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THE DEVELOPMENT OF STUDENTS' SKILLS FROM THE PERSPECTIVE OF THE EVOLUTION OF INDUSTRY 4.0

Irina TODOS[1], Ludmila ROȘCA-SADURSCHI[2], Liliana CECLU[3]

[1,2,3]*Cahul State University, Piața Independenței 1, Cahul, Republic of Moldova*

Abstract. With the advent of Industry 4.0, education systems globally face a critical need to adapt to rapidly changing technological and professional demands. This study investigates the alignment of STEAM (Science, Technology, Engineering, Arts, and Mathematics) skills among students with the evolving requirements of Industry 4.0, using data from a survey at Cahul State University.
By analyzing skill deficiencies and students' awareness of sustainable development and digital tools, the study identifies both challenges and opportunities in curriculum design. Findings reveal that students acknowledge their skill gaps and demonstrate an openness to enhancing their competencies in areas essential for modern industry, including digital literacy, sustainability, and entrepreneurial capabilities. The results support recommendations for targeted curriculum enhancements, which could be pivotal in developing a workforce prepared to thrive in the digital economy.

Keywords: *Industry 4.0, Education 4.0, STEAM skills, highly qualified students, Skills4future.*

JEL code: *I250*

INTRODUCTION

Industry 4.0 represents the integration of cyber-physical systems, automation, and data-driven decision-making within industrial processes. This technological shift, also known as the fourth industrial revolution, is driven by advancements in artificial intelligence, machine learning, the Internet of Things (IoT), and big data. Such progress necessitates a complementary transformation within the education sector, often referred to as Education 4.0. This educational model aims to equip students with critical skills to meet the demands of an increasingly digitized and interconnected world.

This study examines how well students are prepared for Industry 4.0, focusing on the development of STEAM skills. It evaluates students' perceptions, knowledge levels, and attitudes toward sustainable development and key digital technologies, as well as the current curriculum's ability to meet these evolving needs. The findings offer insights into how educational institutions can align with national and international strategies, such as Moldova's "European Moldova 2030" and "Education 2030," to foster relevant competencies in their graduates.

At the present time we are all observing the growth rate of the transformation process of the industry, thus identified and known as the fourth industrial revolution or Industrial Revolution 4.0 (IR 4.0). The rate of growth of this industrial revolution is exponential, a fact that attests to this is the enormous progress in the development of digital network infrastructure, the Internet, as well as the large-scale use of artificial intelligence. These transformations will affect all areas of socio-economic life leading to a rethinking of education systems and skills training for future employees.

The challenges of this industrial revolution for the educational system is the permanent trend towards the modernization of education with the use of new methods and technologies in the training process. Thus, we can affirm that the industrial revolution favored the emergence of the concept of Education 4.0, which aims to prepare students "for the challenges of Industry 4.0 and to provide them with the skills and knowledge they will need in the digital age"[1]. The relevant authorities and teaching staff are looking for appropriate training strategies that focus on developing the individual potential of the student to be prepared with the necessary skills to build their future through technology-enabled innovation.

Also, we observe the tendency to reform the educational process which is no longer based on the transfer of knowledge from teacher to student, but focuses on developing students' skills to solve problems in the real environment, as well as integrated ICT tools that lead to the increase of skills students, thus cultivating both soft and hard skills. These measures lead to the education and training of a highly qualified workforce with knowledge, skills and competences, ready to develop them throughout their life and to be employed in modern companies.

Thus, we can mention that education focuses on the development of STEAM skills in students, by encouraging critical thinking, creativity, solving complex problems, communication and teamwork, skills that will be useful to them in the workplace and will defend them from other categories of staff, less qualified. STEAM education is based on developing new ways of thinking and learning that will prepare them for the job market.

These trends of transformation and adaptation to the new educational requirements can also be traced in the legislation of the Republic of Moldova with the approval at the state level of the National Development Strategy "European Moldova 2030"[2] and the Development Strategy "Education 2030"[3]. According to these strategies, the educational system in the Republic of Moldova is focused on providing opportunities for all citizens to develop from an early age, throughout their lives, and to develop skills and competencies necessary to be capitalized both at a personal level, as well as professional

To identify the willingness of higher education institutions to provide the infrastructure that will allow students to use digital technologies in the teaching-learning-assessment process, as well as providing opportunities for interactive learning and solving real-life problems, in order to develop skills STEAM, so that students can face the challenges of Industry 4.0, within the **project No. 101081787** - *"Developing and improving the STEAM skills of students and teachers for curriculum innovation and sustainable development of higher education institutions and local businesses"* **(Skills4future)** a a study was conducted on a sample of students from the "Business and Administration" and "Engineering and Management in the Food Industry" higher education programs of the "B.P.Hasdeu" State University in Cahul, between April and May 2023 .

The aim of this study was to identify and analyze STEAM skills deficiencies among students, as well as the existence of other skills currently required to be developed among students (entrepreneurship, creativity, innovation, etc.).

METHODOLOGY

This study was conducted with a sample of 34 undergraduate students enrolled in the "Business and Administration" and "Engineering and Management in the Food Industry" programs at Cahul State University, Republic of Moldova. Data collection was carried out between April and May 2023 using an online survey administered via Google Forms. The survey instrument was organized into four distinct sections to comprehensively assess students' attitudes, perceptions, and skill levels related to Industry 4.0 competencies. The sections included:

1. Attitude, Perception, and Knowledge of Sustainable Development
2. Assessment of Students’ STEAM Skills
3. Learning Needs and Expectations for STEAM Skills Development
4. Primary Findings and Results

Sample Characteristics

- Gender Distribution: 73.5% female and 26.5% male.
- Academic Year: 20.6% first-year, 32.3% second-year, 26.5% third-year, and 20.6% fourth-year students.
- Program Enrollment: Approximately 60% of respondents were enrolled in the "Business and Administration" program.

