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STRUCTURAL CORRELATION BETWEEN MATHEMATICS AND ART IN THE CLASSROOM EDUCATION

STRUKTURALNA KORELACIJA SADRŽAJA NASTAVE MATEMATIKE I LIKOVNE KULTURE U RAZREDNOJ NASTAVI

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ABSTRACT

The correlation-integration system, that is, the methodological model, is based on the principle of interdisciplinarity of the sciences, so it establishes a system of intersubject connection, contrary to the traditional isolation of teaching subjects. This model of teaching gives the most answers to students because it enables them to see subjects, phenomena and processes, relationships and connections between them as a part of the overall reality, that is, to structure knowledge from different subject areas into a common whole. The aim of the paper is to point out the importance of the application of structural cross-curricular correlation of certain teaching contents, i.e. to determine whether students of lower years of elementary school can connect knowledge from the field of geometry in mathematics and geometric abstraction in fine arts, in accordance with the current curriculum. Students of the third and fourth years of elementary school in the Tuzla area, in the second semester of the school year 2020/21, participated in the research. The research was conducted with a questionnaire, and the questions were divided into three categories: general data, recognition and naming of mathematical and artistic elements in the analysis of abstract works of art, and reduction of a figurative work of art to basic geometric shapes. The results of the correlation analysis showed, among other things, that children who achieved better results at the end of the previous year, achieved better results at the end of the semester in both subjects (mathematics and fine arts), and were also more successful at observing artistic and mathematical concepts in completely abstract art works. Given that a large percentage of students (65.6%) achieved exceptional achievement, it can be concluded that teachers are engaged when it comes to connecting teaching content, because students can mostly recognize artistic, compositional and mathematical elements in the analysis of abstract works of art.

Key words: structural correlation, art and mathematics, geometric abstraction.

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SAŽETAK

Korelacijsko-integracijski sistem, odnosno metodički model temelji se na principu interdisciplinarnosti nauka, pa se njime, suprotno tradicionalnoj izoliranosti nastavnih predmeta, uspostavlja sistem međupredmetne povezanosti. Ovakav model nastave najviše odgovora učenicima jer omogućuje da predmete, pojave i procese, odnose i veze među njima, sagledavaju kao dio sveukupne stvarnosti, odnosno da znanja iz različitih predmetnih područja struktuiraju u zajedničku cjelinu. Cilj rada je ukazati na značaj primjene strukturalne međupredmetne korelacije određenih nastavnih sadržaja, odnosno utvrditi da li učenici nižih razreda osnovne škole mogu da povezuju znanja iz oblasti geometrije u matematici i geometrijske apstrakcije u likovnoj umjetnosti, u skladu sa aktuelnim nastavnim planom i programom. U istraživanju su sudjelovali učenici trećih i četvrtih razreda osnovne škole na području Tuzle, u II polugodištu školske 2020/21. godine. Istraživanje je provedeno anketnim upitnikom čija su pitanja podijeljena u tri kategorije: opći podaci, prepoznavanje i imenovanje matematičkih i likovnih elemenata u analizi apstraktnih umetničkih djela, te svođenje figuralnog umjetničkog djela na osnovne geometrijske oblike. Rezultati korelacijske analize su, između ostalog pokazali da su djeca koja su ostvarila bolji uspjeh na kraju prethodnog razreda, ostvarila bolji uspjeh na kraju polugodišta iz oba nastavna predmeta (matematike i likovne kulture), te su također uspješnije uočavala likovne i matematičke pojmove na potpuno apstraktinim likovnim djelima. Obzirom da veliki procenat učenika (njih 65,6%) ostvarilo odičan uspjeh, može se zaključiti da su nastavnici angažirani kada je u pitanju povezivanje nastavnih sadržaja, jer učenici većinom mogu prepoznati likovne, kompozicijske i matematičke elemente u analizi apstraktnih umjetničkih djela.

Ključne riječi: strukturalna korelacija, umjetnost i matematika, geometrijska apstrakcija.

