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STEM PROJECT "MODULAIR"-AN INVESTMAN IN THE ENVIRONMENTAL FUTURE

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Abstract: The worry about the future of nature, computers, and the survival of man is of particular importance. The problem of environmental, technological upbringing of students is up to date and imperative because it directly affects the environment and children's health. The active methods used in "Creative studio "ARTY"", put the trainee in a state of creative analysis and synthesis, of active action, through which the relevant knowledge and skills are formed. Learning in "Creative studio "ARTY"" is seen as an active, constructive process, oriented towards the personal development of learners. An especially active and widely applicable method is the project.
Key words: Ecological; IT; STEM; creativity; "ModulAir"; school; "Creative studio "ARTY""; project.

1. INTRODUCTION

In his popular TED talk [1], Ken Robinson made the powerful point that most of the students doing work in your classrooms today will be entering a job force that none of you can visualize. That talk is from almost ten years ago, so we already know he was right and can only assume he will continue to be so in the years to come [2].

Learning a specific skill set doesn't have the value in today's world that it once did. Learning how to be more creative (and thus adaptable) – now that is what prepares students for life beyond the classroom [2].

The new type of social organization stimulates a new type of thinking, which requires new teaching techniques in schools. "Creative studio "ARTY"" (Advanced

Research Technologies by Young developers) is an idea that unites clubs, classes and extracurricular activities at school (Secondary School of Math and Science "Asen Zlatarov") [3, 4, 9, 10].

In "Creative studio "ARTY" (Advanced Research Technologies by Young developers) all students, members of various clubs, are included. Most activities are during class time, in keeping with the curriculum and educational requirements.

The options of interactive learning that we apply are: STEM; Teaching as a research-based experience with new technologies; "The student as a teacher"; Training Games Based Learning, Work Based Learning; Incidental learning [3, 4]. The creation of the "Creative studio "ARTY"" is an approach that motivates students to self-government, creative activity and participation in school life [3, 4, 9,10].

Optionally, students and teachers participate in extracurricular activities. Within our partnership with Technical University of Sofia (College of Energy and Electronics) the purposes of this project are implemented in stages and pre-set themes [5, 6, 7, 8].

The STEM-education (Science, Technology, Engineering, Math) corresponds to the term "education in the natural sciences and technical disciplines." That is what education is becoming one of the hottest topics in the educational agenda. The closure of most educational groups - one of the main obstacles to the development of talented children in Bulgaria [8].

Introducing more creativity into classroom and assignments doesn't have to make job harder. It can actually make it a lot more interesting. Having to go home to a stack of dull papers to grade was never anyone's favorite part of teaching. Giving assignments that require more creativity will likely result in more engaging work for students, and a more entertaining grading process for teacher.

Defining creativity is a daunting task, given the wide range of definitions [11, 12, 13, 14]. People often come up with their own definitions of creativity, such as `the ability to create' [11, 15]. According to Random House Webster's Unabridged Dictionary (v3.0), creativity is `the ability to transcend traditional ideas, rules, patterns, relationships, or the like, and to create meaningful new ideas, forms, methods, interpretations, etc.' This definition stresses the creation of something innovative and useful from pre-existing knowledge and experience, which agrees with how most engineers see creativity [11, 16]. In other words, creative engineers should be able to explore and scrutinize the available data or information and generate novel solutions to specific engineering problems or to the production of a unique product [11, 17].