The survey utilized a combination of Likert-scale and open-ended questions to gather both quantitative and qualitative data, providing a nuanced understanding of students' awareness, values, and competencies aligned with Industry 4.0 demands. To ensure data validity and reliability, the survey underwent a pre-testing phase, followed by iterative revisions to refine question clarity and alignment with the study objectives.

RESULTS AND DISCUSSION

This study aimed to identify existing perceptions and attitudes towards the investigated variables, which were obtained through the questionnaire survey method. The survey involved collecting information online using a Google form, and was structured in four sections:

1. Attitude, perception & knowledge of Sustainable Development
2. Students and the level of STEAM skills
3. Learning needs & expectations for STEAM skills development
4. Main Findings & Results

The research was conducted on a sample of 34 students of the bachelor programme in Business & Administration and Engineering and Management in the food industry from Cahul State University "B.P.Hasdeu", Republic of Moldova**.** The demographic analysis of the sample shows the following distribution:

- 25 persons (73,5%) female and 9 persons (26.5%) male students;
- 20.6% are enrolled in the 1st study year, 32.3% are enrolled in the 2nd study year, 26.5% are enrolled in the 3rd study year, 20.6% are enrolled in the 4th study year.
- About 60% of the respondents are students of the Business and Administration program.

In the conducted study, we aimed, first of all, to analyze the degree of knowledge of the concept of **"sustainable development"** by the students. The first aspect analyzed was with reference to students' values related to sustainable development, and the results are presented below in figure 1.

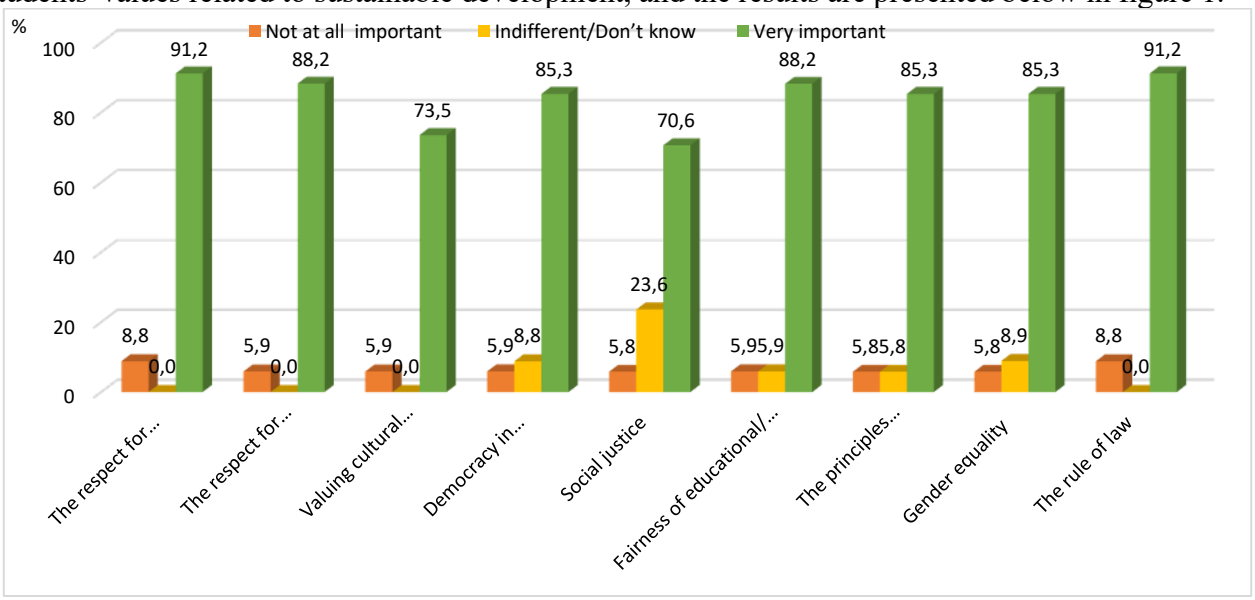

Figure 1. The distribution of student's values related to sustainable development

Analyzing the data in the figure above, we can say that most students (31 people or about 91.2%) rated the following values as "very important" for them: *Respect for human rights and freedoms* (i.e., dignity, equality, solidarity, justice, citizens' rights, etc.) and *Compliance with the law*, i.e., for 8.8% of respondents these values are unimportant. *Respect for EU fundamental freedoms* (i.e., free movement of goods, capital, services and labor) for 88.2% of respondents are very important, and 5,8% ticked as indifferent. *Capitalizing on cultural diversity* is very important for 73.5% of respondents, but for 17.6% it is indifferent and 5.8% is not very important.

So, *Respect for EU fundamental freedoms* (is free movement of goods, capital, services and labor) and *Fairness of education/work systems* for 88.2% are very important values. And for 85,3% very important values are: *Democracy in society*, *Principles of equality and solidarity*, *Gender equality*. Only for 70.5% or 24 people, *Social Justice* is very important.

As the Republic of Moldova wishes to be part of the EU and adjusts its legislation in accordance with the provisions of the acquis Communautaire, the second aspect sought was - **The students' awareness related to the 17 SDGs.** The analysis of student's awareness with regard to the 17 Sustainable Development Goals (SDGs) is presented in figure 2.

