Applied Value of Mathematics for Sustainable Development & Mathematical Culture of Students

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Abstract

There are many publications devoted to the problems of sustainable development and education for sustainable development to date. However, most of them are of a generalized declarative nature. Therefore, when developing curricula, the inclusion of sustainable development ideas in educational practice causes significant difficulties for teachers. The complexity and versatility of the concept of sustainable development require building the learning process based on a multidimensional approach through the unity of social, psychological, and educational aspects. Within the framework of this approach, the article examines the role of mathematics in implementing the concept of sustainable development. The article presents some examples of applying mathematics to ensure sustainability in various spheres of human activity: economy, industry, social and humanitarian. The research reveals that mathematics has applied value in solving sustainability problems in various spheres of human activity and has a humanitarian potential, performing ideological, moral, educational, and aesthetic functions. Through the study of mathematics, the individual joins the world culture and becomes a member of the human community. The goal of teaching mathematics in sustainable development is the formation of the mathematical culture of students.

Keywords: Mathematical education for sustainable development, mathematical culture, mathematical competency

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Introduction

Education for Sustainable Development is a concept formulated by the United Nations (2015) in the 2030 Agenda for Sustainable Development (goal 4, target 4.7). According to Leal Filho et al. (2018), Shulla et al. (2020), education is not only closely related to other goals and objectives of sustainable development. It is also a decisive factor in the implementation of these goals. This role of education is because, within schools and universities, young people will prepare to promote sustainable development, apply means and methods that allow building a sustainable future on the planet. Despite a sufficient number of studies concerning the general provisions and principles of education for sustainable development, this problem remains relevant since there is a need to understand the interaction and application of sustainable development ideas in specific contexts and, particularly, in education at all its stages.

Problem Statement

At the present stage, a fundamental problem of education is searching for means and methods of integrating sustainable development goals into educational programs and individual disciplines. Initially, sustainable development was understood as a balance between economic growth and environmental protection, and sustainable development education was considered environmental education. Therefore, there is experience in including sustainable development ideas in teaching such disciplines as biology, chemistry, and life safety. However, for most educational courses, such traditions do not exist. Lack of experience in integrating sustainable development ideas into everyday teaching practice is a challenge for many academic disciplines, including mathematics teachers.

There is no definite answer to how to integrate ideas of sustainable development in mathematics teaching in schools and universities. Due to the complexity and intricacy of understanding the concept of sustainable development, the search for ways to include sustainable development goals into education should be based on a multidimensional approach to learning through the unity of social, psychological, and educational aspects (Kuznetsova & Matytcina, 2018). Within this approach's framework, we considered some issues reflecting the psychological aspects of the professional training of applied mathematicians and their educational motivation features (Kuznetsova 2019, 2020). For the successful professional training of bachelors in applied mathematics, we should orient to the future. Therefore, studying the social aspects of mathematics and mathematical education in universities for sustainable development is urgent.

Research Questions

This work is part of the study of the problems of professional training of future mathematicians in universities. In this paper, we explore two issues.

- First, it is necessary to examine the role of mathematics in implementing sustainable development goals.
- Secondly, it is necessary to formulate the goals of studying mathematics in higher education in harmony with sustainable development ideas.

Purpose of the Study

Following the questions posed, we formulated two purposes of the study. The first one is to identify and substantiate the role of mathematics in ensuring society's sustainable development. The second one is to formulate the goals of mathematics education in higher education.

Research Methods

When solving the set tasks, we used theoretical, general scientific, and particular-scientific research methods. Theoretical methods include analyzing philosophical, methodological, psychological, pedagogical, and scientific and technical literature, analyzing educational standards and educational programs for training university students in mathematical disciplines. General scientific methods include analysis, synthesis, generalization, classification, systematization, and comparison. Particular-scientific methods include system-element, system-structural and system-functional analysis of the goals and content of professional mathematical training in universities, a generalization of teaching experience.

Findings

For many centuries, mathematics has played and continues to play an essential role in the life of humanity. As a result, the study of mathematics allows an individual to join the world culture, to become a full member of the world community. In the modern knowledge society, the role of mathematics is increasing. Our research allows us to formulate the following aspects of mathematics and mathematics education in the context of sustainable development.

Mathematics as a tool for solving sustainable development problems

Mathematics plays a vital role in solving problems of sustainability in various branches of human activity. As emphasized by Saward (2017), Stein (1961), mathematics allows us to see the studied phenomenon's essence and represent the problem's mechanisms. We find

confirmation of these words in modern studies of the economy, industry, and the social sphere. For example, Rimondi et al. (2020) examine the impact of economic growth and financial development on wealth concentration. Using the vector autoregression model, the authors described an approach to the study of unequal distribution of resources in society (on the Russian economy example). Based on the analysis of finite changes, Sysoev et al. (2019) performed a sensitivity analysis of neural network models to study the classifier for detecting abnormal records in data arrays of a medical nature. Sysoev et al. (2020) presented a solution to the traffic flow optimization problem using a neurostructural remodeling approach. As a result, traffic becomes stable and safe, and air pollution from exhaust gases is reduced. Through mathematical modeling, Kuznetsova (2019, 2020) explores the features of university students' academic motivation, making it possible to implement student-centered education principles in the teaching process. Studies by Galkin et al. (2020), Oreshina and Dabas (2020), Sedykh and Istomin (2020), Zhbanova et al. (2015) demonstrate the capabilities of mathematics in improving production processes at a ferrous metallurgy enterprise. The studies' results make it possible to improve the quality of products, reduce the cost of raw materials and energy, reduce the amount of production waste that pollute the environment, reduce the risk of emergencies, and improve labor safety. A study of the region's socio-economic situation (Kuznetsova et al., 2020) showed the presence of positive trends: economic growth, employment growth, and a decrease in industrial waste pollution, which can be considered a movement towards sustainable development. Many people contribute to this result, including applied mathematicians in the industry.