Stages of creativity According to Taylor [11, 18], creativity is perceived as a hierarchy from a low to a progressively higher level (see Fig. 1):

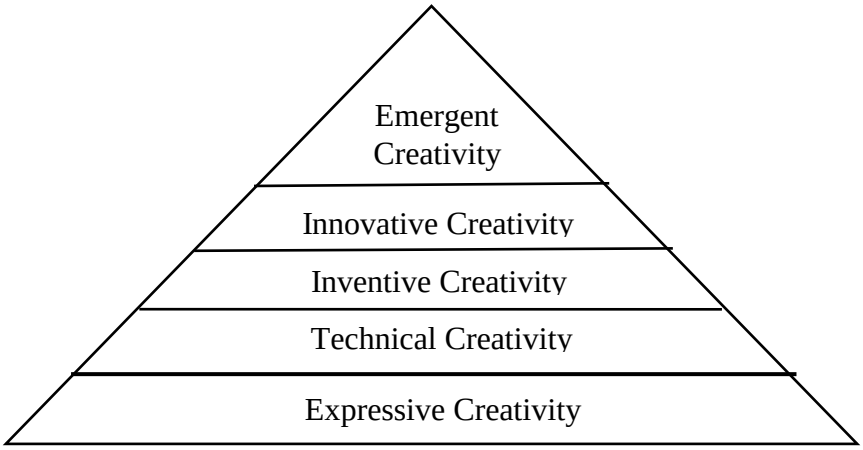

Fig. 1. Taylor's hierarchy of creativity.

Every invention, both practical and whimsical, was the product of creativity.

Effective education for sustainable, creative development is called upon to form ecological consciousness and a new attitude of the individual to the environment. All this should be linked to the formation of patterns of behavior in humans that support the ecological equilibrium and the quality of the living environment. It can be summed up that the formation of environmental consciousness is individual in the individual, but its manifestations in personality behavior can lead to coordination of activities for sustainable development in society. Therefore, the humanistic paradigm, which is based on the personality of the student, on his uniqueness, uniqueness, individuality, is appropriate. The main principles of pedagogy that put the pupil in the center of learning are dialogue, focusing on the individual development of the student, providing the necessary freedom to make independent decisions, creativity, choice of content and techniques of learning and behavior. Therefore, the effective formation of environmental consciousness is achieved through education emphasizing the creative development of the student's personality, along with the development of other competencies.

Ecological problems are everywhere around us: pollution with industrial and household waste, soil erosion, acid rain, ozone hole, fires, deforestation, biodiversity loss, etc. Environmental issues are one of the most acute in the early 21st century and are relevant to the whole world. What are the possible solutions?

Basic concepts in the field of ecological society at the present stage are:

Ecological literacy-includes scientific, social, economic, organizational and ethical dimensions. Ecological literacy means understanding how human decisions and actions affect the quality of the environment, as well as the understanding that using as a basis for responsible and effective citizenship, choices and social policies have implications for the natural world.

Care for the environment. Key features of ecological consciousness are: scientific knowledge, care for nature, caring for people, awareness of the general

laws of the development of society and nature. The supreme is inherent only in the human form of reflecting the relationship between nature and society.

Responsible attitude towards the environment. Contains two components:

Readiness for action - formed by needs, values, ideals and the active life position;

Ability to work - includes the following skills: predicting different outcome variations, making decisions, choosing a way of doing business.

Ecological responsibility is an interactively moral-ecological quality, manifesting above all an adequate responsible attitude of the personality towards nature, containing in itself such signs and categories as responsiveness, concern, etc.

Ecological culture.

Rules of conduct, knowledge, beliefs, readiness for action and practical nature conservation actions.

A system of material and spiritual values created by man in his public practice that materializes and regulates the relationship between society and nature.

Ecological culture is: individual - possession of the individual; public / communal / - possession of a certain group of people; Universal ecological culture - a result of the historical development of mankind reflected in his material and spiritual culture. Culture and consciousness are closely related.

Ecological ethics.

Ecological ethics, these are the moral principles that guide the human attitude towards the environment, as well as the rules of behavior in the environment with care for its preservation.

Ecological literacy, ecological culture, ecological awareness and environmental ethics regulate environmental behavior. It is expressed in actions and actions that preserve the nature and self-health of man. Ecological behavior is determined much more strongly by man's personal experience than by knowledge.

