic, creating confusion, or simply for entertainment. Manipulation comes into play as fake news often employs various techniques to exploit people's emotions, biases and cognitive vulnerabilities. It can even speculate on the cognitive dissonance (L.Festinger), individuals experiencing discomfort when they hold inconsistent or conflicting belief.

On social media platforms, persuasion and/or manipulation can be achieved through various mechanisms: societal proof (influencers/celebrities endorsing products), reciprocity (in relationship with followers), scarcity, authority and consistency, filter bubbles. The linguistic methods mostly used: rhetorical questions, repetitions, metaphors, inclusive language, power words, use of urgency words, framing, use of humor, call for action ("Share this!"). ("An inclusive, real-world investigation of persuasion in language and verbal behavior", by Vivian P. Ta, Ryan L. Boyd et al. (2021). Bogdan Oprea, in his book from 2022 offers a synthesis of the topic of fake news. In the article "Social clicks: what and who gets read on Twitter" (Gabielkov et al., 2016) documents a paradigm shift in accessing information, based on a study of clicks: from "pull" to "push" since the proliferation of social networks. All four Paul Grice's maxims of conversation: quality, quantity, relation, manner are distorted on social media platforms.

Critical Discourse Analysis (CDA) offers a robust framework for examining how language and discourse reproduce power relations, ideologies, and social practices. Developed by scholars such as Norman Fairclough (1995) and Teun van Dijk (1998), CDA is particularly useful in analyzing fake news because it focuses on how language is used to legitimize certain viewpoints while marginalizing others. CDA posits that discourse is not neutral but is shaped by socio-political structures, and it, in turn, shapes social realities. Through a CDA lens, fake news can be analyzed as a form of discursive manipulation, where language and genre are used not merely to inform but to influence and shape the beliefs of the audience. By examining how language choices in fake news—such as lexical selection, syntactic structure, and metaphor use—reinforce certain ideologies, CDA provides critical insights into the mechanics of persuasion in digital misinformation.

In the context of visual rhetoric, intertextuality extends beyond textual elements to include visual references. Memes, for instance, often draw on culturally significant images (e.g., historical photographs or pop culture symbols) to invoke specific emotions or associations. The "Plandemic" meme series, for example, references visual symbols associated with healthcare and government authority, creating a juxtaposition between these symbols and conspiracy theories about global control. This visual intertextuality strengthens the meme's message by drawing on familiar imagery that resonates with users.

Polyphony in digital media also manifests through the interplay of multiple genres—such as memes, videos, and articles—that reinforce one another across platforms. By strategically incorporating different genres, fake news creates an ecosystem of misinformation, where various forms of content circulate simultaneously, giving the impression of widespread credibility.

In the digital age, visual content plays a crucial role in the dissemination of fake news. Visual rhetoric, which focuses on how images communicate meaning and influence perception, is particularly important when analyzing genres such as memes and deepfakes. Semiotics provides a theoretical basis for understanding how visual elements function within these genres to create persuasive and often deceptive messages. Semiotically, images function through a system of signs, where visual elements (icons, symbols, colors) carry specific meanings. In the context of

fake news, semiotic analysis reveals how certain symbols are manipulated to evoke trust or fear. For instance, a deepfake of a political leader giving a controversial speech can manipulate the audience's perception by using the leader's recognizable face (icon) and familiar body language (symbol) to falsely attribute harmful intentions. The analysis of such visual signs and their role in deception is essential for understanding how visual rhetoric contributes to the spread of misinformation.

Cognitive Biases - systematic patterns of deviation from rationality, play a key role in the spread and acceptance of fake news. Psychological research has demonstrated that people are more likely to believe and share misinformation that aligns with their pre-existing beliefs or emotions, even when presented with factual corrections (Pennycook & Rand, 2018). Understanding these biases is crucial for analyzing how fake news is both created and consumed.

Two cognitive biases are particularly relevant to fake news: **confirmation bias** and the **illusory truth effect**. Confirmation bias refers to the tendency of individuals to seek out and interpret information in a way that confirms their pre-existing beliefs. In the context of fake news, this means that users are more likely to engage with and share content that reinforces their ideological stance, regardless of its accuracy. Social media platforms, through algorithms that prioritize content based on user preferences, further exacerbate this bias by creating echo chambers in which users are exposed primarily to information that confirms their views.

The illusory truth effect occurs when repeated exposure to false information increases its perceived truthfulness. This bias is particularly dangerous in the age of viral content, where fake news spreads rapidly across platforms. Even when users are initially skeptical of a piece of misinformation, repeated exposure—through memes, articles, or videos—can lead them to accept it as true. For example, during the spread of misinformation about COVID-19, repeated claims about the virus being a hoax circulated across multiple platforms, eventually gaining credibility among certain audiences despite overwhelming evidence to the contrary.

The combination of these **cognitive biases** with **the discursive power of visual rhetoric** and **intertextuality** creates a potent mechanism for the spread of fake news. By exploiting the emotional and cognitive vulnerabilities of users, fake news creators can ensure that their content resonates and spreads, even in the face of contradictory information.

Cross-Platform Dynamics and the Ecosystem of Misinformation

The digital media landscape is characterized by its fragmented and highly networked nature, where different platforms serve as conduits for the circulation of content. The cross-platform dynamics of fake news refer to how discursive genres adapt to the specific affordances of each platform—whether it's the brevity of tweets, the virality of YouTube videos, or the meme culture of Instagram—and how this adaptation facilitates the spread of misinformation across different audience demographics. Each platform imposes its own constraints and possibilities for the dissemination of fake news. For instance, Twitter's character limit forces users to distill complex misinformation into short, often sensationalist snippets, while YouTube allows for longer, more elaborate narratives to be constructed through video. Facebook, with its focus on community and networked sharing, encourages the circulation of fake news within ideological bubbles, further reinforcing confirmation bias. The cross-platform nature of fake news dissemination means that content created in one genre (e.g., a meme) can be transformed and repurposed for another (e.g., a video), increasing its reach and adaptability. These cross-platform dynamics create an interconnected ecosystem of misinformation, where content is constantly recycled, recontextualized, and redistributed.

3. Discursive Genres and Fake News

The discursive genres that shape communication on social media platforms have significantly evolved, facilitating the creation and spread of fake news. As dynamic constructs, these genres adapt across platforms, harnessing both textual and visual elements to manipulate meaning and influence audience perception. This section explores three prominent discursive genres—memes, deepfakes, and fake news articles—demonstrating how each genre's affordances contribute to the proliferation of misinformation.

3.1 Memes as a Discursive Genre

Memes have emerged as a powerful discursive genre, defined by their brevity, visual appeal, and ability to encapsulate complex ideas within a single image or short video. The strength of memes lies in their intertextuality and polyphony, drawing on shared cultural knowledge to

establish meaning while allowing for diverse interpretations depending on the audience. These characteristics make memes particularly potent vehicles for fake news.

A key factor in the spread of memes is their emotional appeal. Research has shown that emotionally charged content—whether humorous, shocking, or fear-inducing—tends to be shared more widely than neutral information (Vosoughi, Roy, & Aral, 2018). Memes capitalize on this by condensing emotionally charged messages into digestible, easily shareable forms. The use of humor, irony, or exaggerated visuals enables memes to bypass critical scrutiny, encouraging users to engage with content without questioning its veracity.

For example, during the COVID-19 pandemic, the "Plandemic" meme series gained widespread traction by incorporating humor, fear, and conspiracy-laden visuals to suggest that the pandemic was orchestrated by global elites. The images often featured familiar visual tropes, such as shadowy figures or distorted medical symbols, evoking distrust of authority. By framing the content within the familiar and popular genre of memes, these visuals allowed the misinformation to cross from fringe platforms into mainstream discourse on Twitter, Facebook, and Instagram. The ability of memes to thrive in a highly networked, cross-platform environment demonstrates their role as a genre that perpetuates fake news, with intertextuality enabling their messages to resonate with diverse audiences.

3.2 Deepfakes as a Visual Genre

Deepfakes represent a newer, highly sophisticated discursive genre that manipulates visual and auditory elements to create hyper-realistic fake videos. Unlike traditional forms of visual manipulation, which rely on editing still images, deepfakes generate entirely new content using machine learning algorithms. As such, they represent a unique form of visual rhetoric, where deception is hidden within the hyper-realism of the footage itself. The power of deepfakes as a discursive genre lies in their ability to evoke strong emotional responses, particularly when they feature well-known public figures. This emotional manipulation, coupled with the seeming authenticity of the footage, makes deepfakes particularly effective in undermining trust in media and public institutions.

A prominent example of this is the Mark Zuckerberg deepfake, which surfaced in 2019. In the video, Zuckerberg appears to boast about controlling the world's data, effectively presenting a

dystopian version of himself that plays on public fears of corporate overreach. The deepfake mimicked Zuckerberg's voice and mannerisms so convincingly that, despite being revealed as fake, it sparked widespread debate about data privacy and the manipulation of public opinion. The video's virality across multiple platforms, including YouTube, Twitter, and Facebook, illustrated how deepfakes, as a genre, tap into users' cognitive biases -specifically the illusory truth effect, where repeated exposure to fake information increases its believability.

Furthermore, deepfakes, like memes, exploit intertextuality. The Zuckerberg deepfake, for instance, alludes to broader concerns about tech monopolies and surveillance capitalism, building on real-world events like the Cambridge Analytica scandal. This layering of intertextual references amplifies the fake news content, as audiences already primed to distrust tech companies are more likely to accept the manipulated footage as plausible.

3.3 Fake News Articles and Headlines

Another crucial discursive genre in the dissemination of misinformation is the fake news article. These texts, often indistinguishable from legitimate news at first glance, use the conventions of traditional journalism—headlines, datelines, citations—to construct an appearance of credibility. However, the manipulation often occurs within the structure of the article itself, where selective reporting, false citations, or fabricated quotes distort the narrative to suit ideological purposes.

The genre of fake news articles is particularly effective due to its reliance on sensationalism, a feature that has long been used in tabloid journalism to capture reader attention. Sensationalist headlines, in particular, are a key element in shaping audience perceptions before they even engage with the content of the article. Studies have demonstrated that readers often internalize the message of a headline even when the body of the article contradicts it (Ecker, Lewandowsky, & Tang, 2014). In the context of fake news, this creates an environment in which the headline alone can do the work of spreading misinformation.

One example of this is the circulation of headlines during the 2016 U.S. presidential election that falsely claimed Pope Francis had endorsed Donald Trump. Despite being quickly debunked, the headline went viral on Facebook, accumulating millions of shares. The simple, declarative structure of the headline played on readers' cognitive biases, particularly confirmation bias, as it aligned with existing narratives about religious figures' influence on political decisions. The

intertextuality of this genre is evident in how it mimics the conventions of legitimate news outlets, making it difficult for casual readers to discern truth from fabrication.

The discourse genres on social media that mostly favor the spreading of fake news include: social media posts- text-based status updates, links to articles or websites, multimedia content (images, videos); memes and visual content- manipulated images or videos, highly shareable, exploiting humor, satire, or emotional appeal; user comments and replies – which can become echo chambers.

By examining the interplay between language, technology and social dynamics, the affordances of social platforms, we can better understand the phenomenon of fake news and react to it. From Bahtin to Ducrot (as examined by Ligia S. Florea, Polifonia în structurile limbii, 2022), we are aware of the fact that the speaker is not always the source of the message, being sometimes just a carrier of others' points of view. In order to interpret the meaning of a certain message, one needs to identify the initial source/voice. The problem is even more complicated in the case of social media discourse, which is not fixed, but dynamic, characterized brevity, consisting of text accompanied by emojis or other visuals, constantly evolving, encompassing a diverse array of voices, extending beyond the confines of any single platform.

The voices that are "heard" belong both to humans and nonhumans (bots, trolls, cyborgs), the images and videos may be manipulated by A.I and what we "see" is not the truth. In a "concert" of voices all present in the social media discourse we can but try to: identify the main voice, determine the perspective, the author's position or the source of misinformation. We should also try to identify the opposing voices, by looking for contrasting voices that challenge or counter the main voice. We can also proceed at analyzing the argumentation strategies. According to Ducrot's theory we establish the role of different types of argumentation operators: **concessions**- instances where the main voice acknowledges counterarguments or opposing points- indicating biased reasoning; **contradictions** – between different parts of the text, refutations – opposing voices countering the claims made by the main voice.

Inspired by the article "Leçons de << p'tits profs>> sur la Toile" (Liana Pop), I identified the following possible meta-discursive genres, which often emerge as a response to the spread of misinformation, used to critic or debunk fake news:

1. Fact-checking articles/posts- organizations or individuals examine claims made in fake news, providing evidence-based refutations. ("Did NASA Discover a New Earth-like Planet?"; Debunking the 5G Conspiracy Theories").
2. Debunking videos - they may feature a person analyzing claims, using evidence, logic and sometimes humor ("Debunking Health Myths: fact vs. Fiction").
3. Data visualization and Infographics – to present accurrate information in a visually compelling way.
4. Database that collect fake news - eg. Veridica- collects fake news and disinformation narratives from central and eastern Europe. ("Moldova is leaving the CIS at the behest of the West": 23 May 2023- false narrative carried by the Russian media).
5. Subreddits "r/Not TheOnion (Reddit- social media platform and online community where users can participate in discussions) – users can share and discuss news articles or headlines that seem so bizzare or absurd that they could be mistaken for satire, real news that are difficult to believe.
6. Community-driven fact-checking – on some social media platforms encourage users to actively participate. (Pizzagate 2016, Momo Challenge 2018, Covid 19-Misinformation).
7. Satirical memes- use humor, sarcasm, visual elements to mock or expose the absurdity of some fake news.

4. Case Studies: The Power of Discursive Genres in the Spread of Fake News

To demonstrate how discursive genres operate in real-world scenarios, this section analyzes two prominent case studies: the "Plandemic" meme series and the Mark Zuckerberg deepfake. These examples illustrate how visual rhetoric, cognitive biases, and cross-platform dynamics converge to amplify the reach and impact of misinformation.

4.1 The "Plandemic" Meme Series: Misinformation through Memes

The "Plandemic" meme series emerged during the early stages of the COVID-19 pandemic, blending conspiracy theories about government and pharmaceutical control with evocative, fear-mongering imagery. This case study illustrates how the meme genre can simplify complex

narratives into bite-sized, emotionally charged content, making them easily digestible and highly shareable across platforms.

The central claim of the "Plandemic" meme series was that COVID-19 was not a natural pandemic but a manufactured event orchestrated by global elites to control populations and profit from the sale of vaccines. Memes in this series used a variety of visual and rhetorical strategies to evoke distrust in health authorities, including images of government leaders with exaggerated facial expressions, references to pharmaceutical symbols, and text overlaid with dramatic, conspiratorial language. The use of humor, irony, and intertextual references to popular dystopian films (e.g., *The Matrix*) contributed to the memes' viral spread, drawing on cultural knowledge to bolster their message.

The genre of memes is particularly effective in spreading fake news because of its polyphony and intertextuality. In the case of "Plandemic," the memes referenced real events, such as the global vaccine rollout, while weaving in falsehoods about governmental conspiracies. These memes tapped into cognitive biases, especially confirmation bias, where users who were already skeptical of government intervention were more likely to share the content. Memes that invoked imagery of medical professionals juxtaposed with captions like "Don't Trust the System" or "Follow the Money" preyed on pre-existing fears and uncertainties, making them compelling even to those who might not fully believe in the conspiracy.

Moreover, the visual simplicity of the memes—a single image combined with minimal text—allowed them to bypass deeper cognitive scrutiny. The immediate emotional impact, coupled with the ease of sharing on platforms like Twitter, Instagram, and Facebook, made the "Plandemic" memes a prime example of how discursive genres can operate across platforms to spread misinformation.

4.2 The Mark Zuckerberg Deepfake: Visual Manipulation and Cognitive Bias

The second case study focuses on the deepfake of Facebook CEO Mark Zuckerberg, which appeared in 2019. This deepfake presents a striking example of how sophisticated visual rhetoric can be weaponized to manipulate perceptions of public figures and influence discourse around issues like privacy, surveillance, and corporate power.

In the video, a convincingly realistic Zuckerberg appears to deliver a speech about controlling the data of billions of users, boasting about the power it gives him. While entirely fabricated, the deepfake was remarkably persuasive due to its precise replication of Zuckerberg's voice, facial expressions, and body language. Its credibility was further bolstered by its dissemination through multiple platforms, including YouTube and Instagram, where it was viewed by millions before being flagged as fake.

This case illustrates the power of deepfakes as a visual genre capable of manipulating audiences by exploiting cognitive biases, particularly the **illusory truth effect**. Even though the deepfake was quickly debunked, the initial exposure left a lasting impact on viewers, who became more skeptical of Zuckerberg and Facebook's role in managing personal data. The deepfake reinforced pre-existing narratives about corporate overreach and surveillance, tapping into the wider cultural distrust of tech companies exacerbated by real-world scandals such as Cambridge Analytica. The **intertextuality** of the deepfake is evident in its references to these events, using them as a backdrop to enhance the believability of the video.

Furthermore, the **cross-platform dynamics** of this deepfake were critical in its spread. The video was shared across YouTube, Twitter, Facebook, and even smaller fringe platforms like 4chan, where it was discussed and analyzed by various communities. Each platform's unique affordances—such as the rapid sharing capabilities of Twitter or the algorithmic amplification on YouTube—allowed the video to reach different audiences, further entrenching the misinformation. This case highlights how deepfakes, as a genre, have a multiplier effect on the dissemination of fake news, thanks to their ability to adapt to various platforms and cognitive biases.

By comparing these two case studies, it becomes evident that while the genres differ—memes versus deepfakes—the underlying discursive strategies remain consistent. Both capitalize on visual rhetoric, cognitive biases, and cross-platform dissemination to create an ecosystem where misinformation thrives. These genres rely on a combination of simplicity, emotional appeal, and intertextuality, which makes them particularly suited for the rapid and wide circulation characteristic of fake news.

5. Conclusions

The Future of Discursive Genres in Fake News Propagation

The analysis of discursive genres in the spread of fake news reveals a complex interaction between visual rhetoric, cognitive biases, and platform-specific dynamics. Memes, deepfakes, and fake news articles each exploit the affordances of their respective genres to craft persuasive, emotionally charged narratives that resonate with users across multiple platforms. Through the use of intertextuality and polyphony, these genres manipulate meaning and create a networked ecosystem in which misinformation circulates with unprecedented speed and reach.

As digital technologies evolve, the sophistication of these genres is likely to increase. Advances in artificial intelligence and machine learning suggest that deepfakes, in particular, will become more realistic and harder to detect, posing significant challenges for media literacy and fact-checking efforts. Memes, with their ability to distill complex messages into shareable content, will likely continue to be powerful vehicles for the spread of misinformation, especially in politically charged or crisis-driven contexts.

Addressing the spread of fake news requires an approach that combines technological solutions with media literacy initiatives. While platforms like Facebook, Twitter, and YouTube have implemented fact-checking mechanisms and AI-driven content moderation, these measures often lag behind the rapidly evolving genres of fake news. Therefore, greater emphasis must be placed on educating users about the tactics employed by misinformation creators, particularly how visual rhetoric and cognitive biases are manipulated to serve ideological purposes.

Finally, future research should continue to explore how discursive genres adapt to new digital environments, including emerging platforms like TikTok and decentralized social networks. Understanding these dynamics will be crucial in developing more effective strategies to combat misinformation and its far-reaching societal impacts. In conclusion, while the battle against fake news remains ongoing, recognizing the power of discursive genres in shaping public discourse is a critical step toward mitigating the spread of misinformation. By interrogating the rhetorical, cognitive, and technological dimensions of these genres, scholars and policymakers can better understand the mechanics of fake news and develop targeted interventions to protect the integrity of public discourse in the digital age.

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Methods of Developing Creative Thinking through Mathematical Problem-Solving Techniques

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Abstract

This study evaluates various problem-solving methods and their contribution to the development of creative thinking in young schoolchildren and as a specific objective the identification of the most effective methods in the development of creative thinking. Twenty-eight second-grade students participated in the study, which was divided into four groups, depending on the methods used to solve mathematical problems. Each group used different problem-solving techniques to solve mathematical problems: the method of mathematical logic, the method of visual representations, a teamwork method of decomposition and reassembly (used by computer scientists when developing new software), and a teamwork method of solving problems through games. The Torrance test (Technical and Normative Manual) was used to evaluate creative thinking - verbal form A (for testing) and form B (for

retesting). After obtaining the scores, they were entered into the SPSS program - Statistical Package for Social Sciences. Results show that the methods used to solve mathematical problems play a significant role in the development of creative thinking in young schoolchildren and that mathematical games have the greatest impact on the development of creative thinking in young schoolchildren.

