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# THEORETICAL AND METHODOLOGICAL FOUNDATIONS FOR DEVELOPING STUDENTS' RESEARCH ACTIVITIES BASED ON PROBLEMS RELATED TO SOLIDS OF REVOLUTION

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**Abstract.** This article highlights the theoretical and methodological foundations for developing the research activities of secondary school students. The essence of research activity, its structural components, and the pedagogical conditions for its organization are analyzed. The possibilities of developing students' research activities through the use of problems related to solids of revolution in geometry lessons are revealed. The article substantiates the didactic significance of research-oriented tasks related to cylinders, cones, spheres, and frustums, and demonstrates the effectiveness of problem-based learning, modeling, practical activities, and the use of information and communication technologies. In addition, the role of the teacher in organizing research activities, assessment criteria, and the importance of developing a system of research tasks are discussed.

**Keywords:** research activity, solids of revolution, research-oriented problems, spatial thinking, independent thinking, problem-based learning, mathematical modeling, competency-based approach, information and communication technologies, creative approach.

The main goal of the modern education system is not only to provide students with ready-made knowledge, but also to shape them into individuals who can think independently, conduct research, make rational decisions in problematic situations, and apply their acquired knowledge in practice. In the context of globalization, scientific and technological progress, and the digital society, a person's successful activity largely depends on their ability to conduct independent research, analyze information, generate new ideas, and justify their own opinions. Therefore, the development of students' research activities in general secondary schools is considered one of the important directions of pedagogical theory and teaching methodology.

Research activity is a cognitive activity aimed at the independent study, observation, analysis, hypothesis formulation, drawing conclusions based on evidence, and substantiation of obtained results regarding a particular problem, phenomenon, or process. In such activities, the student is not a passive subject who simply receives ready-made knowledge, but an active participant who searches for knowledge, processes it, and applies it in new situations. Research activity increases students' interest in learning, teaches them to think independently, defend their views, compare different solution methods, and arrive at the most appropriate conclusion. From a pedagogical point of view, research activity is one of the important factors ensuring students' intellectual development. This is because, during the process of research activity, students do not limit themselves to memorization or repetition. On the contrary, they observe, ask questions, identify cause-and-effect relationships, compare, generalize, and draw conclusions. Such processes develop students' thinking operations. This process is especially important in mathematics education, since mathematical knowledge is based on logical consistency, reasoning, proof, and modeling.

To fully understand the essence of research activity, it is necessary to distinguish it from ordinary learning activity. In traditional learning activity, a student usually receives information

provided by the teacher, memorizes it, and performs exercises according to a model. In research activity, however, a problem is posed before the student. The student searches for ways to solve the problem, makes assumptions, tests different methods, analyzes mistakes, and arrives at a final conclusion. Thus, research activity requires students' activeness, independence, and creativity.

Although the research activities of secondary school students are not at the level of complex scientific research, they embody the main elements of scientific inquiry. In particular, stages such as identifying a problem, posing questions, formulating hypotheses, collecting information, observing, analyzing, verifying results, and drawing conclusions are organized in a manner adapted to the level of school students. The main purpose here is not to require students to create scientific innovations, but to develop their culture of scientific thinking, inclination toward inquiry, and independent learning skills.

One of the important characteristics of research activity is problem-basedness. If the task given to a student consists only of simple calculations or the application of a ready-made formula, it cannot be considered research-oriented. A research task should contain a certain degree of uncertainty for the student. For example, the task "find the volume of a cylinder given its radius and height" is reproductive in nature. However, the question "among cylinders with the same volume, which one has the smallest surface area?" encourages students to investigate, compare, and draw conclusions. In this respect, research activity develops deeper thinking skills in students.

Students' research activity can be expressed through the following structural components:

First, the motivational component. This reflects the student's interest in learning, inquiry, and problem-solving. If students do not develop internal interest and motivation, research activity cannot be effective. Therefore, teachers should encourage students' curiosity through real-life examples, interesting questions, problem situations, and practical tasks during the learning process.

Second, the cognitive component. This refers to the student's possession of knowledge, concepts, principles, and theoretical information. To carry out research activity, students must have a certain stock of knowledge. For example, in order to solve research-oriented problems related to solids of revolution, students should know cylinders, cones, spheres, frustums, their elements, and formulas for surface area and volume.