The innovative projects under consideration in “Creative studio “ARTY”” (Advanced Research Technologies by Young developers), combined with the rich palette of well-established STEM, IT, ecological, health, civic and environmental education models, are the necessary integration to deliver effective education for sustainable development.

2. PROJECT GOALS AND ESSENCE

"ModulAir" is a scalable, cost-effective modular solution to indoor air pollution. It uses plants and their microbial environment to filter toxins out of the air in addition to enriching it in oxygen.

The system is entirely modular and can be assembled in any number of different combinations. The physical parts are made out of ecologically safe recycled materials.

All of the different modules consist of the same few elementary components which allows for rapid mass-scale production.

Originally inspired by NASA's study on Interior Landscape Plants for Indoor Air Pollution Abatement [23], our project takes the concept a step further.

2.1. Main development stages

Developing a design concept is the most "fun" part of design engineering. This is where your imagination can run free and you can come up with new and creative ideas.

But design concepts that can be engineered are special. We are not trying just to design something that looks new. We are trying to find a balance between all the different factors that influence a product. The product must appeal to its intended users at a variety of levels: function, usability, cost, reliability, shape & color, etc. This is why it is so important to study the design problem so carefully. Without really understanding the problem, there is little hope of generating concepts that can be turned into realizable products that satisfy all its requirements [19].

“Creative studio "ARTY" (Advanced Research Technologies by Young developers) is a great way to stimulate the develop of ideas and concepts. The creation of the “Creative studio “ARTY”” is an approach that motivates students to self-government, creative activity and participation in school life [3, 4, 9, 10].

Steps how the project was started:

The first reason, which made us even start thinking about such a project was the boring and useless way of school giving us the information. The only thing students are supposed to do is memorizing some definitions in different classes so they can pass. But have you ever asked yourself what is the purpose to “just pass”. Students nowadays aren’t expected to be more than workers who do the same thing every day without using their brains at all. However, some students try doing something different, they are being punished and now rewarded for any initiative they take.

Pissed of the educational system we began collecting different ideas and inspirations out of our classes, asking more questions and reading different articles.

Then we found the NASA’s study [23] and the final idea was complete.

Through the process of developing the idea, there were many discussions and conflicts but we got over them and began working as a real team.

We made a concept and a plan to stick to.

Thought about further developing and future of the project.

Then we built a prototype and turned back so we can see the mistakes made from the beginning to the end and try not to do the again.

2.2. Problem Definition

"ModulAir" is made to remedy the poor air quality in closed spaces (indoors). Pollution indoors is caused at large by the off gassing of everyday items such as paper, inks, anything really. Due to the nature of indoor environments where air circulation is often poor, these pollutants build up unnoticed over time. Most people are unaware of the effect this can have on them and do not suspect it is their environment that's making them sick.

The most common and harmful pollutants in indoor air are Benzene, Trichloroethylene and Formaldehyde. Filtering these 3 out of the air was our main focus when choosing the plants to use (Fig 2).

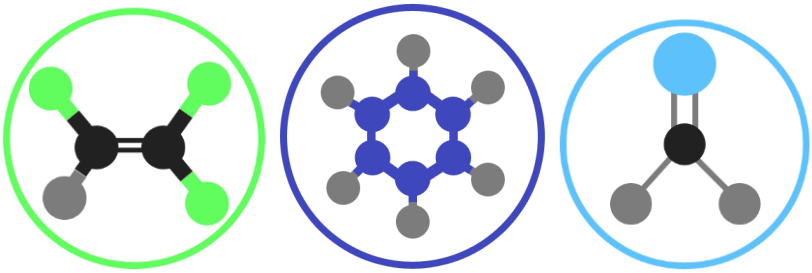

Fig. 2. Artistic representations of the molecules of Trichloroethylene, Benzene and Formaldehyde [22].