Keywords: mathematical problem-solving, creative thinking, creativity, primary school teaching.

JEL Classification: I2, C02.

1. Introduction

Creative thinking is the ability to generate novel ideas or solutions in problem-solving (Hadar & Tirosh 2019). This definition builds on Guilford's (1967) division of creativity into nine constructs: fluency, flexibility, novelty, synthesis, analysis, reorganization/redefinition, complexity, and elaboration.

The development of creative thinking in children is one of the greatest challenges of modern education, and mathematics, by its nature, offers the ideal framework for stimulating its development. In this paper, we aim to highlight the importance of problem-solving methods and strategies in developing creative thinking in young schoolchildren. Creative thinking can be enhanced by problem-solving skills, as it is shown by various studies conducted (Ndiung & Menggo 2024; Chaiyarat 2024). However, it is difficult to cultivate students' creative thinking, when the teaching is limited to textbooks and teaching courseware produced by teachers, making the classroom boring (Li & Zhang 2024). By designing suitable activities in the classroom, teachers can cultivate creative thinking and exploit this in other study areas.

Often students tend to focus on solving routine problems rather than developing their problem-solving skills, and more emphasis should be placed on non-routine problem-solving abilities (Nuryadin et al. 2023). Suryanto et al. (2021) argue that training students to determine problems, convey ideas, and generate creative solutions needs to be the main goal of learning

activities. The creative process is conducted by giving assignments to be completed creatively, not by giving the answers or the technique. When the teacher provides all the necessary information and techniques, the students are replicating the process. While this is a good practice for most students internalizing the algorithm and providing a solid knowledge for future problems could also be an inhibition when it comes to creative thinking. By applying the same methods and not constructing new ones, creative thinking cannot evolve.

Solving math problems involves creative techniques, but the methods applied may contribute differently to the development of creative thinking.

In the early school period, the learning process demands children's creativity intensely. When they enter school, children are exposed to continuous intellectual work, sometimes unknown to them. At this age, children naturally incorporate certain traits characteristic of creativity. The development of the potential for thinking and creativity is achieved through activities that require independence, investigation, and originality.

2. Literature Review

Harold (2024) states that creativity is not just a means for personal and individual expression, a way of admiring and showcasing the beauty and the spreading of important and valuable messages, but it can also consist of problem-solving and solution-finding for the world's greatest and most complex problems (Keen 2011), increasing comprehension and increase empathy (Decety & Cowell 2014) which can lead to positive and better ethical behavior (Haney 1994).

The opposition between critical and creative thinking is false, and it is mistaken to view them as radically different and unconnected (Bailin 1987). Innovation is a product of creativity which is not simply novelty but also valuable, and critical judgment is crucially involved in such creative achievement. When constructing a creative solution to a problem, the initial recognition that there is a problem to be solved, the identification of the nature of the problem, and the determination of how to proceed all involve critical assessment. Moreover, Bailin (1987) noted that creativity is not a question of generating fresh solutions to problems, but of generating better solutions, and thus it involves changes that are effective, useful, and significant.

In defining mathematical creativity, the classification of its components is often discussed between several types of creative thinking (Zhang et al. 2020). Moreover, mathematical creativity is widely acknowledged as one of the most important goals of mathematical education (Leikin & Pitta-Pantazi 2013; Leikin & Sriraman 2017; Mann 2006; Schoevers et al. 2019).

Sriraman (2005, p. 24) has provided a working definition of school-level mathematical creativity in which mathematical creativity is related to problem-solving and problem-posing. He defined mathematical creativity as the process that results in novel and/or insightful solution(s) to a given problem or analogous problems, or the formulation of new questions and/or possibilities that allow an old problem to be regarded from a new angle requiring imagination. Schoevers et al. (2019) consider that mathematical creativity also refers to the cognitive act of combining known concepts in an adequate, but for the pupil new way, thereby increasing or extending the pupil's understanding of mathematics. For example, when the student is constructing new concepts in mathematics using other experiences and knowledge or making connections with other subjects of study.

To promote mathematical creativity and creative thinking a pedagogical environment is needed. This is characterized by an open atmosphere in which students can develop new mathematical concepts in interaction with others, through collaboration or teamwork (Colucci-Gray et al. 2017; Kaufman et al. 2010).

Smare & Elfatihi (2024) found that in numerous studies published between 2010-2022, conducted on groups of students with ages between 3 and 14, a variety of pedagogical strategies yielded an immensely increase in creativity in problem-and-project-based learning strategies. This is because such tasks encourage risk-taking, resilience, experimentation, curiosity, and thus creativity (Albar & Southcott, 2021). Research also revealed a positive correlation between fact-finding and problem-finding with the number of ideas produced and the originality of these ideas (van Hooijdonk et al. 2020).

Moreover, Schoevers et al. (2019) found that most pedagogical strategies applied in schools are creativity enhancement strategies as well, but the regular mathematical lessons have a more specific learning goal than the interdisciplinary lessons, namely practicing arithmetical strategies versus learning about conceptualizations of shapes, space, and patterns. Thus,

creativity is not a goal for a normal mathematical lesson, but rather a by-product of the learning strategies.

Through problem-solving, however, students are asked to construct or employ new methods to find the solution or the best solution. This helps develop creative thinking and creativity by identifying mathematical structures that lead to a different, more creative, set of opportunities ((Stein & Kaufman, 2010; Stein, Remillard, and Smith, 2007).

3. Methodology

Research objective and hypothesis

The general objective of this research is to identify and evaluate the importance of problem-solving methods in developing creative thinking in young schoolchildren. More specifically, the aim is to identify the most effective methods in the development of creative thinking. To this end, we have selected four methods to be applied to a group of students. Also, some of the students worked individually and some worked in teams, by collaboration.

Main hypothesis (H_M). We assume that the methods used to solve problems in mathematics have a significant role in the development of creative thinking in young schoolchildren.

Secondary hypothesis (H_S). We presume that some methods and strategies of problem-solving are more effective than others in the development of creative thinking in young schoolchildren. Teamwork could be more effective in developing creativity than individual work. This would be consistent with other results that show that cooperative learning remains a powerful pedagogical tool for teachers aiming to develop students' creative thinking (Chaiyarat 2024).

Subjects

The study involved twenty-eight second-grade students, 53.57% girls (N = 15) and 46.43% boys (N = 13), with ages between 7 and 9. They were divided into four groups, depending on the methods used to solve mathematical problems. Thus, group 1 used the method of mathematical logic, group 2 used the method of visual representations, group 3, the method of decomposition and reassembly, and, lastly, group 4, the method of solving problems through mathematical games. The last two groups were asked to work as teams, but the first two had to work individually.

Instruments

The research design is an experimental one with multiple groups, structured as follows:

- Batch selection and division: Participants (young schoolchildren) were randomly divided into four groups, with each group experimenting with a different method of solving math problems.
- Basic measurement: Before the intervention begins (application of problem-solving methods assigned to each group), data was collected on the level of creative thinking of the participants in each group using valid and reliable tools for measurement.
- Intervention: Each group receives specific instructions and materials to work with the assigned problem-solving method.
- Post-intervention measurement: After the groups have completed the activities specific to their method, data on the level of creative thinking of the participants in each group was collected again.
- Data analysis: Pre- and post-intervention data were compared for each group to assess changes in creative thinking after the application of the respective method.
- Interpretation of the results: It was analyzed whether there are significant differences between groups in terms of the growth of creative thinking and determine which method was most effective in achieving this goal.

For creative thinking data collection, the Torrance test (Technique and Normative Manual) (Torrance, 1966) was used for the evaluation of creative thinking – verbal form A (for testing) and form B (for retesting).

For the analysis of data, we have conducted SPSS (Version 26.0) calculations, the ANOVA test, and paired-sample t-tests.

Ethics

The ethical requirements in this work have been fully respected. All participants and their parents expressed their consent for participation in the research, and this was a fundamental aspect in ensuring respect for their rights and dignity. Participants' voluntary consent was obtained before the research began, giving them a clear understanding of the purpose of the study, the procedures involved, and the possible risks or benefits.

In addition, to protect data privacy, appropriate security measures have been implemented for the storage and management of participants' personal information. The data collected has been treated with confidentiality and has not been disclosed to third parties or unauthorized persons.

Intervention

The pedagogical intervention lasted six weeks, 18th of March to the 26th of April 2024, and constituted six different pedagogical activities for each group. All activities were gamified to ensure that the cooperation and interest of the students were kept. **Table 7** (Appendix) is a summary of the activities conducted in the pedagogical program.

Data analysis and results

Before intervention test results were compared between groups to ensure that the levels of creativity were similar since the selection was performed randomly.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Mathematical logical method	7	89,4286	8,96023	3,38665	81,1417	97,7154	78,00	101,00
Visual representation method	7	93,5714	8,24332	3,11568	85,9476	101,1952	82,00	103,00
Decomposition and reassembly method	7	92,1429	9,90671	3,74438	82,9807	101,3050	79,00	106,00
Gamified problem-solving method	7	90,0000	11,41636	4,31498	79,4416	100,5584	73,00	110,00
Total	28	91,2857	9,30495	1,75847	87,6776	94,8938	73,00	110,00

Table 1. Descriptives
Creativity before intervention

The analysis of the data in **Table 1** shows that all four groups selected for the evaluation of creativity before the intervention obtained average scores above 89. Group 1 – which will use the Logical-mathematical method has an average of 89.43 and moderate variability (standard deviation of 8.96), with extreme values between 78 and 101. Group 2 – selected to use the Visual representation method has a higher average of 93.57 and a similar dispersion, with values between 82 and 103. Group 3 – which will solve the problems with the help of the Decomposition and reassembly method has an average of 92.14, but a slightly higher variability (standard deviation of 9.91), and the scores vary between 79 and 106. Finally,

Group 4 which will use the gamified problem-solving method has an average of 90, but the highest variability (standard deviation of 11.42), with values between 73 and 110, indicating a wide dispersion of results. The overall mean is 91.29, with moderate variation (standard deviation of 9.30), suggesting a high level of creativity, with insignificant differences between participants.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	77,429	3	25,810	,274	,844
Within Groups	2260,286	24	94,179		
Total	2337,714	27			

Table 2. ANOVA. Creativity before intervention

Creativity before intervention

	Statistic[a]	df1	df2	Sig.
Welch	,293	3	13,254	,830
Brown-Forsythe	,274	3	22,596	,843

a. Asymptotically F distributed.

Table 3. Robust Tests of Equality of Means

Looking at the results in **Table 2** - ANOVA and **Table 3** - Robust Media Equality Tests for Pre-Intervention Creativity, the variability of creativity between groups is statistically insignificant. In ANOVA, the sum of squares between groups is 77.429, and the sum of squares within groups is much larger at 2260.286, indicating that most of the total variability (2337.714) comes from individual differences within groups, not from differences between groups. This is also supported by the F-value of .274, with a significance value (Sig.) of .844, much higher than the significance threshold of .05, suggesting that there are no statistically significant differences between groups in terms of creativity before the intervention.

From a psychological point of view, these results suggest that, before applying any methods of stimulating creativity, participants, regardless of the group they belonged to, had similar levels of

creativity. The fact that significant variability comes from within groups indicates an individual diversity in creativity, but this diversity is not influenced by belonging to a particular group.

In **Table 3**, robust tests (Welch and Brown-Forsythe) confirm the ANOVA results, both of which have very low values for their statistics (.293 and .274), and the significance (Sig.) values of .830 and .843 are again much higher than the .05 threshold. These results indicate that the averages of creativity between groups are equal, and the differences observed are not large enough to be considered statistically significant.

Psychologically, the results in the tables confirm that the participants' level of creativity before the intervention was evenly distributed among the groups. This may suggest that subsequent interventions are the ones that will generate relevant differences, and this uniform starting point allows for a correct assessment of the effectiveness of those interventions.

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Creativity after intervention - Creativity before intervention	17,17857	11,38568	2,15169	21,59348	12,76367	7,984	27	,000

Table 4. Paired Samples Test

Analyzing the data in **Table 4** - Test for paired samples, a significant difference between creativity before and after the intervention is observed. The average difference between creativity before and after the intervention is 17.17857, which indicates a substantial increase in post-intervention scores. This difference is supported by a standard deviation of 11.38568, which shows moderate variation in how participants were affected by the intervention. The 95% confidence interval for the mean difference is between 21.59348 and 12.76367, which means that there is a high probability that the true mean difference is within this range, with all values being positive. This confirms that the intervention had a consistent impact on creativity, leading to an overall increase in scores.

The t-value is 7.984, with 27 degrees of freedom (df). This significantly positive t-value suggests that the intervention had a significant effect on the participants' creativity.

Psychologically, these results indicate that the intervention had a positive effect, leading to an increase in creativity levels. This consistent increase in scores indicates that the intervention was effective in stimulating creativity, promoting flexibility and fluidity in thinking, but also involving divergent ways of thinking.

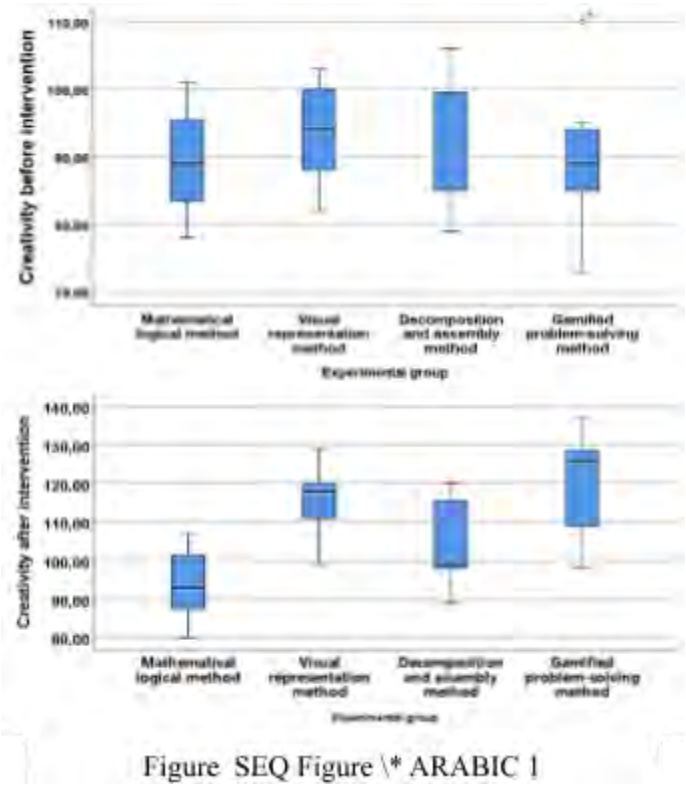

Figure SEQ Figure * ARABIC 1

Figure 1. Creativity before and after intervention

The box plot graph (**Figure 1**) shows the level of creativity after the intervention for four experimental methods: the logical-mathematical method, the visual representation method, the decomposition and reassembly method, and the problem-solving method through games. Regarding the statistical analysis, it is observed that the logical-mathematical method has the lowest median, suggesting that participants who used this method had the lowest increase in levels of creativity after the intervention, and the relatively narrow interquartile interval indicates a low variability in their performance.The visual representation method has a higher median than the logical-mathematical method, and the graph box suggests moderate variability, indicating

that most participants scored higher, but there is a greater dispersion of results. The decomposition and reassembly method has a median like that of the visual method, but the interquartile range is wider, reflecting greater variability between participants' scores. In contrast, the method of problem-solving through games has the highest median of all methods, suggesting that it was the most effective in stimulating creativity, but also the most variable, indicated by the large interquartile interval and the length of the whiskers.

Psychologically, these results suggest that methods involving visual representation, decomposition-reassembly, and games stimulate creativity more effectively than the logical-mathematical method. The logical-mathematical method, which is based on sequential reasoning and structuring, seems to limit the creative capacity of the participants, leading to more modest results. On the other hand, the method of solving problems through games, which involves a more relaxed and exploratory approach, stimulates creativity at a higher level but is also the most unpredictable, reflecting the fact that some participants may be more receptive to playful approaches than others.

Dependent Variable: Creativity after intervention. Tukey HSD

(I) Experimental group	(J) Experimental group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Mathematical logical method	Visual representation method	-21,4286*	6,29193	,012	-38,7856	-4,0716
	Decomposition and reassembly method	-11,0000	6,29193	,322	-28,3570	6,3570
	Gamified problem-solving method	-25,4286*	6,29193	,003	-42,7856	-8,0716
Visual representation method	Mathematical logical method	21,4286*	6,29193	,012	4,0716	38,7856
	Decomposition and reassembly method	10,4286	6,29193	,367	-6,9284	27,7856
	Gamified problem-solving method	-4,0000	6,29193	,919	-21,3570	13,3570
Decomposition and reassembly method	Mathematical logical method	11,0000	6,29193	,322	-6,3570	28,3570
	Visual representation method	-10,4286	6,29193	,367	-27,7856	6,9284
	Gamified problem-solving method	-14,4286	6,29193	,128	-31,7856	2,9284
Gamified problem-solving method	Mathematical logical method	25,4286*	6,29193	,003	8,0716	42,7856
	Visual representation method	4,0000	6,29193	,919	-13,3570	21,3570
	Decomposition and reassembly method	14,4286	6,29193	,128	-2,9284	31,7856

Table 5. Multiple Comparisons.

Based on observed means.

The error term is Mean Square (Error) = 138,560.

*. The mean difference is significant at the,05 level.

The statistical analysis in **Table 5** - Multiple Comparisons reveals significant differences between certain experimental groups in terms of creativity after the intervention. The logical-mathematical method presents significant differences compared to the visual representation method, with an average difference of -21.43 ($p = .012$), and to the problem-solving method through games, where the average difference is -25.43 ($p = .003$). These results indicate that participants who used the logical-mathematical method had a significantly lower level of creativity after the intervention compared to those who used the methods of visual representation and problem-solving through games.

No significant differences were observed between the visual representation method, the decomposition and reassembly method, and the game-based problem-solving method, suggesting that these three had a similar impact on the participants' level of creativity. In conclusion, visual or game-based and problem-solving methods stimulated creativity to a greater extent than the logical-mathematical method, with no significant differences between them and the other methods.

From a psychological point of view, these results suggest that methods that involve visual representation and problem-solving through games are more effective in stimulating creativity, probably due to the activation of more flexible, intuitive, and exploratory cognitive processes. In contrast, the logical-mathematical method, which is based on sequential reasoning and structuring, seems to limit creativity, which may indicate that rigorous and logical thinking does not optimally favor the expression of creativity. It suggests that participants benefited more from playful and visual approaches, which allowed them to think divergently and explore more innovative solutions.

Dependent Variable: Difference. Tukey HSD

(I) Experimental group	(J) Experimental group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Mathematical logical method	Visual representation method	-17,2857*	3,54082	,000	-27,0535	-7,5180
	Decomposition and assembly method	-8,2857	3,54082	,117	-18,0535	1,4820
	Gamified problem-solving method	-24,8571*	3,54082	,000	-34,6249	-15,0894
Visual representation method	Mathematical logical method	17,2857*	3,54082	,000	7,5180	27,0535
	Decomposition and assembly method	9,0000	3,54082	,079	-,7677	18,7677
	Gamified problem-solving method	-7,5714	3,54082	,170	-17,3392	2,1963
Decomposition and assembly method	Mathematical logical method	8,2857	3,54082	,117	-1,4820	18,0535
	Visual representation method	-9,0000	3,54082	,079	-18,7677	,7677
	Gamified problem-solving method	-16,5714*	3,54082	,001	-26,3392	-6,8037
Gamified problem-solving method	Mathematical logical method	24,8571*	3,54082	,000	15,0894	34,6249
	Visual representation method	7,5714	3,54082	,170	-2,1963	17,3392
	Decomposition and assembly method	16,5714*	3,54082	,001	6,8037	26,3392

Table 6. Multiple Comparisons

Based on observed means.
The error term is Mean Square (Error) = 43,881.
*. The mean difference is significant at the,05 level.

The statistical analysis in **Table 6** - Multiple Comparisons (Tukey HSD) shows that the logical-mathematical method shows significant differences compared to the visual representation method and the game problem-solving method, with mean differences of -17.29 and -24.86, respectively, both with a meaning p = .000. This indicates that participants who used the logical-mathematical method recorded a significantly smaller increase in creativity compared to those who used visual or gamified methods. Also, the decomposition and reassembly method differs significantly from the game problem-solving method, with a difference of -16.57 (p = .001), suggesting that the gamified method stimulated creativity more than the decomposition and assembly method. In conclusion, visual and game-type methods seem to be much more effective in maintaining or increasing creativity, while the logical-mathematical method has a modest impact on the creativity of the participants.

