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CONSTRUCTIVIST APPROACH TO EDUCATION WITH REFERENCE TO CONSTRUCTIVISM IN THE TEACHING OF MATHEMATICS

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Dedicated to 75th years of life and 50 years of scientific work of Academician Mirjana Vuković

ABSTRACT. Constructivism as a philosophy of education can be said to be based on the work of Giambattista Vico , the philosopher of the 18th century who believed that people only understand what they themselves make. Many philosophers and educators have worked on this idea, but the ideas behind constructivism were developed by Jean Piaget and John Dewey. Today, when rapid changes are taking place in all countries with the goal of improving education, teachers show great interest in education with a constructivist approach, because constructivism is an approach by which we learn new things we encounter by connecting them and putting them in certain relationships with already acquired knowledge. The Ministry of Education of our country should start with radical changes and harmonize the changes with the most common approach in new programs in the world, which is precisely the constructivist one. The impact of this fundamental change in the understanding of education seems inevitable for the education and upbringing of both students and teachers in our country.

1. THEORETICAL FRAMEWORK

Constructivism has its roots in philosophy, and was applied in sociology and anthropology, as well as in cognitive psychology and education. In literature, constructivism is treated as a scientific theory and a theory of cognition, but also as a theoretical paradigm (in sociology, cognitive science and psychology), that is, as an image of man and as a didactic position or learning strategy. Constructivism, from the point of view of learning theory, is an approach that tries to explain how people learn, and from a philosophical point of view, it is a term that is related to epistemology . A lot has been said about the constructivist approach in education in recent years, and it is quite old. Giambattista Vico (1668 - 1744), Jean Jacques Rousseau (1712 - 1778) and Immanuel Kant (1724 - 1804) are considered representatives of constructivism in the past centuries.

Giambattista Vico, a thinker of the 18th century, gave constructivism the modern "look" it has today. With the work, "De antiquissima Italorum sapientia ", published in 1710, he opened a new perspective to epistemology, defended the point of view that people understand only what they themselves have built and said that "a person understands something only when he can explain it". [8]

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Immanuel Kant advocated similar views and emphasized that people are not passive recipients of knowledge. According to him, they receive it actively, connect with previous knowledge, and via adding their own thoughts, adopt it. [15] According to Rousseau, the most suitable program for children is one that opens the door to the child's natural curiosity and desire for learning and knowledge. The curriculum should not be imposed by adults, but should have the student at the center and reflect the child's interests and occupations. [16]

Constructivism can be linked to the clarification of the very nature of knowledge. It is believed that the learner should build knowledge for himself, because each person individually and socially acquires his knowledge. We can take two things from this:

1. Teachers should not concentrate on the topic or the lesson, but on the individual thinking about his task (learning);

2. There is no knowledge independent of the knowledge created from the experience of the learner. [9]

According to Von Glasersfeld [17], knowledge, no matter how we define it, is in a person's head and is shaped based on and related to his personal experiences. The constructivist approach implies that language learners should form the meanings of phrases, sentences and texts individually. [14] [7]

We can say the following about the basic principles of this approach: Students add meaning to the new concepts they encounter only within their existing understandings. Therefore, this is an active process in which students connect their existing knowledge with new ideas and create new knowledge [10]. According to the more education-oriented definition of constructivism, the association of knowledge is closely related to experience. Students come to class with their own experience and thought structures formed by that experience. These previously created constructs can be good, bad or incomplete. The student reorganizes his thought structures creating a connection between the new knowledge and experience and the old one. In order for new knowledge to be useful and complete part of the student's memory, conclusions, details and relationships between older understandings and new ideas must be drawn and created by the student himself. Otherwise, new, memorized information, unrelated to previous experiences, will be forgotten very quickly. In short, in order for learning to be with understanding, the student must add new knowledge to existing material in an active way.

Even though many 20th century scientists worked on the application of constructivism in the classroom and in the development of children, the following stand out: Piaget, Dewey, Bruner, and Vygotsky.