Benzene is a very commonly used solvent and is also present in many basic items including gasoline, inks, oils, paints plastics, and rubber. Benzene has long been known to irritate the skin and eyes. Furthermore it has been shown to be mutagenic to bacterial cell cultures and has shown embryotoxic activity and carcinogenicity in some tests. Chronic exposure to even relatively low levels causes headaches, loss of appetite, drowsiness, nervousness, psychological disturbances, and diseases of the blood system, including anemia and bone marrow disease.

Trichloroethylene (TCE) is a commercial product with a wide variety of industrial uses. Over 90 percent of the TCE produced is used in the metal degreasing and dry-cleaning industries, but it is also used in printing inks, paints, lacquers, varnishes, and adhesives.

Formaldehyde is a ubiquitous chemical found in virtually all indoor environments. Consumer paper products, including grocery bags, waxed papers, facial tissues, and paper towels, are treated with urea formaldehyde(UF) resins. Many common household cleaning agents contain formaldehyde. Formaldehyde irritates the mucous membranes of the eyes, nose, and throat. The most widely reported symptoms from exposure to high levels of this chemical include irritation of the upper respiratory tract and eyes and headaches. Until recently, the most serious disease attributed to formaldehyde exposure was asthma." [23].

2.3. Project Solution

The solution is based on NASA's study on Interior Landscape Plants for Indoor Air Pollution Abatement [23]. It explores the efficiency of different commonly found plants in removing toxins from the air. The study found that It is not the plants that do most of the work, rather the accompanying microorganisms that live in their roots. In alignment with these findings they proposed a system that pumps air through the roots of the plant.

We have further developed the originally suggested concept. Many other experimental systems have been previously built based on NASA's study, however they were mostly a novelty and just explored the feasibility of the idea.

One such project that took of recently was "Clairy", which got crowd funded on Kickstarter. It is a plant pot with a fan mounted on the side. This is one of the first such products that has been commercially successful. It fails to deliver on a few promises unfortunately, as a single plant has a negligible effect on the indoor air quality. The system requires a fair amount of maintenance, it is expensive and the effect unnoticeable. Despite being advertised as an air purification system it is more of an accessory.

In contrast, "ModulAir" is first and foremost focused on being an effective, low-cost, low-maintenance scalable solution to the problem of poor Indoor air quality.

"ModulAir" is a honeycomb-like structure, made up of hexagonal modules (cells). This maximizes the amount of volume each cell has compared to It's surface area, reducing the material needed to build the structure while also allowing for great spatial flexibility (Fig. 3).

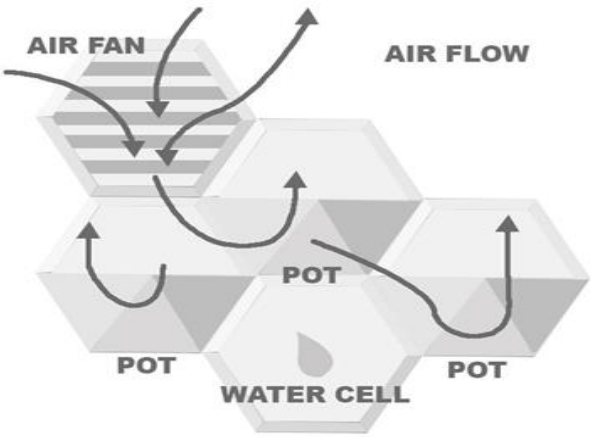

Fig. 3. Drawing depicting the flow of air through the system

Each cell is made out of the same few types of elementary parts however they can be classified by purpose, for example the following four that we came up with for the purpose of testing the feasibility of the idea.

- An air pumping cell that delivers high volumes of air to it's neighboring cells.
- A linking cell, that links It's surrounding cells together.
- A water collection cell, where water is stored until needed.
- And lastly, the most important cell - the plant cell, each housing a single plant.

Another module has been suggested however if it is to be implemented that would be further down the line of development. It is an algae panel, that can be mounted on top of the first 3 cells and thus it uses the sunlight that falls onto them. This algae can later be used for fuel or fertilizer.