Third, the practical-activity component. This means the student's ability to perform practical actions in the process of solving a problem. These include analyzing the conditions of a problem, drawing diagrams, creating models, performing calculations, conducting experiments, verifying results, and justifying solutions. In geometry lessons, especially, working with models, constructing cross-sections, and visualizing shapes in space contribute to the development of this component.

Fourth, the reflective component. This refers to the student's ability to evaluate their own activity, identify mistakes, verify the correctness of solutions, and critically analyze results. Reflection occupies an important place in research activity because students not only achieve a result but also become aware of the process through which they reached it.

The necessity of developing research activity in general secondary schools is determined by several factors. First of all, modern education is based on a competency-based approach. This approach implies not only possessing knowledge but also being able to apply that knowledge in various educational and real-life situations. Research activity serves exactly this purpose because, in the research process, students apply knowledge to practical situations, make independent decisions, and justify their results. Secondly, international assessment programs evaluate students' functional literacy, logical thinking, ability to analyze practical situations, and

problem-solving skills. In such assessments, memorizing formulas or following ready-made algorithms is not sufficient. Students are required to understand the meaning of a problem, identify the given information, construct a mathematical model, and interpret the result from the perspective of real-life situations. Therefore, the development of research activity in school education is an important condition for improving students' functional literacy. Thirdly, in today's information environment, students are exposed to a huge amount of information. Under such conditions, it is more important to teach them how to search for, select, analyze, and use information rationally rather than simply providing ready-made information. Research activity develops exactly these skills. Students learn to critically analyze given information, draw well-grounded conclusions, and support their opinions with evidence. Fourthly, research activity develops students' creative abilities. Any research problem requires searching for multiple solution methods, testing different assumptions, and applying new approaches. This process develops students' creative thinking, initiative, and intellectual independence. In geometry problems especially, the possibility of obtaining the same result through different methods increases the flexibility of students' thinking. Fifthly, research activity develops students' self-development skills. During the process of completing research tasks, students identify gaps in their knowledge, search for additional information, monitor themselves, and evaluate their results. This contributes to educating individuals who are prepared for independent lifelong learning in the future.

There are broad opportunities for developing research activity in mathematics. This is because mathematics is a science based on logical thinking, reasoning, proof, modeling, and generalization. Every mathematical problem, if organized through an appropriate methodological approach, can become a means of encouraging students to engage in inquiry. For example, instead of presenting a formula in a ready-made form, if students are assigned to derive the formula through experimentation, observation, or logical reasoning, the lesson acquires a research-oriented character.

Organizing research activity in geometry lessons is considered even more effective. This is because geometry develops students' spatial imagination, diagram-based thinking, and the ability to perceive relationships between shapes. The topic of solids of revolution has particularly rich didactic potential in this regard. Objects such as cylinders, cones, spheres, and frustums are frequently encountered in real life. Problems related to these objects encourage students not only to calculate, but also to model, measure, compare, and draw practical conclusions.

For example, determining the volume of a cylindrical container may be an ordinary computational task. However, the question "What should be the radius and height of a cylindrical container in order to obtain the maximum volume using the same amount of material?" encourages students to conduct research. In this case, students determine the relationship between surface area and volume, compare different values, and draw general conclusions. Through this process, mathematical knowledge gains practical significance.

Research-oriented problems related to solids of revolution are also important in developing students' spatial thinking. Spatial thinking involves the ability to visualize three-dimensional objects, understand their cross-sections, and comprehend the relationships between surface area and volume. These skills are important not only in mathematics, but also in physics, technical drawing, technology, architecture, and engineering. Thus, the development of research activity through the topic of solids of revolution has interdisciplinary significance.

The role of the teacher is extremely important in developing research activity. A teacher should not merely provide ready-made answers, but should act as an organizer who guides students toward inquiry, creates problem situations, and stimulates thinking through questions. In doing so, the teacher should select tasks while considering students' age characteristics, level of

knowledge, interests, and abilities. If research activity is excessively difficult, students may lose interest; if it is too simple, there will be no need for inquiry. Therefore, tasks should be organized step by step according to their level of complexity.