INTRODUCTION

Educational work that starts from the principle of interdisciplinarity, i.e. the integration of meaningfully related contents of two or more scientific disciplines, is one of the most important approaches that leads to the efficient acquisition of knowledge, i.e. a deeper student understanding and a deeper understanding of the purpose of the teaching material (Z. Dolenec and P. Dolenec, 2013). Correlation and integration are an extremely important part of the teaching process, because they enable the creation of connections between the fragmented contents of teaching subjects and their integrated study. (Dimić and Vidić, 2015). It has always been based on the fact that the knowledge of complex objective reality is not integrated or complete if it is acquired only from the point of view of individual, mutually unrelated sciences, i.e. teaching subjects, because life is neither mathematics, nor physics, nor chemistry, nor music, nor art in general, but it is all together and much more than that, because as a whole it is not the sum of individual elements (Rojko, 1987). According to Salopek (2012), we distinguish thematic and structural correlation. With structural correlation, the keyword is selected, i.e. term.

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Thus, a poem can serve as an occasion to observe rhyme, a sense of rhythm, or a certain regularity in the construction of a verse, and then the same rhythm is represented through colors and shapes. In verses, we achieve it by the proper alternation of long and short syllables, in fine art by the proper alternation of colors and shapes. in music by changing tones, of different durations and pitches. The educational content requires a diverse approach, during which the student will develop the abilities of observation, discovery and logical reasoning (Lazzarich, 2017). Keywords, that is, concepts in visual arts refer, among other things, to visual language. And just as in the literary language different voices, letters and words thrown in without grammar have no sense, so also thrown lines, colors and spots without compositional rules (balance, contrast, rhythm...) have no artistic or aesthetic sense, that is, content. After all, this is how kitsch often arises, i.e. ignorance of art grammar (Huzjak, 2008). Concepts such as rhythm, contrast, proportion, balance, symmetry make up the "grammar" of visual language, and we also encounter them in music, literature, mathematics and other areas of science and art. However, in our educational system, the awareness of them is often insufficient and they almost never make cross-curricular connections. The reason for this may lie in the "layman's" understanding of the purpose of art education, which even today (as well as in the professional-applicative phase of the 19th century) is predominantly focused on mere description, technical and skillful performance of a given visual motif. With the help of artistic language, we build an artistic composition. Motifs such as winter, spring, flowers are only carriers of art problems, i.e. visual language. In this work, therefore, in addition to researching the possibility of students' cross-curricular connection of content, we also tried to point out the possible arbitrary, oblivious to the content, preparation and implementation of art education.

Mathematics and art

Mathematics or geometry has always been present in art, but in different periods, in different branches of fine arts, it had different meanings and roles. In periods when art was viewed only through the prism of describing nature (reality), artists searched for a way to translate reality into a picture, that is, a way to translate three-dimensional reality onto a two-dimensional surface (canvas, paper, etc.). Then geometry appeared in the role of geometric perspective. With the appearance of linear or *geometric perspective* in the 15th century, the Renaissance begins, a new period in Europe. Centuries later (in the 20th century), *geometric abstraction*, as an artistic direction, would treat geometric objects as objects of art. However, we can see the mathematical planning of images much earlier than perspective was discovered. Searching for a reflection of the rules of creation in nature, artists searched for ideal *proportions*, i.e. the golden ratio. The golden ratio is a mathematical-structural term, most often used throughout the history of art. The most significant Renaissance artist, in the broadest sense, is certainly Leonardo da Vinci (1452 – 1519). The contributions of his genius mind are significant in sculpture, painting and architecture, as well as in the fields of mathematics, physics and engineering. Leonardo da Vinci's most famous drawing is Vitruvian man, i.e. "Proportions of the human body according to Vitruvius", where Leonardo da Vinci very precisely presented to mathematicians the ideal proportion - golden section, symmetry and balance of a human. Therefore, his goal was to show mathematically that human and nature are one, and this idea of his was materialized in Vitruvian man.

