ASSOCIATION BETWEEN ATTITUDES TOWARDS SCIENCE SUBJECTS AND GRADES: THE MEDIATION ROLE OF LEARNING STRATEGIES

Tanja Maltar Okun
Elementary school Sveti Petar Orehovec, Croatia
E-mail: tanja_maltar@yahoo.com

Majda Rijavec, Marko Ćaleta
University of Zagreb, Croatia
E-mail: majda.rijavec@ufzg.hr, marko.caleta@ufzg.hr

Abstract

The students' attitudes towards school subjects may influence their behaviour and various educational outcomes. The research aimed to test students' attitudes towards the subjects of Biology, Chemistry, and Physics, and to examine the associations between those attitudes and students' learning strategies and grades achieved. The study included 245 eighth-grade students from five schools in Koprivnica-Križevci County in the Republic of Croatia. Attitude scale towards science subjects and Learning strategies scale were employed. The results of the analysis of variance showed a significantly higher assessment of interest for Biology and Physics than for Chemistry, while the assessment of importance for Biology was significantly higher than for Chemistry and Physics. Attitudes toward Biology, Chemistry, and Physics were positively correlated with the grades achieved in those subjects. Results of the mediation analysis indicated that the learning strategies were mediators between the attitude towards the science subject and the grades achieved in those subjects. Students with a more positive attitude towards a subject employ a deeper approach to learning, which ultimately results in a higher grade.
Keywords: *lower secondary education; mediation analysis; school achievement, scientific subjects; student attitudes*

Introduction

The importance and benefits of scientific learning, both in general and in the education system, have increased in step with the increasingly rapid development of science and technology. Since the natural sciences[1] are considered the foundation of virtually everything we use today and are surrounded by (International Council for Science - ICS, 2006), contemporary and future societies require a higher level of general competencies in these scientific fields. However, lifelong engagement in the natural sciences demands more than just knowledge and skills, and this largely depends on the attitudes students have towards them (Braš Roth et al., 2017). Since these attitudes are formed early (already between the ages of 10 and 14 years), it is important to encourage and maintain positive attitudes, as after that period, they are difficult to change (Osborne & Dillon, 2008; Savelsbergh et al., 2016). For that reason, natural science classes in primary and lower secondary school have a powerful and long-term effect on students.

1 In Croatia, the natural sciences in the compulsory education system include the subjects Nature and Society, Nature, Biology, Chemistry, Physics and Mathematics. The subjects of this study are students in 8th grade classes and the subjects of Biology, Chemistry and Physics.

ISSN 1822-7864 (Print) ISSN 2538-7111 (Online) https://doi.org/10.33225/pec/22.80.547

Students' Attitudes Towards Science Subjects

Research has confirmed that the negative attitude of students towards natural science subjects has not changed in decades (Adejimi et al., 2022; Durrani, 1998; Lyons, 2006; Mazana et al., 2019; Potvin & Hasni, 2014; Sjøberg & Schreiner, 2005). This is also the case in Croatia, as most students still show negative attitudes towards the science. Students assess these classes as too difficult, inefficient, boring, overly abstract, with too many concepts to learn and notes to take, and too little experience-based learning (Jokić, 2013; Marušić, 2006; Ward et al., 2005). A positive experience at the start of scientific education will lead to students achieving greater success, having a more positive attitude toward the sciences, and greater future interest in science overall (Akpınar et al., 2009). A positive attitude can also be encouraged by higher grades in these subjects, and support from teachers, parents, and colleagues (Ekici, 2010; Osborne et al., 2003; Samikwo, 2013).

Most students in lower secondary and secondary schools around the world show positive attitudes toward Biology (Hussaini et al., 2015; Martin et al., 2008; OECD, 2007), perceiving this subject to be interesting, important, relevant, and easier to understand (Prokop et al., 2007; Spall et al., 2003). Recent research in Croatia (Jokić, 2013; Marušić, 2006; Šimičić & Pešut, 2021) showed that students assessed Biology, unlike most other school subjects, to be very interesting, challenging, most understandable, and moderately hard, and for the most part, as useful and important for their future lives.

For Chemistry, students' attitudes are predominantly exceptionally negative. In the literature, the most common reasons for this are listed as the teaching methods, the content-heavy curriculum, presentation of isolated facts, and lack of relevancy. Students see Chemistry as a subject that is too difficult, too broad, too abstract, boring, and unimportant (Edomwonyi-Otu & Avaa, 2011; Osborne & Collins, 2001). Research in Croatia (Jokić, 2013; Marušić, 2006; Šimičić & Pešut, 2021) revealed similar issues, and this is the reason that Chemistry is the least liked subject. Croatian students also assessed it to be uninteresting, hard to understand, abstract, difficult, useless, and unimportant for their future life. They believe that they must invest great efforts in learning Chemistry and that too much course content is taught.

For Physics, the situation is even more unfavourable, and many countries are investing great efforts to change the negative attitudes toward Physics (Drury & Allen, 2002; Institute of Physics, 2001). Students found Physics to be conceptually too difficult, requiring a great deal of work, to be unpleasant, scary, difficult to understand, unattractive, requires applied mathematical knowledge and a specific vocabulary, with overly broad curricula and programs, and the content is explained too quickly (Çalişkan et al., 2007; Spall et al., 2004; Stefan & Ciomoş, 2010). Research in Croatia (Jokić, 2013; Marušić, 2006; Marušić & Sliško, 2009; Šimičić & Pešut, 2021) found that Physics was one of the subjects that Croatian pupils were least interested in, and the reasons were the same as in other countries. However, Croatian students found it to be somewhat easier and more useful for the future than Chemistry (Jokić, 2013).