Mathematics as a tool for the formation of a personality capable of perceiving and embodying the ideas of sustainable development

Solving sustainable development problems requires individuals who can act under challenging situations sustainably, considering the near and long term, understanding the social, cultural, and economic consequences. Mathematics can and should become an essential tool for forming personality since the value of mathematics is not only in its applied usefulness. No less significant is mathematics humanitarian potential, expressed in implementing its worldview, moral, educational, and aesthetic functions. In conditions of sustainable development, the formation of a worldview can be considered the leading goal of mathematical education.

The mathematical worldview can be defined as a set of such personal qualities that contribute to the correct orientation of a person in the world, his desire for truth and beauty, mastery of the principles of mathematical culture, scientific foundations of the profession, methods of cognition and rational transformation of the world and himself.

The mathematical worldview is characterized by a trusting attitude towards mathematics and its capabilities, an attitude towards the world in anticipation of its recognizability and "reasonable structure." The worldview role of mathematics also lies in the fact that mathematics considers the external world abstractly-idealized as a model, allowing one to describe objects of different nature in a single universal way. Mathematics gives evidence of the unity of nature, society, and cognition, helps to penetrate the essence of phenomena and processes, and identifies their internal entities and connections. The role of mathematics in the formation and development of thinking skills is well known: abstract (logical), heuristic (creative), algorithmic (performing).

The fact that mathematics forms relationships and unique personal qualities of those who study or apply it: striving for truth, evidence, intellectual honesty, hard work, perseverance, the ability to see the essence of phenomena, highlight the main thing, a creative research approach to business, democracy. Uspensky (2007), one of Kolmogorov's student's modern mathematicians, testified:

Mathematics is entering world culture with its ethical aspect. The presence of such in mathematics may seem strange. It, however, is. Mathematics does not allow lies. It requires that assertions not only be proclaimed but also proven. It teaches to ask questions and not be afraid of not understanding the answers. It is democratic by nature: its democracy is due to the nature of mathematical truths. Their immutability does not depend on who proclaims them, an academician or a schoolboy (p. 20).

The presence of these qualities is essential not only in professional activities.

The aesthetic role consists in the fact that mathematics gives an understanding of the world as a whole, the basis of the "device" of which is the interconnectedness of parts, orderliness, beauty, and harmony. Mathematical ideas can evoke emotions comparable to emotions, include when reading literary works, listening to music, contemplating architecture. Unfortunately, the ossified ways of teaching mathematics rarely allow one to feel its aesthetic side, accessible, at least in part, not only to mathematicians. Mathematicians, however, feel this side with complete clarity (Uspensky, 2007).

Formation of students' mathematical culture as the primary goal of mathematics education at universities

Determining the role and place of mathematics in achieving sustainable development goals allows us to conclude that the goal of mathematical education in schools and universities should be to form students' mathematical culture since culture can be considered the highest level of manifestation of human competence. Consequently, the problems of finding means and

methods of forming a mathematical culture among schoolchildren and university students are very urgent.

The formation of students' mathematical culture will be effective only if it is a purposeful, specially organized, systematic process that considers a future specialist's requirements. Consequently, it is necessary, first of all, the teacher's readiness to manage this process. The formation of a mathematical culture is a joint creative activity of a teacher and students. For achieving the desired result, it is necessary to apply an integrated approach (systemic, activity-based, and cultural), organize a personality-oriented educational process, build subject-subject relations between teachers and students, create a creative atmosphere, positive emotional background.

An essential factor that must also be taken into account in forming a mathematical culture is an increase in motivation for studying mathematics. This purpose is carried out through active learning forms, strengthening the applied component, introducing special courses in philosophy, history, and mathematics methodology, developing and profiling departments of special courses on using mathematical methods for solving applied problems.

Experience shows that it is impossible to reveal the humanitarian potential of mathematics without presenting proofs, maintaining the clarity and rigor of reasoning, focusing on the methodological and ideological aspects of the material being studied.

The study and application of the mathematical modeling method effectively contribute to understanding the value of mathematical knowledge, its connection with natural science and social sciences. Each of the modeling stages, from setting a problem to interpreting the results, requires integrating knowledge of various branches of mathematics and an understanding of the essence of the subject area. Thus, building interdisciplinary connections, mathematical modeling contributes to forming an integral scientific picture of the world, while the learning process ceases to be a sequence of disparate, unrelated academic disciplines.

Finally, in current conditions, students' mathematical culture formation is impossible without introducing information technologies into the educational process. The use of a computer as a means of teaching, a means of automating computations, a tool of cognition, combined with traditional forms of education, opens up new opportunities in solving the problems facing higher education in terms of education for sustainable development.

Conclusion

The global crisis that humankind faces today requires maximum efforts, consolidation, and mobilization of the human factor. Modern mathematics is a powerful tool for solving problems for sustainable development and has significant humanitarian potential. The practical value, ideological, moral, educational, and aesthetic functions of mathematics will be fully realized if the goal of teaching mathematics is to form a mathematical culture based on a multidimensional approach to learning through the unity of social, psychological, and educational aspects.

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