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FOSTERING STEM EDUCATION FOR YOUTH EDUCATIONAL CARTOONS METHODOLOGIES AND E-LEARNING TECHNOLOGIES



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Research Phase Report

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1 RESEARCH PHASE 1- DETERMINING UNDERACHIEVED SCHOOL SUBJECTS IN STEM FIELD

1.1 What is STEM education, and why is it important for children – principles and advantages?

What is STEM education?

At its core, **STEM education** is a type of learning and development that integrates four specific areas of **science, technology, engineering and mathematics**. **STEM education** is not simply referring to grouping together the distinct but related four disciplines; but it is rather **an integrated approach to better equip students with key-skills to succeed in a career and consider real-world applications**. Therefore, the keyword in this model of education is **integration**.

A little bit terminology

In 2001, scientific administrators at the U.S National Science Foundation (NSF) introduced the acronym **STEM** in preference to previous **SMET** acronym of the same four disciplines when referring to the education policy, the career fields in those disciplines or a curriculum that integrated knowledge and skills from those fields¹. Even there is no **universal agreement** on which disciplines are included in **STEM** – for e.g. in the U.S the **science in STEM** includes also **social science**², such as **psychology or political science**, but not in the U.K - **STEM** is an umbrella term that combines all four areas in an interdisciplinary and applied approach. The trend is to add more domains of knowledge under this **unique term** for this **model of teaching and learning**. So, there are other variations for this term: **A-STEM or STEAM** - more focused on **arts**³, or **applied mathematics**⁴ or **agriculture**⁵ - or **eSTEM - environmental STEM**⁶, or **STREAM**⁷ - includes **robotics** and **arts** as fields, or

¹ <https://www.britannica.com/topic/STEM-education/STEM-education>

² <https://www.britannica.com/topic/STEM-education/images-videos>

³ <https://edtechchina.medium.com/the-stem-education-in-china-theres-a-long-way-to-go-7e67a2c439f4>

⁴ <https://vtx.vt.edu/articles/2012/07/073112-uged-steampartnership.html>

⁵ <https://stem.fiu.edu/research/projects/steam-science-technology-engineering-agriculture-and-mathematics-education-in-agroecology/>

⁶ <http://www.westseattleherald.com/2013/04/30/news/arbor-heights-elementary-implement-estem-curricul>

⁷ <https://home.edweb.net/webinar/connect-science-technology-engineering-robotics-arts-math-classroom/>

STEEM⁸ - adds **economics** as a field, and last but not least **STEMIE**⁹ - adds **inventing** and **entrepreneurship** as means to apply **STEM** to real world problem solving and markets.

A little bit history of the definition

Throughout the second half of the 20th century, officials in developed countries focused on improving science, mathematics, medicine and technology instruction intending to not only increase literacy in those content areas but also expand existing workforces of scientists and engineers. They pointed out the link between these domains and prosperity and ability to address societal problems, in an innovative way.

In the early 2000s, in southwestern Pennsylvania, researchers made a study to frame the region's STEM needs and they developed a definition for STEM that has since become widely used, because it clearly links education goals with workforce needs:

*"[STEM is] an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy."*¹⁰

In the 2012 report *Science, Technology, Engineering, and Mathematics (STEM) Education: A Primer*¹¹, STEM education was defined as:

"Teaching and learning in the fields of science, technology, engineering, and mathematics. It typically includes educational activities across all grade levels—from pre-school to post-doctorate—in both formal (e.g., classrooms) and informal (e.g., afterschool programs) settings."

So, this approach takes into consideration not only students K-12 (kindergarten through 12th grade) but also youth and adults up to post-doctorate educational level.

In 2017 was the first official China government recognition of STEM education. According with their understanding, STEM education refers not only to those four field Science, Technology, Engineering and Maths, but rather to a mixture of several knowledge in more fields, skills and character traits: "arts, robotics, coding, creative thinking, creative education, education makers and a very Chinese-characteristic one, Suzhi Education

⁸https://www.researchgate.net/publication/354528577_STEEM_and_re-Project-Based_Learning_Design_A_Case_Study_about_Learning_Economics_by_IT_Students_at_School

⁹ <http://www.ornventionconvention.org/stemie-coalition/> or www.stemie.org or <https://inhub.thehenryford.org/icw/home>

¹⁰ Ditto note 1 (<https://www.britannica.com/topic/STEM-education>)

¹¹ <https://sgp.fas.org/crs/misc/R42642.pdf>

(which means a well-rounded character encompassing health, education, sophistication and nobility).”¹²

In the 2018 *Scientix Observatory Report - Education Policies in Europe*, STEM education “is placed at the “intersection” of science, technology, engineering and mathematics [...]and refers to a rupture with “traditional” teaching¹³. Here we have to understand that STEM education does not abandon “**traditional**” subjects, but gives up on the “**traditional WAYS/methods of instruction**”- in which lessons focus on the memorization process: delivery of special subjects content (by the teachers) and acquisition of knowledge (by the students)..

Also, at the level of European countries there is no common understanding of what STEM refers to. There is confusion between the various definitions of STEM - **what exactly the term stands for**- and the **various educational approaches** that can be implicit in the acronym.

Beyond the debates of this concept and its conceptual boundaries, in most national and international reports, STEM term is next to “teaching”/“education” that is usually interchangeable with “science teaching”. This is **a term used to refer to “all of physical sciences, life sciences, computer science and technology, and [...] includes mathematics [...] – in other words, to the various domains of knowledge covered by the acronym**¹⁴

Principles

STEM education is also a blended learning environment and shows students how the scientific method can be applied to daily life. As with any type of education, STEM has a curriculum that aims to develop relevant future skills among students by presenting a coherent learning platform that is largely focused on real-world applications of problem-solving. In order to accomplish its goals, STEM education model has to fulfil some principles¹⁵:

- **Quality and rigour**

STEM has clear, specific and precise contents from those four fields in an integrated and applied approach. In this way, one experimental topic can combine elements from technical design or material technology or technical executions - specific to engineering field, with calculations and mathematical evaluations or physics elements

¹² Ditto note 3

¹³https://www.scientix.eu/documents/10137/782005/Scientix_Texas-Instruments_STEM-policies-October-2018.pdf/d56db8e4-cef1-4480-a420-1107bae513d5

¹⁴ Ditto13

¹⁵ https://ibn.idsi.md/sites/default/files/imag_file/245-255_2.pdf

- **Relevance and applicability**

STEM addresses the question “will I ever use this knowledge?”; STEM education makes connections possible with the real world, so all learning processes become **relevant and useful** for students. Investigating issues that students have empathy towards could motivate them to take action and find proper and ingenious solutions.

- **Accessibility to everyone**

connects abstract STEM concepts to the *easy-to-understand* things; STEM is using **gradual learning** of the new knowledge in close connection with previously acquired ones, in an integrated manner.

