

Type of the Paper (Proceedings, Abstract, Extended Abstract, Editorial, etc.)

Innovative teaching and learning pathways for responsible use of resources focusing on the ESEE region [†]

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[†] Presented at the International Conference on Raw Materials and Circular Economy, Athens, and 05-09 September 2021.

Abstract: In a world depicted by rapid growth and consumerism, where pressing societal issues such as, the critical climate crises, resources exploitation in developing countries and much more, it is essential to educate all citizens about raw materials, their uses and about responsible production and consumption [1]. Developing life-long learning programmes is an essential tool to educate the population starting with the youngest members of society (pre-school) to adulthood (life-long learning) with a special focus on the life-world orientation from a learners' perspective. The wider society learning flagship project, 'Raw MatTers Ambassadors at Schools' (RM@Schools), is an innovative programme funded by the European Institute of Innovation & Technology (EIT) which promotes science education and careers in the raw materials sector. Since the project's commencement in 2016, it has gained stronger European representation with a current total of 32 partners from 18 countries. This includes the consortium members from a parallel funded programme, RM@SchoolsESEE. This project aims at extending best practices and diversifying the current portfolio to East and Southeast European countries. What makes this project so innovative is in the programme and individual learning pathways. Considering a multidisciplinary and cultural perspective, a framework was developed to assist in forming raw materials ambassadors through engaging programmes for school pupils from aged 10 up to 19 years old and through the development of educational hands-on toolkits that range from experiments to game-based tools and much more [2]. In particular, and as a way to increase impact, the project aims to mentor teenagers from all educational disciplines between the ages of 14-19 years old to become 'Young RM Ambassadors'. This approach utilises state-of-the-art teaching and learning methods resulting in peer-to-peer knowledge exchange and dissemination. Built into the programme is a continuous feedback loop that involves stakeholders from all sides of the knowledge triangle: educators, pupils, professionals and researchers.

Citation: Murphy, M.; Pacher, C.; Innovative teaching and learning pathways for responsible use of resources focusing on the ESEE region. *Mater. Proc.* **2021**, *3*, x. <https://doi.org/10.3390/xxxxx>

Published: date

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Keywords: Education 4.0, Raw Materials, Teaching and learning, Ambassadors, Responsible use of resources



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1. Background

In 2020, the RM@Schools-ESEE (East & South-East Europe Countries) project started, which emerged from the RM@Schools project and currently runs parallel with it. The project aims to foster and strengthen the motivation of students of schools in the ESEE region, to deal with RM-related STEM (Science, Technology, Engineering and Mathematics) subjects and to choose a professional career in these fields to ensure the future of these subjects in Europe. By being dedicated to the ESEE region, RM@Schools-ESEE is expanding the Raw Materials Academy's efforts towards young students (11-19 years old) across Europe to promote a wide dissemination action on RM-related themes in schools and society through strategic European partnerships among research, school, and industry. An active

learning approach will be proposed to schools by RM Ambassadors (experts in some RM-related issues and trained teachers) by involving students in experiments with RM-related hands-on educational kits, in excursions to industries, and in science dissemination activities. The students will be asked to become Young RM Ambassadors themselves (science communicators) by creating dissemination products and/or collaborating with experts during public events. All the produced resources and the best communication materials realised by students will be accessible online on the website of the project to be shared with a wider public. Groups of delegates (partners, teachers and students from high schools) from all the Consortium' countries will take part at the annual European Conference jointly organised with RM@Schools 4.0 project, to puzzle unique great European Networks of schools, universities, research centers and collaborative companies. New hands-on tools for supporting experimental activities at school will be set up and developed, as well as successful educational tools realised in other projects will be used in the RM@Schools-ESEENetwork to share the common benefits [3]. Finally, career orienting actions will be performed both at the European and local level. In fact, International RM@Schools Summer Camps for the most motivated and interested students from all the partners' countries will be organised, as well as local Career Orientation Days where RM@Schools students will interact directly with universities and companies to obtain information on job opportunities in the different sectors.

