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PRIMARY SCHOOL STUDENTS' ATTITUDES AND INTEREST IN AFTER-SCHOOL STEAM ACTIVITIES

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Abstract: STEAM represents an educational approach that integrates the "arts" into the existing STEM framework. Studies suggest that STEAM education positively affects students' learning, problem-solving skills, creativity, attitudes, and motivation. The research aims to analyze primary school students' perceptions of an after-school STEAM workshop. A quasi-experimental design was used. The instrument used in the study was a questionnaire developed by the authors. The sample consisted of 93 third-grade students. All students participated in the workshop about tessellations using the STEAM approach. The results showed that, in general, students expressed highly positive attitudes toward the STEAM workshop and increased interest in participating in after-school STEAM activities. It was determined that girls favored activities related to the arts more than boys, but there were no statistically significant differences in overall attitudes. However, there were statistically significant differences in two items in favor of boys. The boys expressed stronger interest in using digital tools and interactive boards and learning new, unknown things compared to girls. Students' responses imply that they can recognize tessellations, but frequent repetition of this topic is necessary. The findings also suggest that more school and after-school STEAM activities should be organized as they positively influence students' attitudes and enhance their interest and motivation for STEAM which might be important when choosing future careers in these fields.

Keywords: STEAM, after-school activities, primary school students, attitudes, interest

INTRODUCTION

In recent years, the share of STEAM education has been growing in the contemporary educational system. This holistic approach to learning not only fosters

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an interdisciplinary understanding of problems but also promotes the development of "Four Cs" skills: communication, creativity, critical thinking, and collaborative problem-solving, which are essential skills for the 21st century (NEA, 2012). Elementary school students, in particular, are at a crucial point where early educational experiences can significantly influence their future academic interests and career paths. The current social and economic context underscores the urgency of equipping young students with STEAM competencies. The global economy increasingly demands a workforce capable of handling technology and innovation, with industries constantly evolving toward automation and digitalization. The Fourth Industrial Revolution has accelerated the pace of technology adoption and blurred the boundaries between humans and machines across various sectors and geographical areas. Technology is only changing the way we work, but it is also altering job content, the skills required, and which jobs are being replaced (World Economic Forum, 2023). According to the World Economic Forum's report on the future of jobs, by 2025, 85 million jobs could be displaced due to shifts in the division of labor between humans and machines, while 97 million new roles may emerge that are more adapted to the new division of labor among humans, machines, and algorithms (World Economic Forum, 2020). This dynamic economic landscape requires a strong educational foundation that STEAM education can provide.

STEAM education, which integrates Science, Technology, Engineering, Arts, and Mathematics, evolved over time through the contributions of various educators and institutions. The concept of STEAM as we know it today was popularized by Georgette Yakman, an educator and researcher, in the early 2000s. Yakman developed the framework to include the arts in the traditional STEM (Science, Technology, Engineering, and Mathematics) model, recognizing the importance of creativity and design in fostering innovative thinking and problem-solving skills (Yakman, 2008).Yakman's STEAM framework emphasizes the interconnectedness of these disciplines and aims to provide a more holistic education that prepares students for the complexities of the modern world. Her work has been instrumental in promoting STEAM education and influencing educational policies and curricula worldwide.

Including Art in the traditional STEM framework relies on numerous studies of creative processes and the role of Art in fostering innovation. Scholars such as Howard Gardner, known for his theory of multiple intelligences, argue that creativity and Art play a vital role in cognitive development and should be an integral part of educational curricula (Gardner, 1983). Gardner's research suggests that incorporating artistic elements into STEM education can enhance students' ability to think divergently and approach problems from multiple perspectives. Elliot Eisner, an American professor in the fields of Art and Education and a vocal advocate for integrating arts into the education system, believed that Art education should not be viewed as a separate subject but as a complementary component to other subjects (Eisner, 2002). He considered that arts education should be integrated into other subjects to make learning more engaging and meaningful. Eisner's approach to arts education emphasized the importance of observation, experience, and communication in the learning process. Education expert Ken Robinson, an advocate for radical changes in education and the role creativity plays in it, argued that creativity is as important in education as literacy and should be treated with the same status (Robinson, 2006). Robinson's support for creativity in education underscores the importance of nurturing students' creative capacities alongside their academic abilities and technical skills.

