EFFECTS OF SHORT-TERM STEM INTERVENTION ON STUDENTS' ATTITUDES TOWARDS STEM

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Abstract. This research aimed to investigate the effect of the STEM approach on attitudes of ninth-grade students towards STEM and investigate the differences between boys' and girls' attitudes towards STEM. The quasi-experimental design with the experimental and control group and with pretest-posttest was conducted. This research was carried out with 67 ninth-grade students (aged between 14 and 15) of a public school in the 2019/2020 school year. The students in the experimental group were taught one area of Mathematics with the STEM approach, while the students in the control group were taught in the traditional way. In addition, a questionnaire to measure students' attitudes towards STEM was distributed to both groups in the form of pretest and a posttest. The results showed that the STEM intervention had a positive effect seen in the increase of positive attitudes towards STEM in the experimental group. The results also showed that girls had more positive attitudes than boys.

Keywords: STEM intervention, STEM approach, attitudes towards STEM, attitudes toward mathematics, ninth-grade student, algebra

Introduction

STEM approach in education, which builds a connection between business and education, is a method used to integrate science, technology, engineering, and mathematics and transform theoretical knowledge into practice (Akgündüz et al., 2015). STEM is an educational approach that enables a student to think systematically, be open to communication, develop ethical values, search, produce, create and solve problems appropriately (Bybee, 2010b; Dugger, 2010; Rogers & Porstmore, 2004).

STEM education provides many benefits. For example, students become better problem solvers, more positive and motivated learners, and improve their mathematics and science achievements (Furner & Kumar, 2007; Stinson et al., 2009). The fact that the STEM approach increased motivation and interest in STEM has motivated us to conduct the research described in this paper. Also, given that STEM approach in education is just beginning in B&H and that is being used sporadically (one or two STEM projects or STEM areas covered per school year), we wanted to see how our students respond to STEM interventions. Our research aims to examine the effect of short-term STEM approach/STEM activities on students' attitudes towards STEM areas. The following research questions developed from the research objective: (1) is there any meaningful difference between boys and girls in attitudes towards STEM before intervention; (2) is there any meaningful difference between boys and girls in attitudes towards STEM after intervention; (3) is there any meaningful difference between the experimental and control groups in STEM attitudes before and after intervention?

Background

Literature review

With the help of technology and information, the world is developing and changing fast. Meeting the increasing needs and keeping up with progress is possible with innovation. Innovations require critical thinking, problem-solving skills, cooperation, leadership abilities, a flexible frame of mind, ability to adapt, entrepreneurship, ability to communicate in verbal and written ways, accessing and using information, curiosity, and imagination – in short, 21st century skills (Wagner, 2008).

The STEM areas and STEM approach in education and research are in the public interest of countries worldwide. We live in a time when knowledge is acquired quickly, in a time when some occupations disappear, and other ones arise, and when requirements within surviving occupations change and thus become more complex. Therefore, the priority of education is to enable students to cope with the changes they will face during their lives as successfully as possible (Avdispahić, 2018).

A year-by-year decrease is present in the number of students willing to take education in the fields of science, mathematics, and engineering (Stohlmann at el., 2012). These areas are necessary for the development of a country, so it is important to educate individuals who can use and apply different disciplines together. Likewise, it is necessary to constantly change and upgrade curricula to increase interest in these areas. To this end, some countries have integrated the STEM approach into all levels of education (Bybee, 2010b; Çorlu, 2014). Primary school educators must inculcate the importance of STEM in the mathematics curriculum. One way to improve mathematical problem-solving skills among schoolchildren is to use the STEM approach (Abdullah et al., 2014).

Numerous studies about students' attitudes towards STEM exist. Research by Babarović et al. (2018b) showed that STEM intervention has specific positive effects on the attitudes of primary school students towards scientists. They believe that changing attitudes towards scientists is an essential factor in increasing interest in STEM. Some previous studies have shown that a student's decision about a career in STEM area depends on the image he or she has about a person in that career and whether he or she can imagine himself or herself as a person in that STEM career (Bennett & Hogarth, 2009; Gilbert & Calvert, 2003). Babarović et al. (2018b) also showed that STEM intervention equally impacts the attitudes of students of different ages and genders and students of different initial school achievements in mathematics. However, the effects of the intervention on the increase of career interests in STEM areas are modest. They are present only in the youngest group of students (4th grade), and only in the area of mathematics and technology. For students aged between 10 and 11 years old (4th grade) STEM interests are certainly not structured and stable, so the intervention may have greater effects.