- **Active methods of learning**

uses instructional learning strategies that engage students; STEM units typically focus on **project-based learning**; in this way, students are challenged to solve problems that require them to apply the knowledge already acquired in various fields and to find connections between these fields. “Learning by doing” is a **tangible and memorable experience** that improves creativity. **NOW** they can **SEE directly the links between domains** *rather than viewing learning applicable only to “one box”*¹⁶

- **Co-sharing the responsibility of learning**

Creates a friendly learning environment that allows students to **make mistakes and learn from them**; this type of environment helps students become self-directed learners who monitor and adjust their approach. Feedback from peers, teachers and self evaluations would be critical in allowing students to practise metacognition and improve future learning.

- **Meeting the needs of an ever- changing world**

Creates better premises to equip students with future skills (STEM skills and digital skills) required by the labour market, where the most current jobs will be transformed.

Advantages and benefits of STEM Education

- **STEM offers an excellent transformation of the curriculum** and eliminates the teaching of disciplines/areas/fields as independent and abstract. Using **experimental subjects or themes**, STEM education represents an interdisciplinary approach that integrates sciences into technology, engineering and mathematics.

- **STEM education can be implemented from an early age**; introducing kids to STEM during their early years of learning can generate further curiosity and ability. It will also assist in sharpening their scientific knowledge in fields that they are interested in.

¹⁶ https://learn.coolaustralia.org/wp-content/uploads/Origin_Secondary_PrinciplesOfSTEM.pdf

- **STEM is ...another concept for innovation; this dynamic field presents students the opportunity to innovate and challenge their knowledge.** This is one of the primary reasons for the rising demand for STEM jobs. Herein, children are presented with the opportunity to work in jobs which are different, pioneering work and hardly dreamt of (Artificial Intelligence, Engineering, Robotics, Medicine, Nanotechnology, Astrophysics, Math and so on).
- **An abundance of job opportunities** - All the jobs that fall under the umbrella of STEM are continuously expanding over the years. There is a gradual rise in the demand for STEM jobs. The continual advances in technology are changing the way students learn, connect and interact every day. Skills developed by students through STEM provide them with the foundation to succeed at school, at the job and daily life.
- **Encourages the development of the following skills:**
 - **Problem solving** -in STEM education, based on projects, students are asked to solve certain tasks that involve several stages: analysing the problem, generating alternative solutions, analysing the effects of the solutions, making a decision for a certain solution, designing, developing and testing the product=solution.
 - **Creativity-** due to the interdisciplinary approach, STEM-educated kids try to come up with unique ideas while solving complex problems. They develop this skill with inspiration from their teammates. Thus, it encourages children to explore new things, use their imagination and build their inventions. They see how can be put into practice their ideas
 - **critical analysis** - linked with solving problems skills, also STEM education facilitates the development of critical thinking skills. They learn to break down a problem into smaller tasks and generate solutions for each of these tasks, to analyse the consequences of each solution, to evaluate and integrate them into the final solution
 - **independent thinking** - In relation to the first 3 skills, STEM allows the development of independent thinking, as an alternative to conventional thinking, which is still promoted in traditional education. Traditional education emphasises “what” to think rather than “how” to think, which a prerogative of STEM education is. Due to the fact that the STEM approach is based on experimentation, on connections that seem impossible from a glance or from a known perspective, it creates multiple possibilities to do things differently, the student leaving the comfort zone.
 - **initiative** - in relation to the first 4 skills, STEM education allows the student to have the courage to start an action, without fear that they will fail or be penalised for failure, training the others as well, without feeling that they are doing something forced and in a particular kind
 - **communication and other social skills like teamwork** - working in team creates possibility to learn from each other, to develop their communication skills, both at

the content level (vocabulary enrichment), but also at the operational level (incorporation of new concepts, notions into current language, in an articulate manner)

- o **digital literacy** - STEM education, by keeping up with new technologies and incorporating them step by step into the other disciplines, stimulates the development of digital skills, without which we can no longer speak almost in any sphere of activity.

KEEP IN MIND!

- STEM education is a learning approach that combines science, technology, engineering and maths
- Its recent successor, STEAM, also incorporates the arts
- Rather than teach the five disciplines as separate and discrete subjects, STEAM integrates them into a cohesive learning paradigm
- It is based on real-world applications
- It is a model of education through project-based method
- Has a curriculum that respects a several strong principles
- Develops a relevant future skills to meet the needs of a changing world

1.2 Analysis of the national situation

In Romania, STEM education - an integrated, projects-based educational approach - is not implemented as an institutionalized education model (in public education). There are no clear programs, procedures and guidelines or piloting methodology to implement this type of education.

However, some teachers apply this concept separately, especially, those who due to the nature of their field of activity (e.g. physics, chemistry, biology), use the investigation method, in laboratories or in some educational research centers, during the extracurricular activities or during the winter holidays or the summer schools. Such centers are: Student Research Center (CCE), from the “Mircea cel Bătrân” National College, Constanța county or from the Măgurele Education and Research Platform, Ilfov county¹⁷ or Robotics Academy – Urban Camps ¹⁸

¹⁷ <https://msciteh.educatiepentrustiinta.ro/>

¹⁸ <https://www.academiaderobotica.ro/tabere-urbane>.

STEM/STEAM education remains rather a desideratum in the educational system in Romania. Although it is a relatively new concept, applied in isolation in some urban centers, there are no national framework programs to implement this type of education.

STEM education appears as a priority with 5 long-term objectives in the document called *Vision and Strategy for 2018 -2030* within the national project "Educated Romania"- launched in 2016, by the Romanian Presidency with the support of the European Commission and OECD (Organisation for Economic Co-operation and Development).

At the university level, it appears recently, both **implicitly**, in the National Strategy for Research, Innovation and Intelligent Specialization 2022 -2027, approved by Government Decision No 933/July 2022 - and **explicitly**, in the National Research, Development and Innovation Plan, approved by Government Decision No 1188/September 2022 - Program 5.10 Science and society¹⁹.

It is worth mentioning that at the national level, the categories of disciplines under the STEM umbrella (science, technology, mathematics) are specified within the Educational Framework Plans, issued by the National Center for Education Policies & Evaluation for pre-university education. In addition, it is mentioned also at the level of early education – at the chapter *Activities on experiential fields – Science* (Curriculum for early education -2019 - Ministry of National Education, 2019²⁰).

In primary education, mathematics is taught in the first two interdisciplinary grades alongside other STEM disciplines within a discipline named Mathematics and Nature Sciences, while in the last three grades of this cycle it benefits of a disciplinary approach²¹.

In secondary lower secondary education, pupils begin to be enrolled in other STEM disciplines (Biology - 5th-8th grade, Physics - 6th-8th grade, Chemistry - 7th-8th grade, Technological Education and Practical Applications, Informatics and ICT - 5th-8th grade), mathematics continuing to keep a constant number of 4 hours/week.

Mathematics is a compulsory discipline for the graduation of the gymnasium cycle that counts for the admission at high school and for certain profiles and specialisations it is a compulsory discipline within the baccalaureate exam (the end of the 12th grade) which counts for admission to university studies.²²

Regarding education in the private formal education system - carried out through nationally accredited schools - as well as in the non-formal education system - carried out

¹⁹ [https:// uefiscdi.gov.ro/](https://uefiscdi.gov.ro/)

²⁰ <https://rocnee.eu/index.php/dcee-oriz/curriculum-oriz/planuri-cadru-actuale>

²¹ [TEACHERS' PERSPECTIVE ON THE PREMISES AND PRIORITIES OF STEM EDUCATION - Authors: A. Popovici, O. Istrate, C. Mironov, 2019, SCIENTIFIX – The community for science education in Europe](#)

²² Ditto note 22

by various companies and non-governmental organizations - the STEM/STEAM concept is implemented due to the application and the adaptation of school programs from outside Romania to the Romanian environment. For example the Romano-Finland School ERI Sibiu, the International School and Kindergarten in Bucharest and the "Pro Ingenio" High School and so on.