This implies the necessity of incorporating the creativity inherent in Art into the traditional STEM framework of education. When properly and accurately taught, Art develops creativity and other cognitive competencies that benefit students in every aspect of their education and prepare them for the demands of the 21st century (Sousa & Pilecki, 2013). Therefore, the key contribution of Art to STEAM education is the development of creativity. Art inherently involves a creative approach to solving or exploring a problem. There are numerous definitions of creativity based on different scientific disciplines, indicating the complexity and multidimensionality of the phenomenon. However, we can generally say that creativity includes the ability to think outside the established frameworks and to find new solutions to existing problems. The presence of Art and creativity in education is associated with better results in PISA tests, problem-solving skills, critical thinking, teamwork, change management, collaboration, and other personal qualities highly valued in today's job market (Christopoulos, et al., 2024). Skills and abilities practiced and developed through art, when applied in STEM fields, contribute to knowledge transfer, contextualization of scientific findings, synergy of ideas, and communication of discoveries with the environment (Sousa & Pilecki, 2013). Moreover, STEAM education expands students' learning experiences by connecting skills and abilities from Art with STEM fields, combining divergent and convergent thinking processes that are otherwise considered separate and belonging either to Art or science (Sousa & Pilecki, 2013). Equally important, the collaborative nature of STEAM activities reflects real-life scenarios where interdisciplinary teamwork is essential. The collaborative aspect encourages students to work together, share ideas, and learn from each other, thus preparing them for future professional roles.

In other words, STEAM education provides students with creativity as a means of connecting content areas that were previously considered distinct or separate. It serves to enhance students' interest in exploring these areas from an interdisciplinary perspective. This increased student engagement is particularly important in primary education, where fostering a love of learning and curiosity can significantly influence students' further education.

Teachers and mathematics educators know that many students struggle with learning mathematics. Integrating the arts into math lessons helps students recognize the practical and real-world applications of mathematical concepts. This can be achieved both in regular classroom teaching and through after-school activities. Engaging students in after-school STEAM activities provides a unique opportunity to complement traditional teaching practices with hands-on, investigative learning that can enhance their interest in these fields. Research shows that such extended learning programs and after-school activities positively impact student achievement (Peterson, 2013). It has been found that STEM afterschool activities have influenced students' attitudes toward STEM fields and consequently their long-term academic trajectories (Peterson, 2013), highlighting the potential benefits of more comprehensive STEAM after-school activities.

RESEARCH METHODOLOGY

The aim of the research was to determine primary school students' perceptions of after-school STEAM activities (STEAM workshop). Based on this aim, three research tasks were defined:

1. to investigate whether pupils have positive perceptions about STEAM workshop activities and contents;
2. to investigate whether there are differences in perceptions based on gender; and
3. to investigate whether pupils recognize tessellations[1].

The research was conducted during the 2023/2024 academic year and included a sample of 93 third-grade students from Boško Djuričić primary school in Jagodina. All students attended afterschool STEAM workshop about tessellations held in May 2023. The gender structure of the sample is given in *Table 1*.

Table 1. Gender structure of the sample

Gender	N	%
Girls	40	43.0
Boys	36	38.7
No answer	17	18.3

[1]"Tessellation is an arrangement of closed shapes that completely cover the plane without overlapping or leaving gaps." (Deger & Deger, 2012)

The workshop included five activities. Four of these activities were implemented using a station rotation model, while the fifth activity engaged all students simultaneously. A brief description of each activity is given in *Table 2*.

Table 2. Description of STEAM workshop activities

Activity	Description of activity
A1. Tessellations in Art	Students were introduced to the artist Escher and some of his most famous paintings. They had a task to solve jigsaw puzzles where the pieces were parts of Escher's artworks.
A2. Geometry and tessellations	Students were introduced to different types of tessellations (regular, semi-regular, and irregular). Through a hands-on activity, they used pattern blocks to create tessellations and to solve puzzles which involved completely covering given shapes with the pattern blocks.
A3. Tessellations in games	Students were introduced to the game of Tetris, including information about its creator and the rules. They then played an offline version of Tetrisin pairs competing against each other.
A4. Interactive board tessellations	Students created tessellations using an interactive board and Mathigon polypad (interactive digital manipulatives).
A5. Designing tessellations	Students were divided into groups and each group created their tessellation pattern using cardboard. Their task was to design a section of a 10-meter-long art paper roll using the created tessellation.

The instrument used was a questionnaire created by the research authors. It consisted of three parts. The first part collected background information about the pupils. The second part contained 16 five-point Likert-type items that related to pupils' perceptions of workshop activities and content. In the first 5 items, pupils indicated how interesting and appealing they found each activity. The remaining 11 items asked pupils to rate their agreement with statements about workshop contents and organization of activities (*Table 3*).

The third part of the instrument contained four closed-ended questions that investigated whether students knew what tessellations were before and after the workshop, as well as whether they could identify tessellations in given examples (presented as two groups of images).

The statistical analysis was conducted using SPSS for Windows, version 23.0. P-values lower than 0.05 were considered statistically significant. The normality of data was assessed using the Shapiro-Wilk test of normality. For the quantitative data analysis, descriptive statistics methods were employed (frequency, percentage, mean, standard deviation, and mean ranks), while the Mann-Whitney test was used for non-parametric variables.