From a psychological point of view, results show that visual and gamified methods stimulate creativity more effectively, compared to the logical-mathematical method. This suggests that creative thinking is supported by approaches that encourage divergent thinking, imagination, and flexible exploration of solutions, such as visual representation and problem-solving through games. The logical-mathematical method, which involves sequential reasoning and rigorous

structuring, seems to limit creativity, probably because of its orientation towards convergent thinking and strict problem-solving, which leaves no room for the free expression of new and innovative ideas. Similarly, the decomposition and reassembly method shows better results than the logical-mathematical method, but not as efficient as the gamified method, which suggests that decomposing complex problems into smaller and reassembling the solutions can stimulate creativity, but not in the same manner problem-solving in play. These results highlight the importance of creative approaches that allow participants to manifest their cognitive flexibility and use their imagination in a more open and exploratory way.

Regarding the hypothesis of the study, we point out that the (H_M) has been confirmed for the studied sample. Therefore, solving mathematical problems can boost creativity levels in primary school students. Our secondary hypothesis has been confirmed as well, and the results show that the gamified problem-solving technique has the biggest impact on developing and enhancing creativity levels. Nevertheless, the other methods used in the study had a significant impact on the creativity levels of the students.

4. Results and Discussions

The mathematical logic method has been shown to have less impact on creative thinking and creativity development compared to the other methods. This can be explained by the structured and predictable nature of the logical approach, which encourages sequential reasoning and determinate solutions, but can limit creative exploration. Students are guided to follow clear steps to reach a solution, which can reduce opportunities to think "outside the box" (Yayuk et al. 2020).

The method of visual representations had a significantly greater impact than the method of mathematical logic. This suggests that the use of images, graphs, and visual models stimulates creative thinking by offering varied ways of perceiving and solving problems. Visual representations help students make connections between different concepts and develop their ability to visualize alternative solutions (Walia 2012). This approach encourages mental flexibility and adaptability, which are essential for creative thinking.

The method of decomposition and reassembly, and as a form of organization of teamwork has demonstrated a great impact on creative thinking, even if not as great as that of visual representations, emphasizing the importance of collaboration and social interaction in the learning process. The collaborative process facilitates the development of innovative solutions and helps students see problems from multiple perspectives, thus stimulating divergent thinking and creativity (Temel & Altun 2022).

The method of solving problems through mathematical games had the greatest impact on the development of creative thinking. Math games often involve "play" scenarios that are open-ended and exploratory, allowing students to experiment and learn through trial and error. These activities encourage students to think strategically and develop innovative solutions in an enjoyable and motivating way. Games create an environment where mistakes are viewed as learning opportunities, not failures, which reduces performance anxiety and encourages creative exploration (Beka 2017).

Also, the study shows that mathematics is a suitable platform to foster creativity. It proved that solving problems in groups is effective in fostering creativity (Khalid et al. 2020).

Moreover, teachers should consider integrating gamified problem-solving activities to increase creativity and the interest of the students. We acknowledge that this requires extra effort on the part of the teacher since they should function as a coach, a provider of resources, and a designer, facing complex and varied challenges (Calavia, Blanco & Casas 2021), but creativity and creative thinking is a skill that is necessary for the future, in a world that is constantly changing due to the technological advancement that is happening every day.

5. Conclusions

The study shows that the methods used to stimulate creativity had different effects on the participants. The methods of visual representation and problem-solving through games proved to be the most effective in maintaining and increasing the level of creativity, giving participants greater freedom of expression and stimulating divergent thinking. These methods allowed the exploration of multiple and innovative solutions, contributing to an increased level of post-intervention creativity.

In contrast, the logical-mathematical method had a limited effect on creativity, leading to a slower, but statistically significant, increase in creativity after the intervention. This suggests that strict and structured reasoning, specific to convergent thinking, is less conducive to expressing creativity, as it requires rigid and predictable solutions. Although the decomposition and reassembly method performed better than the logical-mathematical method, it did not stimulate creativity as effectively as visual or gamified methods.

In conclusion, the study highlights that creative approaches that favor cognitive flexibility, free exploration, and divergent thinking, such as games and visual representation, are much more effective in stimulating creativity. Methods that rely on strict and structured reasoning, such as the logical-mathematical method, tend to inhibit creativity, limiting participants' ability to generate innovative ideas.

Psychologically, the results of this study suggest that approaches that encourage exploration, collaboration, and play have a strong effect on the development of creative thinking in young schoolchildren. Methods that allow for multiple open-ended solutions and strategies are more effective in stimulating creativity than those that follow a rigid set of steps.

These findings coincide with psychological theories of active learning and constructivism, which emphasize the importance of active engagement and social interaction in the learning process. They suggest that to develop creative thinking, it is essential to create learning environments that allow students to explore, collaborate, and learn through practical and playful experiences.

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Digitalization in Education: Innovating Value for Stakeholders

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Abstract

Digitalization and digital transformation have significantly influenced various sectors, reshaping the way organizations function, deliver services, create value and engage with stakeholders. Public institutions, including educational ones, such as universities, are increasingly being influenced by digital transformation. As technology continues to evolve, universities are at a critical crossroad where the adoption of digital tools and platforms is no longer optional, but a fundamental aspect of their operations. Digitalization offers an unprecedented opportunity to enhance administrative efficiency, improve the quality and accessibility of education, and facilitate more dynamic interactions between universities and their stakeholders, including students, businesses, local government and the broader community. By leveraging digital technologies, educational institutions have the potential to innovate and redefine the value they offer to their stakeholders. Using the existing literature on digital transformation within public institutions, specifically universities, this article explores how digitalization can serve as a catalyst for innovation in the value offered by public educational institutions to their stakeholders.

Keywords: digital transformation, higher education, value innovation, digital innovation, digital technologies, stakeholder engagement.

1. Introduction

In recent years, the terms “digital transformation” and “digitalization” have emerged as pivotal concepts, reflecting a fundamental shift in how organizations operate and deliver value; this transformation encompasses the integration of digital technologies into all areas of an organization, fundamentally altering how it engages with its stakeholders, processes information, and delivers services. As various sectors have embraced this shift, public institutions, particularly universities, are increasingly recognizing the necessity of digitalization to remain relevant and effective in a rapidly evolving societal landscape. The significance of digitalization and digital transformation in public institutions is profound, especially as these entities encounter mounting pressures to generate value for their stakeholders; in this context, digitalization acts as a pivotal enabler that transforms operational frameworks while promoting co-creation, a collaborative process in which institutions work alongside stakeholders to design and implement solutions that effectively meet the evolving needs of their communities.

Focusing on universities as a case study within the broader framework of public institutions undergoing digitalization is particularly pertinent for several reasons, one of which is that universities are not only centers of education and research but also significant contributors to societal development and economic growth, meaning their role in equipping individuals with the skills and knowledge necessary for the workforce is vital, and digital transformation can enhance their capacity to fulfill this mission.

Thus, this study seeks to address the following research question: How can digitalization act as a catalyst for innovation in the value offered by public universities to their stakeholders? Through a comprehensive analysis of existing literature, this study endeavors to contribute to a deeper understanding of the transformative potential of digitalization in the realm of public higher education, ultimately shedding light on how universities can leverage these changes to better serve their communities and fulfill their missions in an increasingly digital world.

2. Literature Review

Digitalization in Educational Institutions

The rapid evolution of digital technologies has ushered in an era of profound digital transformation that has fundamentally reshaped various sectors, including public institutions. Digitalization, a term often used interchangeably with digital transformation, has garnered significant attention in recent years, particularly as both public and private institutions seek to leverage technology to improve efficiency, drive innovation, and create greater value for their stakeholders. As Brennen and Kreiss (2016) describe, digitalization involves the reorganization of different areas around digital communication and media infrastructures, emphasizing the essential role that digital tools play in transforming processes and interactions within organizations. Conversely, digital transformation, as Vial (2019) argues, encompasses not just the adoption of these technologies but also the comprehensive rethinking of organizational strategies, structures, and cultures, with the goal of maximizing the potential offered by digital tools.

Within the context of educational institutions, particularly universities, this process involves the integration of information and communication technologies (ICTs) into the very core functions of the organization, ranging from administrative tasks to teaching, research, and even stakeholder engagement (Kopp et al., 2019). In this light, digital transformation represents a profound change that significantly impacts institutional identity, ultimately requiring universities to redefine their role in the digital age (Hess et al., 2016). Furthermore, literature underscores that digitalization is not merely about the application of technology, rather, it is recognized as a disruptive force that fundamentally alters the nature of value creation within institutions. For instance, Yoo, Henfridsson, and Lyytinen (2010) explain that digitalization blurs the boundaries between the physical and the digital, thereby opening new avenues for interaction and service delivery that were previously unavailable or unimaginable. This framework is particularly relevant for public institutions, where digital transformation can serve as a key enabler of more transparent, efficient, and responsive service models.

In the specific case of higher education institutions, digital transformation has emerged as a critical priority, especially in the second decade of the 21st century, marking a natural and necessary evolution for universities that aspire to lead change and maintain competitiveness in their respective fields. Not only has digital transformation become a top priority for universities,

but it is also increasingly recognized as essential for numerous other types of organizations. This sense of inevitability is driven by the pressing need for institutions to address the multitude of challenges arising from the rapid and diverse changes in their external environments. However, it is important to note that digital transformation in higher education extends far beyond a mere technological shift, rather, it encompasses a much broader scope, seeking to anticipate and meet the evolving needs and behaviors of stakeholders. Additionally, it aims to offer education, research, and social services that align with user demands in a continuously evolving competitive landscape. This approach to digitalization requires the full integration of core services, the development of advanced digital skills among both academics and students, and the implementation of decision-support systems that are adaptable enough to respond to changing circumstances (Kuzu, 2020). Consequently, the impact of digital transformation on higher education goes beyond technical upgrades, influencing the very mission of universities as they strive to remain relevant and effective in an increasingly digital world.

Public universities, due to their integral role within society, must carefully consider the wider social and cultural consequences that accompany the process of digital transformation. According to the literature, public institutions are tasked with the challenge of finding a balance between pursuing efficiency and innovation, while simultaneously maintaining their commitment to upholding essential ethical principles (Misuraca & Viscusi, 2015). This challenge becomes particularly salient in the context of education, where the implementation of digital technologies has the potential to either democratize access to knowledge, ensuring it is available to a broader audience, or, conversely, deepen existing divides between those who possess access to digital resources and those who do not, known as digital divide, which has been center of attention in the last years (e.g. van Dijk, 2020).

A prominent theme that emerges from the literature on digital transformation is its significant capacity to enhance value creation within various types of organizations, including universities. In the context of public institutions, value creation refers to an organization's ability to deliver services that not only meet but also exceed the needs and expectations of their diverse stakeholders, which include students, faculty, government agencies, and the broader community (Bryson, Crosby, & Bloomberg, 2014). Digitalization presents several avenues through which

universities can create new forms of value. For instance, Sahu (2020) highlights how the adoption of digital tools has the potential to improve the efficiency of administrative processes, which, in turn, can free up valuable resources that may then be redirected toward more strategic initiatives, such as improving the quality of education or expanding research capabilities. Additionally, digitalization opens the door to new opportunities for research and innovation, as it facilitates more seamless collaboration between universities, industry, and government partners. As noted by Hailu (2024), digital tools have fundamentally transformed the way knowledge is produced and disseminated, enabling more interdisciplinary and cross-sectoral research collaborations. These collaborations, in turn, have the potential to drive innovation not only within academic institutions but also across the public sector and society at large.

3. Main directions for understanding Digital Innovation in Universities

As public institutions embrace digital transformation, they are also opening new avenues for digital innovation, which refers to the development and implementation of novel digital products, services, or processes that create fresh value for both the institution and its stakeholders (Nambisan et al., 2017). Digital innovation allows institutions to move beyond simply upgrading their current systems and explore new ways of engaging with their environment, fostering collaboration, and delivering value. For universities, this can manifest in various ways, such as the creation of new educational platforms, the use of big data and analytics for improved decision-making, or the development of online learning environments that expand access to education. The pandemic further accelerated the need for such innovations, pushing universities to embrace digital solutions to maintain the continuity of educational services and adapt to a rapidly changing global landscape (Peters et al., 2022). These innovative approaches allow universities to remain competitive and relevant while also addressing societal challenges through the use of cutting-edge technology.

The integration of digital tools and strategies is particularly significant in the public sector, where digitalization and digital transformation serve as mechanisms for enhancing service delivery, decision-making, and accountability. Public institutions are often under pressure to adopt digital solutions to reduce costs, increase transparency, and meet the growing expectations of

stakeholders, such as government bodies, citizens, and communities (Mergel et al., 2019). Universities, as a critical subset of public institutions, have embraced digitalization not only to improve administrative efficiency but also to enhance the learning experience, expand research capabilities, and increase the accessibility of higher education. Online platforms, digital resources, and data-driven decision-making are increasingly being utilized to improve learning outcomes, streamline university operations, and ensure that students, faculty, and other stakeholders have access to the resources they need to thrive in a digital environment (Gaftandzhieva, et al., 2023). In this way, universities are adapting to the digital age by leveraging the benefits of digitalization to enhance their core functions and improve the quality of their services.

Universities, as public institutions, have a unique role in society, as they serve multiple stakeholders, including students, faculty, government bodies, and the general public. Historically, their mission has centered on producing and disseminating knowledge, fostering critical thinking, and contributing to societal development through education and research. This public mission remains central to universities' identity, even as they evolve to meet the demands of a digital society. In this context, the integration of digital tools and strategies within universities must be aligned with their broader goals of serving the public good and ensuring that they remain accessible, equitable, and inclusive to a wide range of stakeholders. As public institutions, universities are expected to create value not only for their immediate stakeholders but also for society at large by contributing to economic, social, and cultural development.

In line with this, digital transformation in universities presents an opportunity to enhance their public mission by enabling them to expand access to education, improve the quality of learning, and create knowledge that is relevant to the evolving needs of society. Universities are increasingly using digital tools to deliver educational content through online platforms, integrate data analytics into their governance models, and develop digital infrastructures that enhance their research capabilities. By doing so, universities are better positioned to fulfill their role as hubs of innovation, where both students and faculty can contribute to societal development through research, education, and community engagement (Carayannis & Rakhmatullin, 2014). Furthermore, digital transformation allows universities to contribute to the development of

digital literacy and skills within the broader community, thereby preparing individuals to navigate the complexities of the digital age.

Stakeholders of Educational Institutions from the perspective of Innovation and Digitalization

Public universities, as essential societal institutions, interact with a broad range of stakeholders, each contributing to and benefiting from the university's core missions of education, research, and public service. Stakeholder theory, as conceptualized by Freeman (1984), defines stakeholders as any group or individual that can influence or be influenced by an organization's objectives. In the context of universities, these stakeholders include students, faculty, businesses, government entities, and the broader community, all of whom play distinct roles in shaping the institution's functions while expecting value in return.

Students, often considered the most immediate beneficiaries, seek knowledge, skills, and qualifications that will enhance their employability and personal growth. Alongside students, faculty engage in both teaching and research, contributing to the dissemination of knowledge while advancing their respective fields. Businesses, which increasingly rely on universities for research partnerships and access to a well-trained workforce, view these institutions as crucial collaborators for innovation and technological advancement. In parallel, government entities, responsible for funding and policy-making, rely on universities to foster social and economic progress, anticipating contributions to national development and societal well-being. Lastly, the community at large benefits from universities through outreach initiatives, cultural events, and public engagement activities, as these institutions play a vital role in enhancing the social and intellectual fabric of their environments.

Traditionally, universities have created value for their various stakeholder groups by fulfilling distinct roles that align with their historic missions, roles that have evolved over time but continue to reflect core educational and societal objectives. For students, universities have long provided structured educational pathways that culminate in formal qualifications, while also imparting essential knowledge and skills designed to prepare them for professional careers. The traditional academic model, which has historically been centered on in-person education, facilitated direct interaction between students and educators, thereby creating a well-defined

pathway toward both academic achievement and career readiness (Mindruta, 2012; Argandoña, 2011). This direct interaction, which was a hallmark of the traditional university experience, not only enhanced students' learning but also contributed to their personal development through the relationships they formed with faculty and peers. Faculty, on the other hand, found value in the intellectual freedom that universities offered, as these institutions allowed them to pursue both teaching and research in ways that supported not only knowledge generation but also the mentoring of future generations of scholars. Thus, universities served as hubs for intellectual exchange, where teaching and research were deeply intertwined, contributing to the ongoing advancement of knowledge.

For businesses, universities traditionally provided value not only by producing graduates equipped with relevant skills but also by facilitating research collaborations that translated into practical innovations. The partnerships between academia and industry were seen as mutually beneficial, where scientific research conducted at universities could be applied to real-world problems, thereby driving both technological advancements and economic growth (Perkmann et al., 2013). Moreover, these collaborations between universities and businesses helped bridge the gap between theoretical knowledge and its practical applications, creating a symbiotic relationship that benefitted both sectors.

Governments, too, viewed universities as essential to national development, perceiving them as key actors in the promotion of social mobility and the creation of a skilled workforce capable of addressing broader societal challenges. In this sense, universities were not only educational institutions but also engines of social and economic development, contributing to the overall well-being of society through their core missions (Boulton & Lucas, 2008). This dual role of universities, as educators of individuals and as contributors to societal progress, underscored their importance in shaping not just the economy but also the broader social fabric.

Finally, communities benefited from the broader societal contributions of universities, including cultural enrichment, public lectures, and other forms of public engagement that served to enhance the public good. Through these activities, universities positioned themselves as critical anchors within their regions, not only providing education but also fostering a sense of community and contributing to the cultural and intellectual life of the broader society

(Benneworth & Jongbloed, 2010). Consequently, the role of universities extended beyond their immediate educational mandate, as they became integral to the social, economic, and cultural vitality of the regions they served.

As the digital age progresses, stakeholders' expectations are evolving, and universities are being compelled to rethink how they deliver value in this rapidly changing landscape. The integration of digital technologies has introduced new dynamics that affect the core functions of higher education institutions, necessitating a shift from traditional, static models of operation to more flexible and innovative approaches. Universities are now expected to not only provide academic knowledge but also facilitate the development of digital competencies, foster innovation, and contribute to broader societal needs in a more dynamic, real-time manner. This transformation involves reimagining how institutions engage with their stakeholders, including enhancing communication channels, streamlining administrative processes, and leveraging technology to improve access to resources and services. Moreover, universities are increasingly being evaluated on their ability to adapt to technological advancements, making digital readiness a key factor in their continued relevance and success. The growing influence of data, automation, and artificial intelligence within academic settings further highlights the need for institutions to stay ahead of technological trends, ensuring that they can meet the emerging demands of both the knowledge economy and society at large. In this way, the digital transformation of universities is not only reshaping the relationships between these institutions and their stakeholders but also expanding the potential impact that universities can have on society at large.

Digitalization as a Catalyst for Innovation of Value Creation in Educational Institutions

Universities, as complex and multi-faceted institutions, serve a diverse range of stakeholders, including students, faculty, alumni, industry partners, and society at large. Traditionally, the value created by universities was seen as static and primarily transactional, revolving around the conferral of degrees, the production of research outputs, and engagement with external communities through rigid and formalized pathways. However, the advent of digitalization has profoundly transformed the mechanisms through which value is created and distributed. Digital tools and platforms enable universities to operate in a more dynamic, participatory, and

service-oriented manner, reshaping relationships with stakeholders and generating new modes of value creation.

In traditional higher education models, universities were typically seen as closed systems wherein value creation was linear, often flowing from the institution to its stakeholders, and this view largely corresponded to what Vargo and Lusch (2004) termed Goods-Dominant Logic (GDL), where education was treated as a product to be delivered and consumed. Degrees, diplomas, and certifications were seen as the main commodities through which value was provided to students, and this product-based model emphasized the one-directional transmission of knowledge from faculty to students, often measured by metrics such as exam performance, graduation rates, and research outputs. In this framework, students were positioned as passive recipients of educational content, with little opportunity for customization or participation in the development of their educational experience, while faculty, in turn, were evaluated based on research productivity, which was frequently assessed through publications, citations, and tenure-track success. Moreover, external stakeholders, such as industry partners and local communities, engaged with universities primarily through formal and structured partnerships, including recruitment fairs or sponsored research projects, and in this context, value was often perceived as static—a degree or certification conferred by the university was considered the ultimate product, and once delivered, the value creation process was regarded as complete.

Although this transactional view of value in higher education proved effective in certain contexts, it ultimately lacked the flexibility and adaptability needed to meet the evolving needs of modern stakeholders, especially in the face of a rapidly changing, knowledge-driven economy. However, the emergence of digital technologies has begun to challenge these traditional paradigms by fostering a more relational and co-creative approach to value creation in higher education, thereby positioning universities not merely as producers of knowledge, but rather as facilitators of value creation through continuous and dynamic interactions with their stakeholders.