In order to be able to implement the STEM/STEAM concept in Romania, it is needed that teachers should be trained in this respect. According to an analysis made by Mrs. Claudia Nicoleta Ispas, professor of mathematics and informatics - *STEM/STEAM approaches in Romania: Praxiological Aspects*, it shows that "there are teachers and private institutions that have been promoting STEM/STEAM education for years in Romania.

Some physics teachers, due to the nature of the discipline they teach, use the IBL (Inquiry Based Learning) investigation method, an active, attractive learning method that stimulates students' creativity... One of them is Professor Ion Băraru, the founder of the Student Research Center (CCE – in 2010), from the *Mircea cel Bătrân National College*, Constanța [a center known as the "Constanta phenomenon" due to the international awards, including NASA awards). Another one is a computer science professor Emet Eden who works at the International Theoretical High School of Computer Science, Constanța and who coordinates various clubs (Robotics, Manga), in within which students are familiarized with STEM/STEAM education.

In above-mentioned analysis, are specified also some examples of courses dedicated to teachers for initiation or deepening learning of STEM/STEAM subjects. For e.g. The European Educational Resources Office Space – Romania (ESERO Romania) which organized two courses in the summer of 2021, one for primary school teachers and one for secondary school teachers, accessible only to 40 trainees, sustains one of these courses. MSciTeh sustained another one course for teachers (Education and Research Platform - Măgurele) – during The Summer Camp- that was comparatively more generous in terms of number of places - 70 trainees (teachers).

As there are a limited number of places for teacher training, not all teachers have access. Some of these courses are provided more or less free. Moreover, because these courses are held in developed cities of Romania, teachers from rural areas hardly have access to such courses in order to pilot them in the classes in the educational units where they work.

There is also a series of online platforms facilitating the access of teachers and students to STEM/STEAM courses or materials. One of these platforms is the **EduVox** platform. Another one is that one provided by Code for Romania – the Tech for social good program (simultaneously online for teachers from Iași, Cluj-Napoca, Timișoara and Bucharest, via Google Meet & Slack)

The possibility of accessing online courses facilitates the enrollment and participation of teachers in distance learning courses, but there is another barrier - language. Most of the courses are held in English, so not all teachers that are interested have good command of this language, in order to complete such a course.

In Romania, there are interested teachers that are involved in such projects (although they do not call them STEM), who believe in the importance of STEM/STEAM education, especially in the relation to a professional career regarding the current labour market. However, these kinds of manifestations are quite dispersed and not all students from every school have access to STEM/STEAM education.

At the university level, the biggest university centres operate the partnership between universities and specialised research centres and institutions or professional associations that approach STEM education. Such an association is the **General Association of Romanian Engineers**, which is involved in a series of projects aimed at both teaching staff and students or graduates of technical fields. It is worth mentioning that it is a project of an active collaboration between generations - **ProMe Project** - Cooperation and Professional Mentoring between Generations. It aims to provide opportunities for an active occupation of the older adults, during the transition period from active professional life to retirement, and even later. The project aims to develop an IT platform that will allow professional cooperation between generations and interaction between seniors and younger generations. Therefore, two groups and two roles were assigned: Mentor (Guide) and Mentorate (Disciple).²³

A good thing is that the teachers, regardless of what educational level they work at, have begun to be aware of the need to approach STEM/STEAM education and try to implement it, although it is not yet explicitly found in the specific education legislation, but rather in public policy documents, education in National Strategies and Plans assumed by the Government (as was shown above).

KEEP IN MIND!

- An opportunity is the fact that in the "Educated Romania" project, STEM/STEAM education is promoted as a priority field, establishing objectives and specific measures for implementation, in accordance to the fourth educational public policy documents recommended by the OECD:
 - Improving the Teaching Profession in Romania
 - Improving Professional Leadership in Romania's School System
 - Improving Access to Quality Early Education in Romania
 - Improving Educational Equity in Romania
- This signifies an official recognition of the STEM concept, at least of the policy level.
- The concept STEM appears within two Government documents regarding tertiary education - the National Plan for Research, Development and Innovation 2022-2027, as well as in the implementation of the National Strategy for Research, Innovation and Intelligent specialisation 2022-2027.
- Teachers have begun to be aware of the benefits of STEM/STEAM education and have a good attitude regarding implementing it.

²³

https://www.agir.ro/stiri/colaborare-activ%c4%83-%c3%aentre-genera%c5%a3ii-rela%c8%9bia-mentor-mentorat_496.html

1.3 Obstacles and challenges at the national level – underachieved STEM subjects

In Romania, there are some major challenges regarding implementing STEM in an adequate manner:

- **Lack of financial and material resources**

For a good implementation of STEM education in order to raise the interest among students it is needed that school units have modern laboratory equipment and technical tools. Without these it is very hard for a teacher to invite students to experiment or different situations. But this issue generates another one problem:

- **Inadequate and inaccessible training for teachers**

Teachers are the bridge between STEM/STEAM education and students; and for this reason, their training is necessary.

Lack of school laboratory equipment combined with the lack of professional training of the new generations of teachers, especially in the sciences, led to unbelievable situations: the disappearance of interest in the sciences and the emergence of the intensive study of the foreign languages. So, the previous county high schools with specialized profiles in mathematics - physics - computer science profile, practically became high schools with a foreign language profile.²⁴

- **Educational programs/curricula**

Here it is not about the content it is rather about the necessity of the rearrangement of them in such a way as to provide the opportunity for educational partners (teacher-student) to train people adaptable to a prosperous, technologically, scientifically and economically developed society. The students who are engaged in concrete activities with technical support, experimental participate with maximum determination to training the skills necessary for the future scientist, engineer, and technician.

- **Teachers and parents attitude regarding STEM/STEAM**

There is a general confusion among teachers between curriculum and school textbooks. Curriculum (even if it is not an adapted one) is mandatory, not school books! So, they have to be able to apply different active methods in order to attract students in STEM topics. If until now, they did not make any experiments or used different active methods, it is very hard to start to do it now. This lack of openness to new methods or educational approaches combined

The lack of openness to new educational methods and approaches, combined with the lack of equipment in school units and unsatisfactory salaries, led to the capping of a system and, finally, to a poor training of the younger generations.

On the other hand, parents of high-achieving students are interested rather than are not necessarily interested in STEM education, they prefer foreign language study with the

²⁴ <https://agir-constantia.ro/wp-content/uploads/2017/02/Interviu-cu-IB.pdf>

motivation that in Romania their children cannot find well-paid jobs, they can find abroad for better salaries.²⁵

STEM represents the concrete educational framework optimal for the age in which young people manifest their satisfy curiosities, improve their skills related to the use of tools and devices, use ingenuity and strengthen their creativity.