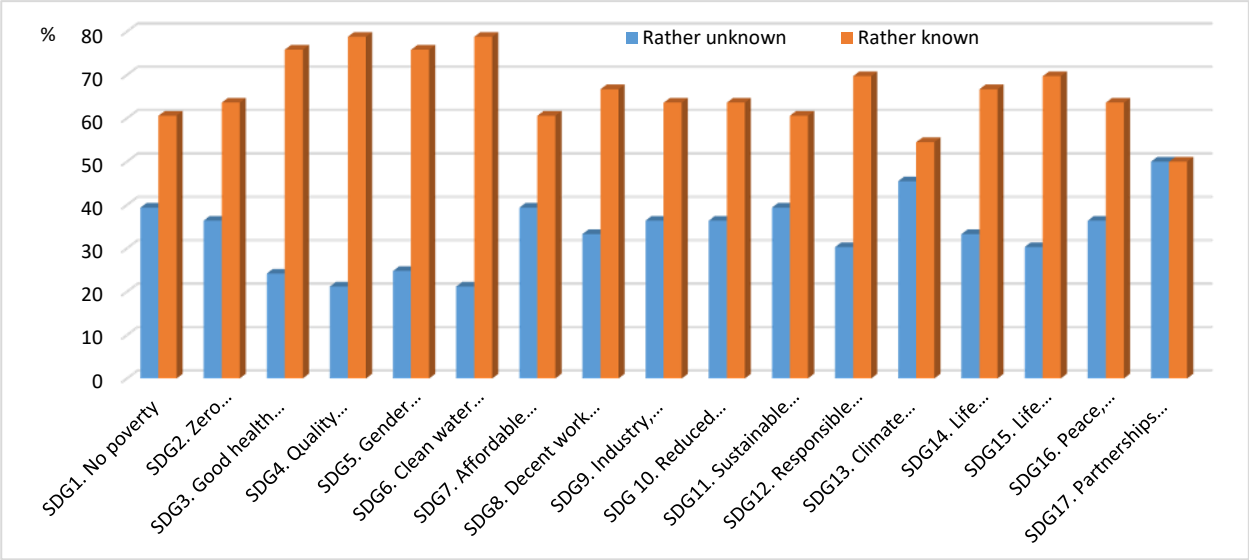

Figure 2. The distribution of students' awareness related to 17 SDGs

In general, we can say that students are familiar with the UE 2030 Agenda and know the Sustainable Development Goals. Depending on the subjects studied and the projects carried out, some objectives are better known by students, others less so. Most students (about 78.8%) know about the objectives: SDG4. Quality Education (Ensuring quality education and promoting lifelong learning opportunities for all) and SDG6. Clean water and sanitation (ensuring the availability and sustainable management of water and sanitation for all). These are followed (with 75.8% of respondents) by: SDG3. Health and well-being (Ensuring healthy lives and promoting well-being for all, at all ages) and SDG5. Gender equality (ensuring gender equality and empowering women and girls).

The least known to students (only 60.6% of respondents know) are: SDG1. No Poverty (Eradication of poverty in all its forms and in every context); SDG7. Clean and affordable energy (Ensuring everyone's access to affordable energy in a safe, sustainable and modern way) and SDG11. Sustainable cities and communities (Developing cities and human settlements so that they are open to all, safe, resilient and sustainable).

Thanks to the activities carried out within this project, students will get to know the practical realization of these objectives. Representatives of the business environment and relevant public institutions will bring practical information regarding the achievement of the objectives of the 2030 Agenda, examples of normative acts and laws where they can be found. Another way to make students aware of the mentioned objectives will be by changing the university curriculum and improving the courses studied by the students in the chosen program.

To better know and understand the current state of affairs - **The degree of knowledge on Economic, Social, Environmental performance dimensions of SD.** The analysis of students of knowledge on Economic, Social, Environmental performance is presented in figure 3.

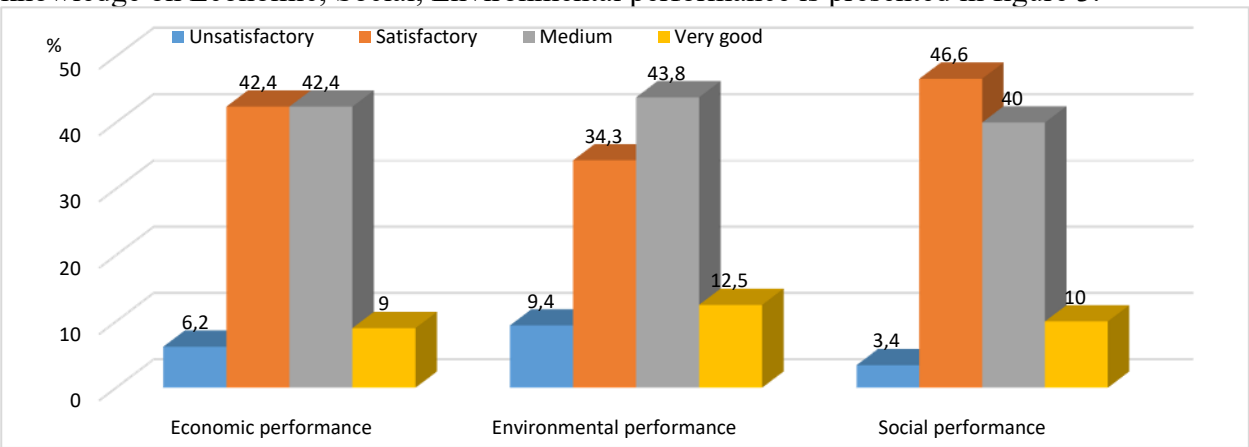

Figure 3. The level of understanding with regard to SD concepts

To the question: Sustainable development involves knowing the interconnections between 3 dimensions/domains of knowledge Economic, Social and Environmental, the interviewed students proved an average knowledge of this interconnection. Only 3-4 students know very well these 3 dimensions and their interconnection.