Digitalization has become a driving force in transforming higher education, not only by introducing new tools and platforms but also by reshaping how universities interact with their stakeholders. By integrating digital technologies, universities have shifted from traditional,

product-centric models to more dynamic, service-oriented approaches that prioritize accessibility, personalization, and collaboration. This evolution has enabled universities to co-create value with students, faculty, industry partners, and society at large, positioning them as central actors in regional and global innovation ecosystems.

At the most general level, digitalization allows universities to extend their educational services beyond traditional boundaries, fostering greater inclusion and social participation. Digital platforms enable universities to offer free or low-cost online courses and resources to underserved communities, contributing to the democratization of education and promoting lifelong learning. These initiatives enhance universities' societal role by addressing educational disparities and promoting broader engagement through citizen science projects and community-driven research (Bonney et al., 2009).

As digital tools facilitate real-time collaboration and data sharing, universities' relationships with external stakeholders have become more interactive and participatory. Historically, universities maintained more formal and transactional partnerships with industry, government, and society, often limited to specific initiatives such as talent pipelines or applied research. However, the advent of digital platforms has transformed these interactions, enabling universities to collaborate more seamlessly with external stakeholders in co-creating solutions to complex challenges (Perkmann, Walsh, 2007; Becker, Eube, 2018). This shift has been particularly notable in open innovation, where knowledge flows in and out of organizations, promoting interdisciplinary partnerships and continuous value creation.

In higher education, students have become direct beneficiaries of the digital transformation process, as digitalization not only enables personalized learning experiences tailored to their individual needs and preferences but also offers greater flexibility and access to a broader range of educational resources. Faculty members, likewise, have experienced a significant shift in their roles, as they are no longer merely knowledge producers but have become active facilitators within a collaborative knowledge ecosystem, where digitalization empowers them to engage more deeply in co-creating value with various stakeholders, including students, industry partners, and community members, through a range of activities such as applied research, consulting opportunities, and the implementation of innovative teaching methods.

In terms of industry partnerships, digitalization has significantly broadened the scope of collaboration between universities and companies. Previously, such partnerships were often limited to closed, proprietary projects with clear boundaries and objectives, but now, digital tools enable more open and continuous collaboration, breaking down traditional barriers to innovation. Open innovation hubs and virtual research centers have become crucial platforms for co-developing solutions to real-world problems, with companies and universities sharing data, expertise, and resources across digital networks (Perkmann, Walsh, 2007; Becker, Eube, 2018). These collaborative efforts extend beyond research and development, providing industry partners with access to upskilling and reskilling opportunities through online programs and micro-credentials, thus ensuring that their workforce remains competitive in rapidly changing markets (Oliver, 2019).

Moreover, universities are playing an increasingly active role in regional economic development through the establishment of digital innovation hubs and entrepreneurship incubators, which foster collaborations among entrepreneurs, startups, local businesses, and government agencies while offering access to university expertise, technology, and mentorship. (Carayannis & Rakhmatullin, 2014). These hubs serve as dynamic ecosystems where students, faculty, researchers, and external stakeholders collaborate extensively to transform academic research into market-ready solutions, thus contributing to both regional and global economic growth in a meaningful way.

4. Conclusions

In conclusion, the ongoing digital transformation of public universities represents a fundamental shift in how these institutions create and deliver value to their diverse stakeholders. As the landscape of higher education evolves, universities are moving away from traditional, static models of value creation characterized by a Goods-Dominant Logic, which treated education as a linear product to be delivered. Instead, the integration of digital technologies has fostered a more dynamic, service-oriented approach that emphasizes co-creation, collaboration, and real-time engagement with students, faculty, industry partners, and communities. This transition highlights

the university's role as a facilitator of knowledge and innovation rather than a mere provider of degrees.

The literature illustrates that digitalization has broadened the scope of collaboration between universities and external stakeholders, enabling more interactive and participatory relationships. By utilizing digital platforms, universities are now able to engage in open innovation, co-developing solutions to complex challenges alongside industry partners and government entities. This paradigm shift not only enhances the educational experience for students, who benefit from personalized learning and greater access to resources, but also empowers faculty to become active contributors within collaborative knowledge ecosystems. As a result, universities are positioned as integral players in regional and global innovation ecosystems, driving economic development through initiatives such as digital innovation hubs and entrepreneurship incubators.

Digitalization and digital transformation change the ways in which value is offered by universities to their stakeholders, as well as the value itself, prompting a fundamental reevaluation of what it means to educate and innovate in today's society. This shift transcends mere technological adoption, beckoning universities to embrace a more holistic understanding of value that encompasses not only the knowledge imparted but also the relationships fostered within and beyond their walls. As institutions evolve, they are called to consider the broader implications of their missions, recognizing that the pursuit of knowledge is intertwined with ethical considerations, social responsibility, and a commitment to the common good. As universities redefine their roles within this broader framework, they become vital agents of change, facilitating dialogue and collaboration that transcends disciplinary boundaries and fosters a culture of innovation. In doing so, they affirm their commitment to not just advancing knowledge but also to enhancing the collective well-being of society, ultimately enriching the very fabric of the communities they serve. Thus, the of value in higher education emerges not merely from the transmission of knowledge, but from the transformative relationships that universities cultivate through digital innovation.

Ultimately, the digital transformation of universities not only addresses the immediate needs of modern stakeholders but also equips these institutions to adapt to future challenges and

opportunities in an increasingly knowledge-driven economy. By embracing digitalization as a catalyst for innovation and collaboration, public universities can enhance their relevance, effectiveness, and contributions to societal progress, thereby reaffirming their mission as engines of education and economic development in a rapidly evolving world. As they continue to navigate this transformative journey, the potential for universities to redefine their value propositions and fulfill their commitments to diverse stakeholders is both significant and promising.

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Is the Education in Standardization One of the Best Approaches in Training the Next Generation of Experts?

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Abstract

The growing complexity and globalization of industries highlight the crucial role of standardization in ensuring quality, interoperability, and innovation across sectors. Europe needs the best standardization experts to pursue its global standard-setting ambitions to safeguard a digital, green and resilient single market. As industries evolve, the demand for experts well-versed in standards and their implementation becomes increasingly urgent.

The strategic importance of standards requires more attention and promotion. Students do not often get the value of learning about standardization until a later stage of their career. At the same time, the industry, public authorities, and societal stakeholders need experts to assist them in the standardization process. Increasing the incentives for students and universities to engage in standardization depends on market attractiveness and societal perspective on standardization

This paper presents an example of best practice of collaboration between national standardization bodies of Romania, Bulgaria, Universitat Politècnica de València, Spain and University of Life Sciences "King Mihai I" from Timisoara, Romania in developing micro-credential courses. This paper investigates whether the integration of standardization into educational frameworks represents a new and necessary vision for developing the next generation of experts.

Keywords: higher education, curricula, standardization, research, quality assurance.

1. Introduction

In an increasingly globalized and interconnected world, standardization plays a key role in ensuring the interoperability, quality and safety of products and services. Standards provide the framework for industries to operate effectively, facilitating international trade, innovation and competitiveness in global markets. In particular, the European Union (EU) relies on standards to support its ambitions for a digital, green and resilient single market. These standards are essential to ensure a sustainable transition to a green and digital economy, but their success crucially depends on the knowledge and skills of the workforce (Bakhouyi et al., 2017; Balan & Tulcan, 2013; De Vries & Egyedi, 2007; De Vires et al., 2010).

However, despite the obvious importance of the standards, education in this area is often neglected in traditional academic programs. Students often encounter standardization concepts only later in their careers, often in the context of specific job requirements. This lack of early formal education in standardization contributes to a skills gap between market demands and graduate training. As industries rapidly evolve under the pressure of technological innovation, climate change and international regulations, it becomes increasingly urgent to develop well-trained experts who understand and implement these standards (Fiofanova, 2021; Ionescu et al., 2020; National Research Council, Board on Science Education, & Committee on Guidance on Implementing the Next Generation Science Standards, 2015).

In this context, education in standardization becomes not only relevant, but essential. Integrating standardization into the university curriculum can have a significant impact on training the next

generaon of experts. From ensuring quality and regulatory compliance, to supporting innovation and international collaboration, education in standardization can equip future professionals with the skills to navigate a dynamic and competitive global environment. At the same time, students who acquire a solid knowledge of standards are better prepared to meet the challenges of sustainability, safety and efficiency in various economic sectors (Plakhotnik et al.. 2023; Puiu S, 2020).

An example of efforts to integrate standardization education in higher education is the European B-Green-ED project, carried out within the Erasmus+ Program. The project involves collaboration between renowned universities from four European countries: Bulgaria, Spain, Romania and Lithuania, together with national standardization bodies from Romania (ASRO) and Bulgaria (BDS). The project's main aim is to develop innovative micro-credentials that meet the demands of the labor market and support the transition to a green and digital economy. These micro-credentials were designed to provide students and professionals with the opportunity to gain specialized knowledge in critical areas such as carbon footprint assessment, quality management, and bioeconomy. The micro-credential courses have been structured to be flexible, accessible and adapted to the needs of the market, allowing participants to acquire relevant skills in a short period of time, but with a significant impact on their career. The B-Green-ED project thus represented an innovative initiative to integrate standardization in education, meeting both the needs of students and industry (Boosting the green future via university micro-credentials /B-GREEN-ED).

This paper aims to analyze the impact of this initiative on the education and training of the next generation of standardization experts. We will focus on evaluating the results obtained in the pilot courses of the B-Green-ED project and explore how these micro-credentials can contribute to the development of a new educational model focused on standardization. We will analyze the relevance of this educational model for various industries and discuss the benefits and challenges of its implementation in the European and international context.

2. Material and Methods

2.1 Project context

The present study is based on the activities and results of the B-Green-ED project, carried out under the auspices of the Erasmus+ program (KA 220 – Higher Education). This project was coordinated by an international consortium of four universities and two standardization bodies. The main goal of the project was to develop and pilot micro-credentials oriented towards ecological standards and sustainability management, thus addressing the challenges of the transition to a green and digital economy in Europe (Boosting the green future via university micro-credentials /B-GREEN-ED).

The consortium involved the following institutions: Bulgaria- Burgas Free University (BFU) - project coordinator and Bulgarian Institute of Standardization (BDS), Spain- Polytechnic University of Valencia (UPV), Romania - University of Life Sciences"King Mihai I" from Timişoara (USVT) and Romanian Standardization Association (ASRO), Lithuania- Mykolas Romeris University (MRU).

2.2 Purpose and objectives of the study

The main objective of the B-Green-ED project was to support the transition to a European green economy by developing innovative educational practices that include standardization in higher education programs. Through micro credentials, the project aimed to provide students and professionals with the opportunity to acquire specific skills in highly standardized areas such as carbon footprint assessment, bioeconomy risk management, circular economy, environmental and management systems (Boosting the green future via university micro-credentials /B-GREEN-ED).

This study investigates the methodologies used within the project to develop, implement and evaluate these micro-credentials. In addition, we aim to analyze how these courses have contributed to the formation of relevant skills for the labor market and the creation of a workforce prepared for future challenges.

2.3 Development and implementation of micro-credentials

Within the B-Green-ED project, 12 micro-credential courses were developed and piloted, organized by the four partner universities. Desk research on the current state regarding the provision of training on standards, turned out a proposal of 15 areas of interest for standards

learning, grouped in 6 domains, in accordance with the opinions of the experts interviewed, who are active in these fields. The two national standardization bodies, BDS and ASRO, made a research and analysis of European and International standards in the defined areas and domains and proposed 153 standards among which universities have chosen 46 standards to develop the micro-credential courses.

These courses have been structured to cover relevant areas from a standardization and green economy perspective. The **Table 1** shows the titles of the courses implemented in each of the partner countries:

University	Course Title	Standards
BFU (Bulgaria)	*Circular Economy business models and green standards*	CLC/TR 45550:2020, EN 45555:2019, EN ISO 14006:2020, 45554:2020
	Electronics and Communication of Renewable Energy Sources – green standards	EN ISO/IEC 13273-2:2015, EN ISO 50001:2018, EN IEC 62934:2021
	Engineering and Exploitation of Energy Systems – green standards	EN ISO 50001:2018, EN IEC 62933-1:2018, EN ISO/IEC 13273-2:2015
UPV (Spain)	Quality management system standards	ISO 9000:2015, ISO 9001:2015, ISO 9004:2018, ISO 10006:2017, ISO 10007:2007, ISO 18091:2019
	Environmental Management Systems standards	ISO 14001:2015, ISO 14004:2016, ISO 14006:2011, ISO 14031:2013, ISO 14040:2006, ISO 14044:2006
	Waste Management and Industrial Pollution control standards	ISO 24161:2022, ISO 15270:2008, ISO 18601:2013, ISO 18602:2013, ISO 14064-1:2018
USVT (Romania)	Risk management in the bioeconomy	ISO 31000:2018, ISO 31073:2022, IEC 31010:2019, EN IEC 31010:2019, IWA 31:2020, EN ISO 22005:2007
	Carbon footprint assessment	IWA 42:2022, EN ISO 14067: 2018, EN ISO 22526-1:2021, EN ISO 14090:2019, EN ISO 14091:2021
	Biomass and Good Practices in the Management of Degraded and Desertified Lands	EN ISO 17225- 1:2021, ISO 17828:2015, BS EN ISO 18135:2017
MRU (Lithuania)	Andragogic technologies and safe environment	EN ISO 56000:2021, EN ISO 21001:2018, EN ISO 14040:2006,
	Social responsibility and career management	ISO 26000:2010, ISO 21500:2021, ISO 31073:2022, EN ISO 14001:2015
	Social responsibility in family work	ISO 26000:2010, IWA 34:2021

Table 1. Micro-credential courses implemented in the partner countries' universities
Source: Boosting the green future via university micro-credentials /B-GREEN-ED

All micro-credentials have been designed based on a standardized framework, following EU training and certification guidelines (Carțiș A et al.). This framework included essential elements such as learning outcomes, form of participation (online or hybrid), assessment methods and identity verification during assessments. Each course has been structured to provide a clear set of transferable skills, useful for both students and professionals wishing to

specialize in the field of standardization.

2.4 Piloting methodology

The piloting of the micro-credential courses took place over 12 months, within the framework of the international partnership. Each partner university was responsible for organizing and implementing the courses at the national level, involving students and professors from various fields. The courses were conducted online, through e-learning planorms specially developed for this project. In addition, some courses were organized in a hybrid format to facilitate access to participants from diverse geographic areas.

To assess the success of implementation, each partner collected data from participants using satisfaction questionnaires and semi-structured interviews. These questionnaires were structured in three sections:

1. **Course structure and feasibility**– Evaluation of course design and clarity of educational materials.
2. **Relevance and viability of courses**– Evaluation of the relevance of the topics covered for the needs of the labor market.
3. **The quality and efficiency of the courses**– Evaluation of the quality of educational content and the effectiveness of teaching methods.

2.5 Evaluation Indicators

To measure the effectiveness of micro-credential piloting, the following qualitative and quantitative indicators were used:

Qualitative indicators: (1) relevance of courses to industry needs and labor market requirements; (2) the quality of the educational materials, according to the feedback provided by the participants; (3) student satisfaction with course structure and content; (4) effectiveness of teaching methods and transferability of acquired skills.

Quantitative indicators: (1) total number of students enrolled and attending courses; (2) percentage of students who completed courses and earned micro-credentials; (3) number of completed satisfaction questionnaires and degree of participation in end-of-course evaluations.

2.6 Data Analysis

The collected data were analyzed using descriptive statistical methods to assess the level of satisfaction of the participants and the impact of the courses on the acquired skills. The answers to the satisfaction questionnaires were centralized and compared between the partners, in order to identify possible differences in the perception and effectiveness of the courses depending on the national context. In addition, semi-structured interviews with students and faculty provided a more nuanced perspective on the challenges and successes encountered in implementing micro-credentials.

3. Results

Analyzing the data collected in the framework of the B-Green-ED project, we identified a series of determining factors that underline the effectiveness of education in standardization as a method of training the future generation of experts. In this research, multiple perspectives were examined that highlight the relevance and applicability of this approach in various industrial and educational sectors.

Our study focused on evaluating the impact of micro-credential courses, run in partnership with higher education institutions and standardization bodies, on students' professional skills. The feedback and results of the evaluations allowed the identification of eight fundamental reasons that justify the integration of education in standardization as an effective strategy for training professionals able to respond to the demands of the global market.

These reasons reflect the various benefits that standardization education can bring, not only in terms of competitiveness and operational efficiency, but also in supporting innovation, collaboration and compliance with international regulations. Next, we will present and discuss each of these reasons, analyzing their essential contribution to the development of a specialized workforce capable of operating in an increasingly complex economic and technological environment. (**Figure 1**)

3.1. Promoting global skills

Standardization education plays a key role in training the next generation of experts, particularly due to its ability to promote global competencies. In a globalized economy, where products and

services are traded and used internationally, standards provide a common basis for efficient operation and interoperability of systems. Thus, the knowledge acquired through standardization courses is not limited to a local or regional market, but has global applicability (Puiu S, 2020; Romanian Standards Association).

In the B-Green-ED project, students reported a significant improvement in their ability to understand and apply international standards. For example, they learned how to interpret European (EN) and international (ISO) standards, as well as how to implement them in a variety of industrial and geographical contexts. This competence is extremely valuable for companies operating in transnational environments, where compliance with international standards is essential to be able to access foreign markets.

Figure 1. The reasons for the integration of education in standardization in the training of future experts

Source: Original by authors

Furthermore, education in standardization not only provides students with an in-depth understanding of standards, but also prepares them to operate in diverse environments where legislation and regulations vary from country to country. This ability to navigate the various systems of standards and regulayions gives graduates a competitive advantage in the global job market. They thus become more adapted and prepared to manage the challenges associated with

international trade, global supply chains and international compliance requirements (Rosa, 2016; Tyumaseva et al., 2020).

3.2. Stimulating innovation within safe limits

Innovation is an essential component of economic and technological progress, but without clear and rigorous standards, innovation can become a chaotic, incoherent process. Standards provide a stable framework in which innovation can take place in a safe and controlled manner, ensuring that new solutions and technologies are compatible with existing regulations and quality requirements. In this sense, standardization education plays an important role in balancing creativity with regulatory compliance (Comité Européen de Normalisation; Leisyte et al., 2015; Mentel et al., 2020; Plakhotnik et al., 2023; Zaporozhchenko et al., 2022).

A key aspect of the micro-credential courses piloted within the B-Green-ED project was precisely learning how standards can support innovation (Boosting the green future via university micro-credentials /B-GREEN-ED). Students were taught to identify areas in a process or technology where innovation can bring significant benefits without compromising safety, quality or regulatory compliance. For example, in areas such as bioeconomy or carbon footprint assessment, students learned how to innovate methods to reduce ecological impact while respecting international environmental standards.

Education in standardization also helps to develop critical thinking towards innovation, giving future experts a solid knowledge base on the limits and opportunities created by standards. (Comité Européen de Normalisation; Leisyte et al., 2015; Plakhotnik et al., 2023). Although standards provide clear rules and well-defined structures, they do not prevent the development of new technological solutions. On the contrary, they serve as starting points for innovative solutions that are scalable and widely applicable, thus ensuring sustainable and secure development.

Therefore, through education in standardization, students learn not only how to innovate, but also how to do so within safe and efficient limits, thereby contributing to technological progress and the development of solutions that comply with existing regulations and standards.

3.3. Quality and efficiency assurance

One of the most important aspects of education in standardization is the direct link it has with improving the quality and efficiency of processes and products (Comité Européen de Normalisation; Leisyte et al., 2015; Plakhotnik et al., 2023). In any industry, implementing standards helps increase consistency, reduce errors, and ensure compliance with local and international regulations. Students who gain knowledge of standardization are equipped to implement quality assurance processes effectively, which can have a direct impact on an organization's performance.

Through pilot courses developed in the B-Green-ED project, students learned how to apply quality management standards (e.g. ISO 9001) and specific environmental standards (ISO 14001) to optimize organizational processes. They were trained in evaluating and monitoring production and operating processes to identify weaknesses and implement corrective measures based on internationally recognized standards. Thus, education in standardization provided students with a set of tools and methodologies that directly contribute to improving the quality of products and services provided by an organization.

In addition to quality assurance, efficiency plays a central role. Standards help eliminate redundancies and optimize resources, resulting in less time, energy and money. In the project, trainees learned to identify and implement procedures that reduce waste and improve operational efficiency. This is especially essential in sectors such as the bioeconomy and waste management, where resources must be used as responsibly as possible to meet sustainability requirements.