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Although a lot is known and written about the presence of mathematics in fine arts, the question arises whether classroom teachers instruct students enough to recognize and understand that connection, but also to apply it practically. The stereotypical attitudes according to which art is based on feelings and science on reason spill over into the educational practice. Thus, in the methodical advice to teachers of literature and media culture, we can read: "An emotional approach to the world is important for art. Science, on the other hand, deals with the acquisition and arrangement of human knowledge, and a rational approach to reality is important for it" (Bežen, 2005, 13; according to Huzjak). The painter Paul Cézanne gives us a reply to the absence of the intellect during artistic creation: "An artist is not a bird." He composes". What does it mean to "compose"? "What is a composition? Arrangement and relationship of parts of a whole (...). The arrangement determines the composition formally, and the relationship in terms of content; by talking about the arrangement we "describe" the picture, and by investigating the relationship we "interpret" it" (Ivančević, 1997, 54, 74; according to Huzjak). A work of art hides contents that are not obvious, and that can only be interpreted by those with an educated mind about its rules. Leonardo insists that painting is a science, referring to geometry and abstraction. "And you, who writes scientific works, when you write by hand, don't you copy what is in the spirit, as a painter does?" (Da Vinci, 1964, 22; according to Huzjak).

Abstract art

Abstraction is one of the fundamental thought processes. In science, especially in mathematics, abstraction is the mental separation of a general, essential property of an observed object or phenomenon from other properties, irrelevant to a specific study, and the rejection of those irrelevant properties (Kurnik, 2000). We find a similar interpretation in abstract art, because geometric abstraction, as a direction in modern art, is created by the process of analysis, by simplifying the observed reality into geometric figures (Damjanov, 1986). In order to understand the essence of abstract art, we need to know that the concept of art is understood differently in different historical contexts. What has always been questioned is the relationship between art and reality. Greek thinkers woven the concept of *mimesis* into the roots of the philosophy of art, thereby indicating that the purpose of art is to imitate reality. The concept of artistic mimesis, i.e. the phenomenon of imitation, will be present until the emergence of modern art. Abstract or objectless art came to life in the 20th century, when artistic practice was freed from mimesis, and increasingly tended towards the abstraction and reconstruction of the sensory or visible world. "The new spirit of the 20th century expresses most clearly the thought that runs through many programmatic texts of the Expressionists and Futurists: the truth exists, it should not be repeated" (Lucie-Smith, 1978). The image should acquire its own special autonomy and exist parallel to visible nature. Lines and colors that previously served to show objectivity now become objectivity themselves. Thus, for the majority of non-objective (abstract) art, its cognitive, gnoseological dimension is consciously neglected, because it ceases to use visual language in the narration of reality and truth. By insisting on the autonomy and purity of the artistic language itself, it achieves ontology and wants to become reality and truth itself (Vinketa, 2012). The artist himself creates an original artistic reality, which has no cognitive (mimetic) reference to reality: its objectivity is its freedom, the purity of creation. (Labus, 2006).

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Abstract art is recognizable in two basic directions, the organic abstraction of Wassily Kandinsky and the geometrical abstraction founded by Kazimir Maljevic. Geometric abstraction is a type of abstract art that combines geometric shapes in non-illusionistic spaces into non-object compositions, i.e. non-representations. It is based on pure geometric shapes of square, triangle and circle. The most important stage of geometric abstraction is purification from details. Any geometrized shape is without details. What we were interested in, among other things, in this research is the ability of younger school-age students to reduce, analyze, and simplify the observed realistic motive. By reducing the artistic composition (artwork) to basic geometric shapes, we "read" the artistic composition, that is, we see the relationships and arrangements between the parts of the picture. The students were given the task of observing the reproduction of Henri Matisse, *Red Interior, Still Life on a Blue Table* from 1947, to try to simplify the composition, i.e. reduce it to pure geometry, ignoring details, but taking into account the relationship and shape of the figures, sizes and arrangement parts to each other, as well as to the whole. We chose this picture because the objects on it already seem dematerialized, and the spatial qualities are easy to understand.

MATERIAL AND METHODS

Sample of respondents

The sample of respondents consisted of 160 students, aged 10 and 11, from three elementary schools ("Sjenjak, "Tojšići" and "Treštenica") from the Tuzla area.