When organizing research activity, it is advisable to follow several methodological conditions. First, a problem situation should be created during the lesson. Second, students should be given opportunities for independent thinking and hypothesis formation. Third, tasks should have practical and real-life significance. Fourth, students should not only find results but also explain and justify them. Fifth, students' mistakes should be analyzed and regarded as a natural process leading to new knowledge.

Research activity may be organized individually, in pairs, in small groups, or collectively. Individual research tasks develop students' independence. Pair and group work, on the other hand, develops communication skills, cooperation, the ability to justify one's opinion, listen to others, and arrive at common decisions. Group activities are especially effective when working with geometric models, where each student performs a specific role: one draws diagrams, another performs calculations, another analyzes results, and another presents conclusions.

The use of information and communication technologies is also of great importance in developing students' research activity. With the help of dynamic geometry software such as GeoGebra, Desmos, and Cabri 3D, students can visually observe the formation process of solids of revolution, their cross-sections, and changes in surface area and volume. For example, observing how the volume of a cylinder changes when its radius or height is altered through software helps develop students' experimental thinking. This is considered an important element of research activity.

In addition, digital tools enable students to compare results, create tables and graphs, build models, and present conclusions in a visual form. Such an approach develops not only students' mathematical competencies but also their information-processing skills. At the same time, the use of digital tools helps make lessons more engaging and effective.

The assessment process also plays a special role in the development of research activity. While traditional assessment is often focused on the final result, in research activity the process itself should also be evaluated. In other words, attention should be paid to how students understand the problem, formulate hypotheses, choose solution methods, provide evidence, correct mistakes, and draw conclusions. Such assessment increases students' interest in inquiry and encourages their active participation.

There are also certain problems in developing students' research activity in general secondary schools. In some cases, the educational process is still organized on the basis of a reproductive approach. Students memorize ready-made rules, repeat standard problems, and are rarely involved in independent inquiry. Such a situation limits their creative and critical thinking. In particular, if spatial shapes are not sufficiently studied through visual models in geometry lessons, it becomes difficult for students to achieve a deep understanding of the topic.

Another problem is the insufficient development of a system of research-oriented tasks. Although textbooks contain many standard problems, there is a need for more tasks that encourage independent inquiry, provide multiple solution methods, and are connected with real-life situations. Therefore, it is advisable for teachers to develop additional research-oriented tasks appropriate to the topic and gradually integrate them into the teaching process.

To develop students' research activity, it is necessary to use a system of questions effectively during lessons. For example, questions such as "Why?", "How?", "What happens if the condition changes?", "Can it be solved in another way?", and "How can this result be applied in practice?" encourage students to think more deeply. Such questions are especially effective in

the topic of solids of revolution, where students attempt to independently identify the relationships between the elements of geometric shapes.

The effective development of research activity also has a positive impact on students' personal qualities. During such activities, students develop patience, perseverance, responsibility, accuracy, discipline, and a critical approach. This is because, while completing a research task, a student may not achieve the correct result on the first attempt. The student makes mistakes, analyzes them, tries again, and eventually arrives at the correct conclusion. This process intellectually strengthens the student.

Another advantage of developing research activity within the topic of solids of revolution is that this topic is directly connected with real life. For example, cylindrical pipes, conical roofs, spherical objects, reservoirs, containers, and technical details are frequently encountered in everyday life. By analyzing such objects from a mathematical perspective, students gain a deeper understanding of the practical significance of geometry. This, in turn, increases their interest in mathematics.

Research activity related to solids of revolution may be organized in the following directions: observing the formation process of solids; identifying relationships between their elements; deriving formulas for surface area and volume; investigating cross-sections; determining optimal dimensions under conditions of equal volume or equal surface area; and studying real-life objects as geometric models. Each of these directions engages students in independent thinking and inquiry.

For example, students may be given research-oriented tasks such as: "How does the volume of a cylinder change when the radius increases and the height decreases?", "If the slant height of a cone remains unchanged, how does its lateral surface area change when the radius increases?", "How is the volume of a sphere related to its radius?", and "How does the volume of a frustum depend on the ratio between its larger and smaller radii?" Such questions encourage students to perform deeper analysis rather than simply applying formulas.