STEM interventions may have specific effects on maintaining interest in the STEM area in the upper grades of primary school, probably more than on their increase. Namely, several studies have shown that younger children have a high level of interest in science and mathematics, but by passing through the educational system, this interest is being reduced, especially among girls (Mitchell & Hoff, 2006; Riegle-Crumbet et al., 2011). Therefore, STEM interventions in upper grades of primary school may be a protective factor aimed to maintain students' interest in STEM. Several longitudinal studies have shown that interests become stable and invariant after the age of 14 (Tracey, 2002; Tracey et al., 2005). Developmental theories stress that adolescence, particularly 13 to 14 years of age, is the crucial period in the process of interests' formation (Super, 1953; Gottfredson, 1996).

Murpy & Beggs (2005), as well as team members of ASPIRES project (Archer et al., 2012), found in their research that students' interest in science at the age of 10 is great and that there is no difference at that age between girls and boys in the degree of interest expressed. With growing up and moving to higher grades of primary school, students′ interests decline in general, but more and more differences are beginning to appear between girls and boys. The difference in students' interests becomes deeper during adolescence (Burušić, 2018). Research by Burušić (2018), as well as research by Lindahl (2007) has shown that the upper grades of primary school (around the age of 13) are a crutial period for the formation and structuring of interest in the STEM area and especially interest in STEM careers. Therefore, all efforts to direct students towards STEM areas should be focused on this development period since such attempts are increasingly ineffective in later development periods (Burušić, 2018).

For this reason, in our research, we have chosen the upper grade of middle school (ninth grade) to investigate the effects of STEM activities on students' attitudes towards STEM and the differences between boys' and girls' attitudes towards STEM. In addition, the quasi-experimental design with the experimental and control group and with pretest-posttest was conducted.

STEM education in Bosnia and Herzegovina (B&H)

The Agency for Pre-Primary, Primary and Secondary Education (APOSO) began to develop the Common Core Curriculum defined on learning outcomes (CCC) in 2012 to modernize and improve the quality of preschool, primary and secondary education. The CCC is the basis for changing and improving existing curricula. In the process of developing the CCC based on key competencies, APOSO has defined eight subjects of education, and one of them is the subject of mathematics.

In 2015, APOSO published the CCC. It first defines the areas and components for each area. Then, learning outcomes were defined for each component, and indicators were defined for each learning outcome. Indicators are defined following the developmental age of a child at the end of preschool education (age 5-6), at the end of the third grade (age 8-9), at the end of the sixth grade (age 11-12), at the end of the ninth grade (age 14 - 15) and at the end of the secondary education (age 18 - 19).

For each of the six STEM subjects - Biology, Chemistry, Physics, Geography, Mathematics, Technics and Information Technology, and for each of the development periods for which learning outcomes have been defined, a Draft of Operational Teaching Curriculum (OTC) for STEM competencies has been prepared. OTC connects defined learning outcomes and related indicators from different subjects, which should lead to greater understanding and development of necessary skills in joint implementation. OTC for mathematics provides numerous links between mathematics and other STEM disciplines and lists their applications in various sectors of the knowledge-based economy. The document is divided into four parts according to the age of the students (1 - 3, 4 - 6, 7 - 9, and 10 - 13 grade). Each of these four parts is divided into four areas of mathematics (sets, numbers, and operations; algebra; geometry and measurements; data and probability), which are further divided into components, then into narrow outcomes and even narrower indicators. Outcomes and indicators are related to the areas of a knowledge-based economy in which they are applicable and to outcomes/indicators from other STEM disciplines. Examples of interdisciplinary STEM projects are also given, and detailed explanations of the mentioned connections with various sectors of the economy and other disciplines.

Methodology

Participants

The quasi-experimental design with the experimental and control group and with pretest-posttest was conducted. Students were divided into these two groups based on prior knowledge so that there was no statistically significant difference between the groups.

Research was carried out with 67 ninth-grade students (33 students in the experimental group and 34 students in the control group). Before this research, students did not have an interdisciplinary STEM education. They were traditionally taught in the sense that they have natural sciences, mathematics, and informatics, but these subjects are taught separately and very often the curricula are not harmonized.