Measuring instruments

The research was carried out with an anonymous questionnaire where questions were divided into three categories: general data, recognition and naming of mathematical and artistic elements in the analysis of abstract works of art, and reduction of a figurative work of art to basic geometric shapes. The questionnaire contained four artistic reproductions from the period of modern art, where art collection was adapted to the age of the students.

Data processing methods

The research data was processed using the method of descriptive and inferential statistics. The basic statistical parameters of frequency and percentages were calculated, and the results were tabulated. Correlation analysis was used to verify the research objective. Research data was processed in the statistical package SPSS 23 for Windows.

RESULTS AND DISCUSSION

The results in Table 1 show that the research included a total sample of 160 respondents, of which 81 (50.6%) were male and 79 (49.4%) were female. Of the 160 respondents included in the research, 26 (16.3%) were from "Sjenjak" Elementary School, 95 (59.4%) from the Elementary School "Tojšići" and 39 (24.4%) from the "Treštenica" Elementary School. In relation to the year they attend, 58 (36.3%) respondents are in the third year, and 102 (63.8%) are in the fourth year.

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Table 1. Demographic characteristics of the respondents

Variables	N	%
Gender		
Male	81	50.6
Female	79	49.4
School		
Sjenjak	26	16.3
Tojšići	95	59.4
Treštenica	39	24.4
Year		
Third	58	36.3
Fourth	102	63.8

Table 2 shows the distribution of respondents according to school grades. In the case of 105 (65.6%) respondents, the general grades at the end of the previous year was *excellent* (highest grade 5). Grade *very good* (4) school achievement was achieved by 46 (23.8%) respondents, while 9 (5.6%) respondents achieved *good* (3) school achievement at the end of the previous year. At the end of the first semester, 124 (77.5%) respondents achieved overall grade *excellent* (5) in the subject of fine arts, while 88 (55%) of respondents achieved overall grade *excellent* (5) in the subject of mathematics. 25 (15.6%) respondents achieved overall grade *very good* (4) in fine arts, and 42 (26.3%) in mathematics. Grade *good* was achieved by 9 (5.6%) respondents in fine arts and 11 (6.9%) respondents in mathematics.

Table 2. Distribution of respondents according to grades

Variables		Failed (1)	Sufficient (2)	Good (3)	Very good (4)	Excellent (5)	Total
Overall grade at the end of the previous year	f	-	-	9	46	105	160
	%	-	-	5,6	28,8	65,6	100,0
Overall grade in the subject art culture at the end of the first semester	f	-	-	11	25	124	160
	%	-	-	6,9	15,6	77,5	100
Overall grade in the subject mathematics at the end of the first semester	f	2	3	25	42	88	160
	%	1,3	1,9	15,6	26,3	55,0	100,0

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This data is not not surprising if we bear in mind that in our country, as well as in the educational practice of some more developed countries, it is common for students to achieve better results in lower years of elementary school compared to higher years. Similar results were obtained by Kadrum-Bošnjak, Peršić and Brajković (2007) in the study "Permanence of student school achievement in younger years of elementary school and at the transition from 4th to 5th year." Namely, the vast majority of students in younger years of elementary school - over 85% of them – achieve grades *excellent* (5) or *very good* (4). The research also showed that at the transition from classroom to subject teaching, school achievement decreases. School achievement in mathematics declines the most, while general school achievement declines the least (Kadrum-Bošnjak, Peršić and Brajković, 2007). So, while the continuity of student school achievement during classroom teaching is very high, the fact is that student success drops sharply and significantly with the transition from the fourth year to the fifth year of elementary school. Before proceeding to the interpretation of the results in table 3, it is necessary to say, for ease of reference, that the first four variables are related to general data, while the remaining ones relate to the possibility of recognizing, naming and applying geometric and art elements in abstract art deeds. Within that category, children were offered four art reproductions in the following order: Piet Mondrian's *Composition with Red Blue and Yellow, Composition Study - Cow, first version by Theo van Doesburg, then Supermatism, by Kazimir Maljivić, and Red Interior with a Blue Table, by Henri Matisse*. The first and third images are geometrically abstract, while the second and fourth images are semi-figurative works of art, i.e. the motif can be recognized on them, although abstract. In all the offered pictures, the students had the task of recognizing and naming the geometric and artistic elements, as well as the elements of the composition and the motif, except for the last picture. In connection with that picture, the students had the task of simplifying it, i.e. first looking at it, and then trying to draw it in a simplified form, i.e. in pure geometry, on an empty surface. So that part of the task concerns practical application, that is, the possibility of applying what the child previously recognized and understood.