2. Needs and impact

Indifference and sparse interest are generally diffused on the importance of science and technology, especially when dealing with raw materials. When thinking about young people, one of the reasons could be related to the way science is currently taught in schools, which may not always be appealing and effective in showing the real impact of RM in everyday life. As reported by the UNESCO document, education is the primary agent of transformation towards sustainable development, increasing people's capacities to transform their visions for society into reality [4]. Education not only provides scientific and technical skills, it also provides the motivation, justification, and social support for pursuing and applying them. A collaborative dialogue between students, teachers, scientific experts, and industries is the most effective means to transfer scientific progress and to promote technological advances. Moreover, the European educational system is overall not able to generate a future class of citizens sensitive and appropriately prepared to face RM issues, requiring the knowledge of different disciplines such as sustainable exploration, extraction, processing, recycling, substitution, and the relative impact on the environment [5]. In this perspective the RM@Schools project represents a key action to introduce and promote this topic in schools and together with schools into society.

3. Project objective and scope

The general scope of the project is to promote and assist a wide dissemination action on RM science in Schools and to Society by strengthening, implementing, and expanding the already collaborative processes activated within the framework of the RM@Schools project through a wider collaborative dialogue and networking between European and Local Actors, and strategic partnerships between different actors of RM sectors, including Industry. The core process of this project is to make Research and Industry connect with Schools, who in turn, need to connect with Society, in a common learning environment. Through this process, RM@Schools is particularly aimed to ensure that young people increase their personal and collective competence with the scientific and technological skills they need in their everyday lives, as well as in their future professional careers. These skills are and will be ever more essential to enable every citizen to participate successfully in the Research and Innovation processes of global societies, to make informed choices and to be engaged actively in a democratic knowledge-based society [6]. Thus, the RM@Schools project addresses the challenges to contribute to build up a society that

enables citizens to participate to the responsible research and innovation processes of RM experts (Universities, Scientific Organizations, Mineralogical and Geological Museums, different Societies/Associations), Secondary Schools (science Teachers and school authorities), and Companies working on RM-related chains, will create the basis for the development of a network of RM Ambassadors able to increase the interest of youngsters towards RM values and explain the opportunities and the potential criticality of RM.

4. Methodology

An active learning approach will be implemented by involving students in experiments with RM-related hands-on educational toolkits, in excursions to industries, and in science dissemination activities. The best practice examples will be used for two educational approaches, one targeting school students aged 10 to 13 years, the other one for 14 to 19 years old students. In particular, students from 14 to 19 years old are asked to become RM Ambassadors themselves (peer to peer education) by creating dissemination products by using both their native and the English language [7]. All the produced materials and the best communication materials realized by students will be accessible online on the website (Virtual Centre) of the project to be shared with a wider public.

4.1 Target groups

1. 10 - 13 and 14 - 19-years-old students:

The need to have different tools for rethinking science has been envisaged and the crucial step is to individuate a real breakthrough in science dissemination, which can be attractive for youths. As also pointed out by the well-known phrase of Confucius "If I hear I forget, if I see I remember, if I do I understand", there is a need to use an active learning by doing experimental approach, i.e. set-up of laboratories where students can meet science by experiments, is an improvement of science teaching [8]. On the other hand, by taking into consideration creativity of modern teenagers and their familiarity with communication tools and digital devices, an active learning through the involvement of the students in communication activities can complete and potentiate the knowledge obtained by the experimental approach. Thus, all students, even the youngest, will be asked to become science communicators themselves (Young RM Ambassadors) and create dissemination products focused on RM by using the native idiom (10-13-year old students) or two idioms, the native and English languages (14-19-year old students). Through this approach, English and the native language will ensure the possibility for exchanging information between European high school students, as well as the communication in local society. Thus, a peer-to-peer dissemination process will be activated: Student groups are a great way to meet other students while exploring own interests, developing leadership skills, and becoming active in the RM@Schools community. Thus, some students (14-19-year old students) will be successively trained to collaborate with RM Ambassadors for supporting the organization of public Events and they will serve the community. Dissemination activities cannot exclude social networks both as a consequence and as a driver of the significant technological exposure of young people. Indeed, it is known that dissemination of science through social networks produces a domino effect in the interest raised by scientific topics, crossing the borders of research and industrial environments. Thus, groups of selected students (14-19-year old students) will be trained to become RM Correspondents, able to report their direct experience during visits in industries/research centres/Museums, and create digital content focused on RM issues to be shared on the web under the supervision of the RM ambassadors. By sharing the students' dissemination products on Social Networks like Facebook and You Tube, high visibility will be given to RM-related issues and newest findings, and social users' critical involvement will be promoted thanks to the possibility to comment.