3.4. Improving collaboration and communication

Another major benefit of standardization education is its ability to facilitate effective collaboration and communication between experts from various fields and countries. Standards act as a "common language" between industries and organizations, providing a clear set of rules and specifications that are understood and applied globally. In a world where international collaboration is increasingly common, this common language becomes essential for the success of transnational projects and initiatives (Comité Européen de Normalisation; Leisyte et al., 2015; Mentel et al., 2020; Plakhotnik et al., 2023; Zaporozhchenko et al., 2022).

Through the micro-credential courses, participants in the B-Green-ED project had the opportunity to learn how to collaborate effectively using internationally recognized standards.

For example, bioeconomy students were trained to collaborate with experts from other fields, such as engineering, environment or management, using common quality and sustainability standards. This cross-disciplinary approach created a collaborative learning environment where all participants had a clear understanding of common requirements and objectives.

Moreover, standards facilitate collaboration not only between disciplines, but also between organizations and countries. In international or transnational projects, the use of common standards allows teams from different regions to work effectively together without encountering cultural or technical barriers. Thus, students who have learned to apply standards in international collaborations are better prepared to integrate into global teams and manage complex projects, regardless of the national or cultural context.

3.5. Supporting sustainability and safety

International standards play a key role in supporting sustainability and safety in all economic sectors. Through standardization education, future experts gain the knowledge to create and implement sustainable solutions that comply with environmental regulations and ensure the safety of workers, consumers and communities. These skills are becoming increasingly valuable in a global market that prioritizes the transition to a green economy (Comité Européen de Normalisation; Leisyte et al., 2015; Mentel et al., 2020; Plakhotnik et al., 2023; Zaporozhchenko et al., 2022).

Within the B-Green-ED project, the pilot courses were designed to give students a solid foundation in environmental and safety standards. For example, courses on carbon footprint assessment and bioeconomy risk management provided participants with the necessary tools to assess the impact of human activities on the environment and propose measures to reduce it, while respecting international environmental standards such as would be ISO 14001.

Education in standardization enables students to understand the importance of applying rigorous safety standards in various industries, from manufacturing to construction and high technology. These standards not only protect workers and end users, but also help reduce the risks of accidents, pollution or environmental damage. Through their implementation, future experts are able to contribute to the development of sustainable solutions that comply with the safety and environmental standards imposed by international legislation.

3.6. Preparing for regulatory compliance

Navigating a complex regulatory landscape, both nationally and internationally, is a challenge for many organizations, especially those operating in global markets. Standards provide a clear path to ensure regulatory compliance and avoid risks associated with non-compliance, such as legal sanctions, product withdrawals or reputational damage. Through standardization education, students acquire essential skills to understand and apply the standards required for compliance in various sectors (Comité Européen de Normalisation; Leisyte et al., 2015; Mentel et al., 2020; Plakhotnik et al., 2023; Zaporozhchenko et al., 2022).

The B-Green-ED micro-credential courses directly addressed the issue of compliance, training students to use international standards as tools to navigate complex regulations. For example, participants in risk management and carbon footprint assessment courses learned to implement solutions that comply with European and international greenhouse gas emissions regulations. This knowledge not only prepared them to comply with legislative requirements, but also gave them the opportunity to contribute to reducing the impact on the environment.

In an ever-changing global landscape, regulatory compliance is not only a legal requirement, but also an opportunity to gain a competitive edge in the marketplace. Organizations that implement standards and comply with regulations are better positioned to access international markets and maintain a trustworthy image in the eyes of consumers and authorities. Students educated in the field of standardization understand these advantages and can apply the knowledge gained to ensure compliance of the organizations with which they will work.

3.7. Reducing costs and duplication of effort

One of the major benefits of education in standardization is the ability to reduce costs and eliminate duplication of effort within industrial and organizational processes. By adopting and implementing internationally recognized standards, organizations can avoid the high costs associated with trial and error in product and process development. Standards provide a clear and efficient framework that helps establish optimized working methods and avoid costly and ineffective experiments (Comité Européen de Normalisation; Leisyte et al., 2015; Mentel et al., 2020; Plakhotnik et al., 2023; Zaporozhchenko et al., 2022).

In the B-Green-ED project, students were trained to recognize and capitalize on the economic

benefits of applying standards in various industries. For example, in the quality management and waste management courses, participants learned how to use the standards to optimize production and logistics processes, thereby reducing resource wastage and operational costs. This was particularly relevant for companies aiming to comply with strict environmental regulations and adopt sustainable practices.

Another important aspect of the application of standards is the reduction of redundancies. Standardization avoids the need to develop ad hoc solutions for each project or product, as there are already clear specifications and guidelines that can be followed. This allows companies to save time and resources, especially in international projects, where collaboration between teams from different countries can be simplified thanks to the application of common standards.

3.8. Expanding employment opportunities

In a globalized and dynamic economy, skills related to standardization are becoming increasingly valuable to employers. Education in standardization not only prepares students to comply with regulations and optimize processes, but also provides them with a wide range of skills that broaden their employment opportunities. Understanding and applying international standards is a highly sought-after skill in various industries, from manufacturing and technology to the service sector and public administration (Comité Européen de Normalisation; Leisyte et al., 2015; Mentel et al., 2020; Plakhotnik et al., 2023; Zaporozhchenko et al., 2022).

The micro-credential courses developed under the B-Green-ED project have demonstrated that education in standardization opens doors to a variety of professional opportunities. Students who attended these courses acquired skills that increased their attractiveness on the labor market, as many companies are looking for specialists who understand and can implement the standards needed to access international markets. For example, knowledge of quality management and environmental standards is essential in industries such as the bioeconomy and green energy, where companies must comply with strict regulations.

Moreover, education in standardization provides students with an adaptability that is highly valued by employers. Future professionals become able to quickly integrate into multidisciplinary and international teams using a common language based on clear standards. This makes students educated in standardization extremely versatile and prepared to take up

positions in a variety of fields, from project management to compliance audits and business consulting.

4. Discussions

Although the results of the study indicate numerous benefits of education in standardization, it is important to also consider certain limitations and challenges that have arisen during the implementation of micro-credentialing courses. These shortcomings provide useful insights for further improving educational approaches in this area and extending the positive impact to a wider audience.

One of the limitations of the study is the relatively small sample of students who participated in the pilot courses. Each partner university managed a limited number of trainees, which may influence the ability to generalize the findings to a wider level. Also, the cultural and economic variability between the participating countries (Romania, Bulgaria, Lithuania and Spain) could affect the perception and applicability of standardization education in other national contexts. In addition, micro-credential courses were conducted in a predominantly online or hybrid setting, which may influence the degree of interaction between students and faculty. This teaching method, although flexible, could limit some practical aspects of standardization education, which would require physical interaction or practical exercises to better understand the concrete application of the standards.

In the process of implementing micro-credential courses, one of the major challenges was related to access to adequate educational resources. Since standardization is a technical and specific field, not all teachers had the necessary training to teach this topic effectively, which led to the need for additional training. This aspect can represent a significant obstacle for universities that want to implement similar courses but do not have specific expertise in standardization.

Another challenge was keeping students interested throughout the entire program. Standards, while fundamental to various industries, may seem abstract or complex to students. Finding interactive and dynamic teaching methods was essential to the success of the courses, but it took extra effort on the part of the teachers to integrate these methods into a basic educational framework.

To overcome these challenges and increase the effectiveness of education in standardization, continuous improvement of teaching methodologies is necessary. One solution would be the integration of more advanced technologies, such as interactive simulations, virtual reality or educational games, which could make standardization more accessible and interesting for students. These technologies would allow students to experience concrete application of the standards in a safe and controlled environment.

At the same time, collaboration with industry could be intensified. Currently, partnerships between academia and the private sector are valuable, but there are unexplored opportunities for industry organizations to be more actively involved in the design and delivery of standardization courses. Thus, the courses would become even more relevant to the current needs of the labor market, and students would benefit from practical experiences in direct collaboration with companies.

Although the results of the study suggest significant benefits of education in standardization, their generalization to a wider context should be done with caution. The piloting of the micro-credential courses was carried out in higher education institutions in Europe, and the applicability of this methodology may vary according to educational and industrial systems in other regions of the world. However, the basic principles of standardiza6on educa6on remain relevant and can be adapted to different national or regional contexts.

Although standardization education demonstrates undeniable value in training the next generation of experts, it is important that institutions consider these limitations and challenges in order to maximize its impact and relevance. Proposed improvements and closer collaboration between academia and industry could turn this initiative into an internationally replicable model.

5. Conclusions

Education in standardization is emerging as a fundamental approach for the training of future experts who will have to face the complex challenges of a globalized, digitized and sustainability-oriented economy. Our study, conducted as part of the B-Green-ED project, demonstrated the significant benefits of integrating standardization-focused micro credentials into higher education. Through these courses, students had the opportunity to acquire essential

skills not only for regulatory compliance and quality improvement, but also for promoting innovation and collaboration in interdisciplinary and international environments.

The results of this study clearly indicate that education in standardization should not be seen only as an educational option, but as a necessity for future professionals who will work in key sectors of the economy, such as bioeconomy, engineering, information technology and waste management. The eight reasons identified in our research highlight the diversity of advantages that this form of education can offer: from improving global skills and stimulating innovation within safe limits, to reducing costs and expanding employment opportunities.

However, in addition to these benefits, our study also revealed a number of limitations and challenges that require further attention. First, the limited sample of students and the specific context in which the micro-credential courses were conducted require caution in generalizing our findings internationally. Also, the challenges related to the training of teachersn to teach such a technical and specific field, as well as the difficulties in maintaining students' interest in a subject perceived as abstract, require innovative solutions and more advanced pedagogical methodologies.

Active involvement of industry in the design and delivery of standardization courses is essential to increase their relevance. Partnerships between academia and the private sector must be strengthened to ensure that education in standardization reflects the realities and needs of the labor market. Companies in industry sectors that depend heavily on standards compliance – such as manufacturing, technology and energy – can directly contribute to the development of relevant educational programs and provide students with access to internships and real-world applications of the standards in the business environment.

Another practical direction is the use of advanced technologies to make standardization education more attractive and interactive. Simulations based on virtual or augmented reality, as well as interactive educational platforms, could facilitate applied learning of the standards and increase student interest in this field. These technologies could simulate complex industrial processes where standards are applied in real time, providing students with a safe environment for experimentation and learning.

Based on the results obtained and the limitations identified, there are several future research

directions that can deepen the understanding of the impact of education in standardization on professional and economic development.

- **Extending studies to a larger international sample**. To obtain a more comprehensive picture of the effects of education in standardization, it is necessary to expand the research internationally, involving universities and institutions in other geographical regions. Comparative studies between different educational systems and industries can reveal new insights into the applicability of standardization and the cultural and economic variables that influence the success of this form of education.

- **Long-term evaluation of the impact of micro-credentials**. An important aspect worth researching is the long term evaluation of the impact of standardization education on students' careers. To what extent have the skills acquired through these courses influenced their professional path? What positions do these students occupy within companies and how often do they apply knowledge of standards in their work? Longitudinal studies could provide valuable answers to these questions.

- **Exploring new technologies in teaching standardization**. Another interesting area of research is evaluating the effectiveness of new technologies in teaching standardization. How can teaching methods based on simulations, virtual reality or artificial intelligence be used to improve learning? Future research can investigate how these technologies can be integrated into educational programs to increase student engagement and retention.

- **The impact of university-industry collaboration on the quality of education.** Future research could look in depth at the impact of university-industry collaborations on the quality of education in standardization. To what extent does the involvement of companies in the design of educational programs contribute to their relevance and timeliness? This line of research could highlight good practices and develop new models of collaboration between academia and the private sector.

- **Standardization for new emerging industries**. In the context of rapid changes in the technological and economic landscape, future research could explore the role of education in standardization in emerging industries such as artificial intelligence, blockchain or the circular economy. To what extent are current standards applicable to these new fields, and how can

standards education prepare experts for the unique challenges of these industries?

Education in standardization is an essential element in building a workforce capable of managing the complexities of the global market and meeting the challenges of sustainability, innovation and compliance. Although there are limitations and challenges associated with its implementation, its benefits are undeniable. The future research directions proposed in this paper offer opportunities to deepen and expand our understanding of this vital field, thus contributing to the development of a more efficient, sustainable and compliant economy with international regulations.

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Micro-Credentials and Green Standards – An International Approach of Sustainability Learning

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Abstract

This paper presents the experience gained through the successful implementation of international project B-Green-ED Project (Project No 2022-1-BG01-KA220-HED-000085821) which main objective is to stimulate the European green economy and climate neutrality by developing innovative higher education practices related to the implementation of micro-credential (MC) courses developed in cooperation with European standardization bodies. The developed innovative micro-credential courses have been in line with labor market needs and facilitate the provision of flexible, accessible, and inclusive learning focused on the industry/sector-related environmental, management, and green standards that support the transition to a green and digital economy. The information structure in the micro-credentials template inside the B-GREEN-ED project follows the EU standard for constitutive elements of micro-credentials

proposed by the European Commission Consultation Group. During the B-GREEN-ED project, a set of micro-credentials courses have been developed and piloted. Inside the B-GREEN-ED project, micro-credentials have been conceived as stand-alone activities, though the university partners may consider recognizing univocally a specific set of online courses, depending on their own internal education strategy.

Different surveys have been done to test and check the student's opinion about the micro-credential development and organization. Overall, students believed that micro-credentials provided a competitive advantage in the labor market. Job prospects and career opportunities can be improved using these credentials by demonstrating continuous learning and practical skill application. According to the students, micro-credentials were crucial for fostering a more knowledgeable and skilled workforce, leading to societal advancement.

Keywords: micro-credentials, green economy, standardization, quality assurance.

1. Introduction

The European Commission has recognized the key role standards play on the internal market and internationally, for boosting the competitiveness of the economy and applying innovations, however, the impact of standards is highly dependent on the level of knowledge among the workforce.

The B-Green-ED project (Boosting The Green Future Via University Micro-Credentials) has been funded as an ERASMUS+ KA2 activity (agreement number 2022-1-BG01-KA220-HED-000085821). The project has been developed in 2023-2024 by four High Education Institution (HEI) partners from Bulgaria (Burgaski Svoboden Universitet - BFU), Romania (Universitatea de Științele Vieții „Regele Mihai I" din Timisoara - USVT), Spain (Universitat Politècnica de València - UPV), Lithuania (Mykolo Romerio Universitetas - MRU) and two Standardization Institutions from Romania (Asociația De Standardizare Din Romania - ASRO) and Bulgaria (Bulgarski Institut za Standartizacia - BDS).

The main objective of the project is to boost the European green economy and climate neutrality through the development of innovative HE practices related to the implementation of

micro-credentials designed in cooperation with European standards bodies that meet the market needs and facilitate the provision of flexible, accessible, and inclusive education in relevant industry/sector standards that support the transition to a green and digital economy.

In the framework of this aim the achievement of the following objectives has been foreseen:

- encouragement of innovation in the provision of flexible training opportunities that enhance the existing HE degree programs via the design and development of curricula for micro-credential courses aiming to overcome skills mismatches related to management, environmental and green standards, and standardization;
- supporting the inclusive and resilient remote high-quality learning and teaching through the establishment of a digital learning plaoorm that provides a tailored virtual learning environment that facilitates access to HE, including for those from disadvantaged backgrounds;
- fostering the usage of digital technologies and e-learning standards for the development of high-quality interoperable and re-usable learning content and educational tools;
- strengthening the relation academia-industry to provide more inclusive curricula and more flexible learning pathways that meet market needs with responsiveness and agility.

During the B-Green-ED project, 12 micro-credentials have been implemented, as shown in **Table 1**.

Country	Partner	MC Course Name
Bulgaria	BFU	1st Course (BFU) - Circular Economy, Business Models and Green Standards
		2nd Course (BFU) - Electronics and Communication of Renewable Energy Sources
		3rd Course (BFU) - Engineering and Exploitation of Energy Systems
Lithuania	MRU	1st Course (MRU) -Andragogical technologies and safe environment
		2nd Course (MRU) - Social responsibility and career management
		3rd Course (MRU) - Social responsibility in family work
Romania	USVT	1st Course (USVT) - Risk Management in Bioeconomy course

		2nd Course (USVT) - Carbon footprint assessment
		3rd Course (USVT)- Biomass and Good Practices in the Management of Degraded Lands and Desertification
Spain	UPV	1st Course (UPV) - Quality Management Systems standards
		2nd Course (UPV) - Environmental Management Systems standards
		3rd Course (UPV) - Waste Management and Industrial Pollution Control Standards

Table 1. List of micro-credentials implemented in the B-GREEN-ED project

2. The B-Green-ED Micro-Credential Strategy

In recent years, a trend towards diversification of education provision by higher education institutions can be observed. In addition to traditional bachelor, master or doctoral degree programmes, various new short, more flexible, learner-centered forms of education and training that fit the needs of a wider range of learners have been offered. Also, other public and private providers offer different forms of short-term education and training targeting various groups of learners. This is the response to the changes on the labor market, where a growing number of adults, with a higher education degree or lower, will have to reskill and upskill to fill the gap between the competencies acquired through initial formal learning and emerging knowledge and skills needed. In particular, the COVID-19 crisis has resulted in a substantial increase in demand for various forms of flexible on line continuing education and training offered by higher education institutions and other providers (D.Orr et al, 2020).

These alternative forms of learning are offered under different names (MICROBOL, 2021), leading to confusion and problems with their understanding, recognition and appreciation by prospective learners and employers. This has resulted in an effort, in Europe, to address this issue and develop measures that would allow interested stakeholders to better understand and recognize the value of various forms of short education and training programmes and the resulting credentials, for which the term “micro-credentials” is currently increasingly commonly used. Although the development of various forms of micro-credentials is primarily

market-driven, they are beneficial not only for professionals who would like to update their competences or acquire new competences that would give them a better position on the labor market. Micro-credentials, especially those offered by higher education institutions, bring benefits to students enrolled in traditional degree programmes, complementing or supplementing these programmes, through enhancing students' opportunities to develop transferable skills useful for their future careers.

Micro-credentials also create new opportunities for various groups of non-traditional students – life-long learners. They address the needs of those who would like to enhance their personal competencies and also create pathways into tertiary education for various groups of learners from disadvantaged backgrounds. With the demographic changes observed in Europe, it is of a key importance to create the education offer for elderly people that would allow for active ageing in the digital age. Therefore, offering various short-term forms of learning certified by micro-credentials can be seen as the essential part of the "third mission" of universities and their social responsibility (Carțiș A. et al, 2022).

Micro-credentials have the high potential of social impact. They allow people to maintain and acquire various competences that enable them to participate fully in society, ensure their personal, social and professional empowerment, and thereby create better lives and better opportunities for all. Therefore, micro-credentials are high on the agenda of various political initiatives taking place at the European level. This is reflected in several documents of the European Commission, including:

- the communication on achieving the European Education Area by 2025 (European Commission, 2020);
- the updated Digital Education Action plan (European Commission, 2020);
- New Skills Agenda for Europe (European Commission, 2020).

In this context, it is expected that the significant progress will be made because of the European Universities Initiative with European Universities developing and testing micro-credentials, thereby paving the way for other higher education institutions to follow. In fact, several European Universities alliances, including European Consortium of Innovative Universities (ECIU) and Young Universities for the Future of Europe (YUFE), have already reported some

achievements in this area. High expectations regarding the contribution of the European Universities to the development of micro-credentials have been emphasized in a recent European Commission document for the meeting with rectors of European Universities (European Commission, 2021), where one of its six sections is devoted to the European approach to micro-credentials. In the report of the European Commission Consultation Group (2020), a micro-credential is defined in the following way:

> *"A micro-credential is a proof of the learning outcomes that a learner has acquired following a short learning experience. These learning outcomes have been assessed against transparent standards. The proof is contained in a certified document that lists the name of the holder, the achieved learning outcomes, the assessment method, the awarding body and, where applicable, the qualifications framework level and the credits gained. Micro-credentials are owned by the learner, can be shared, are portable and may be combined into larger credentials or qualifica-ons. They are underpinned by quality assurance following agreed standards".*

An essential part of the micro-credential's framework is the micro-credential template. In this sense, the proposed EU standard for constitutive elements of micro-credentials, introduced by the European Commission Consultation Group, essentially defines elements of a micro-credential template. The information structure in the micro-credentials template inside the B-GREEN-ED project follows the EU standard for constitutive elements of micro-credentials proposed by European Commission Consultation Group (2020). For each one of the micro-credentials, the information shown in **Table 2** has been recorded.