Constructivism of Piaget relies on cognitivism. In one of his works, he requires teachers to take into account the stages in the development of a child's mind. He believes that the basis of understanding is discovery. "To understand is to discover or rediscover in order to build again. In creating creative future members of society, building knowledge plays an important role." Children, in their free time, in classes that provide them with opportunities for activities that interest them, should discover connections and ideas. Understanding is built, step by step, through active participation. In this way, Piaget says that knowledge is not a "passive copy of reality", but that it is a construction that an individual manages to build over time. [11] [12]

For Dewey, education is about activity. Knowledge and ideas are born from situations that are significant for the learner and from which he can draw significant experiences. These situations occur in settings such as the classroom where students who master the materials form a community that learns together by building their knowledge. [3]

Another important name for constructivism is Lev Vygotsky. While some critics argue that he is not a constructivist because he insists too much on the importance of the social environment in learning, others believe that he actually insists that children as builders should create their own views. He believes that children learn scientific concepts as a result of comparing their own views with those of adults. A child can only memorize a concept that has just been brought to him from the world of adults. In order to be able to turn it into his product, the child must use the connection between the concept and the idea presented to him.

Bruner also has views that shed light on the constructivist approach. For him, learning is a social process in which students can apply new concepts to existing knowledge. The student, with the aim of combining the new experience with the existing mental constructions, chooses information/knowledge, creates a hypothesis and makes a decision. A sense of independence, which is developed by encouraging students to learn new elements on their own, is the core of effective learning. In addition to this, educational programs should be designed in the form of a spiral structure that allows students to build on newly acquired knowledge.

The principles that briefly characterize Bruner's theory are:

- *Education should support experiences that will bring students to a state of interest and openness to work.*
- *Education should be built in a way that students can easily understand (spiral constructivism).*
- *Education should be created in such a way that it facilitates the use of acquired knowledge in different situations.*

In addition to the ones mentioned above, modern representatives of constructivism include: Ernst von Glasersfeld (1917), Heinz von Foerster (1911-2002), Paul Watzlawick (1921), Francisco J. Varela (1946-2001) and Humberto R. Maturana (1928).

Only a few works on constructivism were published in the territory of the former Yugoslavia until 2020: Miljak, 1998, Mušanović, 2000, Palekčić, 1999, 2001, 2002, Babić/Irović, 2001, Krstović J. 2001, Gojkov G. in 2002, and in the field of psychology, Dušan Stojnov's book "From psychology of personality to psychology of persons" appeared in 2005.

In recent years, more works have appeared on this topic.

There are different types of constructivism: radical constructivism, moderate constructivism, operational constructivism, methodical constructivism, new constructivism (in pedagogical psychology) and others. The reception of constructivism in pedagogy, i.e. didactics, is more recent, especially in Bosnia and Herzegovina.

Constructivism is one of the theories of learning and teaching that has had the greatest impact on education in practice. One of the most important reasons for this is the search for a solution to serious qualitative problems in education. Research shows that

students from developed countries such as the USA and Germany, especially when it comes to reading comprehension , and success in mathematics and physics, give poorer results than children from developing countries (Pisa-Schock, 2002). Again, research shows that even the most successful children on standardized tests cannot show the same success when their knowledge needs to be compared, integrated or used in everyday practical life [18]. Today, when all countries are busy looking for new changes that will bring education out of this situation and improve the quality of education provided in schools, teachers, primarily those from developed countries, show a great interest in the understanding of education that relies on a constructivist approach [13]. The reason for this is that education based on constructivism has the educational goal for the student to learn. In short, constructivism implies receiving new knowledge by putting it in relation with previous knowledge and thus creating new knowledge related to the already existing one.

Students should be able to apply what they have learned in school in different and unexpected situations in their lives. Classical education, where the teacher is the one who transmits knowledge, and the student is tied to the book, has proven to be extremely unsuccessful in raising students who think, criticize, comment, and interpret. If so, the focus of the classroom should be shifted from the dominance of the teacher and bring the student to the center with a constructivist approach [8].

