Ecology and STEM

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Abstract. This paper is devoted to combining ecology challenges and STEM technologies. We consider ecology as an integral part of STEM process. The including of ecology in the STEM allows not only to develop mathematician calculations and engineering skills but also forms students’ ecological consciousness. The attempt to combine ecology and STEM is aimed to make the knowledge in ecological sphere more practical. STEM education can help in solving the main ecological problems and challenges. STEM lessons, projects, conferences, exchanges could explain and give a living example of damages caused to our planet by irrational using of natural resources. It can improve public awareness and show the careful attitude to our planet.

Key words: ecology challenges, STEM, STEM technologies, ecological consciousness.

1. Introduction
Ecology is a science about environment. The most important purpose of ecological science is the study of environment and the relationship in it. Ecology is closely associated with conservation and environmentalism today, but it is not only this. Ecology also touch human gut flora, the processes of the urban environment functioning and the ecology of the nutrient cycles of the soil. The word “ecology” has come from the Greek language and today it means “house study or living relations study”. That mostly defines its true destination - the studying of relationships between those who occupy a house. Ecology touches upon the problems of organic life and examines such elements as spatial distribution (local or general) abundance and their relationship with our environment. This includes the interaction of different elements with other organisms within that environment - essentially their “interrelatedness” as a functioning network [1]. It is considered to be a form of environmentalism and it is usually associated with ecology sciences. Besides ecology also includes the aspects of such sciences as biology, botany, zoology, genetics, bacteriology, chemistry and physics. Ecology is a science about biodiversity in a given environment. It has much in common with many other sciences. For example, it has common features with physiology, behavioral sciences and the evolutionary sciences as well as it has with environmental sciences [2] in concerning time and space such as physics. In this paper we'll try to consider ecology like a part of STEM education.

2. Materials and methods
The are many areas of ecology, they include adaptation, distribution, abundance, spatial concentration and biodiversity. These processes that constitute biological life. But what are the reasons that make...
ecosystems be changed when subject to external pressures? They change to ones and move of the others, energy and materials are constantly being renovated through an ecosystem. Some ecosystems can change quickly, some of them remain more constant and change slowly. This means an ecological study can include almost everything. It can be something from bacterial cells [3] to gut flora. It can be the fact how many generations of aphids can populate a plant. Or all the ways how deserts form and maintain a constant balance. And the impact of rainforests and ice fields on the Earth's natural processes. Or how all these processes are impacted by planetary fluctuations [4].

Ecology and its various subdisciplines are entering both a new time full of challenges and excitings. Some challenges are accelerating the ecology development. From one hand new technologies could help practitioners to streamline some processes. On the other hand, decision-making politicians could improve public awareness.

Ecology now faces various challenges. The first and biggest challenge is in conservation ecology. One of the most important problems is increasing species extinction because of human-induced climate change. Actually, we can see the influence of average temperature rises on the global ecology [5]. International agreements continue to be made and acted on to reduce carbon emissions targets. We know that ocean acidification leads to damaging aquatic ecologies, damaging coral and affecting biological life that depends on those ecosystems. Ecology and ecologists are expected to remain at the forefront of understanding these serious problems and possible solutions.

Biodiversity is also an important challenge. As land clearance in ecologically sensitive areas makes way for farmland or urban landscapes, this affects the species that comprise this landscape. Loss of habitat without provision for conservation can create serious imbalances between predators and their prey [6], remove vital food sources for herbivorous and carnivorous species. Urban environments are constantly searching how to improve biodiversity within their own environments [7]. Now the urban designers and architects are continuing to promote biodiversity and find survival opportunities for the species that are being displaced or those that have already made a home in our urban landscapes.

The developing ecological damage is another challenge. As previously poor countries improve their economies, livelihoods, lifestyles and global economic power [8], developers are cutting down natural landscapes to make way for urban centers, factories, road network and infrastructure. Balancing of these economics needs against the global ecology is expected to be a major discussion point in both international trade and climate agreements.

Access to water, water security and scarcity together with all of the above is likely to underpin many of our ecological problems.

As we can see ecology is a science itself with many serious global problems to be solved. And it seems to be impossible to solve all these problems by itself. Ecology is not just a science in an abstract sense, it is the part of our everyday life because we all live here and it also can be the part of new stream in an educational and scientific space called STEM. The term STEM (Science (biology, ecology, etc.), Technology, Engineering and Mathematics) is an acronym used by those relevant to the educational method concerning the fields of Science, Technology, Engineering and Mathematics. This term was first used in 2011 by the biologist Judith A. Ramaley, who as head of the Natural Science Institution of the U.S.A., was in charge of developing new educational programs. STEM is an educational approach designed to combine technology and engineering together with science and mathematics, and this combination will be more helpful in order to understand more the laws of the universe.

In our attempt to combine ecology and STEM the basic question to be answered is “How can we give such an understanding to ecology so that children would want to do their best for our nature and planet, improve their knowledge in this sphere and perform actions in order to start academic education and enter working market?” [9, 10].