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Table 3. Results of correlation analysis

Var.	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13
V1	**1,00**	0,03	-0,08	-0,03	**.27****	-0,14	0,01	**.18***	**-.21****	**-.20****	0,03	-0,02	-0,08
V2	0,03	1,00	**.56****	**.57****	0,00	**.16***	0,03	-0,03	0,03	**.21****	0,07	**.21****	0,15
V3	-0,08	.56**	1,00	**.45****	-0,03	0,10	-0,05	-0,06	0,01	0,00	-0,03	**.15***	0,10
V4	-0,03	.57**	.45**	1,00	0,08	**.24****	0,04	0,12	-0,04	**.19***	0,14	**.16***	0,07
V5	.27**	0,00	-0,03	0,08	1,00	**-.17***	0,00	**.51****	**-.18***	**.29****	**.31****	0,01	**.23****
V6	-0,14	.16*	0,10	.24**	-.17*	1,00	0,06	-0,11	0,14	0,11	-0,09	-0,02	0,00
V7	0,01	0,03	-0,05	0,04	0,00	0,06	1,00	-0,09	0,06	0,03	0,14	**-.192***	0,14
V8	.183*	-0,03	-0,06	0,12	.51**	-0,11	-0,09	1,00	0,00	**.30****	**.44****	-0,01	**.16***
V9	-.21**	0,03	0,01	-0,04	-.18*	0,14	0,06	0,00	1,00	-0,07	0,03	-0,03	-0,02
V10	-.20**	.21**	0,00	.19*	.29**	0,11	0,03	.30**	-0,07	1,00	**.29****	-0,08	**.31****
V11	0,03	0,07	-0,03	0,14	.31**	-0,09	0,14	.44**	0,03	.29**	1,00	-0,05	0,07
V12	-0,02	.21**	.15*	.16*	0,01	-0,02	-.19*	-0,01	-0,03	-0,08	-0,05	1,00	-0,01
V13	-0,08	0,15	0,10	0,07	.23**	0,00	0,14	.168*	-0,02	.31**	0,07	-0,01	1,00

Legend: V1 – Year; V2 - General achievement at the end of the previous year; V3 - Grades in the subject art culture at the end of the first semester; V4 - Grades in the subject of mathematics at the end of the first semester; V5- Specify which geometric characters you recognize in the image; V6 - Present in the picture; V7 - How do we call the colors represented in the picture; V8 - In what contrast are the colors; V9- What motif did the artist present in the painting; V10 - From which geometrical shapes is the motif of the painting composed; V11 - Recognize and note the most basic geometric concepts or shapes on the picture; V12 - What do we call the colors represented in the picture; V13 - Simplify the image, reduce it to basic geometric figures

From the Table 3, it can be seen that the variable: "Simplify the image, reduce it to basic geometric shapes" is correlated with the following variables: "Specify which geometric characters you recognize in the image", "In what contrast are the colors" and "From which geometrical shapes is the motif of the painting composed". This result indicates that students who achieved better achievement in the practical reduction (through drawing) of a figurative work to basic geometric shapes are also more successful in recognizing and naming artistic and mathematical elements, as well as motifs in the reproduction of the other two works of art. This means that the students who showed a better result in practical application, i.e. abstracting a semi-figurative work of art, successfully recognized artistic and mathematical values in both abstract and partially abstract works of art. In simplified terms, the possibility of "seeing" or "reading" an art composition for students in the classroom is closely related to their ability to abstract the composition artistically and technically. The results obtained in Table 3 also show that at the level of statistical significance 0.01 and 0.05 there is a positive connection between the years attended by children and the variables: "Specify which geometric figures you recognize in the picture" and "In what contrast are the colors". The grade attended by the children is negatively related at the 0.01 level of statistical significance to the variables: "What motif did the artist present in the painting"; and "From which geometrical shapes is the motif of the painting composed".