The whole system is controlled by a single microprocessor (Fig.5). Various sensors are located throughout the system such as a humidity sensor that controls the watering system. Watering of the plants is done through the use of a misting infrastructure.

It is also linked to the internet via a Wi-Fi module and displays real time sensor data on command (Fig.5).

The structural components are all made eco-friendly recycled materials. Natural resin is used as an adhesive.

3. EXPERIMENTAL RESULTS

The following experimental results have been taken from NASA's study.

These tables represent NASA's experimental findings on the efficiency of plants in filtering out the three aforementioned toxins from the air (Fig. 4).

Trichloroethylene (TCE) Removed from a Sealed Experimental Chamber by Houseplants During a 24-h Exposure Period		
	Total Plant Leaf Surface Area (cm^2)	Total Micrograms Removed per Plant
Gerbera daisy	4,581	38,938
English ivy	5,581	39,938
Marginata	6,581	40,938
Peace lily	7,581	41,938
Mother-in-law's tongue	8,581	42,938
Werneckei	9,581	43,938
Bamboo palm	10,581	44,938
Mass cane	11,581	45,938
Janet Craig	12,581	46,938

Benzene Removed from a Sealed Experimental Chamber by Houseplants During a 24-h Exposure Period		
	Total Plant Leaf Surface Area (cm^2)	Total Micrograms Removed per Plant
Gerbera daisy	4,581	107,653
Pot mum	4,227	76,931
English ivy	1,336	13,894
Mother-in-law's tongue	2,871	26,710
Werneckei	7,242	39,107
Peace lily	7,960	41,392
Chinese evergreen	3,085	14,500
Marginata	7,581	30,242
Bamboo palm	10,325	34,073
Janet Craig	15,275	25,968

Formaldehyde Removed from a Sealed Experimental Chamber by Houseplants and Soil During a 24-h Exposure Period		
	Total Plant Leaf Surface Area (cm^2)	Total Micrograms Removed per Plant
Banana	1,000	11,700
Mother-in-law's tongue	2,871	31,294
English ivy	985	9,653
Bamboo palm	14,205	76,707
Heart leaf philodendron	1,696	8,480
Elephant ear philodendron	2,323	9,989
Green spider plant	2,472	10,373
Golden pothos	2,732	8,986
Janet Craig	15,275	48,880
Marginata	7,581	20,469
Peace lily	8,509	16,167
Lacy tree philodendron	2,373	8,656
Chinese evergreen	1,894	4,382
Aloe vera	713	1,555

Benzene Removal from a Sealed Experimental Chamber by Houseplants in Potting Soil and the Same Potting Soil After Removing all Plant Foliage During 24-h Exposure Periods			
	Initial (p/m)	Final (p/m)	Percent Removed
Marginata			
Full foliage	0,343	0,144	58
Foliage removed	0,348	0,175	49,7
Fresh potting soil control	0,206	0,164	20,4
Leak test, empty chamber control	0,215	0,199	7,4
Marginata			
Full foliage	0,176	0,037	79
Full foliage and soil covered with pea gravel	0,205	0,069	66,3
Janet Craig			
Full foliage	0,369	0,077	79,1
Foliage removed	0,321	0,176	45,2
Golden pothos			
Full foliage	0,122	0,040	67,2
Foliage removed	0,175	0,062	64,6
Fresh potting soil control	0,099	0,091	8,1
Leak test, empty chamber control	0,262	0,254	3,1

Fig. 4. All tests were conducted for a period of 24 hours.

These are the findings of an experiment done to measure how different parts of the plant (roots, leaves, soil etc.) compare in filtering out the toxins.