Measurements

For this research, a questionnaire was prepared to consist of two parts. The first part of the questionnaire contained questions about gender and class. The second part of the questionnaire contained the STEM Attitude Scale (Unfried et al., 2014) translated to the Bosnian language which consists of four subscales (mathematics, science, engineering and technology, 21st-century skills) and 37 items. The scale is a five-point Likert scale (strongly disagree to strongly agree). For example, one of the items that appear in the subscale for math is: “I would consider choosing a career that uses math”. The Cronbach alpha reliability coefficient for the original scale was found to be 0.83 and above. In this research, the Cronbach alpha reliability coefficient values for pre-test and post-tests were calculated as 0.91 and 0.93 respectively. These values indicated that the reliability of the measurements was at an acceptable level.

Students were given instructions on how to fill in the questionnaire (e.g. that they have to answer each statement and fill in only one answer per question). The scale was completed only by students for whom parents or guardians had given written consent.

STEM intervention

Students completed the above-mentioned questionnaire before intervention. The experimental group was taught using the STEM approach and the control group was taught in the traditional way. The research took place in the 2019/20 school year in two parts: (I) The first part was conducted in the period from November 11 to November 27, 2019 (teaching topics: Graphs of the function of direct and inverse proportionality, Linear function, which belong to Component 1 of the area Algebra); (II) The second part was conducted in the period from January 27 to March 11, 2020 (teaching topics: Linear equations and linear inequalities with one unknown - problems with one unknown and Systems of linear equations with two unknowns which belong to Component 2 of the area of Algebra).

During research, certain STEM activities were carried out with the students of the experimental group, through which we tried to connect the mathematical content with the content from other subjects, but also with examples from everyday life. The emphasis was also on practical work, research, group work, and pair work of students. The following is a brief description of some examples done with students: (1) By using GeoGebra software, students were introduced to the graph of a homogeneous linear function $y = kx$ for different values of the parameter k ($k > 0$ and $k < 0$). It was explained to students when this function increases and when it decreases. In addition, GeoGebra was used to introduce students to the linear function $y = kx + n$ whereby it was started with what the students already know about the function $y = kx$. GeoGebra was also used to introduce students to the graphical method of solving a system of linear equations with two variables; (2) One of the examples of connecting a homogeneous linear function (the function of direct proportionality) with Physics, is an example of a linear motion which is described with the equation $s = v \cdot t$. For a constant velocity, we have that it is a homogenous linear function (further information about this activity is available in Appendix 1); (3) A function $m = \rho \cdot V$ that describes how to calculate a mass for given density and volume is an example of the direct proportionality function in case when the density is constant. Students worked in groups to determine the mass and volume of one cube, then the mass and volume for two, three, four,... identical cubes. They wrote down the obtained results in a prepared table. Based on the obtained results, they were supposed to conclude that with increasing mass the volume also increases. They concluded that $m = \rho V$, ie. the mass is directly proportional to the volume. For the cubes, they obtained that the density is $\rho =$

$0{,}83$, so $m = 0{,}83 \cdot V$. Thus, we have a homogeneous linear function $y = kx$, where $k = 0{,}83$, y denotes mass and x denotes volume. In the second part of the activity, students determined the mass and volume for various irregularly shaped small objects made of plastic, wood, metal, and then they made conclusions; (4) Students were given a photograph of the mountain with marked heights and corresponding temperatures. Based on the data from the picture, they needed to determine the equation that connects temperature and altitude. This was an example of the linear function $y = kx + n$; (5) The students were given the task to work in groups to build the tallest possible tower using short and long sticks. Previously, they had to solve a textual problem by applying a system of linear equations with two variables. The solution of this system answered how many long and how many short sticks they can use. The group that made the tallest tower was the winner; (6) The students were given the task to build a tower using red and green rolls of different sizes. The green rolls were twice as short as red. They also used cut pieces of paper so that the rolls could be stacked on top of each other. Some of the tasks for this activity were: (a) Write an equation/function that shows the height of the tower depending on the number of rolls; (b) If the red and green towers are the same height, how many rolls are in each tower; (c) If the number of rolls in both towers is the same, what can we say about the height of the towers; (d) If we want to make a tower 32 cm high in which we would use green and red rolls, determine the number of green and red rolls if green rolls are twice as large as red ones.