So, the first step should be done as soon as possible – to integrate STEM in educational legislation and educational policies in order to be proper implemented at all levels of education.

KEEP IN MIND!

There are four big challenges connected to each other:

- lack of financial and material resources,
- Inadequate and inaccessible training for teachers ,
- congested curricula
- teachers and parents attitude regarding STEM

1.4 Solutions and new approaches

The Romanian educational system oscillates between the outstanding performances of those who participate in various international competitions (e.g. in 2022 - 164 rewarded students in the fields of mathematics, physics, astrophysics, astronomy) and the poor results of those who fail to pass the exam of the baccalaureate (the average of the last 3 years is 32%). Therefore, measures and solutions offered by specialists (really specialists in education) are required in order to dynamize and balance the entire system.

Above all this, are the poor results obtained by our students in the 2018 PISA test, which are already in decline compared to those in 2015 (below the world average)²⁶

In accordance with the measures proposed at the national level in the Educated Romania project, but also from the proposals given by the teachers who apply STEM/STEAM in the classes or at their STEM centers, the following solutions are proposed²⁷:

- Introducing a significant percentage of STEAM-related activities in preschool education programs;
- School programs (curricula) appropriate to the current historical period (the IT revolution, globalisation, super-technology). The general competencies of a national

²⁵ Ditto note 25

²⁶ <https://newsweek.ro/educatie/romania-campiona-europeana-absoluta-la-olimpiadele-scolare>

²⁷ <https://www.edupedu.ro/disciplinele-stem-capitol-separat-in-romania-educata-la-tic-sa-se-predea-si-despre-tehnologii-mobile-si-internet-of-things-educatia-bazata-pe-investigatie-sa-fie-inclusa-in-formarea-initiala-a-pr/>

curriculum must aim at the integration of young people into society through scientific and technical education anchored in reality: to correctly interpret data and evidence from the informational immensity, to consciously design investigations with scientific methods, to correctly explain facts and phenomena.

- In the educational process, priority is given to pedagogical approaches that consider: personalization of learning and with an emphasis on the intense intellectual participation of students: IBL (Inquiry Based Learning), ERR (Evocation, Realisation of meaning, Reflection), Project Based Learning (PBL), the use intelligence of IT tools in formal education
- Restoring the attitude of decision-makers towards education by providing resources: substantial salaries for education staff, restoring spaces for science laboratories, adequate material endowment of schools
- The “depoliticization” of education - in the sense that regardless of the political colour of the government - strategies and public policies documents must correspond to the realities of the system, not to "political platforms" to attract only electors
- Submission of all "scientific" educational materials to evaluations by the competent factors: the national commissions on the discipline, the national scientific society, etc.
- Lively promotion of good practices at the local level (where they exist), at the regional or national level
- A rigorous training of the teaching staff in these methods
- Experience exchanges at European & international level
- Collaboration with as many educational units as possible that practice STEM/STEAM
- Funding for piloting such methods at many schools as possible
- Ensuring the equipment of the necessary laboratories - not only through public funds but private funding as well. For e.g in 2023 -Polytechnic University of Bucharest inaugurated together with Vodafone Romania - Innovation Hub - the first center of excellence for digital research and development ²⁸
- Correlation of STEAM contents on education cycles - primary, secondary, high school and pre-university, but also university, including wit research-development-innovation institutions, through partnerships, activities and joint projects;
- Correlating educational units based on STE(A)M with the business environment to increase integration on the labour market, but also increasing investments from the business environment, which return to the same competitive environment, implicitly increasing well-being and the quality of life.

KEEP IN MIND!

Is needed for new measures to improve national education system,like:

- adapted curricula to the new reality of the moment
- introduction of the new methods for teaching in many units as possible

²⁸<https://upb.ro/upb-a-inaugurat-impreduna-cu-vodafone-romania-innovation-hub-primul-centru-de-excelenta-pentru-cercet-are-si-dezvoltare-digitala/>

- better promotion of the STEM/STEAM centers at all educational levels (from pre-schools up to university),, but also at the geographical levels (local, regional, national, international)
- ensuring a proper funding for both endowment of the schools and teacher staff
- encouraging public-private partnership for a better development of the research and innovation fields
- better correlation between STEM/STEAM learning units, business environment and labour market

1.5 Proposal of topics to be used for the development phase

During the research conducted through focus groups and interviews within the project, the students have talked about the outdated/traditional teaching methods, which do not explain to them the usefulness of the knowledge they have to acquire.

The disciplines they consider the most difficult under the STEM umbrella are: mathematics, physics, chemistry, biology, also ICT, because on the one hand, they do not see the usefulness in real life, on the other hand because they have difficult or no access at all to special laboratories, in order see, practice and understand the phenomena taught orally. Due to the nature of the subjects taught, the notions are very abstract, it is difficult to represent these phenomena in the mind of a preadolescent or adolescent.

The lack of the applied component and the connection of mathematics with life is an old problem, recognized since 2013 by both a former minister of education and the coordinator of the international maths contests team.

It is necessary to emphasise maths connection to real life, in order to make the students understand that mathematics is not just a discipline that they have to complete annually to pass some exams in certain periods of life. Mathematics basically deals with solving problems... it logically helps us to see what solutions could be possible for solving problems... And life also means...problems, so it gives us the logical framework for managing life's problems.

Here are some topics of mathematics that are directly linked with our day to day life...but they must be underline in class:

Geometry - studies the shapes (2D and 3D), properties of the shapes and their spatial relationships. Look around! Geometry is everywhere! Buildings, space stations, submarines, apartment interiors - furniture, carpets - household appliances - washing machines, pots, pans. - clothes - everything has a geometric shape!

Algebra - studies the theory of real (positive or negative) and complex numbers and solving equations by replacing numerical values with letters and the general formulas for particular numerical calculations.

We pay utility bills, we buy different objects, things for which we pay a certain cost...transposed in numbers. So, isn't it good to know what these numbers mean? Wouldn't we like to know the relationship between these numbers? Do we want to become

IT-scientists?... Well, informatics is based on information processing with the help of automatic calculation systems - means algorithms!!!. means a calculation method or procedure, made up of the elementary steps or operations necessary to solve a problem or categories of problems.

Trigonometry - the branch of mathematics concerned with specific functions of angles and their application to calculations²⁹. Trigonometry developed from a need to compute angles and distances in such fields as astronomy, mapmaking, surveying, and artillery range finding.

We are in a new town, we have to get from point A to C, but we see on the map on our smartphones that if we go straight from point A, we get first to point B, then go straight to either left or right to C. If we are able to understand that in fact, the map describes a right triangle (the triangle with an angle of 90 degrees), isn't it simpler and shorter to go on the hypotenuse, i.e. obliquely from A to C??

Daily we look at the clock ... we see how the hands of the clock move clockwise, that is, from top to right, down, then to the left and back up. The opposite of clockwise rotation is counterclockwise or trigonometric rotation.

For example, the diurnal rotation of the Earth, seen from the North Pole, is counterclockwise, but viewed from the South Pole, it is clockwise.