Table 3. Perception of workshop activities and content items

Item code	Item
T1	The whole tessellations workshop was interesting.
T2	I liked that we learned new, unknown things (what tessellations are, where they are, how to create them).
T3	I like that we could try everything on our own (put together a picture, play Tetris)
T4	I like that we were making different things (stacking plastic geometric shapes, making pictures from parts).
T5	I like that I worked together with my friends.
T6	I like that we used the interactive whiteboard to create different figures.
T7	I like that we connected math and art.
T8	I like that we connected math with games like Tetris for example.
T9	I like that we made and colored our own tessellations.
T10	I would like to have such classes at school.
T11	I would like to participate in more such afterschool workshops.

RESULTS AND DISCUSSION

The first research task was to determine pupils' perceptions of afterschool STEAM workshop activities and contents. Students rated all individual workshop activities as very interesting and appealing (see *Table 4*).

Table 4. Descriptive statistics

Activity	M	SD
A1. Tessellations in Art	4.43	0.85
A2. Geometry and tessellations	4.61	0.72
A3. Tessellations in games	4.72	0.59
A4. Interactive board tessellations	4.51	0.82
A5. Designing tessellations	4.52	0.88

However, they perceived activities that contained game elements to be the most interesting (activities A3 and A2). This was followed by activities that engaged elements of their personal creativity (A5 and A4). As the least interesting activity, students recognized activity with standard tessellations patterns (A1).

As part of the same research task, we wanted to determine the pupils' perceptions of the workshop in general, including their evaluation its content and organization. *Table 5* shows the arithmetic means and standard deviations for eachitem assessed in the instrument.

Table 5. Descriptive statistics

Item code	M	SD
T1	4.62	0.81
T2	4.69	0.53
T3	4.74	0.63
T4	4.70	0.76
T5	4.86	0.46
T6	4.68	0.75
T7	4.63	0.74
T8	4.81	0.49
T9	4.59	0.84
T10	4.61	0.88
T11	4.74	0.70

Based on the obtained results, we can conclude that the pupils express strong agreement with the given statements. They had positive perceptions of the whole workshop including its contents and organization. The organizational features rated highest were the opportunity to work in groups with peers (T5) and hands-on work (T3 and T4). Regarding the contents, students particularly enjoyed making connections between mathematical contents and games (T8).

Students expressed interest in participating in more STEAM activities, both during school and in after-school programs.

The second research task was to determine if there were differences in perceptions based on gender. The findings of the descriptive statistics are shown in *Table 7*. The girls evaluated A1 and A5 as more interesting activities in comparison to the boys. On the other hand, boys found A2, A3 and A4 as more interesting activities. This suggests that they preferred the activities involving elements of games and digital technology. Interestingly, the girls favored the activities related to the Arts more.

Table 7. Descriptive statistics

Item code	Girls			Boys		
	N	M	SD	N	M	SD
A1	40	4.48	0.88	36	4.44	0.73
A2	40	4.65	0.62	36	4.72	0.51
A3	39	4.67	0.58	32	4.78	0.55
A4	39	4.36	0.87	32	4.72	0.63
A5	39	4.62	0.88	33	4.33	0.92

However, the results show that there were no statistically significant differences in perceptions of boys and girls about activities: A1 (U=671.500, Z=-0.588, p=0.556), A2 (U=694.000, Z=-0.352, p=0.725), A3 (U=551.500, Z=-1.151, p=0.250) and A5 (U=512.500, Z=-2.146, p=0.068). As for activity A4, we found a statistically significant difference in favor of boys (U=468.000, Z=-2.146, p=0.032). The boys expressed stronger interest in using digital tools and interactive boards than girls.

As for the perceptions about the workshop contents and organization of work, similarly to previously described findings, girls expressed more positive attitudes about those workshop features which involved art (connecting mathematics and art, i.e. creating and designing tessellation patterns). It is interesting that the girls also expressed stronger readiness to participate in more school and after-school STEAM activities in comparison to boys. On the other hand, boys evaluated the features such as the possibility to learn new and unknown things more positively. The same applies to working in groups with peers and hands-on work. Nevertheless, we found a statistically significant difference in the perceptions of boys and girls only in item T2 (U=1391.500, Z=-1.982, p=0.048). The boys liked learning new, unknown things in comparison more than girls. There were no statistically significant differences in other items (*Table 8*).