In the control group, the students were taught in the traditional way (a frontal form of work dominates, teaching without use of technology, without experiment/independent student activities).

Data analysis

The data were analyzed using the SPSS 20.0 program. Significance level was determined as 0.05.

We have investigated the differences between boys' and girls' attitudes towards STEM before the intervention (this is our first research question). As the data are not normally distributed in both populations, the Mann-Whitney U test was used. The results are presented in Table 1.

Table 1. Difference between *attitudes* for gender variable before the intervention

Group		Gender	n	Mean Rank	Sum of Ranks	z	p
E	Mathematics	G	19	17.47	332.00	-0.33	0.760
		B	14	16.36	229.00		
	Science	G	19	18.08	343.50	-0.75	0.461
		B	14	15.54	217.50		
	Engineering and Technology	G	19	17.82	338.50	-0.58	0.577
		B	14	15.89	222.50		
	21st century skills	G	19	19.03	361.50	-1.41	0.163
		B	14	14.25	199.50		
	General attitude	G	19	17.97	341.50	-0.67	0.506
		B	14	15.68	219.50		
C	Mathematics	G	19	18.79	357.00	-0.85	0.410
		B	15	15.87	238.00		
	Science	G	19	18.66	354.50	-0.77	0.451
		B	15	16.03	240.50		
	Engineering and Technology	G	19	19.42	369.00	-1.33	0.215
		B	15	15.07	226.00		
	21st century skills	G	19	19.84	377.00	-1.55	0.128
		B	15	14.53	218.00		
	General attitude	G	19	18.32	348.00	-0.54	0.607
		B	15	16.47	247.00		

Results in Table 1 show there was no significant difference ($p > 0.05$) between boys' and girls' attitudes in any subscale or general attitude for both groups: experimental and control.

We have investigated the differences between boys' and girls' attitudes towards STEM after the intervention (our second research question). The results are presented in Table 2.

The data in Table 2 show that there were significant differences between the students' attitudes for engineering and technology for both groups: experimental and control, where boys have more positive attitudes in both groups.

Table 2. Difference between attitudes for gender variable after the intervention

Group		Gender	n	Mean Rank	Sum of Ranks	z	p
E	Mathematics	G	19	17.39	330.50	-0.27	0.788
		B	14	16.46	230.50		
	Science	G	19	18.71	355.50	-1.19	0.240
		B	14	14.68	205.50		
	Engineering and Technology	G	19	13.50	256.50	-2.43	0.014*
		B	14	21.75	304.50		
	21st century skills	G	19	17.32	329.00	-0.22	0.843
		B	14	16.57	232.00		
	General attitude	G	19	17.18	326.50	-0.13	0.900
		B	14	16.75	234.50		
C	Mathematics	G	19	19.47	370.00	-1.30	0.202
		B	15	15.00	225.00		
	Science	G	19	18.03	342.50	-0.35	0.732
		B	15	16.83	252.50		
	Engineering and Technology	G	19	14.11	268.00	-2.25	0.025*
		B	15	21.80	327.00		
	21st century skills	G	19	17.45	331.50	-0.03	0.973
		B	15	17.57	263.50		
	General attitude	G	19	16.66	316.50	-0.56	0.584
		B	15	18.57	278.50		

Analyzing the experimental and control groups together as one group, there were significant differences ($p = 0.031$) between boys' and girls' attitudes scores before the intervention only for the 21st-century skills. After the intervention, there was significant difference ($p = 0.002$) between boys' and girls' attitudes scores only for the engineering and technology, as we obtained by analyzing each group separately (Table 2).

Differences between the attitude scores of the experimental and control group before and after the intervention (third research question) are presented in Table 3.