Small projects carried out by students are also considered an effective means of developing research activity. For example, mini-research projects on topics such as "Solids of Revolution in Everyday Life," "Determining the Most Economical Shape of a Container," "Comparing the Volumes of Cylinders and Cones," and "Applications of Spherical Shapes in Nature and Technology" create opportunities for students' independent inquiry. In such projects, students collect information, perform calculations, prepare diagrams and models, and present their results.

Thus, the development of research activity among general secondary school students is one of the important requirements of modern education. This activity develops students' independent thinking, problem-solving abilities, logical analysis, creative approach, mathematical modeling, and conclusion-drawing skills. In particular, the use of research-oriented problems in teaching mathematics, especially the topic of solids of revolution, creates broad opportunities for deepening students' knowledge, developing their spatial imagination, and forming practical competencies. Therefore, developing students' research activity through problems related to solids of revolution not only enriches the content of the geometry course, but also contributes to organizing the educational process in an active, creative, and inquiry-based manner.

**References:**

1. Axmedov M., Haydarov F. Methods of Teaching Mathematics. – Tashkent: O'qituvchi, 2018. – 320 p.
2. Bikboyev N., Yangiboyev J. Methods of Teaching Geometry. – Tashkent: Fan va texnologiya, 2019. – 256 p.
3. Polya G. How to Solve It. – Princeton University Press, 2004. – 288 p.

4. Leontyev A.N. Activity. Consciousness. Personality. – Moscow: Prosvesheniye, 2005. – 352 p.
5. Vygotsky L.S. Pedagogical Psychology. – Moscow: Pedagogika, 1991. – 480 p.
6. Matyushkin A.M. Problem-Based Learning and the Development of Thinking. – Moscow: Pedagogika, 1972. – 208 p.
7. Abdullayeva Q., Mavlonova R. Theory and History of Pedagogy. – Tashkent: Fan, 2020. – 410 p.
8. Tolipov O‘., Usmonboyeva M. Pedagogical Technologies: Theory and Practice. – Tashkent: Fan, 2017. – 280 p.
9. Bikboyev N.U. Methods of Teaching Spatial Solids in the School Geometry Course. – Tashkent: O‘qituvchi, 2016. – 224 p.
10. Smirnov V.A. Fundamentals of Geometry and Spatial Thinking. – Moscow: Nauka, 2015. – 300 p.
11. Xolmurodov T., Rasulov A. Innovative Approaches in Mathematics Education. – Tashkent: Tafakkur, 2021. – 240 p.
12. Dewey J. Democracy and Education. – New York: Macmillan, 1916. – 434 p.
13. Bruner J. The Process of Education. – Harvard University Press, 1977. – 97 p.
14. Krutetskiy V.A. Psychology of Students’ Mathematical Abilities. – Moscow: Prosvesheniye, 1968. – 432 p.
15. Hasanboyev J., To‘raqulov X. Pedagogy. – Tashkent: Fan va texnologiya, 2019. – 512 p.
16. Ismoilov E., Rasulov U. Methodology for Organizing Research Activities in Mathematics Lessons // Pedagogical Mastery. – 2023. – No. 4. – pp. 45–51.
17. Ismoilov E.O. Use of information technologies and computer mathematics systems in the process of teaching the topic of differential equations. Eurasian Journal of Research, Development and Innovation (ISSN 2795-7616) (Journal impact factor 7.892). – Belgium, 2024. Volume 29 February 2024. – pp. 10-15.
18. Ismoilov E.O. Tasks with an integrative content aimed at developing students' professional competences and requirements for them. Western European Journal of Linguistics and Education (ISSN 2942-190X) (Journal impact factor 5.035). – Germany, 2024. Volume 2, Issue 11, November 2024. – pp. 188-194.
19. Ismoilov E.O. Fundamentals of developing students' professional competencies based on an integrative approach. American Journal of Pedagogical and Educational Research (ISSN 2832-9791) (Journal impact factor 6.534). – USA, 2024. Volume 30 November 2024. – pp. 116-121.
20. Ismoilov E.O. Developing students’ professional competencies based on an integrative approach: pedagogical mechanisms. Journal of Pedagogical Inventions and Practices (ISSN 2770-2367). – USA, 2025. Volume 51 December 2025. – pp. 14-19.