1. Identification of the learner
2. Title of the micro-credential
3. Country of the issuer
4. Awarding body

5. Date of issuing
6. Workload needed to achieve the learning outcomes
7. Level of the learning experience leading to the micro-credential (EQF and/or national qualifications framework)
8. Learning outcomes
9. Form of participation in the learning activity
10. Prerequisites needed to enroll in the learning activity
11. Type of assessment
12. Supervision and identity verification during assessment
13. Quality assurance of the learning content
14. Integration/stackability options

Table 2. Recorded information from each MC course

The European Qualifications Framework (EQF) acts as a translation device to make national qualifications more readable across Europe, promoting workers' and learners' mobility between countries and facilitating their lifelong learning. The EQF system attempts to relate national qualification systems of different countries to a common European reference framework. Individuals as well as employers will be able to use the EQF to better understand and compare the qualification levels of different countries and different education and training systems.

Formally adopted by the European institutions in 2008, the EQF is being put in practice across Europe. It encourages countries to relate their national qualification systems to the EQF so that all new qualifications issued from 2012 carry a reference to an appropriate EQF level. The EQF system has eight reference levels describing what a learner must know, understand and be able to do – "learning outcomes". In EU language, learning outcomes are specified in three categories: knowledge, skills and competences. Levels of national qualifications will be placed at

one of the central reference levels, ranging from basic (Level 1) to advanced (Level 8). As each B-GREEN-ED micro-credential has learning outcomes defined potentially we can assign an EQF level to it by mapping those learning outcomes onto the European Qualifications Framework (EQF). B-GREEN-ED micro-credentials are included inside EQF 7 and 8.

Inside the B-GREEN-ED project, it has been decided that micro-credentials are awarded by individual universities. Therefore, the principles and procedures for quality assurance used by universities (based on internal procedures or national quality assurance mechanisms) have been applied to micro-credentials. This is essential for micro-credentials bearing ECTS points. However, the appropriate quality assurance in line with the Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG) should also be adopted. Regardless of the approach taken, the quality assurance process is the part of the ENHANCE micro-credential description.

It should be considered that the implementation of a complex quality assurance system for joint micro- credentials would be difficult, especially at the beginning of a project. It would, therefore, be more useful to agree on some basic standards and enhance them based on experience gained with pilot implementations. The problem of assuring quality of B-GREEN-ED joint micro-credentials should also be considered in a wider context when exploring future exploitaBon of the micro-credentials developed inside the project.

Inside the B-GREEN-ED project, micro-credentials have been conceived as stand-alone activities, though the university partners may consider recognizing univocally a specific set of online courses, depending on their own internal education strategy.

3. Quality Assurance Measurement. Qualitative and Quantitative Indicators

Quality assurance (QA) is any systematic process determining whether a product or service meets specified requirements. The ISO (International Organization for Standardization) is a driving force behind QA practices and mapping the methods used to implement QA. QA is often paired with the ISO 9000 international standard. The ISO 9000 family consists of the world's best-known standard for quality management systems (QMS), ISO 9001, and a set of supporting standards on quality management, all published by ISO/TC 176 and its subcommittees.

Therefore, the measurement of Quality Assurance in the B-Green-ED projects helps us to guarantee the designing of micro-credentials that are clear of defects and meet the needs and expectations of target groups.

The following qualitative indicators were used to measure the level of the achievement of the objectives:

- relevance of the MC courses regarding the industry/sector skills sets demands and standards as well as the strategic goals and market needs at local/national/international level;
- quality and efficacy of the approaches and tools for information and data collecting;
- level of participation and appreciation of the piloting sessions;
- the quality of the feedback, data, and specific comments and suggestions collected during the piloting;
- level of satisfaction of the stakeholders involved in the piloting;
- transferability of the outcomes (courses and strategies);
- stackability and portability of the MC courses developed.

For evaluating the quality level of the outputs, and the achievement of the objectives the following quantitative indicators were considered:

- the number of target group representatives involved in the piloting;
- the number of questionnaires and data-collecting tools developed;
- the number of micro-credential e-courses' instances piloted and approved;
- the number of higher education micro-credential courses in standardization and management, environmental, and green standards registered in the online B-Green-ED Catalogue.

4. Structure, content and results of the satisfaction surveys for UPV and USVT

The MC courses in UPV and USVT were delivered between March and July 2024. **Table 3** and **Figure 1** provide the information about the exact number of participants in every micro-credential course, as well as the number of the participants in the satisfaction surveys.

	USVT-1	USVT-2	USVT-3	UPV-1	UPV-2	UPV-3
Total number of participants in each course	114	59	55	29	36	41
Total number of participants that completed the satisfaction survey	65	28	25	18	22	27
Ratio of participation in the satisfaction survey	57.0%	47.5%	45.5%	62.1%	61.1%	65.9%

Table 3. Participants and satisfaction surveys for every micro-credential course in USVT and UPV

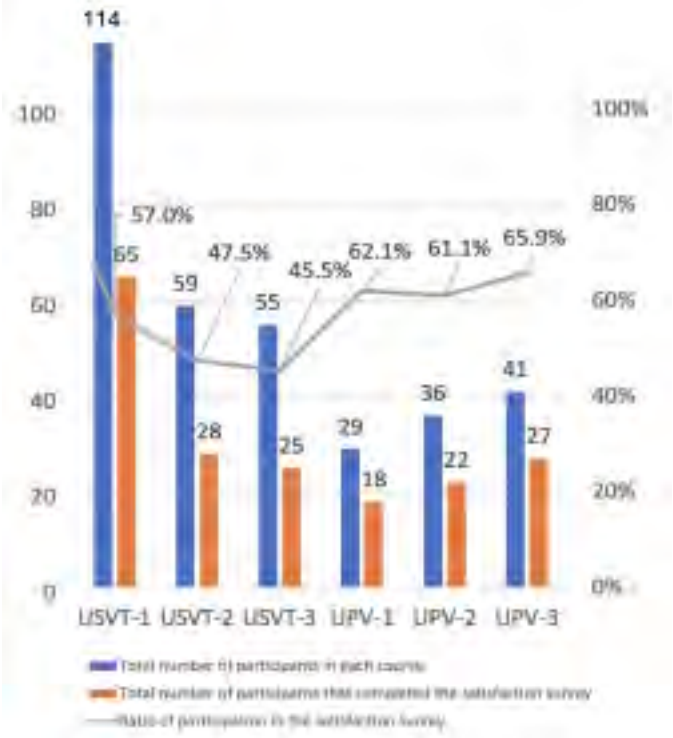

Figure 1. Participants and satisfaction surveys for every micro-credential course

A total number of 334 students have participated in the micro-credential courses organized by USVT and UPV during the B-Green-Ed project, largely exceeding the expectations. Besides, the overall ratio of participation in the satisfaction surveys is 56.51%, which is a very high value that provides robustness to the conclusions of the surveys.

The B-GREEN-ED satisfaction surveys include 11 different questions that are grouped inside 3 sections. Section 1 refers to design, structure, and feasibility and includes the following three questions:

- **Question 1.** - The course was well-designed and satisfied my need to learn more about European and international standards in ecology and management.
- **Question 2.** - The topics covered were relevant to the course, and the information was presented at an appropriate level of complexity.
- **Question 3**. - The micro-credential course has clear instructions and an easy-to-follow navigation structure.

Section 2 refers to relevance, viability, and overall satisfaction about the MC courses, and includes the following three questions:

- **Question 4.** - This micro-credential course was engaging and interesting, providing useful and relevant information for my needs.
- **Question 5.** - Thanks to the course organized into micro-credits, I have a clear understanding of the subject.
- **Question 6.** - My expectations were met in this course organized on microcredits.

Finally, Section 3 refers to suitability, efficacy, and quality of the MC courses, and includes the following five questions:

- **Question 7.** - The course provided me with a significant amount of useful and practice-oriented information
- **Question 8.** - My knowledge and understanding related to the ecological and management standards of the European and international sector/industry addressed in the course improved and expanded.
- **Question 9.** - The online tools and facilities for interacting with my instructor and other classmates are easy to use.
- **Question 10.** - The recommended additional materials and resources are relevant and contribute to a deeper understanding of the concepts.
- **Question 11.** - The educational content was presented in a clear and easily understandable language with an appropriate level of difficulty.

Figures 2, 3 and 4 show the results of the satisfaction surveys organized by USVT and UPV and for sections 1, 2 and 3, respectively.

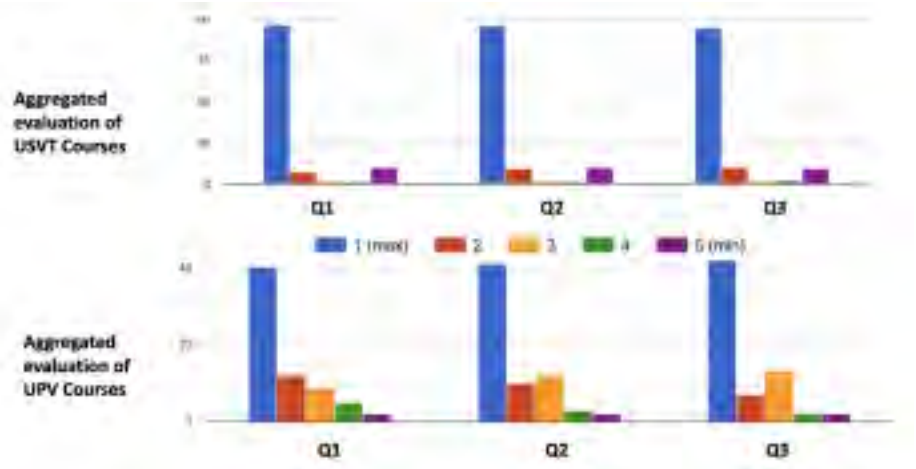

Figure 2. Satisfaction survey results for Q1, Q2 and Q3

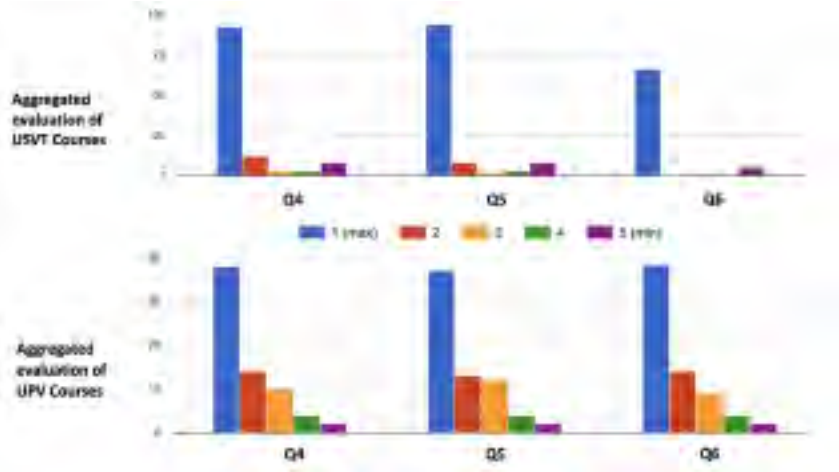

Figure 3. Satisfaction survey results for Q4, Q5 and Q6

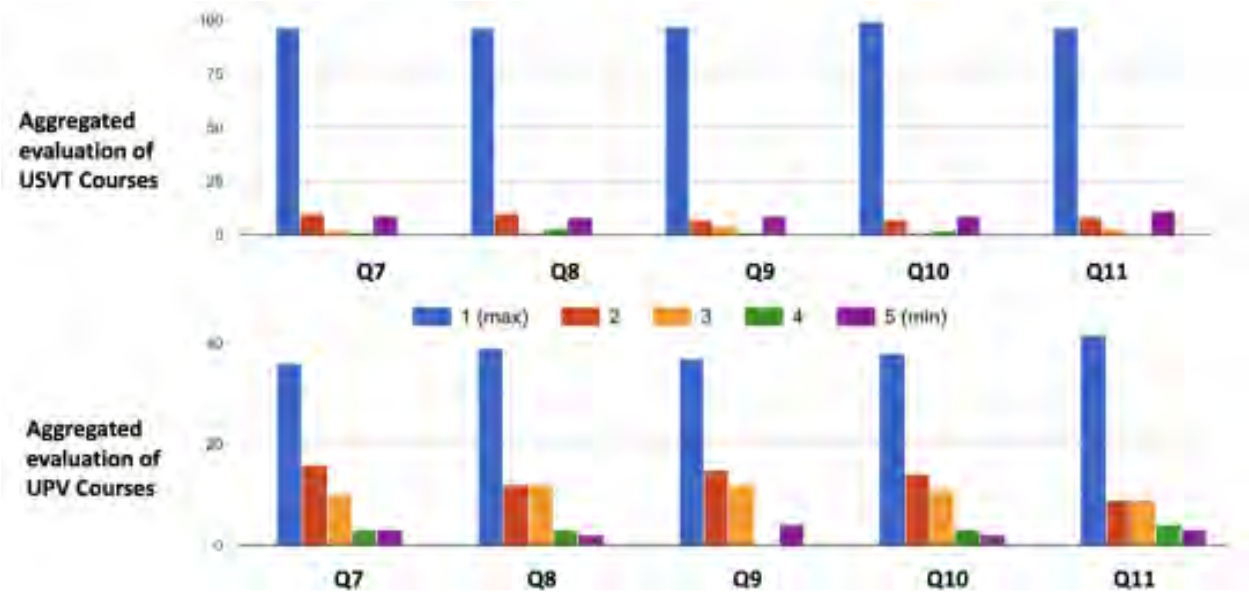

Figure 4. Satisfaction survey results for Q7, Q8, Q9, Q10 and Q11

5. Conclusions and Recommendations

Overall, the B-GREEN-ED courses have been very well-received, but there are still areas where improvements can improve the learning experience for future students. Participants (students, trainees) reported significant gains in specific skills relevant to their fields. They highlighted how these new competencies enhanced their personal and professional capabilities, making it easier to grasp and apply concepts quickly. Trainees pinpointed areas where they can become more engaged and develop berer strategies for learning. The practical and interactive aspects of the courses kept them highly engaged and motivated, encouraging improvements. The results of satisfaction surveys conducted by partner universities revealed several areas where micro-credential courses could be improved.

To enhance the quality of these programs, several recommendations have been put forward. One key area for improvement is the adaptation of course content to the specific needs of students. While the overall course design was well-received, some students expressed that the content did not directly address their specific requirements. To address this, it is recommended to conduct

pre-course surveys to gauge students' prior knowledge and expectations, and to offer multiple course tracks with varying levels of depth or focus on specific areas of interest. Additionally, clearly describing the proficiency level required for each topic within the course can help manage expectations. Another area for improvement is the selection of topics. Some students found the chosen topics to be less relevant to their interests or lacked the desired depth. To address this, it is recommended to examine student feedback to identify well-received topics and those that need improvement, and to consider adding guest lectures or expert interviews from different sub-fields. Additionally, offering students a choice of elective modules can allow them to customize their learning experience.

While the micro-credential format was generally well-received, some students expressed concerns about its effectiveness. To address this, it is recommended to conduct discussions or targeted surveys to gain insight into the reasons for these concerns, and to explore alternative micro-credential structures or add extra learning resources. It is also important to effectively communicate the advantages and learning outcomes associated with the micro-credential format to manage expectations. To enhance the practical application of micro-credential courses, it is recommended to evaluate student feedback to identify areas where the course could benefit from including more hands-on exercises or case studies, and to make explicit the practical skills students will acquire by the end of each module or unit.

Finally, providing additional materials such as industry reports, real-world application examples, or opportunities for project-based learning can enhance the learning experience and provide students with valuable practical experience. Overall, the survey highlighted several areas where the course could be improved to meet the needs of students and improve the learning experience. By implementing these recommendations, micro-credential courses can become even more effective in providing students with the knowledge and skills they need to succeed in the labor market.

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The Intention to Leave: An Overview of the Factors Determining the Turnover from the Teaching Career in the Romanian Education System

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Abstract

To maintain a high level of education quality, schools must attract new and well-prepared teachers while retaining and developing existing and effective ones (Guarino, Santibanez, and Daley, 2006). In this context, the issue of teacher retention becomes an increasingly intense concern, especially since the teaching profession is extremely demanding, generating stress, burnout, and potentially leading to the intention to leave the system (Farber B., 2000). Exhausted, some teachers choose to leave their careers in the early years of activity, others in the middle of their careers, or when they have reached the final stage of professional development. Although working conditions are similar, teachers' responses to stress and its consequences are relatively different (Chang, 2009).

Thus, this study investigates the predictors of the intention to leave, considering the career development stage of Romanian teachers. The study is presented as a comparative analysis, and its main contribution is the understanding of specific factors leading to the turnover from the profession at different career points. The research method used is a sociological survey based on a questionnaire. A total of 194 teachers from the Romanian pre-university education system responded online to a questionnaire that addresses their work experience, including aspects such as working conditions, mindset towards stress, receptivity to distress, degree of emotional

exhaustion, depersonalization, and reduced personal accomplishment, as well as the intention to leave.The data is analyzed using the SPSS program, employing multiple regression analysis to test the effects of each predictor on the intention to leave, depending on the career development stage. The data is analyzed using the SPSS program, employing multiple regression analysis to test the effects of each predictor on the intention to leave, depending on the career development stage.

1. Introduction

Ingersoll (2001) characterizes teaching as a "revolving door through which a large number of teachers leave the job for reasons other than retirement" (Ingersoll, 2001, p. 501). Thus, two types of turnover are identified: involuntary, through retirement or health-related causes, and voluntary. Within the second category, there is a subset of teachers for whom the intention to leave does not mean giving up their career but rather moving to another educational institution. From this perspective, the intention to leave consists of the manifestation of the feeling of staying or leaving the organization, or even the system (Ingersoll, 2001). It should be noted that the intention to leave does not always translate into actual turnover (Rhodes and Doering, 1993), yet it is a predictor of actual turnover. The literature discusses person-job fit and how a strong relationship between the two variables leads to a lower intention to quit (Cable and Edwards, 2004). It is important to consider that a person who expresses the intention to leave but does not act on it now has a high probability of materializing it at some point. Until the actual turnover from the organization, it is likely that the employee will have negative shifts in job performance. As can be seen, there are high costs associated with the intention to leave, up to the costs generated by the actual turnover. The intention to leave is an acute problem in the education system (Ingersoll, 2001), and it has most often been associated in the literature with variables such as stress (Kyriacou, 2001), emotional exhaustion (Leung and Wincy, 2006), and job dissatisfaction stemming from working conditions (You and Conley, 2015). The teaching profession is the only one in which novice teachers have exactly the same responsibilities as experienced teachers (Tait, 2008). Therefore, identifying the factors that predict the intention to

leave based on the career development stage could create support mechanisms for teachers and reduce the costs of turnover, ultimately increasing the quality of education.

2. Literature Review

Rinke shares the idea that teachers' careers are arranged along a continuum, with a series of "entry and exit points" (Rinke, 2008, p. 11). Researching the relationship between working conditions and teachers' intentions to leave at different points in their careers reveals how programs can be developed to increase the chances of retaining teachers in the system. Data shows that 25% of teachers in the USA leave teaching before their third year (Skaalvik and Skaalvik, 2011, p. 1029). Studies conducted by Goddard and Goddar (2006) found that 21% of respondents in a survey of 112 first- and second-year graduate teachers in Queensland schools reported a serious intention to leave their current teaching position, with 12% indicating a serious intention to leave the profession altogether. Studies by Arnup and Bowles (2016) in Australia show that approximately one-third of the teachers in the sample (31.9%) intended to leave the profession. An analysis of available data from 2005 indicated that between 25% and 40% of educators in Western countries resigned within the first five years of teaching (Ewing and Manuel, 2005).

There is extensive research linking teachers' intention to leave with emotional exhaustion. Leung and Lee (2006) state that "Physical exhaustion constituted a major factor in explaining teachers' intentions to leave their jobs" (Weisberg and Abraham, 1999, p. 338). Workplace variables that have significant indirect effects on teachers' intention to leave include job satisfaction, job commitment, and career commitment (You and Conley, 2015). Job involvement and teacher efficacy are positively related to job satisfaction and negatively related to burnout and the intention to leave (Høigaard, Giske, and Sundsli, 2011). The lack of support from the institution and colleagues (Leung and Wincy, 2006), as well as resilience (You and Conley, 2015), also play a role.

Borman and Dowling (2008) conducted 14 studies investigating the relationship between salary and teachers' attitudes towards leaving the education system. They found that low salary significantly predicted the attitude to leave the system, especially among less experienced

teachers (with less than five years of experience) and those with more career experience. The results are also supported in the case of Romanian teachers, according to research conducted by Dumitru and Talpos (2012), which indicates dissatisfaction among Romanian teachers regarding their salaries.