Table 3. Differences between the attitude scores of the experimental and control group before and after the intervention

		Gender	n	Mean Rank	Sum of Ranks	z	p
Before	Mathematics	E	33	37.41	1234.50	-1.41	0.157
		C	34	30.69	1043.50		
	Science	E	33	36.20	1194.50	-0.91	0.362
		C	34	31.87	1083.50		
	Engineering and Technology	E	33	37.15	1226.00	-1.34	0.181
		C	34	30.94	1052.00		
	21st century skills	E	33	35.50	1171.50	-0.62	0.534
		C	34	32.54	1106.50		
	General attitude	E	33	39.36	1299.00	-2.22	0.026*
		C	34	28.79	979.00		
After	Mathematics	E	33	39.03	1288.00	-2.09	0.037*
		C	34	29.12	990.00		
	Science	E	33	36.03	1189.00	-0.84	0.399
		C	34	32.03	1089.00		
	Engineering and Technology	E	33	40.03	1321.00	-2.50	0.012*
		C	34	28.15	957.00		
	21st century skills	E	33	35.50	1171.50	-0.62	0.533
		C	34	32.54	1106.50		
	General attitude	E	33	39.48	1303.00	-2.27	0.023*
		C	34	28.68	975.00		

Table 3 shows the existence of significant differences between the general attitude scores of the experimental and control group before the intervention, where students in the experimental group have more positive attitudes. After the intervention, there were significant differences between the students' attitude scores for mathematics, engineering and technology, and general attitude. The mean score of the experimental group was found to be significantly higher than that of the control group. We believe that there occurred a change in attitude scores for mathematics and engineering and technology because the students of the experimental group were exposed to an intervention that emphasized the use of technology and the application of mathematics.

Discussion

For students to be successful in STEM subjects, their attitudes towards science, technology, engineering, and mathematics are important. Therefore, it is very important to develop positive students' attitudes towards STEM from the first levels of education. There is a limited number of studies about students' attitudes towards STEM where students were actively involved. In our country, such studies have not been conducted before.

The main objective of this research was to investigate the effect of the STEM approach on ninth-grade students' attitudes towards STEM. That is why we tested differences in attitudes between the experimental and control group before and after the intervention. The results obtained before the intervention indicated that there were significant differences between the general attitude scores of the experimental and control group, while after intervention there were significant differences between students' attitudes scores for mathematics, engineering and technology, and general attitude. When we compared the results before and after the intervention (Table 3), we can see that the experimental group students' attitudes, for subscales for which the difference is statistically significant, became more positive, while in the control group the opposite happened. Thus, the STEM intervention had certain positive effects on students' attitudes towards STEM. This effect is seen in the increase of positive attitudes after the intervention for certain subscales and general attitudes in the experimental group compared to the control. An increase in positive attitudes towards mathematics and engineering and technology was expected due to the content of the intervention. It is important to emphasize that increasing interest in the STEM area is an important factor for the development of students' careers in STEM. Some earlier studies, which were aimed at the lower grades of primary school, showed that STEM activities positively affect students' attitudes towards STEM. Yamak et al. (2014) found that STEM activities enhanced the fifth-grade students' attitudes towards science. Rehmat (2015) conducted a study with fourth-grade students and concluded that problem-based STEM activities improved the students' attitudes towards STEM. Sari et al. (2018) used the single-group pretest-posttest experimental design and found that problem-based learning (PBL) activity integrated with STEM had positive effects on the attitudes towards the 21st-century skills, engineering and science but not on the attitudes towards mathematics. The study by Ugras (2018), in which the pretest-posttest single-group experimental design was used, concluded that STEM activities improved the STEM attitudes of the seventh-grade students. A study by Gülhan & Şahin (2016), in which a quasi-experimental design with an experimental and control group of fifth-grade students was used, also found a positive effect of STEM activity on students' attitudes. There were significant differences between the students' attitudes scores for science, engineering and technology, and general attitude, but there were no significant differences between the students' attitudes scores for mathematics and 21st-century skills.

One of the aims of this research was to investigate the differences between boys' and girls' attitudes towards STEM before and after the intervention. Based on the results obtained before the intervention, we see that there was no significant difference between boys' and girls' attitudes for any subscale and general attitudes for both groups: the experimental and control one. Also, based on the obtained results, we see that the girls' attitudes were more positive than the boys' attitudes for both groups (but the differences were not statistically significant). Analysis of the results obtained after the intervention (Table 2) shows that there were significant differences between the students' attitudes scores for engineering and technology for both groups, where the boys' attitudes became more positive, and in girls' case, the opposite was true. Since this change occurred in both groups, we cannot say with certainty that the reason for the mentioned change was the STEM approach. It is also important to note that for all other subscales, girls' attitudes are more positive than boys' attitudes, but this difference is not statistically significant. Thus, the results obtained are consistent with the results of previous studies that the intervention has an equal effect on the attitudes of students of different genders (Rosenzweig & Wigfield, 2016).

