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We are the makers – IoT: Learning Scenario – From diamond to nanotubes. Allotropic forms of Carbon (by Romanian team)

1. Title of the Scenario	***From diamond to nanotubes. Allotropic forms of Carbon***
2. Target group	Secondary school students between 13-17 years old
3. Duration	This scenario can be divided in 2 different sessions each lasting 3 teaching hours (one teaching hour = 50 minutes).
4. Learning needs	Position of the Carbon element in the Mendeleev Periodical System, structure of carbon atom, valence, 3D designing
5. Expected learning outcomes	• Understanding of "allotropic form" concept • Understanding the structure of allotropic forms of Carbon: diamond, graphite, fullerene and carbon nanotubes • Learning of physical and chemical properties of allotropic forms of Carbon • Understanding the relation between structure and properties • Learning about possible applications of allotropic forms of Carbon • Understanding the principles of 3D printing, how it works • Developing 3D designs representing the structures of: diamond, graphite, fullerene and nanotubes • Safely 3D printing
6. Methodologies	Lesson 1: Presentation of Carbon allotropes: diamond and graphite Discussions Learning by doing, 3D designing and printing Lesson 2: Presentation of Carbon allotropes: fullerene and nanotubes Discussions Learning by doing, 3D designing and printing
7. Place / Environment	Science laboratory
8. Tools / Materials / Resources	Projector, Audio system, Copies of the students' sheets Power Point presentations: (1) Nanoparticles, (2) Carbon allotropes: diamond and graphite, (3) Carbon allotropes: fullerene and nanotubes 2 students' sheets

9. Step by step description of the activity / content	Lesson 1: Nanoparticles presentation, Carbon allotropes: diamond and graphite presentation (given). i. Nanoparticle presentation – to capture students' attention ii. The teacher has to explain the concept of allotropy, allotrope forms of the carbon, structure of diamond and graphite, properties iii. Discussions about structure and properties of allotropic forms (diamond and graphite) iv. 3D designing of at least two graphite sheets v. 3D designing of a diamond unit formed by 4 tetrahedrons vi. 3D printing of unit structure for diamond and 3D graphite model designed before vii. Discussions about differences between printed structures and identification of properties differences viii. Identification of possible applications of diamond and graphite ix. Evaluation based on a student sheet (given) Lesson 2: Carbon allotropes: fullerene and nanotubes presentation (given). i. The teacher have to explain the concept of allotropy, allotrope forms of the carbon, structure of fullerene and nanotubes, properties ii. Discussions about structure and properties of allotropic forms (fullerene and nanotubes) iii. 3D designing and printing of graphene structure iv. Discussions about differences between printed structures and identification of differences of properties v. Identification of possible applications of diamond and graphite vi. Evaluation based on a student sheet (given) vii. Conclusions
10. Feedback	Lesson 1: During discussion sessions teacher will find out, based on students' feedback, if they understood the concept of allotropy, structure of diamond and graphite, relation between structure and properties, and if they can give additional examples about possible applications of both allotropic forms. Lesson 2: During discussion sessions teacher will find out, based on students' feedback, if they understood the structure of fullerene and nanotubes, relation between structure and properties, and if they can give additional examples about possible applications of both allotropic forms.
11. Assessment & Evaluation	Lesson 1: The student sheet comprises exercises in order to obtain a feedback and identify if the students understood the concept of allotropy and the structure, properties and applications of diamond and graphite Lesson 2: The student sheet comprises exercises in order to obtain a feedback and identify if the students understood the structure, properties and applications of fullerene and nanotubes

Obs. Depending on student's 3d modelling skills the teacher may ask the students to build the graphite sheets, diamond unit structure and a graphene sheet from scratch or he/she may give them the hexagon.stl, tetrahedron.stl and nanotube_hexagon.stl files to start with.