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These results show that students from higher years recognize geometric shapes and color contrast better, that is, they are more successful in analyzing a completely abstract work of art. Students from lower years are more likely to recognize the motif in the picture and the geometric shapes from which it is composed, that is, they are more successful in analyzing a semi-figurative work of art.

Although the difference in the age of the respondents is not significant, this data can be interpreted in such a way that younger students are more receptive to visual motifs. It is also known that they tend to look for a motif in a work of art firstly, and only later for artistic and technical characteristics, as well as artistic problems. Duh, Kljajić and Nurikić, (2010) according to Kušćević et al. (2009) state that previous research has shown that students in the early school period are attracted to figural motifs more than abstract motifs. The authors comment on the claim with the fact that the child's gaze is spontaneously directed to the realistic creation of motifs, while it is necessary to respect the lack of understanding of visual language at that age of the child's development. Table 3 shows that the second variable "General achievement at the end of the previous year" correlates highly with school achievement in mathematics and art at the end of the first year, but also with the variables; "Present in the picture"; "From which geometrical shapes is the motif of the painting composed" and "How do we call the colors that are present in the picture". Therefore, the students who achieved a higher overall grades at the end of the previous year also showed a higher achievement at the end of the semester in both subjects (mathematics and art), and also better recognized and analyzed art and math concepts in completely abstract art works. Given that a large percentage of students (65.6%) achieved overall grade *excellent* (5), it can be concluded that teachers are engaged when it comes to connecting teaching content, because students can mostly recognize artistic, compositional and mathematical elements in the analysis of abstract works of art. Similar results were obtained by Duh, Kljajič and Nurikić, (2010) in their research on the perception of art problems among elementary school students. In the research, it was determined that half of the students in the third year of elementary school, regardless of gender and region, recognize the dominant artistic problems in the works of art.

CONCLUSION

The research aimed to determine whether students of lower years of elementary school can connect knowledge in the field of geometry in mathematics and geometric abstraction in arts, in accordance with the current curriculum. This way, an insight into the practice of the teacher's work is obtained, and the importance of the application of structural cross-subject correlation of certain teaching contents is pointed out. Students of the third and fourth years of elementary schools in the area of Tuzla, in the second semester of the school year 2020/21, participated in the research. The research was conducted with a questionnaire, the questions of which are divided into three categories: general data, recognition and naming of mathematical and artistic elements in the analysis of abstract works of art, and reduction of a figurative work of art to basic geometric shapes.

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The results of the correlation analysis showed, among other things, that children who achieved better grades at the end of the previous year, achieved better grades at the end of the semester in both subjects (mathematics and art), and also more successfully observed art and math concepts in completely abstract works of art. Given that a large percentage of students that achieved overall grade *excellent* (5), it can be concluded that teachers are engaged when it comes to connecting teaching content, because students can mostly recognize artistic, compositional and mathematical elements in the analysis of abstract works of art. It was also established that students from higher years recognize geometric shapes and color contrast more, that is, they are more successful in analyzing a completely abstract work of art. Students from lower years are more likely to recognize the motif in the picture and the geometric shapes of which it is composed, that is, they are more successful in analyzing a semi-figurative work of art. Although the difference in the age of the respondents is not significant, this data can be interpreted in such a way that younger students are more receptive to visual motifs. It is also known that they tend to look for a motif in a work of art firstly, and only later for artistic and technical characteristics, as well as artistic problems. It was also observed that students, who achieved better results in artistic and technical application, i.e. abstracting a semi-figurative work of art, were more successful in recognizing artistic and mathematical values in both abstract and partially abstract works of art. In simplified terms, the possibility of "seeing" or "reading" an art composition for students in the classroom is closely related to their ability to abstract the composition artistically and technically.

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