Unfried et al. (2014) found that at this age (ninth-grade) girls have more negative attitudes towards science, technology, and engineering than boys and that this difference is statistically significant. According to their results, the difference between boys' and girls' attitudes is not statistically significant for mathematics. Results show that, in general, mathematics attitudes are slightly less positive than science attitudes. Across primary and secondary education, the gap between male and female engineering and technology attitudes is wider than for science or mathematics. Research by Babarović et al. (2018a) in which seventh-grade students (13 years old) participated showed that boys, in general, expressed more interest in STEM occupations and activities than girls. The biggest difference in interests was found in technology and engineering, and a small but significant difference in favour of boys was found in mathematics. They did not observe significant gender differences in science interests.

The results of our research showed that girls usually have more positive attitudes than boys. The difference in favour of boys is present only for the engineering and technology subscale. So, our results are partly in contrast to the results of previous research according to which boys usually have more positive attitudes. However, our results are in line with the data published in the "Women and Men in Bosnia and Herzegovina" publication of the Agency for Statistics of B&H for 2020. According to this publication, more than half of the secondary school students attended technical schools in the school year 2018/2019, while every fourth secondary school student attended grammar school. Differences in gender representation are the highest in vocational schools, where about 70% are boys. In other types of secondary schools, the percentage of girls is higher. When we look at enrolled students at all levels of higher education from the academic year 2014/2015 until 2018/2019, the number of girls is constantly higher than the number of boys. Also, when we look at the number of graduate students from the academic year 2014/2015 until 2018/2019 the number of girls is constantly higher than the number of boys. However, with regard to employment, men have an advantage over women. According to data for 2018, the employment rate for women is 25.0 and for men 44.1. This is a consequence of a very traditional society in Bosnia and Herzegovina, in which women fight for a better position every day and one of the ways to do that is through education.

Conclusion

The conducted STEM intervention for ninth-grade elementary school students had a positive effect which is seen in the increase of positive attitudes towards STEM in the experimental group. The obtained results confirmed the results of previous research that the intervention equally affects the attitudes of students of different genders. Future interventions should involve students of different ages because STEM interventions aimed at younger students may have a greater impact. Also, interventions should be longer and more comprehensive and implemented within the school curriculum. The results showed that girls usually have more positive attitudes than boys, except for the engineering and technology subscale. We saw that before the intervention, girls had more positive attitudes than boys and the difference in attitudes was not statistically significant, while in the results after the intervention boys had more positive attitudes than girls and this difference was statistically significant.

Developing students’ positive attitudes toward math increases achievement (Yaratan & Kaspoğlu, 2012). This research was limited but indicates the importance of STEM intervention/approach in developing positive attitudes, so we can recommend the introduction of STEM in schools. The research was limited in time due to COVID, but also because the STEM approach in teaching is being recently introduced in B&H so that there will be shorter projects within traditional teaching. Therefore, not everything will change, so our goal was to see if such short interventions have an impact on students’ attitudes towards STEM. This research was carried out with 67 ninth-grade students. New studies can be carried out with larger and different groups (grades) of students.

Although previous research has also examined the impact of the STEM approach on students' attitudes towards STEM, in the literature available to us, this research is the first to include the previously mentioned teaching topics in the field of algebra in the ninth grade. Therefore, we believe that we have contributed to the research in dealing with STEM and we hope that our results will motivate all teachers to introduce a STEM approach to teaching mathematics and other STEM subjects.