In navigation, compass pointers increase clockwise around the wind rose, starting at 0° at the top of the rose. So we know how to control and monitor the movement of a boat from one place to another.

We need to assemble the furniture for our house, we need screws and nuts to "tighten" in order to obtain a functional furniture...If the element to be rotated - the screw - is facing the viewer, then we "tighten" the screw clockwise. If we want to weaken it, then we turn the screw counter clockwise.

In astronomy, we talk about prograde (counter-clockwise or trigonometric) and retrograde (clockwise) movements of celestial bodies. The Sun moves around the Earth in a retrograde direction, and the other planets and satellites move in a counter clockwise direction.

Probability - refers to the numerical set that expresses the random character (possible or uncertain) of an event, a phenomenon. It is simply how likely something is to happen. It is expressed as a number in the range from 0 (means impossible to happen) and 1 (certain) , or, using percentage notation, in the range from 0% to 100%. As a mathematical formula probability equals the number of favourable outcomes divided by the total number of outcomes.

So, at the start of a football match, the referee tosses a coin (head or tails) to determine which team has the kick-off. One team chooses "heads" the other one "tails". So it is an unpredictable event. We cannot say for certain if the flip coin will be head, or tail. But the probability of getting heads or getting tails is 50% or ½.

²⁹ <https://www.britannica.com/science/mathematics>

KEEP IN MIND!

- All the major mathematics branches (geometry, algebra, trigonometry, probability) have direct application in the real world!
- Teachers should show to the students more often why is needed of maths in daily life

2 RESEARCH PHASE 2 – DETERMINING MOST SOCIALLY EXCLUDED YOUTH TYPE

2.1 Overview of the national education system: structure and present situation

The national education system is structured into educational levels in order to ensure the coherence of instruction and education according to the age and individual characteristics of pupils and students. The national education system comprises the following levels:

- **early education** (0-6 years), consisting of: pre-school level (0-3 years) and pre-school education (3-6 years)
- **primary education** comprises preparatory class and grades I-IV.
- **Lower secondary education or secondary education** comprises grades V-VIII. Access to upper secondary education is carried out by national assessment examination.
- **Upper secondary education** can be: secondary education (classes IX-XII/XIII, with theoretical, vocational and technological profiles), 3-year vocational education, or vocational and technical education.
- **Non-university tertiary education** includes post-secondary education.
- **Higher education** is organised in universities, academies of studies, institutes, schools of higher education, called higher education institutions or universities, provisionally authorised or accredited³⁰

A recent overview of the education system in Romania is given by the Education and Training Monitor 2022, which analyses the performance of education in relation to the other member states, based on 7 key indicators³¹.

³⁰ The organisation of the education system and its structure, the European Commission, 2022, <https://eurydice.eacea.ec.europa.eu/ro/national-education-systems/romania/organizarea-sistemului-de-educatie-si-structura-sa>

³¹ <https://op.europa.eu/webpub/eac/education-and-training-monitor-2022/ro/country-reports/romania.html>

Figure 1: Key indicators overview

			Romania		EU	
			2011	2021	2011	2021
EU-level targets	2030 target					
Participation in early childhood education (from age 3 to starting age of compulsory primary education)	≥ 96 %		84.1% ¹³	78.2% ²⁰	91.8% ¹³	93.0% ²⁰
Low achieving eighth-graders in digital skills	< 15%		:	:	:	:
Low achieving 15-year-olds in:						
Reading	< 15%		40.4% ⁰⁹	40.8% ¹⁸	19.7% ⁰⁹	22.5% ¹⁸
Maths	< 15%		47.0% ⁰⁹	46.6% ¹⁸	22.7% ⁰⁹	22.9% ¹⁸
Science	< 15%		41.4% ⁰⁹	43.9% ¹⁸	18.2% ⁰⁹	22.3% ¹⁸
Early leavers from education and training (age 18-24)	< 9 %		18.1%	15.3% ^b	13.2%	9.7% ^b
Exposure of VET graduates to work-based learning (2025)	≥ 60 %		:	7.1%	:	60.7%
Tertiary educational attainment (age 25-34)	≥ 45 %		22.5%	23.3% ^b	33.0%	41.2% ^b
Participation of adults in learning (age 25-64) (2025)	≥ 47 %		:	:	:	:
Other contextual indicators						
Equity indicator (percentage points)			:	39.0 ¹⁸	:	19.30 ¹⁸
Early leavers from education and training (age 18-24)						
Native			18.1%	15.3% ^b	11.9%	8.5% ^b
EU-born			:	: ^{bu}	25.3%	21.4% ^b
Non EU-born			:	: ^{bu}	31.4%	21.6% ^b
Upper secondary level attainment (age 20-24, ISCED 3-8)			79.7%	83.3% ^b	79.6%	84.6% ^b
Tertiary educational attainment (age 25-34)						
Native			22.5%	23.2% ^b	34.3%	42.1% ^b
EU-born			: ^u	: ^{bu}	28.8%	40.7% ^b
Non EU-born			: ^u	: ^{bu}	23.4%	34.7% ^b
Education investment						
Public expenditure on education as a percentage of GDP			4.1%	3.7% ²⁰	4.9%	5.0% ²⁰
Public expenditure on education as a share of the total general government expenditure			10.4%	8.8% ²⁰	10.0%	9.4% ²⁰

Sources: Eurostat (UOE, LFS, COFOG); OECD (PISA). Further information can be found in Annex I and at Monitor Toolbox. Notes: The 2018.EU average on PISA reading performance does not include ES; the indicator used (ECE) refers to early-childhood education and care programmes which are considered by the International Standard Classification of Education (ISCED) to be 'educational' and therefore constitute the first level of education in education and training systems – ISCED level 0; the equity indicator shows the gap in the share of underachievement in reading, mathematics and science (combined) among 15-year-olds between the lowest and highest quarters of socio-economic status; b = break in time series, u = low reliability, : = not available, 09 = 2009, 13 = 2013, 18 = 2018, 20 = 2020

Early childhood education and care (ECEC) continues to face problems of low participation and inadequate infrastructure.

In 2020, the rate of participation in ECEC of children in Romania between the age of 3 and the starting age of compulsory education was one of the lowest in the EU (78.2% vs an EU average of 93%). The insufficient provision of childcare and long-term care is detrimental to women's participation in the labour market (OECD, 2022). Romania aims to increase participation in ECEC by expanding capacity. The network of crèches, kindergartens and other ECEC services in Romania is not sufficient to meet demand. As part of the 'Educated Romania' programme, Romania plans to increase participation in pre-school education of children up to 3 years old to 30% and to 95% for children aged 4-6 by 2030.

Recent legislative changes are expected to improve the accessibility and quality of ECEC services. In 2022, the government adopted new legislation on the organisation, functioning, financing and monitoring of crèches and other ECEC facilities.³²

National tests show poor educational outcomes in schools in Romania, confirming the poor results seen in the tests set by the OECD Programme for International Student Assessment (PISA) 2018⁴. The results of Romania's national report on the level of literacy of students in Romania, published in May 2022, show that **only 11% of students in Romania are fluent readers. 42% of the students are marked as 'non-functional', which is close to illiteracy.**

During the 2020/2021 school year (COVID-19 pandemic situation) approximately 65 000 students did not attend school at all (Unicef, 2021). School closures have disproportionately affected vulnerable **children in rural areas as they had limited access to digital equipment and were not sufficiently prepared for remote teaching** (European Commission, 2022). A recent Unicef report stated that nearly 70% of all children in Romania were not able to access quality online learning during school closures (Unicef, 2021).