The economic dimension is known medium and satisfactorily by an equal number of respondents (14 people each or 42.4%), 3 people - very good and 2 people - unsatisfactory.

The social dimension is known at an average level by 14 students (43.8%), satisfactory - by 11 students (34.3%), very good - by 4 students and unsatisfactory by 3 students.

The environmental dimension is known at a "satisfactory" level by the majority of respondents (about 46.6%), about 40.0% know this field „medium” (12 people), very good - 10% or 3 people and unsatisfactory - 1 person.

This result denotes a need to intensify the activities within the interdisciplinary group projects and emphasize the importance of these 3 dimensions: economic, social, environmental

Another important aspect of the study concerned - **The degree of adopting behaviors to leave more sustainable.** Analyzing the obtained data, the following situation is highlighted, presented in figure 4.

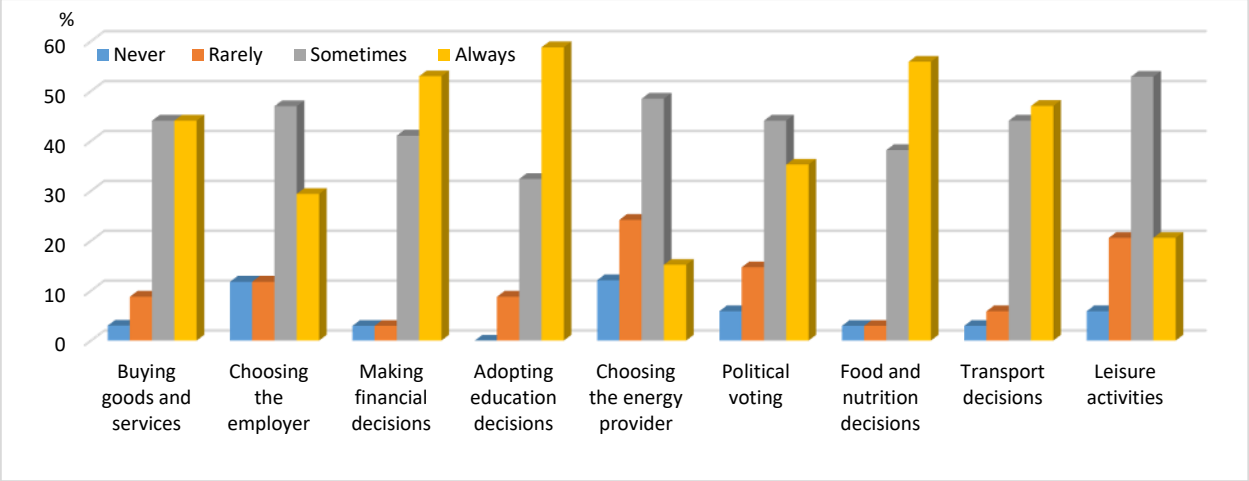

Figure 4. The frequency of adopted sustainable measures

To the question regarding *"the measures taken for a sustainable development and what sustainability issues they think about when they approve the following decisions"*, the students gave the following answers:

- More respondents think about sustainable development and sustainability *"always"* when they adopt: decisions in education - 58.8%, decisions about food and nutrition - 55.9%, financial decisions -53%, decisions about transport - 47, 05% and when buying goods or services - 44.1%, the same number of people think about this "sometimes".

- *"Sometimes"* the respondents think about sustainable development and sustainability in the following situations: leisure activities - 18 people (52.9%); choosing the energy supplier (48.5%); choice of employer (47.0%); the purchase of goods or services, the political vote and decisions regarding the transport of which 44.1% or 15 people chose this form of answer.

- They *"rarely"* think about sustainable development and sustainability in the case when: they have to choose the energy supplier - 8 people or for leisure activities - 7 people.

We are glad that very few people from those interviewed chose the "never" option. We believe that the young people interviewed are responsible for the environment and are "for" sustainable development

Another aspect investigated was - **The shared responsibility for SDGs.** The analysis of responsibilities for the implementation of sustainability-related directions is presented in figure 5.

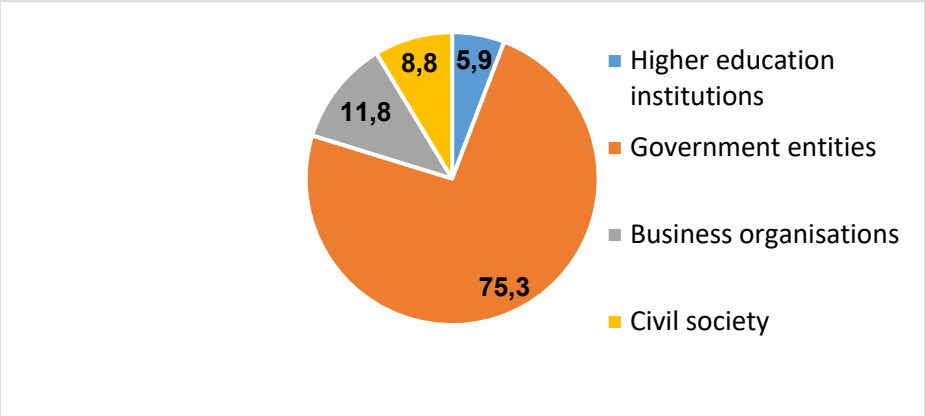

Figure 5. The responsibilities for implementing SDGs in the country

Most respondents (75% or 25 people) believe that the responsibility for the implementation of the Sustainable Development Goals in the country rests with the Government/State Organizations. If we were to take it in descending order, then the second place in terms of importance would go to Organizations from the business environment (the opinion of 11.8% of respondents). The third place (in the opinion of 8.8% of the respondents) belongs to the Civil Society and the last place would be the Higher Education Institutions.

