



FORMATION OF COMPETENCES FOR SUSTAINABLE DEVELOPMENT IN THE STUDY OF CLIMATE CHANGE IN THE PHYSICS COURSE IN BULGARIAN SCHOOLS

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Abstract:

The present study focuses on the formation of sustainable development competence in students by integrating knowledge of physics and other subjects in the study of climate change. Opportunities for cross-curricular connections were explored, through which students gain a broader and deeper understanding of climate-related issues and can develop critical thinking.

An attempt to analyse curricula in several subjects in terms of understanding climate and climate change has been made. Ideas on how cross-curricular connections can be made to qualitatively upgrade knowledge and form the relevant competence are offered.

In order to achieve a deeper understanding of complex climate processes, it is proposed to use an integral approach, which connects physics concepts such as temperature, transitions between states of matter with certain geographical phenomena such as precipitation, the water cycle, the urban heat island, and with concepts from chemistry and biology.

The formation of skills for applying physical concepts in descriptions of climatic phenomena, the use of data tables and various diagrams, knowledge of astronomical objects and patterns, and handling measuring instruments helps students develop a more in-depth understanding of climate, climate change and their impact on people's lives and health.

1. INTRODUCTION

In recent decades, substantial attention has been paid toward education for sustainable development, which relies on the concept of sustainable development, formed on three main pillars important for future global development: economic, social and environmental. The application of this concept can be successfully implemented in the study of natural science subjects (physics, chemistry, and biology) and in a subject such as geography, because in this way students can make clear connections between subject knowledge and understanding the essence of the main topics related to sustainable development.

Applying certain educational approaches helps students acquire the knowledge, skills and attitudes they need to make informed choices aimed at achieving and preserving the kind of world they and future generations would like to live in and work. The school must "enable students to make informed decisions and responsible actions for ecological integrity, economic viability, and a just society for present and future generations" (UNESCO, 2017).

One of the main issues in education for sustainable development is related to what students need to know and be able to do when they graduate from school in order to be as useful to themselves as

possible, improve their quality of life, and be able to solve problems in their community, including harmonizing the relationship between society and nature (Vasilevska, D. & Geske, A., 2020). There is a clear need for students to acquire competencies for sustainable development, which will subsequently help them to be full and valued members of society. The competencies developed in this type of educating are largely related to critical thinking and problem-solving skills. (Chavdarova-Kostova, S., 2022).

One of the major global problems is related to climate change. It is a constant subject of consideration by several international organizations, which are taking steps to solve it. For example, the European Union has taken numerous policy measures to achieve carbon neutrality by 2050. (EU, 2024) The growth of the Earth's population and the constant development of industry are serious prerequisites for climate change. Therefore, education for sustainable development (ESD) becomes a priority in the deepening anthropological crisis. It is an education for personal and social development that includes the ecological, social and economic dimensions of development. This education integrates environmental, ecological, health and civic education into a single whole and places emphasis on life itself. One of its tasks is to form a climate culture related to understanding and making decisions to improve climate change. Applying the integral approach can significantly help students gain knowledge that is the basis for a correct understanding of climate change. The integrated study of concepts, phenomena and facts that are related to climate, but are traditionally studied in different subjects such as Physics and Astronomy, Man and Nature, and Geography and Economics, can lead to a more in-depth understanding of scientific facts, the development of critical thinking and problem-solving skills.

2. METHODOLOGY

In this article, we examine the possibility of integrating knowledge related to understanding climate change in the study of physical knowledge in the subjects Man and Nature (4th, 5th and 6th Grade), Physics and Astronomy (8th Grade) and Geography and Economics (5th Grade).

The application of knowledge from thermodynamics in the context of the school study of physics and geography is of particular importance as it provides a basis for understanding the physics and climatic phenomena affecting the environment. The

purpose of the article is to conduct a study that will determine those concepts and phenomena that are studied in physics and geography at school and that are relevant to understanding the problem of climate change. An attempt has also been made to seek the possibility of applying an integral approach to their study.

The concept of temperature is fundamental in thermodynamics and is directly linked to climate. Temperature, as a physics measure, is studied in the 4th grade within the subject "Man and Nature" and is defined as the degree of thermal intensity of bodies. In the 5th grade, again in the same subject, the understanding of it is expanded by linking it to the intensity of motion of particles. This concept is the basis for explaining the phenomenon of heat transfer and the concept of thermal energy. Understanding these physics concepts is the basis for studying the topics of climate of different regions in geography lessons. Comparing different values of the average annual temperature for a certain period of a given region requires good knowledge of the units of measurement of temperature and an assessment of its real value. Making an interdisciplinary connection between physics and geography based on the understanding of temperature is a good foundation for forming knowledge about the climate and its changes.

In the context of climate change, the increase in the Earth's average temperature is directly related to greenhouse gas emissions, especially carbon dioxide (CO₂), which has a high heat capacity. The study of this physical quantity takes place in 8th grade in physics lessons. Here, students are given data on the heat capacity values of various substances, and they independently estimate its large value for carbon dioxide and for water. The heat capacity of CO₂ plays an important role in climate models. Due to its ability to retain heat, increasing CO₂ concentrations in the atmosphere and water bodies leads to global warming. Connecting their knowledge of chemistry, students appreciate the fact that there is no combustion process without the release of CO₂, and combustion occurs in all internal combustion engines and many manufacturing processes. This gives reason for the teacher to purposefully talk about the importance of carbon emissions that are released during energy conversion processes. When studying physics in 8th grade (Maximov, M., 2017), the First Law of Thermodynamics is considered, which describes the change and conservation of energy in thermal processes - the change of matter during



combustion leads to the sequential generation of thermal energy, which is converted into working mechanical energy by a heat engine. The process of extracting energy by burning natural fuels not only supplies the necessary energy, but also causes environmental pollution. Students need to understand how burning coal and oil leads to the release of CO₂ and other pollutants that affect atmospheric conditions. Teaching may include analysis of emissions data, as well as research into alternative energy sources and their advantages.