Appendix 1: A lesson plan example used during the research

Subject: Math	**Grade: 9**	**Teacher:**
Teaching unit	Homogeneous linear function $y = kx$	
Area	2. Algebra	
Components	2.1.Algebraic expressions, functions, proportions and applications	

Learning outcome	1. Analyze laws, relationships, dependencies, connections, and functions in mathematics and the real world 2. Analyze and display mathematical situations and structures using algebraic symbols and various notations (records), graphs and diagrams, and generalizes based on them 3. Analyze and formulate assumptions of change in different contexts.
Indicator(s)/ part of the indicators for appropriate age	2.1.1.e. Apply function of direct and inverse proportionality.
Precondition s/ correlated outcomes or indicators of the same subject	Preconditions: 2.1.1.b. Distinguish the meaning of equations, equality and inequality. 2.1.3.a. Enter numbers instead of variables and calculate values. 2.1.1.d. Distinguish between proportional and inversely proportional quantities in different contexts. Corelated outcomes: 2.1.1.f. Express a linear function with words and symbols and examine its properties. 2.1.2.a. Display graphically direct and inverse proportionality as well as a linear function.
Motivation - sectors of the knowledge based economy (choose one or two age-appropriate examples from OTC-class starts with this/these example(s))	1. Tourism - observing the number of tourists during the season, the ratio of the number of contents and the number of tourists; the distance of the travel destination and the time required to reach the destination. 2. Modern agricultural production - the ratio of the size of the agricultural area and the amount of necessary material/fence for fencing the agricultural area.
Relation to other subjects (list selected indicators from OTC which connects the subjects)	Physics: 1.1.1.e. Calculate the mean value for a series of repeated measurements of the value of one physical quantity, and present the measurement results. 5.2.1.d. Display measurement data using tables and graphs, interpret them qualitatively and quantitatively, and identify gross errors in measurement. 5.2.2.a. Interpret direct and inverse proportionality in the context of the content of physics - Explain the dependence of the distance traveled on time (for situations where the speed is constant). Biology: 4.3.1.1. Explain the importance of engaging in physical activity for human health.
The aim of lesson	The aim of the class is that students acquire the ability to apply a homogeneous linear function (direct proportionality function) to given data, and to solve real-life problems by applying this function.
Explain the aim to realistic tasks	Application of homogeneous linear function (direct proportionality function) - solving tasks from everyday life. Determining the rules that define the dependence of one quantity on another.

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<td>Purposeful content (choose content that can link activities from different STEM subjects)</td>
<td>Physics: solving problems from uniform rectilinear motion on a straight line and drawing graphs.
Biology: The importance of physical activity for human health.</td>
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<td>Methodical performance, organization of work - materials, technology and media to be used, determine the time required for activities, determine the time for activities that connect subjects (activities of teachers and students)</td>
<td>In the introductory part of the class (5 - 10 minutes) the teacher checks the homework, repeats with students the material from the previous class - an example of the application of the linear function (loan repayment), and new examples listed in the section Motivation - sectors of knowledge-based economy.
For the realization of this class, battery-powered cars with a constant speed are needed (Note: the activity can be carried out with one car, but if we want students to work in groups, we need more of them, depending on the number of groups).
The teacher announces the aim of the lesson, introduces the student to the application of the linear function in physics, divides the students into groups and explains the task of each group. In the main part of the class (20 - 25 minutes) students work in groups. Each group should first make a path for the car. The path can be made on the classroom floor or on connected tables. "Fence" - the sides of the path can be made of books, notebooks, models of geometric bodies (cube, rectangular prisms,...), or other objects available in the classroom. On the made path, students should mark the length of the path of 1m, 2m, 3m, ... (the teacher determines how many measurements) or to place a meternext to the path. Two students in the group can be in charge of the car: START and STOP, and the other students in the group measure the time (e.g. on cell phone stopwatches) that the car needs to cover the length of the road of 1m, 2m, 3m, ... The obtained results are recorded in a table on a board. Below is a proposal for
<table>
<tr><td>Distanc
e
s</td><td>Time
t</td><td>$\boldsymbol{\bar{t}_i = \frac{t_1 + t_2 + t_3 + t_4 + t_5 + t_6}{6}}$</td><td>Spee
d
$\boldsymbol{v = \frac{s}{t}}$</td><td>$\boldsymbol{v}$</td></tr>
<tr><td>$\boldsymbol{s_1 = 1m}$</td><td>$t_1, t_2, t_3,$
t_4, t_5, t_6</td><td>$\bar{t}_1$</td><td>$\boldsymbol{v_1 = \frac{s_1}{\bar{t}_1}}$</td><td></td></tr>
<tr><td>$\boldsymbol{s_2 = 2m}$</td><td>$t_1, t_2, t_3,$
t_4, t_5, t_6</td><td>$\bar{t}_2$</td><td>$\boldsymbol{v_2 = \frac{s_2}{\bar{t}_2}}$</td><td>$v = \frac{v_1 + v_2 + v_3}{3}$</td></tr>
<tr><td>$\boldsymbol{s_3 = 3m}$</td><td>$t_1, t_2, t_3,$
t_4, t_5, t_6</td><td>$\bar{t}_3$</td><td>$\boldsymbol{v_3 = \frac{s_3}{\bar{t}_3}}$</td><td></td></tr>
</table>
the layout of the table for entering the obtained results.
While students work in groups, the teacher monitors the groups and gives the necessary instructions and explains how the arithmetic mean is calculated. At the end of the group work, the obtained results/boards are placed next to each other so that all students can see them. The teacher tells the students that the length of the path increases linearly (1m, 2m, 3m, ...), but also that the time increases "linearly" (draws attention to measurement errors), which means that the length of the path is directly proportional to time. However, the length of the road also depends on another size (Speed!). The teacher incites the students to give the correct answer.
After the students come to the conclusion that $s = v \cdot t$, that is$v = \frac{s}{t}$, the 4th and 5th columns are added to the table and the accounts v_1, v_2, v_3, v. It is enough to enter this data in only one table (from one group). It is concluded that the observed cars move at a constant speed so that we have a linear function $y = kx$, where$y$is the distance, k is the constant speed, and x is the time.</td>
</tr>
</table>