A relevant study for the current research is the one conducted by Sukkyung You and Sharon Conley (2015). The research examines teachers' intention to leave based on their career development stage. In addition to job satisfaction as a moderating factor on working conditions, it introduces work engagement and career commitment. The development stage is operationalized into three stages: novice, early-career teachers, mid-career teachers, and "veterans." Among the workplace variables included are administrative support, autonomy, and student learning motivation. Based on research conducted by Conley and You (2009), Elangovan (2001) tested a conceptual model in which job satisfaction and commitment intervene on workplace variables and influence the intention to leave. The research results indicate that workplace variables have significant indirect effects on teachers' intention to leave through the three mediators. Moreover, the effect of administrative support on work and career commitment was uniform and significant for teachers in the three career groups (You and Conley, 2015). Additionally, mid-career and veteran teachers reported the effect of workplace conditions: greater freedom of action and task autonomy than early-career teachers, contributing to the idea that the relationships between workplace conditions and organizational commitment on the intention to leave are dependent on the career development stage (You and Conley, 2015).

3. Methodology

The main objective of this paper is to identify significant predictors of teachers' intention to leave the Romanian pre-university education system. In this regard, predictors from the areas of organizational, individual, and transactional factors will be tested, as well as the three dimensions of burnout: emotional exhaustion, depersonalization, and reduced personal accomplishment in relation to the intention to leave, considering the differentiation based on career development stage. Organizational factors include predictors such as: overload, learning opportunities, and development opportunities. Individual factors include distress receptivity and

stress mindset, while transactional factors refer to the degree of satisfaction of the needs for autonomy, competence, and relatedness. The aforementioned predictors, subjected to analysis, are independent variables in the research, while the intention to leave is the dependent variable.

Research Hypotheses:

According to Proost, van Ruysseveldt, and van Dijke (2011), when there are many learning opportunities, the intention to leave is low. This means that employees with many learning opportunities in their job are less likely to leave the organization, even if career expectations have not been fully met. Research conducted by Leung and Lee (2006) links teachers' intention to leave to emotional exhaustion, while studies by Høigaard, Giske, and Sundsli (2011) discuss the lack of social support as a predictor of the intention to leave. In light of these studies, we formulated the following hypothesis: H1: We consider that a low volume of learning opportunities, lack of development opportunities, perception of a low degree of satisfaction of basic psychological needs (autonomy, competence, and relatedness), perception of working conditions such as overload, and experiencing the dimensions of burnout (emotional exhaustion, cynicism, and reduced personal accomplishment) predict the intention of teachers to leave the Romanian pre-university education system. Research conducted by Ingersoll (2001), Kyriacou (2001), Ewing and Manuel (2005), Goddard and Goddard (2006), Gavish (2010), Sukkyung You and Sharon Conley (2015) investigating teachers' intention to leave indicates that novice teachers are the most likely to leave their career due to facing a series of stress factors related to learning (Goddard and Goddard, 2006), workload (Kyriacou, 2001), and organizational conditions (Ingersoll, 2001; Elangovan, 2001; Conley and You, 2009). Thus, considering the theoretical findings mentioned, we formulate the following hypothesis: H2: We assume that there are differences between the five groups of teachers regarding the predictors that determine the intention of teachers to leave the Romanian pre-university education system.

Sample Characteristics

In this research, we had 194 respondents, all employed in the pre-university education system. We used snowball sampling, with the research instrument being distributed online and from person to person. The sample consisted of 194 teachers (90.2% women), with an average age of

35 years (SD = 0.998). The distribution of the sample in terms of teaching experience is as follows: 50.5% with teaching experience between 0 and 10 years, 22.7% between 11 and 20 years, 20.7% between 21 and 30 years, 5.7% between 31 and 40 years, and only 1% of teachers with over 40 years of teaching experience. Regarding career development stage, the majority of the sample is represented by teachers with the first degree (36.6%), followed by novice teachers (20.1%), 19.6% with tenure, and the percentage of teachers with the second degree and those with inappropriate qualifications for the position is identical, 11.9%.

N	194	100%
Gender		
Male	175	90,2%
Female	19	9,8%
Age		
18-25	18	9,3%
26-35	65	33,5%
46-55	39	20,1%
56-65	7	3,6%
The environment in which they teach		
Rural	84	43.3%
Urban	110	56,7%
Marital Status		
Married	112	57,7%
Unmarried	66	34%
Level of education		
High School Education	2	1%
Short-term higher education	23	11,9%
Long-term higher education	165	85,1%
PhD studies	4	2,1%
Ciclul de predare		
Kindergarten	15	7,7%
Primary school	81	41,8%
Middle School	50	25,8%
High school	47	24,2%
Post secondary	1	0,5%
Professional degrees		
Novice	39	20,1%
Qualified teacher status	38	19,6%
Didactic level II	23	11,9%
Didactic level I	71	36,6%
	23	11,9%

Without qualifications corresponding to their position		
Sector of activity		
Public	180	92,8%
Private	14	7,2%

Table 1. Demographic Characteristics of the Sample Participants

Research Method

Research Instruments. The research method used is the sociological survey based on a questionnaire. The research instrument consists of a battery of standardized and internationally validated tests, some of which are also validated on the Romanian population (MBI, NSW, and Distress Receptivity), forming a 78-item questionnaire. The questionnaire was distributed online via the Google Forms platform.

The phenomenon of burnout is defined as a "tripartite symptom," composed of the following three dimensions: emotional exhaustion, depersonalization, and reduced personal accomplishment. Considered a response to long-term stress, the phenomenon of burnout in teachers is highlighted by "physical, emotional, and attitudinal exhaustion" (Cunningham, 1983). Emotional exhaustion consists of prolonged feelings of fatigue, depersonalization refers to treating interlocutors as impersonal objects, and reduced personal accomplishment involves a negative self-evaluation by the teacher. In measuring burnout phenomena, we used the Maslach Burnout Inventory (Schaufeli, Bakker, and Demerouti, 1996) (The Maslach Burnout Inventory - General Survey), which contains 16 items scored using a 7-point Likert scale, where 1 means "never" and 7 means "daily." The dimension of emotional exhaustion is allocated 5 items, including "I feel emotionally drained from my work," with a Cronbach's Alpha reliability coefficient of $\alpha = .86$ for our sample of participants (N=194). The cynicism dimension is allocated 6 items, including "I doubt the significance of my work," with a Cronbach's Alpha reliability coefficient of $\alpha = .76$. The final dimension, reduced personal accomplishment, has 5 items, including "I am not effective in solving problems that arise in my work," with a Cronbach's Alpha reliability coefficient of $\alpha = .84$.

Overload is understood in its complexity when viewed from two perspectives: qualitative and quantitative. The former refers to demands that do not consider the academic abilities of teachers, requirements for conflict management, or student motivation, while quantitative overload concerns aspects related to workload and working conditions. In measuring this variable, we used the role overload subscale from the Occupational Stress Index, which includes 4 items, such as "I have to do a lot of work at this job." Scoring was done on a 5-point Likert scale, where 1 means "Strongly Disagree" and 5 means "Strongly Agree." The Cronbach's Alpha reliability coefficient for our sample of participants (N=194) is $\alpha = .83$. Learning opportunities refer to those contexts facilitated by the organization regarding learning. In measuring this variable, we used the "Learning Opportunities" subscale from the Questionnaire on the Experience and Assessment of Work (QEAW) (Veldhoven and Meijman, 1994). Scoring was done using a 4-point scale where 1 means "always" and 4 means "never." With a total of 4 items, including "Do you learn new things at work?", the Cronbach's Alpha reliability coefficient for our sample of participants (N=194) is $\alpha = .83$.

Development opportunities refer to aspects related to career progression, and to measure these, we used the "Opportunities for Development" subscale from the Job Demands-Resources Questionnaire (Bakker and Demerouti, 2014). The subscale consists of 3 items, including "In my work, I have the opportunity to develop my strengths," with a Cronbach's Alpha reliability coefficient of $\alpha = .81$ for our sample of participants (N=194).

The three basic psychological needs postulated by self-determination theory: autonomy, competence, and relatedness (Deci and Ryan, 2000) are considered innate. When these needs are satisfied, they lead to self-motivation and mental health, but their dissatisfaction results in diminished activity and well-being. The need for autonomy refers to the necessity to act with a sense of will and choice (Van den Broeck, Ferris, Chang, and Rosen, 2016; Vansteenkiste, Niemiec, and Bart, 2010). The need for competence is defined as the need to feel a sense of control over the environment and to develop new skills (Deci and Ryan, 2000). Meanwhile, the need for relatedness is defined as the need to feel connected to others, which is satisfied when individuals feel they are part of a group, experience a sense of communion, and develop close relationships (Deci and Ryan, 2000). To quantify the data, we used the Need Satisfaction at Work

Questionnaire (NSW) developed by Anja Vanden Broeck and colleagues (2010), culturally adapted in Romania by Lavinia Țânculescu and Dragoș Iliescu (2014). The questionnaire has a total of 18 items, with 6 for each dimension. For example, "At work, I feel like I am part of a group" for the relatedness dimension, which has a Cronbach's Alpha reliability coefficient of α = .80 for our sample of participants (N=194); "I have the necessary skills to be a good employee" for competence, with a Cronbach's Alpha reliability coefficient of α = .85; and "I feel at ease at work" for the autonomy dimension, with a Cronbach's Alpha reliability coefficient of α = .80. Scoring was done using a 5-point Likert scale, where 1 means "strongly disagree" and 5 means "strongly agree."

Receptivity to distress is a characteristic of emotional intelligence defined as the tendency to become upset when someone else is upset. It is considered a precursor to the phenomenon of burnout and is included in the category of individual factors in the research. This variable was measured using the Responsive Distress scale, which is part of the International Personality Item Pool (IPIP), culturally adapted by Iliescu, Popa, and Dimache (2015). With a total of 10 items, including "I am deeply moved by the troubles of others," scoring is done on a 5-point Likert scale, where 1 means "very inaccurate" and 5 means "very accurate." The Cronbach's Alpha reliability coefficient for our sample of participants (N=194) is α = .80.

The way stress is perceived is considered a predictor of burnout in the research. This variable refers to how teachers view stress, evaluating the nature of stress itself as enhancing or debilitating (Crum, Salovey, and Achor, 2013). Thus, it offers a new approach to stress without denying its long-term negative effects. To measure this variable, we used the Stress Mindset Measure, which contains 8 items, including "The effects of stress are negative and should be avoided." Scoring was done using a 5-point Likert scale, where 0 means "strongly disagree" and 4 means "strongly agree." The Cronbach's Alpha reliability coefficient for our sample of participants (N=194) is α = .78.

Intent to leave consists of the manifestation of the feeling of staying or leaving the organization, or even the system (Ingersoll, 2001). To measure this variable, we used the Intent to Leave scale developed by Mobley, Horner, and Hollingsworth (1978), which contains 3 items, including "I often think about leaving the organization I work for." Scoring was done on a 5-point Likert

scale, where 1 means “strongly disagree” and 5 means “strongly agree.” The Cronbach’s Alpha reliability coefficient for our sample of participants (N=194) is $\alpha = .93$.

Career development stage is operationalized by grouping teaching staff into the following categories: without appropriate studies for the position (teachers occupying a substitute position without having studies in accordance with the position they occupy), beginner, with tenure, second degree, and first degree.

Data collected from the 194 respondents were analyzed using the SPSS program. In the first stage, correlations between variables were made, and then the group separation filter was applied according to the career development stage of the teaching staff, and the correlations between variables were redone. Subsequently, multiple regression procedures were performed.

4. Results and Discussions

In analyzing the hypotheses, we used multiple regression analysis as the statistical procedure. Initially, we refer to the entire population in the sample, and then we will compare the groups based on the criterion of career development stage. The dependent variable is the intention to leave, while the independent variables include the burnout construct and its three dimensions, the three basic psychological needs (need for autonomy, competence, and relatedness), workload, development opportunities, and learning opportunities, all introduced simultaneously. We excluded the variable of distress receptiveness as it did not correlate with the dependent variable. The strongest correlation is with the burnout phenomenon at the construct level ($r = .57$, $p < .01$). It is important to note that all variables present high-intensity statistical correlations, except for the way stress is reported, which shows a low-intensity negative correlation ($r = -.16$, $p < .05$). After the dimensions of the burnout phenomenon, the strongest negative correlations ($p < .01$) with the intention to leave are related to the needs for autonomy ($r = -.46$) and competence ($r = -.40$), followed by development opportunities ($r = -.34$). Meanwhile, strong but positive correlations ($p < .01$) are indicated by the variables of learning opportunities ($r = .42$) and workload ($r = .36$).

The multiple linear regression analysis generated three models to explain the intention to leave. The first model proposes cynicism as an independent variable $F_{change}(1,192) = 69.80$, $p < .001$, which explains 27% of the criterion's variance. The introduction of the second variable into the

model, the need for autonomy Fchange (1,191) = 15.84, p < .001, accounts for an additional 6% of the variance in the intention to leave. The third model includes the variable of emotional exhaustion Fchange (1,190) = 8.56, p < .01, contributing an additional 3% to the criterion's variance. The model that best explains the intention to leave among teachers, according to **Table 2**,is model 3. This model explains 35% of the occurrence of the intention to leave among teachers as a result of a high level of cynicism (β = .26, p < .001), unsatisfied need for autonomy (β = -.22, p < .01), and emotional exhaustion (β = .23, p < .01). The research hypothesis is partially validated; according to the third model, the predictors of the intention to leave are cynicism, the need for autonomy, and emotional exhaustion. The variables: workload, learning opportunities, development opportunities, reduced personal accomplishment, and the needs for competence and relatedness, although they present correlations with the intention to leave, are not included in the models generated for the entire sample.

Variabila	B	*T*	*p*	*R*	R^2	ΔR^2
Model 1				.52	.27	.27
Cynicism	.52	8.37	.001			
Model 2				.57	.32	.6
Cynicism	.38	5.58	.001			
Need for autonomy	-.27	-3.98	.001			
Model 3				.59	.35	.3
Cynicism	.26	3.36	.001			
Need for autonomy	-.22	-3.14	.002			
Emotional exhuastion	.23	2.93	.004			

Note: *p < .05, **p < .01, ***p < .001

Table 2. Regression Models between Predictors of Intention to Leave and Intention to Leave (N=194)

In investigating the second hypothesis, to determine differences regarding the intention to leave among teachers, using the career development stage as a criterion, we will first correlate the predictor variables with the intention to leave, and in the second stage, we will repeat the

multiple regression analysis, separating the groups. According to this, regarding novice teachers, the strongest positive correlations ($p < .01$) are with the dimensions of the burnout phenomenon: emotional exhaustion ($r = .52$), cynicism ($r = .65$), and reduced personal accomplishment ($r = .62$), as well as with learning opportunities ($r = .45$). There is also a positive correlation with workload, but of low intensity ($r = .32$, $p < .05$). The only negative correlation is with the need for autonomy ($r = -.52$). For teachers with qualified status, we have the same correlations as in the previous category, with variations in the scores; however, in the section on strong negative correlations ($p < .01$), the need for relatedness ($r = -.55$) is added. In the case of didactic level II certification, the differentiation appears in the correlation with the need for competence ($r = -.59$), while workload no longer shows correlations with the intention to leave, and for learning opportunities, the correlation exists but is statistically weaker ($r = .47$, $p < .05$). The correlation analysis between predictor variables and the intention to leave for didactic level I presents the variable of development opportunities as an important predictor ($r = -.51$, $p < .01$), while the correlation with workload is strong statistically ($r = .47$, $p < .01$). Regarding teachers without qualifications corresponding to their positions, strong positive correlations ($p < .01$) are recorded with the dimension of cynicism ($r = .58$). Positive correlations, but of low intensity, are recorded in relation to learning opportunities ($r = .45$, $p < .05$) and with the burnout phenomenon at the construct level ($r = .51$, $p < .05$). Within this category, the intention to leave records a strong statistically significant negative correlation with development opportunities ($r = -.58$, $p < .01$).

Before conducting the regression analyses, as mentioned in the analysis of hypothesis number 2, we will discuss the results of the MANOVA test. According to the test results ($F (4, 189) = 2.86$; $p = .025$; partial $\eta^2 = .57$), we observe that the professional degrees has a statistically significant effect on the intention to leave. The analysis shows that the mean scores were statistically significantly different between teachers with didactic level I and novice teachers ($p < .005$), with the dependent variable being the intention to leave, but not with the other categories: didactic level II certification ($p = .171$), with qualified teacher status ($p = .021$), and without qualifications corresponding to their positions ($p = .095$). The test measures the variation of means; our hypothesis focuses on the predictors; however, the test results provide an interesting

perspective, considering that these categories, between which differences were recorded, are located at opposite ends of the career development continuum.

Table 3 presents the intention to leave models for each category of teachers. For the first category, two models were generated. The first model has cynicism as the independent variable (the second facet of the burnout phenomenon) Fchange (1,37) = 27.58, $p < .001$, and explains 43% of the variance in the intention to leave. The second model adds the variable of the need for autonomy Fchange (1,36) = 9.04, $p < .01$, accounting for an additional 12% of the variance in the criterion. Model 2 explains the intention to leave among novice teachers by 54% through the presence of cynicism ($\beta = .55$, $p < .001$) and the unsatisfied need for autonomy ($\beta = -.36$, $p < .01$).

Regarding the intention to leave for teachers with qualified teacher status, two models were generated. The first introduces the need for relatedness as an independent variable Fchange (1,36) = 15.89, $p < .001$, explaining 31% of the variance in the criterion. Model 2 introduces the variable of emotional exhaustion Fchange (1,35) = 4.57, $p < .05$, adding 8% to the variance in the intention to leave. Thus, the intention to leave among teachers with qualified teacher status is explained by the lack of the need for relatedness ($\beta = -.35$, $p < .05$) and the perception of emotional exhaustion ($\beta = .35$, $p < .05$) by 39%. For didactic level II certification, the first independent variable predicting the intention to leave is reduced personal accomplishment Fchange (1,21) = 17.82, $p < .001$, accounting for 46%. The introduction of the variable of the need for competence Fchange (1,20) = 5.11, $p < .05$, leads to a significant increase in R^2 by 11%. Thus, for didactic level II certification, the intention to leave is explained by 57% due to the perception of reduced personal accomplishment ($\beta = .52$, $p < .01$), along with the unsatisfied need for competence ($\beta = -.37$, $p < .05$). In the case of teachers with didactic level I, regression analysis generated three models. The first proposes the need for autonomy as the independent variable Fchange (1,69) = 26.74, $p < .001$, explaining 28% of the intention to leave. The second model introduces the variable of development opportunities Fchange (1,68) = 10.58, $p < .01$, accounting for 10% of the variance in the criterion. The introduction of the variable of workload into model 3 Fchange (1,67) = 6.70, $p < .05$ leads to a 6% increase in the model's explanatory power.

Therefore, for teachers with didactic level I, the intention to leave is explained by the unsatisfied need for autonomy (β = -.30, p < .05), the lack of development opportunities (β = -.37, p < .001), and the presence of workload (β = .29, p < .05), accounting for 43%.

For teachers without qualifications corresponding to their positions, the analysis presents a single model explaining the intention to leave due to the lack of development opportunities (β = -.58, p < .001), accounting for 34%.

Variabila	B	*T*	*p*	*R*	R^2	ΔR^2
Novice Teachers						
Model 1				.65	.43	.43
Cynicism	.65	5.25	.001			
Model 2				.74	.54	.12
Cynicism	.55	4.60	.001			
Need for autonomy	-.36	-3.01	.005			
Qualified teacher status						
Model 1				.55	.31	.31
Need for relatedness	-.55	-3.99	.001			
Model 2				.62	.39	.08
Need for relatedness	-.35	-2.16	.038			
Emotional exhaustion	35	2.14	.040			
Teachers with didactic level II						
Model 1				.68	.46	.46
Reduced personal accomplishment	.68	4.22	.001			
Model 2				.75	.57	.11
Reduced personal accomplishment	.52	3.17	.005			
Need for competence	-.37	-2.26	.035			
Teachers with didactic level I						
Model 1				.53	.28	.28
Need for autonomy	-.53	-5.17	.001			
Model 2				.61	.38	.10
Need for autonomy	-.38	-3.51	.001			
Development opportunities	-.35	-3.25	.002			

Model 3				.66	.43	.6
Need for autonomy	-.30	-1.67	.029			
Development opportunities	-.37	-3.59	.001			
Workload	.29	2.59	.012			
Teachers without Qualifications						
Model 1				.58	.34	.34
Development opportunities	-.58	-3.30	.003			

Notă. $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

Table 3. Regression Models between Predictors and Intention to Leave Based on the Career Development Stage of Teachers

According to the models resulting from the regression analyses, significant differences are observed regarding the predictors in the models that predict the intention to leave for each category of teachers. Therefore, the second hypothesis of the research is confirmed.