Although constructivism was talked about throughout the 20th century, it only became relevant at the end of that century. One of the reasons is brain research, the number of which increased sharply in the 1990s. The results obtained from research in the field of neurophysiology have interested experts who deal with education, and they have tried to use this knowledge in organizing the learning and teaching process, i.e. of the education process. Constructivism is one of the concepts that stood out the most during these attempts. Although constructivism was among the topics explored much earlier by philosophy and psychology, constructivism in mathematics and science programs and education has been attracting attention since the 1990s.

Açıkgöz [1] believes that the term constructivism began to be used simultaneously with the term that has been used very often in recent years, ”active learning”. The theoretical foundations of active learning are based on constructivism and cognitivism.

2. Problem and subject of research

If we talk about schooling processes, two terms are necessarily imposed on us: ”traditional” and ”modern school”. The traditional school, which was connected to the industrial society until the end of the Second World War, is shown in a simplified form: school year - subject - class - lesson. The foundation, the key of a traditional school is the ”amount of material adopted”, which is measured by the degree of state usefulness. After the Second World War, there were intense scientific and technological changes, including a change in the school process. Learning becomes a communication process, and in the new ”modern school” the important terms ”quality school” and ”quality of knowledge” are mentioned. With the collapse of communism and as a result of changes in the civil society itself, a postmodern school or an innovative modern school appears

on the scene, in which, in addition to the technological moment (specific to the modern school), there is also a moral - civility.

School is not what it used to be. It does not lose its importance, but simply changes and becomes different. The school is becoming more and more a center of education, and less an institution of knowledge transmission or a communication link between student and source of knowledge. At school age, students not only acquire a general education in literacy and traditional subjects covered by knowledge, but also have the opportunity to learn using mass media.

If we observe the changes taking place in education, we notice changes at the global and lower school level. The attention of modern society is concentrated on the lower level, where children learn (schools, family, mass media, institutions and programs of free time, etc.).

These changes are followed by regional, national and international research . PISA (Programme for International Student Assessment) is an international test that tries to answer the question of how effectively schools prepare students for the challenges of the future. This program assesses the extent to which 15-year-old students have thoroughly mastered the knowledge and skills essential for participating in social life. OECD member countries (Organization for Economic Cooperation and Development) participate in the research and other countries can also access.

PISA measures knowledge and competences that are important in the workplace and in the private life of individuals, and which are also important for society at the same time. The purpose of the research is to assess the readiness of 15-year-old students for the challenges of life in today's society. Data collection in the PISA test is done in cycles of three years. Data were collected for the first time in 2000, then in 2003. The PISA survey in 2006 included students from 57 countries. The cyclical collection of data in PISA enables effective research into trends in student achievement and the development of educational system reforms. The Agency for Standards of Bosnia and Herzegovina reported on the conducted PISA survey in 2019, but abandoned the same in 2022, when 85 countries participated. Many countries in Europe, especially Germany, initially improved their PISA results, but in recent years the results have deteriorated. Those countries have a large amount of research and are trying to use the results of the research to improve education.

Testing is a function of the efforts of all nations to develop their human capital, which the OECD defines as: "knowledge, skills, abilities and other qualities embodied in individuals that are important for personal, social and economic well-being". This research examines achievements in three areas: natural sciences, mathematics, and comprehension and interpretation of texts.

The school in our country is traditional and we have a long way to go towards establishing a modern school. That path is even more difficult if we remember that our country is underdeveloped, with low productivity, with a low technological base, a large "brain drain" and that it does not provide the conditions for the rapid development of a modern school. Furthermore, traditional schooling cannot satisfactorily address individual differences among students and their developmental needs. [5]

In a traditional school, teaching is directed towards the average student and its scheme is lecture and memorization of teaching material. The modern school is primarily different in terms of learning environment. In it, the ideas of freedom come to the fore, manifested through the autonomy and individuality of students, plurality and tolerance. The teacher changes roles and becomes a student leader.

Modernization of the teaching process by introducing a constructivist approach, in which the teaching process is interactive and the role of the student is emphasized, is a necessary consequence of new knowledge about the nature of learning during the last decades.