2. School Teachers:

Most of the teachers struggle with how to implement themes like RM and science in their lessons and implement their digital culture. The RM@Schools project will give them not only a better understanding of some RM related topics, providing them the right tools to offer their students interesting experiments, but also an improvement of their science communication capabilities by establishing training pathways by the organization of local workshops.

3. Public:

The dissemination approach of the RM@Schools project starts from Research versus Schools and, in turn, reaches Society. A wide Public will be reached through the organization of new Open-access Events or the participation to already existing Events (i.e. European Research Night, Events in Mining Engineering Schools, Open days at Universities, etc.) to create understanding of the real impact of RMs on everyday life and opportunities. These events will be organized by Young RM Ambassadors that will become active players to diffuse the RM@Schools contents among peers. The teachers and students' schools will be encouraged to complete a feedback form in order to evaluate and enhance the quality of the educational program proposed by RM@Schools. In this way the educational approaches can be evaluated and eventually reshaped considering the peculiarities of each country.

4.2 Learning pathway

The toolkit Augmented Reality meets RM provides an introductory lesson about the topic of mining and raw materials. It serves as a first introduction lesson to prepare the students for following experiments, projects or it can also be held as a standalone lesson to teach about raw materials and mining. It can also be used as a different approach to talking about the more familiar concepts of climate change, recycling and circular economy. The lesson can be held in a regular classroom, in a laboratory, outside or also remotely. The lesson is designed for children from ages 10-14. The lesson can also be used for older students if more difficult questions and tasks are given. The 2 main questions to be asked and answered during this lesson are the following:

1. Why do we need mineral raw materials?
2. How does mining work nowadays?

By the end of the lesson the students will be able to:

- Recall the principles of circular economy
- Explain the importance of raw materials in everyday life
- Repeat how mining is done today and, in the future

4.2.1 Learning Pathway – step by step:

- Step 1- Time & Activity:

10 minutes

Augmented reality – brainstorming:

The students will have downloaded an app before the lesson. The teacher can use PowerPoint slides to guide the lesson. The lesson is started and the students will open the Unity app on their phones. They will see the trigger picture provided by the teacher and will scan it with their phone camera within the Unity app.

They will see a mine with haul trucks in 3D. The following questions can be posed to the students:

- What is the name of this machine?
- Where can you find this machine?

- What does this machine do?
- What does that have to do with us?

- Step 2 – Time& Activity:

30 minutes

World Café Method:

The students are divided into groups and will be either placed together, or if given online, sent into breakout rooms. The teacher has already prepared the tasks, which can be found in the PowerPoint presentation. Ideally, there are 4 groups and each group have 7 minutes for each station and task.

1.Task A: Draw a picture about mining (e.g. MIRO board or on the paper provided) Explanation: The students might have an outdated image of mining in their heads or cannot imagine anything at all. Therefore, this task gives them the chance to visualize what they know about mining.

2.Task B: Each group defines three key words about mining and shares them with the groups or in the chat. The students also have to explain their choice for the selected words. The teacher will collect all the words and discuss them with the students. He or she could also create a word cloud with the given words.

3.Task C: Mining countries on the world map. In the PowerPoint slides there is a blank world map, where the students have the task to search the internet for mining sites around the world. The countries found should then be coloured in on the map. The task can be adapted by asking them to locate e.g. the largest gold, copper or iron mine in the world.

4. Task D: Mobile phone

- o How many mobile phones does your family have?
- o What do you do with your old ones?
- o Why do you think it is necessary to recycle your old mobile phone?

The students should discuss these questions within their groups and take some notes. At the end of the lesson these answers and ideas serve as a final discussion about recycling in the plenary session.

- Step 3 – Time& Activity

10 minutes

Closing: The students are being brought back together or into the main room and share all the results with each other. The teacher can draw a conclusion and summarize the main points. In addition, he or she can broaden the task from task D.

The lesson will be closed with an overall assessment by means of a Kahoot quiz and feedback forms for children and teachers to guarantee a holistic assessment of the toolkit.

5. Conclusion and outlook

Education is a powerful tool, and not just for those in classrooms but for the entire society. It is an indispensable instrument in developing technological innovation and creating a bridge of general understanding among civic society. The goal of RM@Schools is to develop a strategic dissemination capacity and methodology to improve the image and education of science & technology in schools for students aged 10 to 19 years old, to foster a circular economy and to illustrate the value of raw materials while promoting new professional careers in this sector.

Funding: This research was funded by EIT, a body of the European Union, grant number 19069.

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