Romania will reorganise its quality assurance system to improve the performance of its education system. The new structure presented in the new law of education will include a

³²[Creșele și alte unități de educație timpurie antepreșcolară se vor organiza și vor funcționa în baza unei metodologii specifice adoptate de Guvernul României | Ministerul Educației](#)

digital-skills assessment test, while there will also be separate tests on Romanian language, literature, and grammar. The law also contains changes to the transition process from lower-secondary to upper-secondary education. It is planned to reorganise extra-curricular education activity in the national education system. Children's clubs and school sports clubs will become official parts of the school network. Romania will reorganise its quality assurance system to improve the performance of its education system. In 2022, in 2022 the government reorganised the Romanian Agency for Quality Assurance in School Education (ARACIP) in order to ensure greater efficiency and professionalism.

Early school leaving continues to be a problem in Romania.

In 2021, the rate of 18-24 year olds not having completed upper-secondary education and not in education or training (ELET - early leaving from education and training) improved slightly, reaching again the 2019 level of 15.3%.

A recent study by World Vision Romania shows that 1 in 10 children of compulsory schooling age in rural areas currently does not attend any educational institution. This study also showed that 1 in 3 teenagers (37%) is absent from school temporarily or permanently because they are working in the household (World Vision Romania, 2022).

Many young Romanians leave the school system without acquiring the skills needed to enter the labour market with its fast-changing needs. This makes their transition from school to paid employment difficult (OECD, 2022).

The Recovery and Resilience Facility will support national efforts to reduce early school leaving. The National Programme for Reducing School Dropout (PNRAS), which was adopted in December 2021, is one of the most significant education measures in the NRRP (national resilience and recovery plan). In March 2022, the Ministry of Education announced a list of schools eligible to participate in the programme, that were identified through Romania's MATE early-warning mechanism - a tool for I based on a vulnerability index, developed by The World Bank in cooperation with European Commission.

Exposure of VET graduates to work-based learning

Although the share of upper-secondary pupils enrolled in VET10 is relatively high (56.6% in 2020, above the EU average of 48.7%), recent graduates' exposure to work-based learning is **very limited (7.1% in 2021, compared to 60.7% EU-wide)**. The NRRP aims to significantly improve equipment and infrastructure for VET schools, including agricultural schools, by investing in laboratories, IT equipment, and the development of 10 regional VET consortia.

The low level of participation in adult learning (4.9% in 2021, lower in comparison with EU average: 10.8%) has led to persistent skills shortages, which hampers economic growth

and makes it difficult for Romania to adapt to a rapidly-changing labour market in the digital age.

Certain ongoing projects, such as **ReConnect**, a skills-forecasting mechanism funded by the European Social Fund, should help provide a better match between demand in the labour market and the supply of skilled workers.

Romania has set a 2030 target of having 17.4% of adults engaged in learning in the past 12 months, which is **three times the rate in 2016**.

Romania is continuing its long-term policy reforms to improve digital learning and strengthen digital skills.

In 2021, only 50% of adolescents in Romania aged 16-19 had basic or above-basic digital skills. This meant that Romania was ranked last among EU countries for digital skills. The EU average was 69% in this age group having basic or above-basic digital skills, and Romania's performance was below the EU's 'Digital Decade' target for 2030 of 80%.

Romania's tertiary education attainment rate remains the lowest of all EU countries.

Over the past decade, this rate has not improved significantly and a long-term stagnating trend can be observed. In 2021, this rate stood at 23.3%, which is almost half of the EU average (41.2%). Among other causes, low levels of higher education attainment is caused by the high rates of early school leaving, the low pass rates at the baccalaureate exam, and the low levels of participation in higher education by students from disadvantaged backgrounds. This results in a lack of highly skilled professionals.

Romania's shares of graduates in information and communications technology (ICT) and science, technology, engineering and mathematics (STEM) are among the highest in the EU, but skills shortages remain. Romania has a high share of total ICT graduates (6.7% vs an EU average of 3.9%). This goes some way to addressing the high demands of the labour market, but skills shortages remain. This goes some way to addressing the high demands of the labour market, but skills shortages remain.

Progress is being made in digitalising higher education. The NRRP provides funding for the digitalisation of universities, including digital infrastructure and developing the digital skills of students and university teaching staff.

KEEP IN MIND!

- The educational system in Romania still faces problems at the level of ensuring the quality and equity of education to different vulnerable groups
- There are efforts made by the government and civil society to balance the inclusive educational system



2.2 Children excluded from the education system: causes, typologies, solution implemented so far.

A recent study by World Vision Romania shows that 1 in 10 children of compulsory schooling age in rural areas currently does not attend any educational institution. This study also showed that 1 in 3 teenagers (37%) is absent from school temporarily or permanently because they are working in the household (World Vision Romania, 2022).

Students at risk of dropping out of school tend to be concentrated in disadvantaged schools in rural areas, which lack resources and experienced teachers (OECD, 2022). Many young Romanians leave the school system without acquiring the skills needed to enter the labour market with its fast-changing needs. This makes their transition from school to paid employment difficult (OECD, 2022).

According to Eurostat, in 2020 Romania had the most children exposed to poverty risk, one of three children facing social exclusion. The pandemic situation accentuated the gap between different population categories, children being most affected. Save the Children Organisation stated that in 2020, in Romania, 275 000 children, aged between 7 and 17 years old were not included in any form of education and 45 000 children from primary, secondary and high school, are abandoning school.

The main categories of children more exposed to social and educational exclusion in Romania are:

- **Children from families affected by poverty:** the AROPE indicator utilised by Eurostat to measure the risk of social exclusion and poverty in Europe shows that the most disastrous percentage is registered in Romania, 41.5% of children, meaning 1.5 million are facing food deprivation and limited access to education and social services. 50.1% of these children are coming from rural areas. Moreover, in the last year, due to the conflict from Ukraine, 40% of Romanian households have smaller revenues since the spending amounts doubled for the main consuming products. Family poverty affects children's education. Children abandon school early for going to work or because parents cannot afford education expenses, clothes, books, transportation. Moreover, some parents themselves have poor education and do not understand the importance of education. The children from these families that are going to school sometimes are facing social exclusion and marginalisation because they cannot afford to have the same clothes or books that other colleagues are having. They do not perform well in all subjects and eventually they abandon school early.

- **Children with parents that went to work in other countries:** according to a study performed by Save the Children Romania one in three children in Romania had or are having one or both parents that are working abroad. Studies show that these children are having a higher probability of consuming alcohol, drugs or behaving more violent in school. The anxiety generated by the parent's absence can be directly linked with poor results in school, aggressive behaviour and school abandonment.
- **Children with special needs: A strong political consensus has emerged in Europe on the** importance of inclusive education, and ensuring children with special educational needs (SEN) are included within mainstream education (RAND EUROPE). At the moment, in Romania, there are two options for children with special needs: a special education system that is formed by special schools and mass education schools.