For the success of teaching, it is important to realize the interest and activity of students in the teaching process. Constructivist learning offers a bold departure from the traditional, objectivist classroom. The goal for the learner is to play an active role in assimilating knowledge into their existing mindset. The ability of students to apply their knowledge, learned in school, in the real world is valued more than memorization bits and pieces of knowledge that may seem unrelated. Constructivist teaching requires the teacher to relinquish his role as information dispenser and instead continuously analyze his curriculum and instructional methodology. It is probably best for the constructivist teacher to have ""instantaneous and intuitive vision of the pupil's mind as it gropes and fumbles to grasp a new idea" [2]. Of course, the constructivist view opens up new approaches to learning, as well as challenges for teachers trying to design it.

Some ideas for teachers to implement constructivism are suggested by Yager [18]:

- *seek and use students' questions and ideas to guide the lesson and the entire unit;*
- *accept and encourage students to present new ideas;*
- *promote student leaders, collaboration, locating information and performing actions as a result of the learning process;*
- *use the student's thinking, experience and interests during the presentation of the lesson;*
- *encourage the use of alternative sources of information;*
- *ask students to present their ideas before presenting the teacher's ideas or ideas from books, etc.;*
- *encourage students to challenge the conceptualizations and ideas of others;*
- *use and respect all ideas presented by students;*
- *encourage self-analysis , evidence that supports ideas and reformulation of ideas in the light of new knowledge;*
- *use student problem identifications;*
- *use local resources as original sources of information that can be used in solving problems,*
- *engage students in searching for information that can be used to solve real-life problems;*
- *extend learning beyond class, class and school time;*
- *focus on the impact of science on each individual student;*
- *refrain from seeing scientific facts as something only students need to master in order to pass tests.*

How students learn is more important than how the teacher teaches is the constructivist didactic credo.

CT Fosnot [6], putting the student in focus, defines constructivist learning as an active process that:

- *implies student independence;*
- *the focus is more on learning than teaching ;*
- *the student has the will to learn;*
- *the student intends to learn;*
- *learning significantly depends on prior knowledge;*
- *the student owns his beliefs, attitudes and knowledge, and new ideas are developed in the process of adaptation and change of old ideas;*
- *learning is a process of creating new ideas, not a mechanical accumulation of data;*
- *motivation is the key to quality learning and a student motivated to learn is ready to explore, possess curiosity and initiative.*

It can be concluded that the constructivist model of learning includes the research activity of students and the development of specific socio-educational communication.

As a researcher, I focused on individualized teaching of mathematics, because it provides breadth in the methodological sense, and at the same time respects the individual capabilities of students. It seems that the constructivist approach to learning is mostly achieved by students in high classes.

Considering greater international success of some of these mathematics major high school students, it is worth investigating the way they learn. That research, in its content and results, would be significant for improving the quality of educational work with children of high school age, and at the same time a valuable contribution to the methodology of teaching mathematics.

There is almost no such research conducted in Bosnia and Herzegovina. Considering the development of modern technologies, and the possibility to monitor research in Bosnia and Herzegovina and surrounding countries and in the world, it is necessary to investigate every segment that is important for the development of divergent thinking, and which is in direct relation to the creativity of students. In connection with what was said about constructivist learning, there is a need to also in our environment explore this learning model.

Here I have in mind the thought of the management guru Peter Drucker, who speaking about the ”age of knowledge” says that *the creativity and talent of employees is the basic economic resource that replaces the former capital.* [4]

If we look back at the goals of mathematics teaching, it is suggested that the way to their realization leads through a constructivist approach to learning and teaching .

The goal of teaching mathematics in elementary school is to ensure that all students acquire basic linguistic and mathematical literacy and progress towards the realization of appropriate standards of educational achievement, as well as to:

- *Enable students to solve problems and tasks in new, unfamiliar situations;*
- *Enable students to express and justify their opinion and discuss with others;*
- *Develop creative and critical thinking;*

- *They develop motivation for learning and interest in subject contents;*
- *It ensures that students acquire elementary mathematical knowledge that is necessary for understanding phenomena and laws in nature and society;*
- *Train students to apply acquired mathematical knowledge in solving various tasks in real life situations;*
- *It represents the basis for successful continuation of mathematical education and for self-education;*
- *It contributes to the development of mental abilities, the formation of a scientific view of the world and the all-round development of the student's personality.*

3. SIGNIFICANCE OF RESEARCH

Research results should have both social, pedagogical and methodological significance, which would contribute to pedagogical practice and theory.