4. THE PROTOTYPE

The water misting system uses a microcontroller and sensors to control the humidity. Sensors are as it follows water level sensor, moisture sensor and a temperature sensor. Each one of them is connected to the Arduino Uno R3 board itself using Atmega328p chip to perform the calculations and measurements. The code we wrote for the Arduino is uploaded onto the board via the Arduino IDE [20] (Fig.5). The code (Fig.6) is precise adjusted in order not to overload the board and fast processing without errors. The Bluetooth module used is HC-05, equipped with the 2nd version of Bluetooth (Fig.5), able to be both slave/master. These modules are based on the Cambridge Silicon Radio BC417 2.4 GHz Bluetooth Radio chip with a baud rate of 9600 bps. Massachusetts institute of technology (MIT)'s App Inventor we used to develop the Android application so the concept could be easily controlled and be ergonomic to use [21]. The structural components are made of recycled materials. 3d and photo editing software I used for concept work. Hexagonal prisms are made that form so when attached to each other they can form a honeycomb-like structure (Fig. 3).

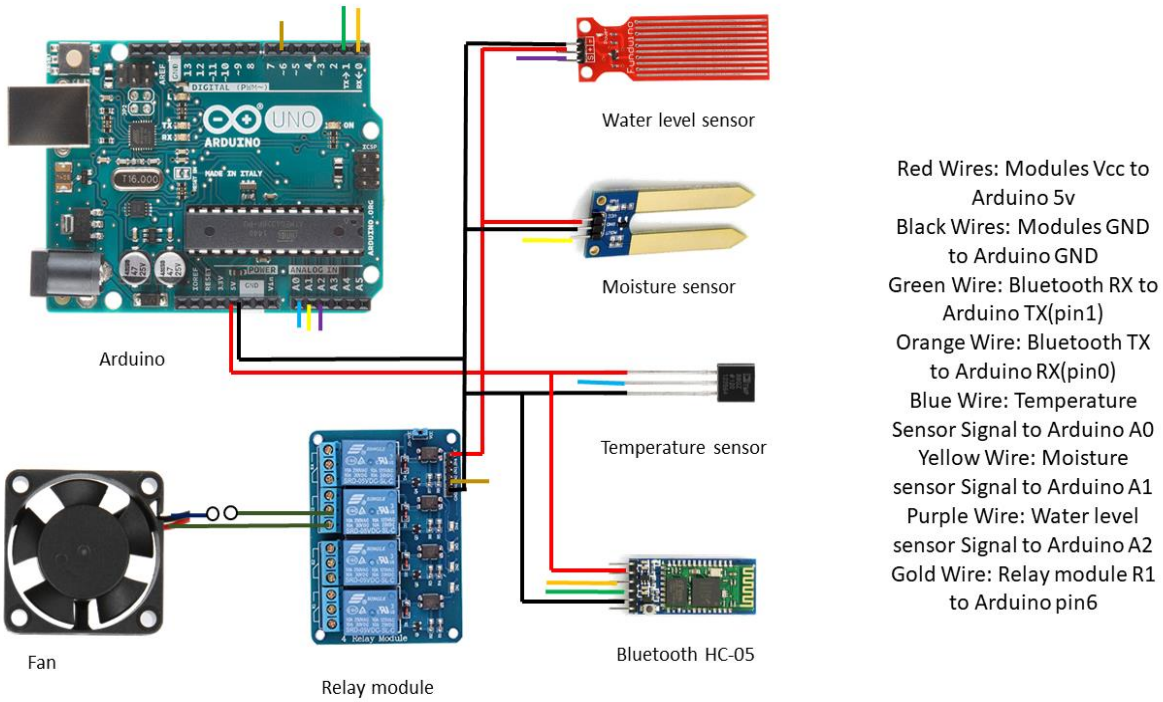

Fig. 5. The wiring