The answer to this question is simple: Students would have to be trained properly so that they can understand that their own prosperity depends on the quality of the whole world they live in, in other words they should be educated in matters like the climatic change, renewable energy sources, natural environment etc. [11]. A nation deeply educated is able to meet the everyday challenges and innovate. With STEM children get the opportunity to develop their capabilities in an ideal environment. STEM
education is now an economic must in the country, as more than 30 prospering occupations will require STEM knowledge in the near future [12]. STEM education is an attempt to evolve from the tutor-centered approach into a teaching method that involves problem solving skills, creativeness and initiatives, as well as research and hands-on activities. STEM offers a chance for children to develop their abilities, to have new ideas, to form new thinking. In STEM education children are encouraged to answer questions and are involved with fun activities based on science, mathematics, engineering and technology. It is really impressive to see the children’s reaction to this method, as they seem to find it more interesting and appealing. By applying STEM through various projects, students learn not only to process facts and focus on solving problems but also gain abilities fitting to global education. In such way of education they learn to develop critical thinking and work in a team, while it has also been reported that the knowledge gap between children from different countries has significantly been decreased. In this philosophy, a new project was born, called STEM. From one hand STEM is aiming to initiate social awareness and ensure everyone’s involvement in achieving real increase in children’s performance in science, technology, engineering and mathematics. From the other hand STEM is based on the knowledge of science, technology, engineering and mathematics.

There’s no doubt in the effectiveness of STEM education and STEM methods in education. There is no doubt in the special role of ecology in the science [13, 14]. But where is the ecology place in the hierarchy of STEM processes? We are just trying to answer this question and to find its place.

Ecology studies the relationship and problems in our environment and STEM helps us to understand the functioning and problems of our world - environment.

STEM education can help in solving of the main ecological problems and challenges. STEM lessons, projects, conferences, exchanges could explain and give a living example of damages caused to our planet by irrational using of natural resources [15]. It can improve public awareness and show how the careful attitude to our planet - our home can save it and us.

3. Discussion
Ecology is increasingly penetrating into various strata of society. Solutions to many important issues are now evaluated based on their impact on the environment. Such an assessment is becoming increasingly difficult, given the need to control and monitor a large number of factors. Environmental mistakes will have a greater influence on our children. To be able to avoid new mistakes and preserve the environment, the younger generation must be very competent in environmental matters. Even now, children are actively involved in various environmental activities, such as those designed to draw public attention to climate change issues (the most famous activist is Greta Thunberg even spoke at the UN). In different countries, environmental lessons are included in the mandatory course of the school curriculum, and the importance of environmental protection is emphasized in the lessons of the "Surrounding world". In high school, students have the opportunity to assess the impact of human actions on nature through the prism of their knowledge of physics, chemistry and biology, and learn more about environmental disasters that have occurred. Thus, environmental issues are intertwined in various aspects of the school curriculum, in fact, being a link of interdisciplinary interaction. This is especially important in countries where STEM is not yet a mandatory curriculum. The topic of ecology is also among the top most popular topics of project activity of schoolchildren, and project activity and STEM are a single whole. The activities of large and medium-sized enterprises cannot do without addressing environmental safety issues. Often entire departments are created for this purpose. Automation systems for managing such complexes are one of the possible tasks of future STEM specialists.

The faculty of mathematics and science education of Belgorod State University with the support of the European Union (Erasmus+ project) this year has opened a new program for training future masters in STEM disciplines. In this program, as many as 3 disciplines are devoted to ecology: Fundamentals of ecology, Environmental Monitoring and Greening of educational programs. STEM teachers who have defended their master's thesis in this area will be able to train STEM specialists who will be well versed, in particular, in the field of environmental safety.
One of the main ecological problems is the environment pollution - water pollution, air pollution, plastic pollution. It is a well-known fact that a plastic bottle is used for 15 minutes on average and takes about 200 years to decompose. About one million plastic bottles are sold in the world every minute. And only 9% of used plastic is recycled, 12% gets burned, and the rest ends up in garbage dumps or the ocean. Because of this we find it in our drinking water and in our bodies (and in the bodies of other animals too). And this is just one of the many types of pollution that is currently taking place on Earth. It seems it's high time for each of us to think about how we can take part in saving our planet.

One of the easiest examples of the STEM practice organizing may be the problem solving task which is offered to students at the beginning of the lesson. For example, we can offer to look at the photo showing the problem of plastic pollution. On the left we can see a huge heap of plastic. On the right - the plastic has been recycled and transformed into shoes. So, we see plastic pollution and plastic recycling. And we give to the students the opportunity to choose, to think, to make conclusions by answering them a simple question:

Where is the plastic bottle you've used today – on the left or on the right? Where can this plastic be tomorrow?

![Figure 1. The problem of plastic recycling.](image)

The visualization of the problem during STEM lessons "turns on" the thinking processes and starts the mechanism of creation. After looking at this picture and thinking the students could unlikely remain indifferent to the ecological problems in general and to the problem of pollution in particularly. Minimum they can do - pick up the plastic bottle and put into special container for recycling. But some of the students can do their maximum - create ecological projects, which may help or even save our planet in the future. In the sheet bellow we can observe the steps of the STEM activity in ecology.