So, according to the opinion of the student-respondents, the role of universities in society is insignificant. We hope that after carrying out several activities from this project, the opinion of the students will change and the responsibility regarding the implementation of the Sustainable Development Goals in the country will be distributed differently.

He concluded this panel, the question in reference to - **The awareness on key digital technologies.** The analysis of the awareness about the use of digital technologies in transforming the way in which the businesses are operating is presented in figure 6.

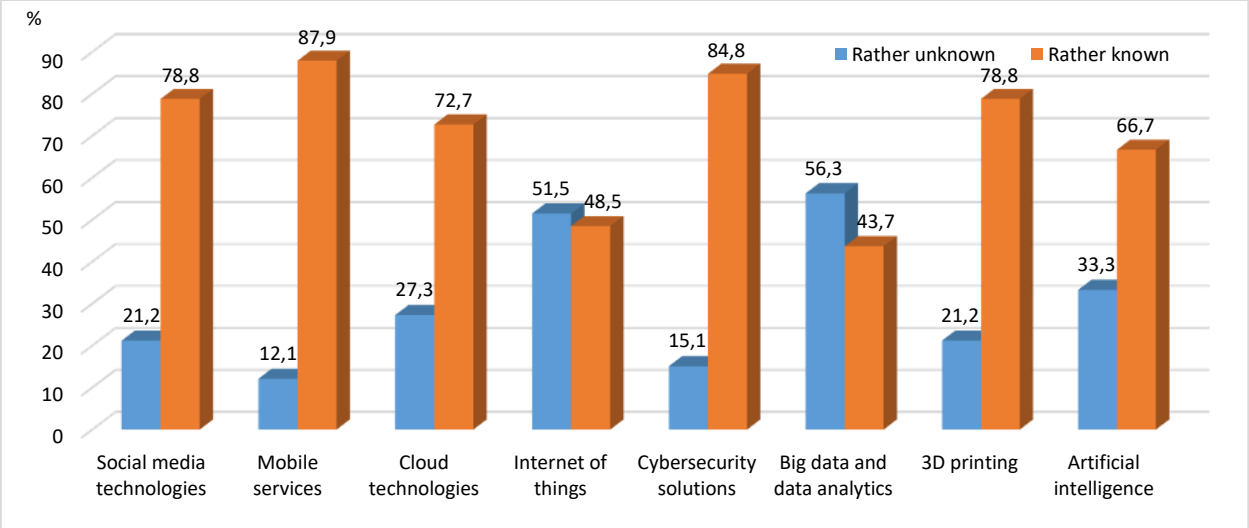

Figure 6. The student’s awareness on digital technologies

Regarding how well the students know the digital technologies used by enterprises, we received the following answers:

- *known:* Mobile services (for 87.9% of respondents), Cybersecurity solutions (for 84.8% of respondents), Social media technologies and 3D printing (for 78.8% of respondents), Cloud technologies (for 72.7 of respondents), Artificial intelligence (for 66.7% of respondents).

- *unknown:* Big data and data analytics (for 56.3% of respondents), Internet of things (for 51.5% of respondents).

The second panel of questions has been reserved **Student’s and the level of STEAM skills,** which included two questions:

- **The student's perception of their level of non-digital skills.** The data analysis shows the following levels of development for non-digital skills: **Figure 7 – 11.**