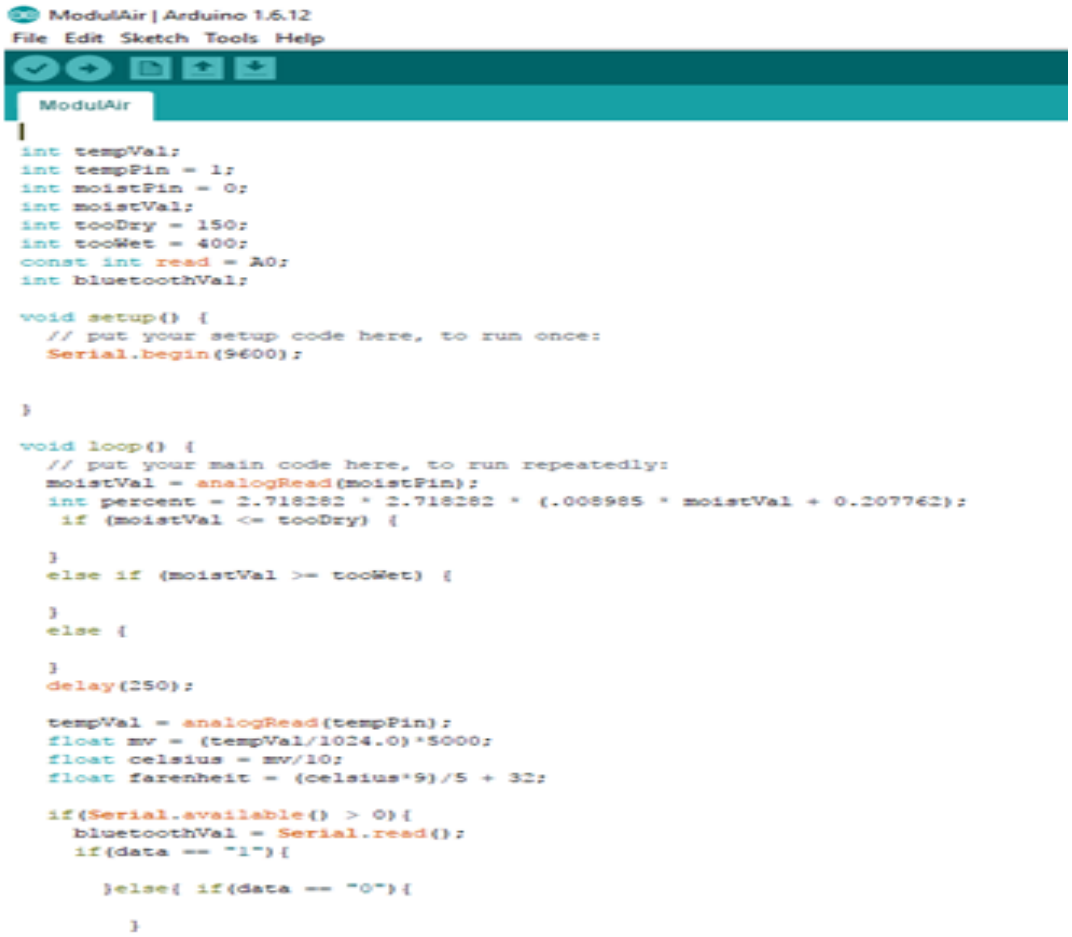

Fig. 6. Part of the code

5. CONCLUSION

In Bulgaria, there are good traditions in the development of environmental education both in theoretical and practical aspects. There have been numerous scientific forums, conferences, many projects in the field of environmental education, with the participation of leading scientists, prominent teachers and students. But life shows that it is not enough to stop here. Globalization and the development of consumer societies, climate change and biodiversity loss due to species extinction, disturbance of natural equilibrium have led to the development of a new philosophy of human-society-nature attitude.

Currently we are still developing the ecological concept “ModulAir”, and we will soon begin testing to find the most practical solutions to the challenges we face. There have been other similar projects cited below that will help us in the development. The final product will come with assembly instructions. The structure is honeycomb-like, made up of hexagonal prisms, each of which is put together from various differently purposed components so that it can be assembled into any configuration desired. Smaller accessories and spare parts will also be provided.