In 2022 Romania had over 100 000 children with special needs, 77 000 were integrated in the general educational system and over 26 000 were integrated in special schools. There is a new approach in Romania concerning orienting children with special needs toward mass education, based on 4 levels of support, on the adaptation of the curricula and complementary services provided based on those 4 levels. Thus every school in Romania will have to have at least a resource room for granting children psychosocial, educational and economic support. The 4 levels proposed by the Ministry of education are:

Level 1- basic – proposed to attend mass education system

Level 2- Supplementary - proposed to attend mass education system

Level 3 – Intensive- 70% of the activities to take place in mass education system

Level 4 – Special – included in special education system

In the same time with the new proposal, the Government launched a new methodology concerning the orientation process of children with special needs, the institutions that are responsible and financial support for families and schools for accommodating them.

Starting with 2020, the National Authority for the Protection of Children's Rights and Adoption made a partnership agreement with the Ministry of Education so that distinct places are allocated in high schools. As a result of this partnership, the Minister of Education issued an Order regulating these separate places for students with SEN in special and mainstream schools, over and above the number of places in the respective educational units. The allocation of candidates to the distinctly allocated places is carried out by the County Admission Commission or City Admissions Commission of Bucharest. Enrolment is based on the student's school and professional guidance certificate.³³

³³ <https://copii.gov.ro/1/copii-cu-cerinte-educationale-speciale/>

All the measures taken in recent past years by the Romanian Government were trying to sustain the integration of children with special needs within the mass education system, where possible.

- **Roma children:** The situation of Roma in the education system remains of concern. 79% of Roma children aged 0-17 are at risk of poverty, leading to educational disadvantage on the basis of both their socioeconomic background and minority status. In 2020, 51% of Roma children aged 6-15 attended schools where 'all or most of schoolmates are Roma' (Fundamental Rights Agency, 2022). At the end of 2019, the government adopted a methodology for monitoring school segregation in pre-university education. Despite the initial plan to implement this methodology in the 2021/2022 school year in order to reduce school segregation, implementation was postponed due to the recurrent closure of schools during the pandemic.³⁴

Early school leaving is particularly high among Roma pupils. Only 22% of young Roma between 18 and 24 years of age have completed upper-secondary education, against 83.3% in the total population (Fundamental Rights Agency, 2022).

The participation rate of Roma children in **early childhood education** is much lower in Romania at 27%, even though researchers agree that the benefits of early childhood education are greatest among disadvantaged children. Most of the kindergartens are located in urban areas, whereas enrolment in rural areas is hampered by capacity shortages. And more than 90% of nursery places for children under the age of 3 are located in urban areas (OECD, 2020).

The gap between students from high socioeconomic backgrounds and students from low socioeconomic backgrounds in Romania is the highest in the EU (EU average: 19.3 pps). Providing education in the language of Romania's national minorities, in particular minorities from disadvantaged backgrounds, is held back by the lack of sufficient resources and staff.

KEEP IN MIND!

- the most excluded children from education system are: those from families affected by poverty, with parents abroad, with special needs and roma children
- there are recent national strategies and programs and other public policies that stipulates measures for a better inclusive education

³⁴ Ditto 31

2.3 Proposal of the most excluded types of youth from the education national system, to be used as characters of the educational cartoons.

Based on the mentions presented above, it seems that students from different backgrounds face different degrees of social exclusion. Although there are efforts from governors side for the inclusive education of SEN children, these efforts must be doubled by the support measures to prevent and combat attitudinal barriers.³⁵

- a) informing the parents whose children attend the school, about inclusive education and social inclusion of the children with disabilities and/or SEN;
- b) informing the students in the educational unit about the inclusive education for the children with disabilities or SEN, using an adapted language their age and, preferably, using peer-to-peer education;
- c) informing the management of the educational unit and teaching staff regarding inclusive education and social inclusion of the children with disabilities and/or SEN
- d) the presence of the facilitator (*shadow person*),, with the child in the educational unit.

In order to empower these marginalised groups and change the attitudes and behaviours of the students and the teachers regarding social inclusion, educational cartoons are a useful solution for promoting empathy, understanding that special needs students are NOT defined by their needs.

KEEP IN MIND!

- students from different backgrounds face different degrees of social exclusion
- educational cartoons are a useful solution for promoting empathy, for better understanding of the children with SEN and better inclusion of them into a proper education system

3 RESEARCH PHASE 3 – SELECTION OF THE EDUCATIONAL CARTOONS METHODOLOGIES AND TECHNIQUES

³⁵ Ditto 33

3.1 Analysis of the existing educational cartoons methodologies and techniques- overall benefits of these methods.

It is well known that at the basis of human development there are three major factors: heredity, environment and education. Researchers point out that the **environment**, the examples that children receive and the things they observe, consistently influence children's later behaviours.

Cartoons are an essential part of every childhood and certainly the most popular form of entertainment, especially for the little ones, but also for the adults.³⁶

Full of entertainment, colourful characters and complex actions, cartoons can be real educational tools, which bring benefits to the child, families, and teacher. Here are some of the benefits:

- It helps the child's development on several levels: linguistic, cognitive, socio-emotional and physical. Children improve their language, develop their sensory perceptions, understand more emotions and discover the most important values through different characters.
- Images and sensorial experiences stimulate and help them to train their imagination. When watching animations, children rely on a variety of senses. The brain learns to make connections on its own, leading to better recognition and focused attention.
- Problem solving skills are developed and working memory improves. When children understand the relationship between the actions and the decisions that characters make and their immediate results, they learn to think ahead and pay attention to building a strategy beforehand.
- Children connected to the world of stories, interesting characters, fantastic and adventurous events can discover new passions and talents, which they can later train in many other contexts.
- It trains critical and analytical thinking. Using multiple skills at the same time allows for deeper connections and makes learning more real. This will encourage a flexible mindset and lifelong learning.

Through drawings, animated videos, children can learn about the world around them, about their own emotions, about the problems and obstacles they may encounter in various situations, about the fantastic, about the real, about friendship and responsibility. It is an alternative learning method that increases students' ability to visualise and understand complex phenomena much more easily, but also to better retain abstract concepts from textbooks³⁷.

³⁶ <https://www.kinderpedia.co/ro/desenele-animare-pentru-copii.html?format=html>

³⁷ <https://spotmedia.ro/stiri/educatie/educatia-prin-intermediul-animatiei-solutia-la-care-apeleaza-tot-mai-multi-profesori-ca-sa-isi-ajute-elevii-sa-isi-dezvolte-gandirea-critica>

Today, the basic informational function of the textbook is gradually being replaced by the function of modelling skills and creating competences, by assimilating not only knowledge but also by developing an autonomous way of thinking.