Table 8. Descriptive statistics and results of the Mann-Whitney test

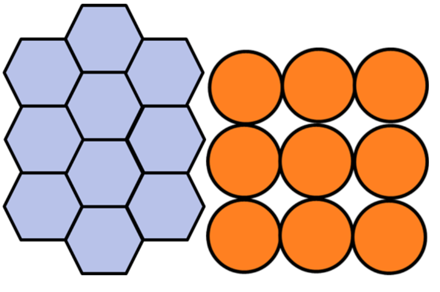
Item code	Girls			Boys			Mann-Whitney U	Z	p
	N	M	SD	N	M	SD			
T1	40	4.58	.813	36	4.53	.941	715.000	-.066	.947
T2	40	4.58	.594	36	4.81	.467	571.500	-1.982	**.048**
T3	40	4.73	.506	36	4.78	.637	648.000	-1.082	.279
T4	39	4.67	.772	36	4.72	.815	645.000	-.948	.343
T5	40	4.83	.549	36	4.89	.398	690.500	-.577	.564
T6	39	4.59	.910	36	4.69	.668	676.500	-.378	.705
T7	40	4.63	.540	36	4.61	.803	659.500	-.792	.428
T8	39	4.79	.469	36	4.75	.604	700.500	-.024	.981
T9	40	4.60	.778	36	4.44	1.027	711.000	-.121	.904
T10	39	4.69	.731	36	4.44	1.107	656.500	-.659	.510
T11	39	4.77	.627	36	4.67	.862	687.500	-.241	.809

The third research task was to investigate whether students knew what tessellations were before and after participation in afterschool STEAM workshops.

The first two items pertained to students' self-assessment of their knowledge of tessellations. While 2.15% did not answer the first item, 92.31% of the remaining students responded that they knew what tessellations are even before the workshops. The students largely demonstrated their ability to assess their understanding of the concepts. On the second item, 36.36% stated that they had forgotten what tessellations are after the workshops but were reminded by the images provided in the first part of the questionnaire.

As a part of the same research task, we wanted to determine if students could correctly identify examples of tessellations given in two sets of images. The first set contained purely geometrical objects while the second set contained real-life examples.

It is interesting to consider how students perceive tessellations in the images provided in the questionnaire. The first set of images pertained to tessellations with geometrical figures. Students exhibited a good perception of tessellations. As many as 89.25% of students correctly identified the tessellation depicted in one of the four images (*Picture 1*). However, a notable issue is the students' misunderstanding of the concept of tessellations, specifically that the figures must cover the entire plane without gaps. Due to this misconception, a significant percentage of students (38.71%) selected the image that shows a regular pattern of geometric figures but does not cover the entire plane (*Picture 2*).



Picture 1. Correct and wrong answer, respectively

Identifying tessellations in photographs depicting real-world examples proved to be a significantly more challenging task for the students. Four out of eight pictures presented examples of tessellations. The students' responses are given in *Table 6*.

Table 6. Students' responses

Type of answer	% of students
Correctly completed task	18.28
Selects some images of tessellation but not all	38.71
Selects images of all tessellations, but also some which are not tessellations	16.13
Selects some images of tessellations and some images which are not tessellations	26.88

By examining students' responses, we found that 31.18% identified a picture containing fractals as a tessellation and 4.30% of the students equated symmetry with tessellation. Interestingly, on average, 76.88% of the students correctly selected images depicting "pure" tessellations, i.e., tessellations without any visible noise (for example, the image of arranged bricks in a wall or paving stones on the street). However, fewer students (61.83%) recognized a tessellation image when another object was present along with the tessellation (for example, a bee on a honeycomb or a chess piece on a chessboard).

Considering these responses comprehensively, we can conclude that students are able to recognize tessellations, but frequent repetition of this topic is necessary.

CONCLUSION

STEAM represents an educational approach that positively affects students learning, achievement, problem-solving skills, creativity, attitudes, and motivation. It fosters creativity as a means of connecting different content areas and enhances students' interest in exploring these areas from an interdisciplinary perspective. Since many students struggle with learning mathematics, integrating the arts into math lessons might help them recognize the practical and real-world applications of mathematical concepts. While this can be achieved in regular classroom teaching, after-school activities have some advantages. After-school STEAM activities engage students in hands-on, investigative learning that can improve their understanding and enhance their interest and attitudes in these fields. The main aim of this research was to investigate primary school students' perceptions about after-school STEAM workshops. The obtained results showed that students expressed highly positive attitudes towards the workshop and increased interest in participating in after-school STEAM activities. Students evaluated the features such as the possibility to work in groups with their peers and hands-on work, as well as integrating mathematical contents with other content areas, with the highest grades. The girls favored activities and features related to the Arts more than the boys, but there were no statistically significant differences in their attitudes. However, we determined that there were statistically significant differences in two items in favor of boys. They showed stronger interest in using digital technology and learning new, unknown things. Overall, students' responses pointed out that they were able to recognize tessellations, but some misconceptions implied that frequent repetitions of this topic may be needed. The findings of this study suggest that afterschool STEAM activities have positive impact on students' interest and engagement. Since students' interest and motivation in STEAM are important factors when choosing future careers, we believe that more attention should be given to the design and organization of these activities.

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