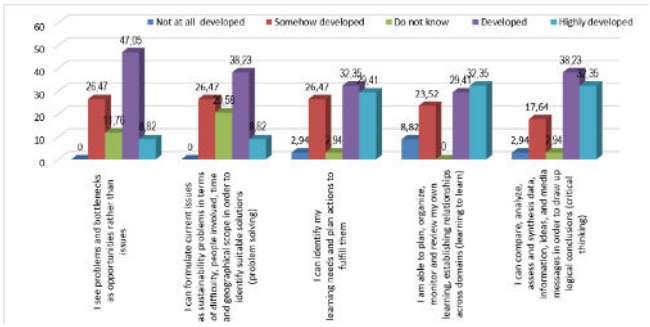

Figure 7. Intellectual skills

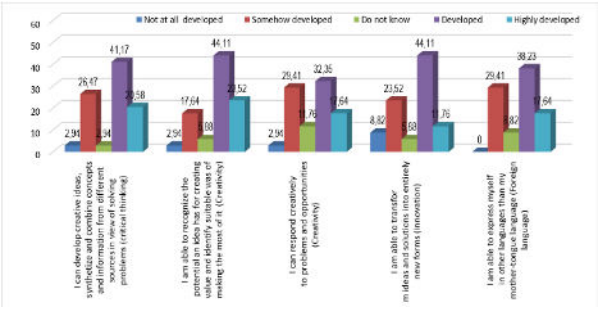

Figure 8. Intellectual skills

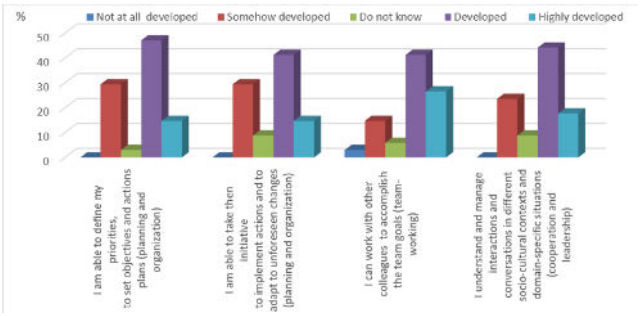

Figure 9. Socio-emotional skills

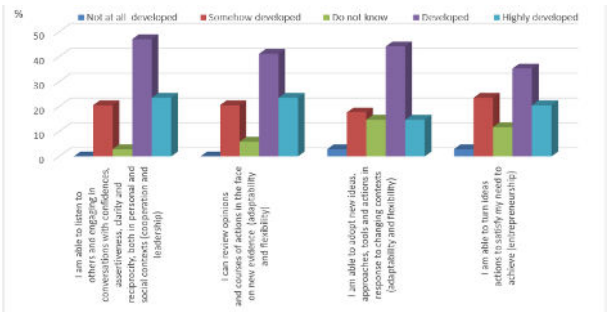

Figure 10. Socio-emotional skills

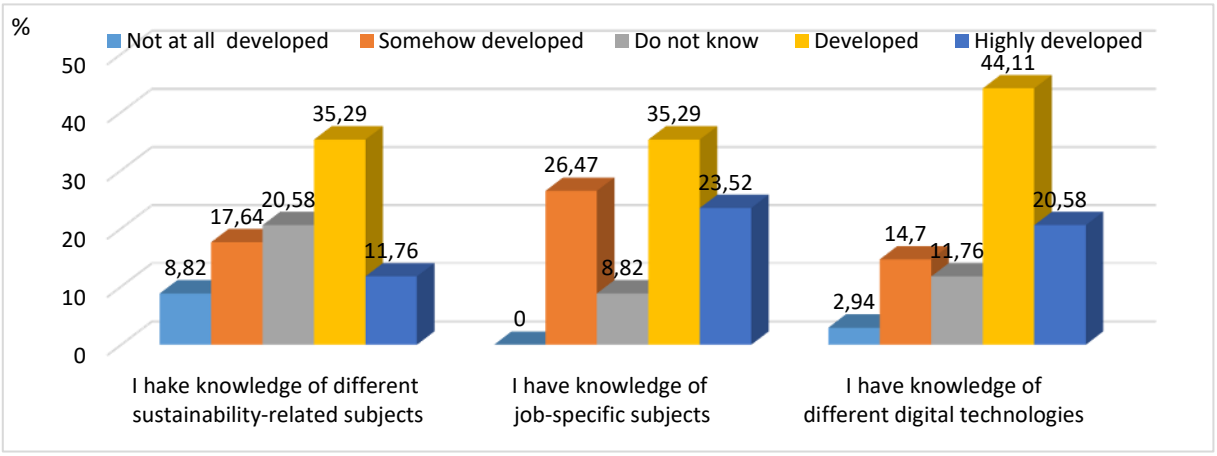

Figure 11. Technical skills

Analyzing the students' answers presented in the graphs above, we can conclude that the level of non-digital skills possessed by students at the present time is "Developed". In particular, socio-emotional skills are developed, with an intermediate level of knowledge, on average, of 45.33%. The most pronounced here are the answers to the following questions, which were appreciated by about 50% of the respondents with "Developed": *I am able to define my priorities, to set objectives and actions plans* and *I am able to listen to others and engaging in conversations with confidences, assertiveness, clarity and reciprocity, both in personal and social contexts*.

On the 2nd place are the "Intellectual skills" competencies with an average score of 40.95%, rated as "developed" and on the 3rd place are "Technical skills", rated on average by 40.6% with "developed". It should be mentioned that in "Intellectual skills" most students (about 50%) gave the qualification "developed" for the question: *I see problems and bottlenecks as opportunities rather than issues*, and the qualification "highly developed" (34.4 %) for the questions: *I am able to plan, organize, monitor and review my own learning, establishing relationships across domains* and *I can*

compare, analyze, assess and synthesis data, information, ideas, and media messages in order to draw up logical conclusions. They speak about the students' ability to organize their own future and plan a successful career.

It should be noted that the second most preferred qualification by the students was "somehow developed". Here we can formulate two conclusions: 1. students do not know their non-digital skills very well, or they cannot self-assess and 2. students have an average level of development of these skills and we must intervene, through the study program and the subjects studied, to the development of the mentioned skills.

- **The student's perception of their level of digital skills is represented in the figures 12 -15.**