The students can stop at any of these steps and they can go to the end and even further. And that is the main purpose of STEM education in ecology - through visualization and thinking to creation and invention.
Table 1. STEM staircase.

| Step  | Description                                      |
|-------|--------------------------------------------------|
| Step 1| Look at the photo, watch film, etc.              |
| Step 2| Make choice and decision                         |
| Step 3| Find out the ways of problem solving             |
| Step 4| Chose the methods and techniques                 |
| Step 5| Calculate the expenses and cost                  |
| Step 6| Create the model                                 |
| Step 7| Find the practical appliance                     |
| Step 8| Analyze the results                              |
| Step 9| Make conclusions                                 |

4. Results
We are going to list successful ecological projects that have been created by people who care about the pollution problem. These Tremendous Ecological Projects that really make our planet healthier and can be realized during STEM practice.

1. Footwear made from recycled plastic bottles

![Figure 2. Footwear made from recycled plastic bottles](https://m.facebook.com/rothys)

The Rothy’s shoe brand creates shoes from recycled plastic bottles. The most popular collection consists of colorful and washable flats which Meghan Markle put on during her recent visit to Australia. The company has already recycled 25 million plastic bottles.

Table 2. Ideas for students STEM practice #1.

1. Study the problem of plastic pollution (Science)
2. Count the cost of one shoe pair production (Mathematics)
3. Create your own shoe pair design (Engineering)
4. Make one shoe pair on 3D printer (Technology)
2. Kids furniture made of broken plastic toys

A Dutch project called EcoBirdy creates furniture from broken and discarded kids toys. Apart from making furniture, the company has also launched an educational project about the harm done by plastic and has installed special containers in kindergartens where kids can leave their broken toys. The company has already recycled 25 tons of plastic toys.

Table 3. Ideas for students STEM practice #2.

| Idea |
|------|
| 1. Collect all the old toys at home and study the problem of plastic pollution (Science) |
| 2. Count the cost of all your old toys (Mathematics) |
| 3. Create your own model of furniture for kids (Engineering) |
| 4. Make your piece of furniture on 3D printer (Technology) |

3. Newspaper wood

Figure 3. Kids furniture made of broken plastic toys.

Figure 4. Newspaper wood project. [https://newspaperwood.com/projects/](https://newspaperwood.com/projects/)
Dutch designer Mieke Meijer has always been perturbed by unsold newspapers because a lot of trees are cut down to produce them. That’s how and why he came up with the ‘Newspaper wood’ idea — a material made from extruded old newspapers and organic glue that resembles wood in its appearance and strength. It can be sawed, polished, and drilled. Today, furniture and interior decorations are made using this brilliant material.

Table 4. Ideas for students STEM practice #3

| 1. Collect all old newspapers at home and study the problem of the wood cutting (Science) |
| 2. Count the cost of one newspaper chair (Mathematics) |
| 3. Create your own model of a newspaper chair (Engineering) |
| 4. Make your newspaper chair on 3D printer (Technology) |

4. The ocean cleanup

The plastic floating in the ocean weighs as much as 1,000 Eiffel Towers and it could take as long as 79,000 years to collect it. The good news is that a 24-year-old Dutchman named Boyan Slat has created a litter trap. It is a floating U-shaped system that is able to catch plastic floating on the surface of the ocean. Slat hopes to catch all the ocean trash within 20 years with the help of these traps. You can watch the principle of this system work here. The project also has famous investors like the founder of PayPal, Peter Thiel. The first trap was set on the water in September 2018. It is planned that a special garbage collecting ship will take out the collected plastic once every several months and send it to be recycled. The bonus is a floating off-shore city made of plastic trash.

Figure 5. A floating off-shore city made of plastic trash
https://www.freischarlert.archi/united-plastic-nation/.

An Australian company called ‘Freischärler’ came up with another method of fighting ocean pollution — a project to build a floating city out of ocean plastic with the help of 3D printers and drones. ‘United plastic nation,’ which resembles an iceberg with a visible underwater section, will become an independent off-shore zone where plants will be grown with the help of the aquaponic method and where all trash will be recycled.
Table 5. Ideas for students STEM practice #4.

|   |   |
|---|---|
| 1. | Collect all old plastic at home and study the problem of water pollution (Science) |
| 2. | Count the cost of your old plastic recycling (Mathematics) |
| 3. | Create your own model of what you can do from this plastic (Engineering) |
| 4. | Make the computer model (Technology) |

5. Conclusion

These projects are being realized now by different international companies. But they can be also realized by students during STEM lessons. Drones, 3D printers, microscopes connected with computers can be used on the ecology STEM lessons. The main advantage of such lessons in fact that they allow not only to develop mathematician calculations and engineering skills but also they form students' ecological consciousness. The realizing of these projects by students themselves forms the new level of ecological personality.

This approach to learning and combining ecology and STEM is certainly not an easy task, but the benefits to students and the entire school community are tremendous. Students and teachers engaged in ecology via STEM make more real-life connections. So that our planet is not a place where you live but instead becomes the entire experience of life and learning itself. We are always learning, always growing, always experimenting and make our world better.

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