The social importance of research stems from the very importance of mathematical education for the overall development of an individual. When we talk about the upbringing and education of high school students, there is no doubt that the teaching of mathematics as a subject in which upbringing and education are realized with mathematical content occupies an important place. Through the teaching of mathematics, students acquire the knowledge needed for everyday life, as well as the knowledge needed for professional education and performing many activities. Bosnia and Herzegovina has a long tradition of institutional high school education, but there is very little scientific research in this area.

Pedagogical significance of research is reflected in the search for an answer to the question, what are the effects of the constructivist approach to learning mathematical content, among high school students. The effects of the constructivist approach to the learning of mathematical content should be reflected in the shift in the field of mathematics teaching methodology and definitely help the student in our schools to find himself in focus and become a more active participant in the teaching process than is the case today. The results of the research should contribute to the improvement of educational work with students of high school age and be at least a small step in the transition from a "traditional" to a "modern" school.

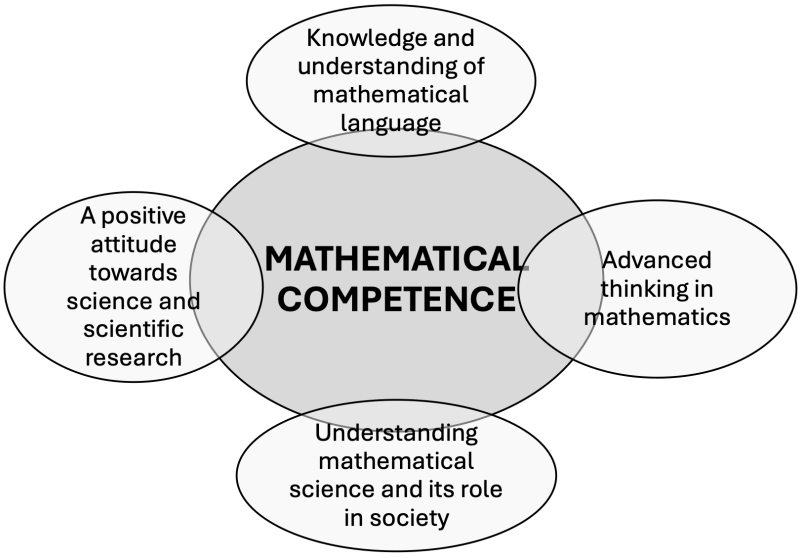
4. THE AIM OF THE RESEARCH

As one of the basic tasks of teaching and learning at school is the acquisition and assimilation of knowledge, a number of requirements are set for the methodology of all subjects, and especially for the methodology of teaching mathematics. They are aimed at finding interesting ways of presenting the material, adequate teaching aids, learning models, and all with the aim of active participation of students in the teaching process, and the acquisition of quality, permanent knowledge that can be used in everyday life.

The main goal of the research would be to examine, analyze and determine the effects of the constructivist approach to learning on the mastery of teaching content in the field of mathematics.

We propose the following schematic representation of how to achieve mathematical competence with a constructivist learning model:

5. FIGURES AND TABLES



6. CONCLUSION

= The fact is that the high school curriculum in Bosnia and Herzegovina is based in a way that requires the teacher to convey as much information as possible to the students. The question arises as to how far teachers are able to go a step further and separate the important from the less important through autonomous reasoning, help children to search for the essence and enable children to develop into people who are eager for knowledge equipped with the tools to obtain knowledge. And a good way of teaching mathematics should contribute to that. Many teachers have not yet dared to do so, but there are quite a few who have bravely stepped onto the path of constructivist learning. The traditional way of teaching will still be present, but if we include elements of constructivism in it, it will not continue to be so rigid and focused only on the content that needs to be processed.

The effects of the constructivist approach to the learning of mathematical content should be reflected in the shift in the field of mathematics teaching methodology and definitely help the student in our schools to find himself in focus and become a more active participant in the teaching process than is the case today.

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