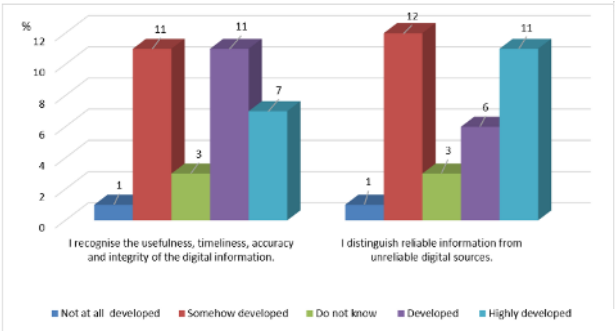

Figure 12. Information and data processing

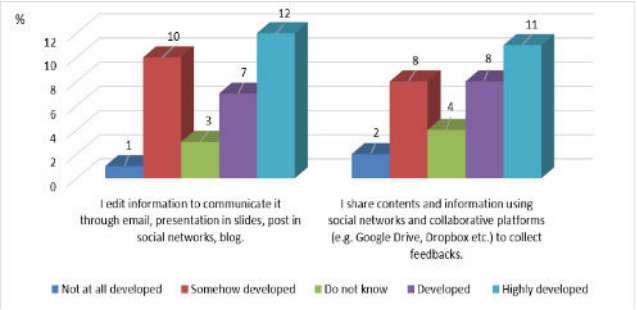

Figure 13. Digital communication

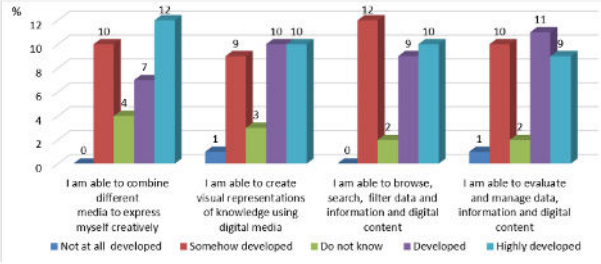

Figure 14. Digital content creation

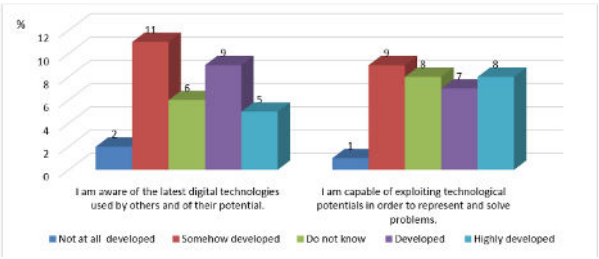

Figure 15. Digital problem solving

In the students' view, the digital skills needed for those working in Business 4.0 were valued differently for those four skill groups 33 students answered this question.

We can say that the category most appreciated by students is "*Digital content creation*". Here in the environment, it was appreciated with 31.1% Highly developed and with 28% Developed. But also, the level of appreciation of Somehow developed is appreciated by an average of 31.1%.

For the category of digital skills "*Information and data processing*", most students rated in the middle (34.85%) as "*somehow developed*". The second level of knowledge was "*highly developed*" with an average of 27.25%, followed by the "*developed*" level - on average 25.75%.

At a high level (Highly developed - 34.85% in the medium) the "Digital communication" category was appreciated by the students. But 18 students, or on average 27.25%, considered this category as Somehow developed.

The category "*Digital problem solving*" is valued on average by students as Somehow developed (30.3%) and Developed - on average 24.25%.

The third part of the survey focused on **Learning needs and expectations for STEAM skills development.** Students were given the opportunity to select the Sustainable Development Subjects to be taught, thus following the analysis of the respondents' answers for the three major economic, social and environmental issues, we can see that all the subjects interviewed were rated "useful" and "very useful", which together gives us a rather impressive percentage of about 100%. Only two Economics subjects that accumulate the lowest score of 94.1% are: Green business, green finance and investments and Sustainable consumption and production: circular economy and EU action plan for circular economy.

Thus, we can mention that the topics mentioned in the survey received a high appreciation from the students, respectively the students understand the importance of a broad approach to the initiation and development of the business and are aware of its sustainable development. But the subjects that received a lower score are probably not sufficiently known to the students, or that they have not encountered in practical activities.

Table 1. Students' expectations for subjects to be taught

	Not useful	Useful	Very useful
ECONOMIC subjects			
Sustainable Procurement practices	3,0	67,6	29,4
Competition, fair-trade regulations and practices	-	70,6	29,4
Green business, green finance and investments	5,9	52,9	41,2
Resources efficiency through sharing economy: co-working space, crowd-funding, freelancers, etc.;	0	67,6	32,4
Sustainable consumption and production: circular economy and EU action plan for circular economy;	5,9	73,5	20,6
Innovation & product responsibility	3	58,8	38,2
Corporate social responsibility	3	64,7	32,4
Social entrepreneurship	3	52,9	44,1
ENVIRONMENTAL subjects			
Environmental compliance	0	52,9	47,1
Supplier environmental assessment	0	61,8	38,2
Circular economy – green productions and consumption, waste to resources – secondary raw materials and water reuse, etc.	0	50	50
SOCIAL subjects			
Green jobs and local community engagement.	0	61,8	38,2
Sustainable employments	2,9	61,8	35,3
Social and labour protection	3,1	42,4	54,5
Occupational health and safety		50	50
Diversity and equal opportunities, and human rights	3,1	42,4	54,5
Sustainable lifestyle and education		50	50

In the view of the student respondents, the most important and useful digital technologies that should be discussed and analyzed in the exercises and case studies were rated as follows: social media (81.8%), mobile service technologies (66.7%), artificial intelligence (60.6%), cyber security solutions (54.5%). The lowest score was taken by: 3D printer (39.4%) and "Internet of things" (33.3%).

- **Digital technologies to be used in case studies and exercises** are presented in Figure 16:

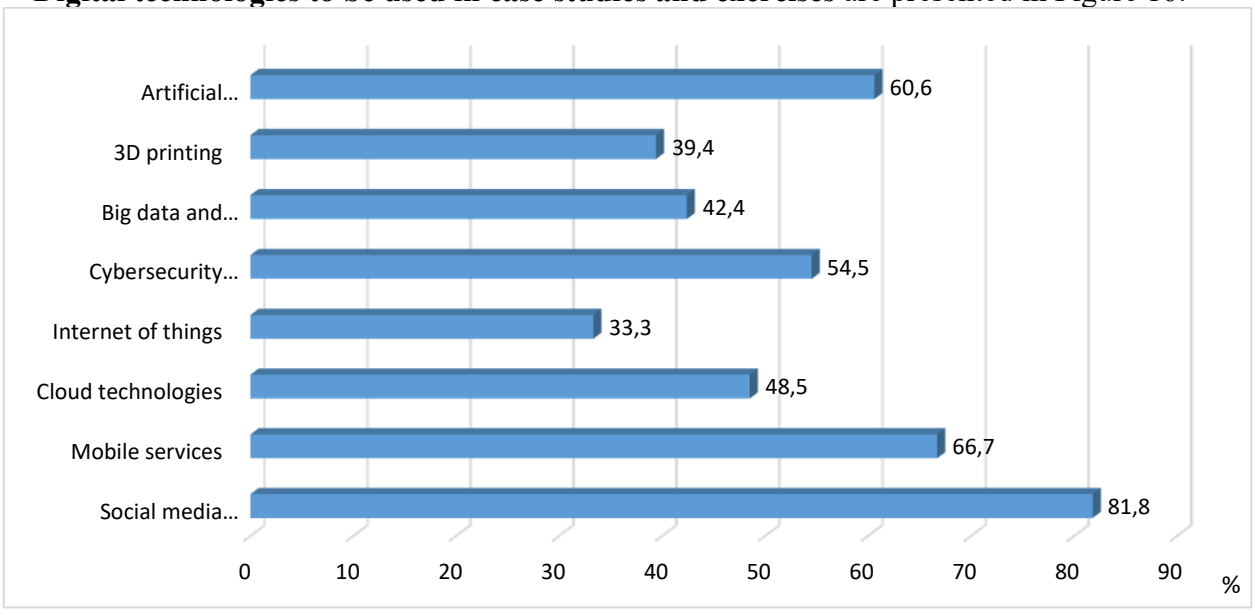

Figure 16. Digital technologies to be used in applications

This is the opinion of the students regarding the need and use of the respective technologies in the operation and development of businesses, which can be very well appreciated. At the same time, it allows us to draw attention to other types of finger activities and demonstrate their importance to students.

- **Sustainability-related sectors to be used in case studies and exercises** are presented in Figure 17.

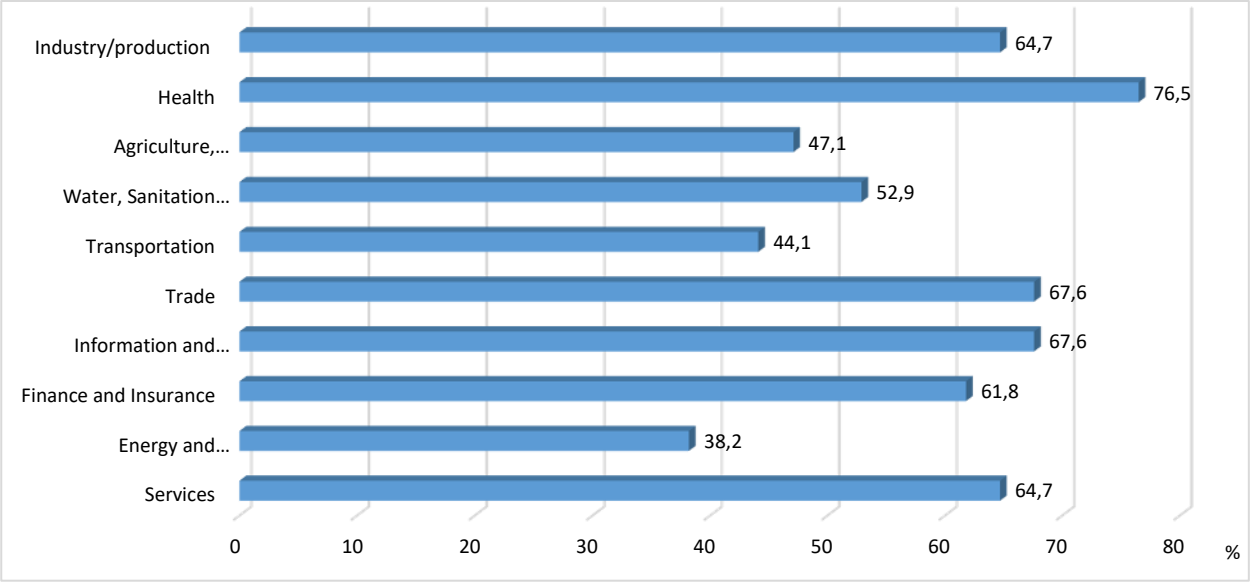

Figure 17. Sustainability-related sectors to be used in applications

When asked: Which of the following areas of activity/industries would be useful to discuss and analyze in exercises and case studies, students put "health" first (76.5% of respondents), second the domains: is information technology and communications and commerce were placed (67.6% of respondents each) and the 3rd place was shared by the domains: Services and Industry/production of goods (64.7% each).

In view of the students' appreciation of the learning needs and expectations for the development of STEAM skills, they highlighted several **Economic** areas, such as: *Competition, fair-trade regulations and practices, Resources efficiency through sharing economy: co-working space, crowd-funding, freelancers, etc.*, practically all areas of the **Environment** and the most important **Social** areas: *Green jobs and local community engagement*, *Occupational health and safety, Sustainable lifestyle and education*.

At the same time, they saw the need for a wider study of digital technologies, in particular: social media, mobile technologies and services, and artificial intelligence, which is very current and necessary today.

The areas that are of major interest to students and need to be addressed more extensively in different case studies, in interdisciplinary group projects and that would be tangential to other areas of student interest, would be: health, information and communication technologies, commerce, services and others

From the results of the survey, it can be concluded that the students recognize the insufficiency of the knowledge and skills, obtained until now, to develop sustainable businesses. Respectively through this appreciation they demonstrate their openness to change, to improvement and are ready to acquire new knowledge and skills.

CONCLUSION AND RECOMMENDATIONS

This study underscores the need for a strategic alignment between educational offerings and the competencies required for Industry 4.0. To enhance students’ readiness for a digital economy, the following recommendations are proposed:

1. Curriculum Enhancement;
2. Skill Development Workshops;
3. Practical Applications;

4. Collaboration with Industry;
5. Regular Assessment and Feedback.

In conclusion, by adopting these measures, educational institutions in Moldova can better align with Industry 4.0 and support students in acquiring the skills and values needed for sustainable economic growth. This alignment is critical in preparing a workforce capable of meeting the challenges and opportunities presented by a rapidly evolving digital landscape.

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