In this context, it is possible to conduct binary lessons, jointly with physics and geography teachers, and to examine the different policies for reducing carbon emissions.

Understanding the water cycle is key for studying climate change, as it represents a fundamental mechanism for regulating Earth's climate and ecosystems. The water cycle describes the processes of evaporation, condensation, precipitation, and transpiration, which all play a role in the transfer of energy and mass within the atmosphere and between different Earth systems. This topic is first studied in the 4th grade within the subject "Man and Nature" and its in-depth examination continues in the 5th grade in the same subject. The idea of integrating this knowledge with the study of climate phenomena in geography requires their time synchronization. Geography lessons in which these phenomena are important precede their study in the physics module in Man and Nature (Demerdzhieva, S., et al 2023). When studying climate, understanding these processes allows you to realize how changes in temperature and atmospheric pressure affect aggregate transitions and how these changes in turn affect climate. For example, as global temperatures rise, water evaporation from the surface of oceans and freshwater bodies increases, leading to a greater amount of water vapor in the atmosphere. This enhances the greenhouse effect and can cause an increase in the intensity and frequency of precipitation.

Integration of physics and geography knowledge can be achieved in the study of natural phenomena such as rainfall (grade 5), wind and atmospheric pressure (grade 6). These concepts are related to aggregate transitions and explain the influence of various climate factors. For example, students can explore how diffusion and convection affect cloud formation and rainfall. Additionally, by understanding the movement of air and its interaction with

temperature and pressure, students can better understand global climate issues.

When studying thermal phenomena in 8th grade physics lessons, it is necessary to emphasize how directly they are related to climate change and are the basis for understanding climate systems. Knowledge of the transitions of state of matter helps students realize the importance of pressure and temperature for their occurrence. (For example, lower temperatures and higher-pressure cause condensation, which is a fundamental process by which clouds and rain form). Conducting a binary lesson as a summary of the topic of transitions between states of matter together with the geography teacher can help with good integration between subjects and a deeper understanding of the problem of climate change. In geography lessons, students study the connections between climate and the formation of climate zones. Studying the water cycle and state of matter transitions is important for understanding freshwater regeneration, which is critical for sustainable development and resource management. For example, the study of regional differences in precipitation amounts and the formation of rivers and microatmospheres in different geographical areas can be related to climatic conditions and their changes.

The known phenomenon of the "urban heat island" is another important aspect related to the integrated study of physics and geography. It is observed in urban areas, where concrete and asphalt surfaces absorb and retain heat, increasing temperatures compared to surrounding rural areas. It is important for students to recognize the physical foundations of this phenomenon, including the role of insulators and the propagation of heat in different environments. It is appropriate to introduce 8th grade students to this phenomenon, as the research approach can be applied to its study (Ivanova, D. & Raikova, Zh., 2022). This can be done in a field study of the local climate, where students can become familiar with real data on temperature, wind, humidity, etc.

Applying the integral and inquiry-based approach to studying physical knowledge and geographical concepts related to climate change can form a deeper understanding of these complex phenomena and develop critical thinking in students (Raikova, Zh., 2019). Existing curricula (4th grade curriculum for man and nature, 2017, 5th grade cur-

riculum for man and nature, 2017, 6th grade curriculum for man and nature, 2020, 5th grade geography and economics curriculum, 2017, 6th grade geography and economics curriculum, 2020, 8th grade geography and economics curriculum, 2016, 8th grade physics and astronomy curriculum, 2016) allow for the creation of clear inter-subject connections that provide a better understanding of the subject matter. Thus, the students perceive with greater interest and more deeply the main climatic phenomena and changes, as well as they can evaluate their impact on the surrounding world.

3. COMMENTS AND CONCLUSIONS

In the context of modern challenges related to climate change, the integration of knowledge from physics and geography into the curricula for students from grades 4 to 8 plays an important role not only in education, but also in forming competence for sustainable development. Through the systematic study of thermodynamic phenomena, as well as the water cycle, students gain tools for understanding the complex processes that affect the environment. Integrating knowledge from these two disciplines allows students to become aware of the interrelationships between climate phenomena and the practical aspects of sustainable natural resource management.

The integration and research-based approach to studying topics related to climate issues encourages students' active participation in the learning process and engages them in developing sustainable solutions for the future. Considering the need for innovation in education, existing curricula offer opportunities to establish clear cross-curricular connections that not only enrich students' knowledge, but also prepare them for active participation in their pursuit of sustainable development.

Developing critical thinking and the ability to analyse climate change data are key to preparing the new generation to address global environmental challenges. Nelson Mandela said that "education is the most powerful weapon which we can use to change the world". (Baggaley, Calleja, Marum, & Marum 2013; Voulvoulis, N. & Burgman, M. A., 2019) It is of utmost importance for the future that young people are educated, engaged, critical thinkers and problem solvers.

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