REFERENCES

[1] Robinson, Ken. " Do schools kill creativity? ". (available at: https://www.ted.com/talks/ken_robinson_says_schools_kill_creativity)
[2] Hicks, K. (2015). Why Creativity in the Classroom Matters More Than Ever, March (available at: http://www.edudemic.com/creativity-in-the-classroom/)
[3] Bozhinov, Kr. (2010) –"Creative studio "ARTY"" - 7th Conference "Information Technologies in Education - necessary investment in the future of Bulgaria" Microsoft-Partners in learning, (available at: http://7conf.teacher.bg/dobri_praktiki/038.pdf) - in Bulgarian.
[4] Bozhinov, Kr.; Hristova, T. (2011) – "Creative studio "ARTY""-Ecology-International scientific and practical conference "key competencies in education, strategies and practices", ISBN 987-954-691-071-4, 22-24 September 2011, Stara Zagora, Bulgaria; (in Bulgarian).
[5] Bozhinov, Kr.; Yotov, S., (2013) "Historical Museum of Botevgrad" (http://museumbot.bg)); 27th Int'l Conf. on Information Technologies (InfoTech-2013), 19-20.IX.2013, pp 88-97
[6] Bozhinov, Kr.; Yotov, S., (2014) "IT project TIMELINE1.0-Beta"; 28th Int'l Conf. on Information Technologies(InfoTech-2014), 18-19 September 2014, Varna, Bulgaria pp 91-98
[7] Bozhinov, Kr.; Iliev, l.; Dzhendov, I., (2015) "IT project "CHALLENGES 3D-THE ISLAND""; 29th Int'l Conf. on Information Technologies(InfoTech-2015), 17-18.IX.2015, pp 41-51.
[8] Bozhinov, Kr.; Banov, M.; Stamenov, v., (2016) "IT project "MATH IS FUN, DRON IS FUN""; 20th International Conference on Information Technologies(InfoTech-2016), 20-21 September 2016, Varna, Bulgaria, pp 326-337.
[9] Electronic School Newspaper "ARTY" - (available at: https://pmgzlatarov.wordpress.com/)
[10] School Video Channel "ARTY" -(available at: https://www.youtube.com/user/ITPMG/videos?view=1?&ab_channel=KrasimirBozhinov)
[11] LIU, ZHIQIANG (ERIC); SCHOÈNWETTER, DIETER J. (2004). Teaching Creativity in Engineering, (available at: https://www.ijee.ie/articles/Vol20-5/IJEE1511.pdf)
[12] C. Baillie, Enhancing creativity in engineering students, Eng. Sci. Educ. J., 11 (2002) pp. 185-192.
[13] J. P. Guilford, Creativity, Am. Psychol., 5, 1950, pp. 444-454.
[14] D. N. Morgan, Creativity today, J. Aesthet., 12, 1953, pp. 1-24.
[15] D. F. Hardy, Students' Definitions of Creativity. (available at: http://www.csun.edu/~vcpsy00/creativity/survey.htm)
[16] S. J. E. Christiano, and M. R. Ramires, Creativity in the classroom: special concerns and insights, in Frontiers in Education Conference, IEEE, Washington, DC (1993).
[17] J. P. Guilford, The Nature of Human Intelligence, McGraw-Hill, New York (1967).
[18] I. A. Taylor, An emerging view of creative actions, in I. A. Taylor, and J. W. Getzels (eds.) Perspectives in Creativity, Aldine, Chicago (1975).
[19] Filippo A. Salustri, (2005) Design Concept Development. (available at: http://deseng.ryerson.ca/~fil/t/conceptdevelopment.html)
[20] Open-source electronic prototyping platform allowing to create interactive electronic objects. (available at: www.arduino.cc)
[21] Anyone Can Build Apps That Impact the World. (available at: http://appinventor.mit.edu/explore/hour-of-code.html)
[22] Chemical hazards compendium. (available at: https://www.gov.uk/government/collections/chemical-hazards-compendium)
[23] NASA's Study of Interior Landscape Plants for Indoor Air Pollution Abatement (available at: https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19930073077.pdf)