<table>
<tr><td></td><td>
In the final part of the class (5 - 10 minutes) students do the following task:
Task 1: Emma started from place A on a train traveling at a constant speed of $60\frac{km}{h}$.
Determine:
a) How many times will Emma cross in 1.5 hours, and how many in 1 hour and 40 minutes?
b) How long will it take Emma to get to place B, 180 km from place A?
For independent work, students are given the task:
Task 2: Heart patients who need to avoid strenuous physical activity are recommended to walk at a speed of 3-4 km/h. If the patient is moving at an average speed of 3.6 km/h, determine:
a) How many kilometers can he cover in 1 hour and 15 minutes?
b) In how much time can a 4.5km road be crossed?
</td></tr>
<tr><td>Assessment strategies (methods of formative monitoring and summative assessment)</td><td>
During the realization of the lesson, the teacher monitors the work of students, their efforts, ideas, suggestions while working in groups. During the solution of Task 1, he/she monitors the work of students and rewards the most active ones.
Fills in the formative assessment table (columns three and five, and column six).
<table>
<tr><td>Name and surname of the student</td><td>Linear function $y = kx, k > 0$ recognizes</td><td>Linear function $y = kx, k > 0$ applies</td><td>Linear function $y = kx, k < 0$ recognizes</td><td>Linear function $y = kx, k < 0$ applies</td><td>Note - how to improve work</td></tr>
<tr><td></td><td>Yes/no/ partially</td><td>Yes/no/ partially</td><td>Yes/no/ partially</td><td>Yes/no/ partially</td><td></td></tr>
<tr><td></td><td>Yes/no/ partially</td><td>Yes/no/ partially</td><td>Yes/no/ partially</td><td>Yes/no/ partially</td><td></td></tr>
<tr><td></td><td>Yes/no/ partially</td><td>Yes/no/ partially</td><td>Yes/no/ partially</td><td>Yes/no/ partially</td><td></td></tr>
</table>
This table (or similar) should continue to be completed in the next class/classes. To evaluate group work (in this and the next class) for each of the students, the activity during the class can be recorded using the following table for formative assessment:
<table>
<tr><td>Name and surname of the student</td><td>Listen carefully to the operating instructions</td><td>Accept assigned role during research</td><td>Walk and watch what other groups are doing</td><td>Look out the window</td><td>Help other members of his/her group</td><td>Understand the process of research</td><td>Take on the role of organizer</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
A summary score can be given after the test from linear functions. It is recommended to include information from formative monitoring in the summative assessment, in order to encourage active students who did poorly on the test to continue their efforts.
</td></tr>
<tr><td>Concluding remarks</td><td>During class, most students are expected to recognize a homogeneous linear function and apply a homogeneous linear function in simple situations. For the next lesson, students should find an example of the application of a homogeneous linear function in another area/subject: biology, chemistry, geography.</td></tr>
</table>

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