Interactive lessons are increasingly used by teachers. The focus of the school curriculum on encouraging skills has led to textbooks being structured in a style that includes lots of practical application and less pure theory. Case studies, analysis and creative assignments have taken the place of rote memorization of the lessons. The didactic task of the teacher focuses more and more on the relationship with the student, on stimulating classroom interaction between students, and formulating engaging courses for younger or older students.³⁸

The most important step in the evolution of school textbooks was the transition from books to electronic support. The years of the pandemic have clearly demonstrated the usefulness of these **online textbooks**, for students of all ages but also for teachers. The simplicity of using a digital textbook, the use of animations by integrating specific animation techniques led to better structured, clearer and useful lessons for students, even hundreds of kilometres away from their teachers.

Also here we mention an overview of the most common animation techniques³⁹:

- **Stop-motion animation** - form of 3D animation in which figures, clay models or dolls are placed in the required position and photographed several times. When the images are played quickly, it tricks the eye into thinking the puppets are moving on their own. Eg. *Corpse Bride* (2015)- Tim Burton.⁴⁰
- **Cutout animation** is pretty much exactly what it sounds like: cutout shapes arranged on a flat surface, and manually moved and repositioned to simulate animation. Cutouts can be coloured paper, white paper, with drawings on it, even photos, and can be completely flat (2D) or sometimes 3D objects. One of the best examples of cutout animation is the animated franchise, *South Park*⁴¹
- **Rotoscopy** - refers to an animation technique to trace each frame of a live action film and draw it frame by frame on animation papers. In this way, rotoscoping turns a live-action film into a cartoon, with characters replicating all the actions of real people, thus avoiding the jerky and awkward movement in previous animations. It's done by projecting live-action film onto glass with light and manually tracing over the image on each frame. This type of rotoscoping existed before the digital age, only the glass and projector have been replaced by drawing boards and digital computers.⁴²

³⁸ <https://www.libriaridelfin.ro/articol/rolul-si-importanta-manualelor-scolare-in-procesul-educational--i113>

³⁹ <https://ro.eferrit.com/tehnici-de-animatie-pentru-incepatori/>

⁴⁰ https://stopmotionhero.com/ro/stop-motion-animation/?utm_content=cmp-true

⁴¹ https://ro.eyewated.com/aflati-despre-animatia-cutout/#google_vignette

⁴² <https://comunitateawordpress.club/totul-despre-rotoscoping-concept-istorie-si-aplicatie/>

Notable examples: Snow White and the seven Dwarfs, Pinocchio and Alice in Wonderland from the Disney Studio, Star Wars (the original trilogy) or *Waking Life*.

- **Cel animation**- Cel animation is the art of creating 2D animation by hand on sheets of transparent plastic called “cels”. Cel is a clear sheet of cellulose acetate used as a space for painting animation frames. It is transparent so it can be placed over other painted backgrounds, then photographed. Cartoons like *The Simpsons* and *Adventure Time* are made with cel animation. It wasn't until 1995 that the first computer-generated film arrived in *Toy Story*, from the then-new studio, Pixar (see the link with below 3D CGI)⁴³
- **3D CGI Animation** - CGI (Computer Generated Imagery) is also used for 2D and stop-motion animation. But it is a 3D CGI animation that has become a popular form of animation. One such example is - Dragon Rider -DreamWorks. The technique was used including for the movie Spiderman.
- **Flash animation** - is a way to create not only simple animations for websites, but also colourful cartoons. Flash animation is created using Adobe Flash or a similar software program.⁴⁴ An example of flash animation: *My Little Pony: Friendship is Magic*.

KEEP IN MIND!

- Cartoon educational methods have many benefits for children, teachers and parents/families
- There are conventional and modern techniques of producing animation, either 2D either 3D
- Whatever technique it is chosen, animation should have a moral values education

3.2 Possible online tools, software and generators capable of creating the cartoons and their components.

Top 10 animation software used in Romania

1. Toontastic 3D (iOS & Android) - you can draw, animate, and narrate swashbuckling adventures, breaking news stories, science reports, and all your other wacky ideas. FREE download, no ads or in-app purchases.

⁴³ <https://www.adobe.com/creativecloud/animation/discover/cel-animation.html#chel>

⁴⁴ <https://www.adobe.com/ro/products/animate.html>

2. FlipaClip (Android, iOS, Windows) - It's a great tool for beginners and aspiring animators to explore their creativity and make animated videos or gifs. Free version +in-app purchase.

3. Pencil 2D Animation (Windows) - An easy, intuitive tool to make 2D hand-drawn animations, completely open source and free to use, even commercially!

4. Mango Animate Whiteboard Animation Video Maker (Mac, Windows) - Character animation software to bring your projects to life with 2D characters and skeletal animation. Turn static images into animated cartoon characters in a snap. Library of free media objects prebuilt in the animation video maker and ready to use, also in-app purchase.

5. MotionBook (iPad, iPhone, Mac) - great app to be used for beginners, provides a set of well-designed digital tools for you to create traditional frame-by-frame animations, on iPad or iPhone, free plus in-App purchase.

6. Synfig Animation Studio (Windows) - a free and open-source 2D animation software, it allows you to easily create impressive animations, without the need to draw every frame by hand, free software.

7. Cartoon Animator4 (Windows) - a 2D animation software designed for ease of entry and productivity. Turn images into animated characters, drive facial animations with your expressions, generate lip-sync animation from audio, create 3D parallax scenes, and produce 2D visual effects.

8. Animation Desk (Android/iOS/Windows): simple and beautiful software for creating animation, cartoons, animatics, 2D hand-drawn animation, and showcasing creativity. Free for beginners & subscription fee for PRO.

9. Scratch (Windows) - the world's largest free coding community for kids, with a simple 2D visual interface that allows young people to create digital stories, games, and animations. Students are learning with Scratch at all levels (from elementary school to college) and across disciplines (such as maths, computer science, language arts, and social studies).

10. Animatron (Windows) – user-friendly interface – free 2D pre-animated characters, backgrounds, and props. Free version - "try-out" features, learn basics of animation & video editing, and share your movies, and subscriptions for PRO.

For those who are interested in learning how to create an animation there are at least 25 on-line free courses that help them to learn basic elements and to develop their skills in this exciting field.⁴⁵

KEEP IN MIND!

- there are at least 10 software for create animation -2d and 3D
- there are free software and easy to access
- there are free on-line courses for doing free animation

⁴⁵ https://worldscholarshub.com/ro/free-animation-courses/#google_vignette

3.3 Proposal of educational cartoons methodologies and techniques;

According to the research carried out in Romania, the most popular cartoons mentioned by students were those from Marvel - Iron man, Batman, Superman, (superheroes) Spongebob, Flash, Cars, Star Wars, Spider Man, CS GO, Five M, Lego , Ninjago, Fam Paris, Barbie, H2O - add Water, Amazing World of Grimball, Regular Show, but also Tom and Jerry or the depressed Squid.

They mentioned that a situation of social exclusion or discrimination can be explained through cartoon characters, giving the example of the character represented by a black cat in a world where the rest of the cats were white.

It is recommended to use the 2D- digital & traditional techniques for the creation of a cartoon that deals with real world problems that can be solved through both STEM approach and social inclusion educational approach.

KEEP IN MIND!

- social exclusion or discrimination can be explained through cartoon characters
- different easy techniques can be accessed by students in order to create their scenarios

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