5. Conclusions

The first hypothesis of the research is partially validated; the predictor variables: workload ($r = .38$, $p < .001$), learning opportunities ($r = .42$, $p < .001$), development opportunities ($r = -.34$, $p < .001$), reduced personal accomplishment ($r = .46$, $p < .001$), and needs for competence ($r = -.29$, $p < .001$) and relatedness ($r = -.40$, $p < .001$), although they show correlations ($p < .001$) with the intention to leave, are not included in the models generated for the entire sample. The partial validation is also given by the predictors that make up the dimensions of cynicism and reduced personal accomplishment. The intention to leave among teachers is determined by a high level of cynicism ($\beta = .26$, $p < .001$), the unsatisfied need for autonomy ($\beta = -.22$, $p < .01$), along with emotional exhaustion ($\beta = .23$, $p < .01$). Our study findings are consistent with those conducted internationally, which include emotional exhaustion (Lee, 2006) as a predictor of the intention to leave, as well as the perception of low autonomy (You & Conley, 2015). The intention to leave among Romanian teachers is due to their experience of cynicism, making them disengaged from their students. Furthermore, they do not feel autonomous; the lack of satisfaction with the need for autonomy in the education system is attributed to excessive centralization and limited

decision-making discretion. In addition, the emotional exhaustion that teachers experience is due to the heavy responsibilities associated with the lack of autonomy.

Regarding the second hypothesis, the results confirm the existence of different predictors that make up the regression models, thus explaining the intention to leave. For example, for novice teachers, the emergence of the intention to leave is explained by 54% through the presence of cynicism ($\beta = .55$, $p < .001$) and the unsatisfied need for autonomy ($\beta = -.36$, $p < .01$). In the case of teachers with qualified teacher status, the lack of the need for relatedness ($\beta = -.35$, $p < .05$) and the perception of emotional exhaustion ($\beta = .35$, $p < .05$) explain the intention to leave by 39%. As we can observe, the unsatisfied need for relatedness is a very strong predictor; teachers with qualified teacher status do not feel like members of the group, as their sense of relatedness is deficient. The emotional exhaustion they feel may stem from a lack of perceived social support, highlighted by the unsatisfied need for relatedness, ultimately leading to the intention to leave the system. For didactic level II certification, the intention to leave is explained by 57% due to the perception of reduced personal accomplishment ($\beta = .52$, $p < .01$), along with the unsatisfied need for competence ($\beta = -.37$, $p < .05$). Teachers didactic level I II certification choose to leave their profession because they feel ineffective, which is due to the lack of autonomy and the high level of learning opportunities, as well as their perception of not feeling competent. It is contrasting how professionals at this point in their careers intend to leave their careers because they consider themselves ineffective, given that they report a large number of learning opportunities. The presence of the variable of learning opportunities in this model draws attention to the need to evaluate the training offered to teachers, as well as their perceptions of professional learning. For teachers with didactic level I, the intention to leave is explained by the unsatisfied need for autonomy ($\beta = -.30$, $p < .05$), the lack of development opportunities ($\beta = -.37$, $p < .001$), and the presence of workload ($\beta = .29$, $p < .05$), accounting for 43%. Being at the far right of the career continuum, teachers with didactic level I have few development opportunities while the work procedures remain the same. Moreover, at the organizational level, they are assigned the responsibility of coordinating methodological committees and mentoring novice teachers, which contributes to the perception of workload. All of these factors lead to the intention to leave the profession due to the relatively few development prospects.

Considering the results of the MANOVA test, which shows a statistically significant variation regarding the intention to leave between didactic level I certification and novice teachers, we believe it is necessary to make a few clarifications. The regression models for the two categories share a common element, the unsatisfied need for relatedness, but show differences regarding the other predictors. Thus, while for novice teachers we discuss the second dimension of the burnout phenomenon, cynicism, determined by the perception of a large volume of learning opportunities and a debilitating way of reporting stress in explaining the intention to leave, in the case of didactic level vI certification, the predictors are the lack of development opportunities and the perception of workload. What we can observe in this regard is that the variation of means does not determine the variation of the predictors; however, the difference between the models is evident. For teachers without qualifications corresponding to their positions, the analysis presents a single model explaining the intention to leave due to the lack of development opportunities ($\beta = -.58$, $p < .001$), accounting for 34%. As mentioned, teachers without qualifications corresponding to their positions cannot advance in their teaching careers without completing their educational training in the field in which they teach. The impossibility of development increases the likelihood of withdrawing from the profession.

Understanding the factors that can determine teachers' intention to leave can contribute to the development of measures and educational policies sensitive to the differences among teachers that ultimately help retain them. Retaining teachers is not an end in itself; there is a need for incentives that will enhance their motivation, specialization level, and that will manifest globally in increasing the quality of education.

The research has certain limitations that should be mentioned. Firstly, we are discussing a cross-sectional study, which does not allow for causal inferences. We note in this context that the research instrument was applied prior to the moment of change generated by the pandemic, and as a result, it is likely that these results have changed currently. Another limitation of the research that we want to mention is related to the sample and the sampling technique. Although we have about 1% of the teaching population in the research, which means a valid percentage, the sampling technique, the snowball technique, has led to the formation of unequal groups based on the career development stage. Last but not least, we are talking about a broad field of research at

the international level; our research was able to highlight only a few aspects, but these aspects were considered important given the objectives and purpose of the study.

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Transforming Higher Education: How Generative AI Might Revolutionize Learning and Teaching

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Abstract

In recent years, the rise of artificial intelligence (AI), particularly through the widespread adoption of generative AI, has significantly impacted various aspects of society, including the economic, educational, and cultural spheres, both in professional and personal contexts. This rapidly evolving technology is poised to become as ubiquitous as smartphones, transforming many aspects of daily life, including how we teach and learn.

Such rapid developments in emerging technologies are generating significant responses from educational actors. From raising concerns to adopting AI for teaching and learning activities, the challenges, limits, risks, barriers, and opportunities of using AI in higher education are becoming central topics of discussion, highlighting its potential for meaningful impact.

This paper aims to investigate how prepared the education system is to face these opportunities and challenges, from both students' and teachers' perspectives. Additionally, we seek to understand the role of other educational actors and stakeholders in enhancing the implementation and use of AI, both in educational contexts and beyond.

Keywords: generative AI, teaching, learning, (higher) education

1. Introduction

The education sector has consistently encountered various challenges, a fact extensively documented in previous studies, including our own contributions (Grosseck & Malita, 2016, Grosseck, Malita & Bran, 2019, Malita, 2008). Over the past two to three decades, the rapid pace of technological advancements has exacerbated these challenges, leading educators to reconsider their teaching methods and integrate emerging technologies into their practices.

Artificial intelligence (AI), particularly generative AI (gAI), is now poised to transform many industries, with education being one of the most significantly impacted. In this sector, AI is both a source of innovation and a cause for concern. Generative AI, a subset of AI designed to create new content—whether text, images, or complex algorithms—has the potential to streamline educational processes by facilitating personalized learning experiences and introducing novel teaching methods. However, it also raises important concerns about academic integrity, equitable access, and the evolving role of human educators in an increasingly AI-driven world.

The integration of AI in education extends beyond the interactions between teachers and students. Institutional leaders, policymakers, and technology developers must actively engage in shaping a system that ensures the ethical and effective use of AI in educational settings. Their involvement is critical to maintaining high standards of education and preserving the integrity of the academic environment, even as AI technologies become more prevalent.

While AI holds the potential to revolutionize education, careful implementation is required to mitigate risks such as academic dishonesty and the erosion of critical thinking. It is essential that AI to be integrated in ways that enhance the educational experiences without compromising core values such as creativity, independence, and ethical responsibility.

This paper seeks to explore how prepared the education system is to meet these new challenges and opportunities brought by the integration of AI into teaching and learning processes. The focus will be placed on the perspectives of two key groups: students and educators, highlighting their experiences and responses to the growing presence of AI in education.

2. Challenges and opportunities of AI in education

The integration of artificial intelligence (AI) into education has sparked significant debate among educators, students, and policymakers. While AI presents numerous benefits, it also introduces several challenges, limitations, risks, and barriers that must be carefully considered in its adoption for teaching and learning processes.

AI has demonstrated great potential in enhancing personalized learning, increasing student engagement, and automating administrative tasks. However, as Annuš (2023) pointed out, important questions remain regarding the ethical implications and long-term consequences of AI in education. One major challenge is ensuring academic integrity. Advanced AI systems, such as generative AI models, can generate sophisticated content, raising concerns about plagiarism and the authenticity of student work. As educators struggle to find effective ways to assess student learning in the context of AI-generated content, there is an increasing demand for clearer guidance on the ethical use of AI tools, along with policies designed to protect the integrity of academic work.

Another critical issue, as highlighted by Sanusi et al. (2023), is the digital divide. This refers to the unequal access to AI tools and technologies across different educational settings. While some students and institutions can afford cutting-edge, AI-driven platforms, others may lag behind due to financial or infrastructural constraints. This disparity is likely to exacerbate existing inequalities, particularly in underprivileged or rural areas where access to high-speed internet and advanced technology is limited.

Despite these challenges, AI offers considerable opportunities to enhance learning. Personalized learning systems, for example, can tailor educational content to individual student needs and learning styles, allowing students to progress at their own pace. Elshamly and Gameel (2023) found that such adaptive learning systems have significantly improved student outcomes, particularly for those who struggle in traditional classroom environments. These systems, ranging from intelligent tutoring platforms to virtual teaching assistants, handle routine tasks and provide immediate feedback on basic concepts, freeing educators to focus on higher-order teaching responsibilities, such as fostering critical thinking and problem-solving skills (Ali et al., 2024).

However, the adoption of AI in education also requires educators to overcome a steep learning curve. Many teachers, as recent studies have shown (i.e. Dimitriadou & Lanitis, 2023), feel unprepared to introduce AI into their classrooms and express a strong need for professional development in this area. This raises concerns about how far educational institutions are willing to go to support and upskill teachers, ensuring they are equipped to manage the complexities of an AI-enriched learning environment.

As AI continues to rise in education, it brings with it both significant challenges and promising opportunities. The key lies in striking a balance between leveraging AI's benefits and addressing its risks. Among the critical issues to resolve are those related to academic integrity, equitable access to technology, and the preparedness of teachers for the effective and ethical use of AI. As Ali et al. (2024) suggest, if integrated thoughtfully, AI has the potential to revolutionize teaching and learning, fostering deeper student engagement and success without compromising the core principles of the academic process.

3. The role of AI stakeholders in education

The successful integration of AI into educational systems largely depends on the collaboration and preparedness of various stakeholders, including educators, students, policymakers, and technology developers. Each of these groups plays a distinct but vital role in shaping how AI technologies are adopted and utilized in teaching and learning environments. Given the complexity of AI adoption, it is essential for stakeholders to understand not only the technology itself but also its broader implications for pedagogy, academic integrity, and institutional policies. Educators are at the forefront of AI usage in the classroom, yet the learning curve can be challenging. Teachers need to acquire new skills and knowledge to effectively integrate AI into their pedagogical practices, whether it's learning how to use adaptive learning systems, virtual assistants, or AI-driven assessment tools. However, as Aljuaid (2024) highlights, many educators are not adequately prepared for this transition. A lack of professional development in AI-related technologies often prevents teachers from fully leveraging AI's potential for personalizing learning or automating routine tasks. Therefore, targeted training programs at the institutional

level are essential to build educators' confidence and competence in using AI technologies in their classrooms.

Students, as the primary users of AI tools, are central to the integration process. They benefit from AI's ability to provide customized learning experiences, with the technology adapting to their pace and delivering personalized content and support. However, as Moroianu, Iacob, and Constantin (2023) point out, there is a risk that students may misuse AI tools, particularly in areas like academic writing, where AI-generated content and plagiarism detection tools often intersect. This issue highlights the importance of enhancing students' literacy regarding the ethical use of AI and fostering a deep understanding of academic integrity. By doing so, students can use these technologies responsibly, without compromising their learning outcomes.

Policymakers play a crucial role in creating the regulatory frameworks necessary for the ethical and equitable use of AI in education. Al-Zahrani and Alasmari (2024) emphasize the importance of addressing issues like the digital divide, as access to AI-powered tools is often uneven across different socioeconomic backgrounds. Policymakers must work on initiatives that promote equal access to AI technologies and ensure that schools, particularly those in disadvantaged areas, have the resources needed to adopt these tools effectively.

Technology developers also have a significant responsibility. They must design AI tools that are not only innovative but also aligned with educational goals. As Wang et al. (2024) suggest, collaboration between educators and developers is essential to ensure that AI systems meet the needs of both learners and teachers. Additionally, concerns regarding data privacy, security, and algorithmic transparency must be addressed to foster trust in the use of AI technologies in education.

Ultimately, the successful integration of AI into education relies on the continuous collaboration and adaptation of all involved stakeholders. With each group contributing to the responsible and ethical use of AI, the potential for transformative impact on learning outcomes becomes increasingly feasible.

4. The impact of AI in education

Artificial intelligence (AI) has rapidly transformed many sectors, and education is no exception. While the integration of AI into schools offers exciting opportunities, it also presents significant challenges and risks that require careful consideration from all stakeholders. AI has the potential to revolutionize teaching and learning by personalizing educational experiences, automating tasks, and increasing accessibility. However, alongside these benefits, there are numerous challenges that affect educators, students, and educational systems alike.

One of the primary challenges is the readiness of teachers and schools to effectively integrate AI-driven tools. The adoption of AI in education demands a shift in pedagogy, as teachers must adapt their instructional methods to include AI-powered systems, adaptive learning platforms, and AI-assisted grading tools. As Gocen and Aydemir (2020) note, the lack of professional preparation and support for educators makes it difficult to fully harness the potential of AI to improve learning outcomes. Without adequate training, teachers may struggle to implement these technologies in ways that enhance student learning.

Another significant risk associated with AI adoption is the threat to academic integrity. Generative AI models, in particular, have raised concerns about plagiarism and the potential misuse of technology by students. These tools blur the line between original work and AI-generated content, posing challenges for educators in assessing student performance. As Ali et al. (2024) emphasize, it is the responsibility of educational institutions to develop robust academic integrity policies that address the ethical use of AI in the classroom. Such policies should equip both students and educators with the knowledge and best practices needed to mitigate risks and promote responsible AI use.

Equity and accessibility also require careful attention. While AI has the potential to democratize education by offering personalized learning experiences and improving access, there is a risk that unequal access to these technologies could exacerbate existing inequalities. Students from disadvantaged backgrounds may not have the same opportunities to use AI tools, potentially widening the educational gap between socio-economic groups. Ensuring equitable access to AI technologies is essential to realizing the full benefits of AI in education.

Despite these challenges, the opportunities presented by AI are substantial. AI has the potential to transform learning through personalized content that adapts to each student's pace, offering more tailored and efficient learning pathways. Additionally, AI can support educators by automating administrative tasks, freeing up more time for direct instruction and student engagement. AI-driven data analytics can also provide schools with valuable insights, helping them make informed decisions about curriculum design and student support services (Gocen & Aydemir, 2020).

While the potential of AI to enhance learning could be quite substantial, stakeholders must navigate the associated risks and challenges carefully. It is important that educators, policymakers, and technology developers ensure that AI integration in schools is both ethical and equitable, maximizing its benefits while minimizing its drawbacks. As the following section will explore, striking this balance is essential to the successful implementation of AI in education.

5. Stakeholders' involvement in the implementation of AI in education

The successful integration of AI into education requires the active participation of several key stakeholders, each contributing to the process to ensure long-term, meaningful impacts. While AI holds immense potential for transforming education - offering more personalized learning, automated assessment processes, and enhanced individual support - it also presents challenges that must be addressed by a wide array of actors within the educational ecosystem (Harry & Sayudin, 2023; Butson, & Spronken, 2024).

First and foremost, teachers and educators play a pivotal role in this transition. As the primary interface between students and AI-driven technologies, educators bear the responsibility of utilizing AI tools not merely for automation, but for advancing learning outcomes. To achieve this, they must be provided with adequate training and ongoing professional development. Equipping educators with the necessary skills to use AI effectively allows them to leverage AI-driven platforms for personalized instruction, addressing individual student needs and providing real-time feedback on academic progress.

Equally important are the students, who are the direct beneficiaries of AI's integration into education. Their active engagement and understanding of AI tools are essential to the successful

implementation of these technologies. AI systems offer personalized learning experiences, instant feedback, and adaptive learning pathways that align with each student's unique strengths and areas for improvement (Malik et al., 2023). However, as students increasingly rely on AI, it is crucial to guide them in the responsible use of these technologies. Without proper guidance, there is a risk that AI could undermine the development of critical thinking and problem-solving skills, as students might become overly dependent on automated solutions.

School administrators and policymakers also play a crucial role in facilitating the adoption of AI within educational institutions. School administrators are responsible for ensuring that the necessary infrastructure is in place, managing data securely, and providing access to AI tools. Meanwhile, policymakers face the challenge of crafting regulatory frameworks that promote AI innovation while protecting student privacy and ensuring that AI serves ethical purposes. As Harry and Sayudin (2023) highlight, one of the key issues policymakers must address is ensuring equity in access to AI technologies, particularly for underrepresented or disadvantaged student populations.

The role of technology developers and AI experts is equally significant. These stakeholders, responsible for designing and refining AI systems for education, must ensure that AI tools are developed with a focus on ethics, transparency, and efficiency. Collaboration between educational institutions and developers is essential for aligning AI systems with the pedagogical goals of educators and the learning needs of students. Furthermore, as Karan et al. (2024) emphasize, AI experts must prioritize data security and adapt their systems to diverse learning environments, ensuring that these tools are accessible and effective across various educational contexts.

Finally, parents and guardians play a critical but often overlooked role in monitoring how AI impacts their children's learning. They must ensure that AI technologies are used to complement, rather than replace, the human interactions that are so vital in education. Parents should be informed about both the benefits and limitations of AI so that they can guide their children in using these tools responsibly *(*Harry & Sayudin, 2023*)*.

Thus, the integration of AI in education requires a collaborative effort. By working together, educators, students, administrators, policymakers, developers, and parents can create an

AI-enhanced educational environment that promotes improved learning outcomes, equity, and ethical practices, setting the stage for a future in education that is both innovative and inclusive.

6. Conclusions

As AI continues to gain prominence in higher education, the landscape of teaching and learning has shifted significantly. Universities around the world are increasingly adopting AI tools across a range of academic activities, but this rapid integration brings with it both opportunities and challenges. While AI holds tremendous potential for personalized learning, automated assessment, and enhanced student support, it also raises critical questions regarding data privacy, ethical implications, and the preparedness of educational institutions to fully leverage this technology.

One of the most pressing concerns is ensuring equitable access to AI tools, particularly given the digital divide that persists across socio-economic lines. As Zawacki-Richter et al. (2019) emphasize, policies must be developed to guarantee all students have access to AI-driven educational resources, regardless of their financial circumstances or technological limitations. Addressing this divide is essential to ensuring that AI's benefits are distributed fairly and that no student is left behind due to a lack of resources.

In addition to equity, universities must prioritize teacher training and professional development to enable educators to effectively integrate AI into their classrooms. Teachers play a pivotal role in guiding students through AI-enhanced learning environments, ensuring that these technologies complement, rather than replace, human instruction. As Bozkurt et al. (2021) point out, educators must also be well-versed in the ethical issues surrounding AI, including student data privacy and potential algorithmic biases. Only through proper training can educators confidently navigate the complexities of AI in education.

Collaboration between educational institutions and AI developers is equally important. Such partnerships will help ensure that AI tools are designed with clear educational objectives in mind and that they adhere to established ethical standards. Regular audits of AI systems are necessary to maintain transparency and prevent issues such as biased decision-making or data breaches *(*Bozkurt et al., 2021*)*. These efforts will help to create AI systems that are not only efficient but also trustworthy and aligned with the values of higher education.

Finally, fostering responsible AI awareness among students is essential. AI should not be viewed as a shortcut to bypass critical thinking or problem-solving, but rather as a tool that enhances the learning experience. Striking this balance will ensure that AI adds value to education without undermining the development of key skills.

As AI becomes more integrated into higher education, universities must carefully balance the opportunities it presents with the challenges it poses. By ensuring equitable access, investing in teacher training, maintaining ethical oversight, and encouraging responsible use, institutions can harness the power of AI to enhance educational outcomes while addressing the concerns associated with its implementation.

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