The attitude towards a subject is a significant predictor of academic success, meaning that a positive attitude activates the thoughts, feelings, and behaviour of the individual, motivating them to participate in learning processes, thereby improving their accomplishments (Albert et al., 2015; Wabuke, 2013).

There is also a possible inverse association, i.e., that accomplishments in a subject can lead to a more positive attitude towards that subject (Akpınar et al., 2009; Beaton et al., 1996). Owiti (2001) and Suzuki (2007) stated that this is a reciprocal influence, in which attitude affects accomplishments, and accomplishments affect attitude. Though the cause-effect relationship between attitudes towards a subject and success in that subject has not yet been fully researched, the results of previous studies have suggested that having a positive attitude

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Vol. 80, No. 4, 2022

towards a subject could help to improve one's success in that subject. The question arises as to which mechanisms mediate the association between one's attitude towards the subject and success in that subject. This paper poses the hypothesis that learning strategies could be a possible underlying mechanism in that relationship.

Learning Strategies

Learning strategies are specific skills that students use to facilitate the acquisition, storing, or recollection of information (Oxford, 1990). Effective learning strategies facilitate the coding of information to increase its integration and accessibility (Weinstein, 1988). Learning strategies have been defined by different authors in different ways, though the deep and surface approaches to learning are most often referred to.

Students applying a *deep learning approach* are intrinsically motivated, seeking sense in the material they are learning, connecting new information with their existing knowledge and experience, and applying it. The purpose of learning is to satisfy their curiosity, out of enjoyment and personal interest (Aziz et al., 2012; Pintrich, 1999). Therefore, a deep learning approach is considered to be the most successful approach, as it leads to a conceptual understanding and retention of content. The results of students who learn in this way are better and longer-lasting (Marušić, 2013; Zhang, 2000).

Students applying a *surface learning approach* are extrinsically motivated, trying to avoid failure, not seeking any sense in what they are learning, and only superficially tackling the course content, reproducing, and remembering facts without making any connections (Gadelrab, 2011). They are motivated only to meet the requirements set by teachers and parents while investing the minimum effort (Duff et al., 2004). The surface approach results in a low quality of all learning outcomes (Coutinho & Neuman, 2008), which is particularly pronounced in learning scientific concepts (BouJaoude, 1992).

Most studies have shown a positive general association between academic success and the deep learning approach, and a negative association with the surface approach (Diseth & Kobbeltvedt, 2010; Hacieminoglu, 2016; Vrkić & Vlahović-Štetić, 2013). In scientific subjects, a significant correlation has been found between self-regulated learning (which includes the deep processing of information) with learning quality and better students achievements in Biology (Ebele & Olofu, 2017; Partin & Haney, 2012; Sadi & Uyar, 2013; Uitto & Kärnä, 2014), Chemistry (Eidelman & Shwartz, 2016; Olakanmi & Gumbo, 2017; Sandi-Urena et al., 2012) and Physics (Cavallo et al., 2004; Hacieminoglu et al., 2009; Vrdoljak & Vlahović-Štetić, 2018). Students who generally have a more positive attitude towards scientific subjects tend to prefer a deep learning approach, which in turn results in better academic success.

Although the positive association between students' attitudes towards scientific subjects and success in these subjects is well-established, the mechanisms underlying this association are not fully researched. Based on the aforementioned theoretical and empirical research, this study aimed to research whether learning strategies are the significant mechanism through which students' attitudes lead to better academic success in scientific subjects. In other words, do students who generally have a more positive attitude towards scientific subjects tend to prefer a deep learning approach, which in turn results in better academic success. The answer to this question contributes to understanding of the importance of students' attitudes toward scientific subjects and their consequences on the process and outcomes of learning.

Research Aim

This study aimed to test the differences in attitudes towards Biology, Chemistry and Physics among eighth-grade students and to examine the association between students' attitudes towards a subject and their grades in that subject. The mediation role of learning strategies in the association of attitude towards subject and grade in that subject was also examined.

The following hypotheses were tested:

H1: The attitude toward Biology is statistically significantly more positive than the attitudes toward Physics and Chemistry.
H2: The attitude towards the subject is positively correlated with the grade achieved in that subject.
H3.1: The attitude towards the subject is positively correlated with the deep learning approach to that subject.
H3.2: The attitude towards the subject is negatively correlated with the surface learning approach to that subject.
H4.1: The deep learning approach to the subject is positively correlated with the grade achieved in the subject.
H4.2: The surface learning approach to the subject is negatively correlated with the grade received in the subject.
H5: The deep and surface learning approach to the subject are mediators between the attitude towards the subject and the grade achieved in that subject.

Research Methodology

General Background

This is an exploratory, quantitative, correlational-type study aimed to research students' attitudes toward natural science subjects and their association with learning strategies and grades. Attitudes toward Biology, Physics, and Chemistry were predictors, learning strategies (deep and surface learning) mediators, and grades obtained in these subject criteria variables. In this context, the study researched the effect of positive attitudes on promoting a deep learning approach, and consequently better grades in school. All variables were measured with self-report questionnaires. Data were collected in the middle of the second term in academic year 2017/18 during two weeks' period.

Sample Selection

A total of 245 eighth-grade students (139 females and 106 males) participated in the study. In Croatian educational system eighth grade is the last grade before enrolling in upper-secondary school. Students start with Biology in sixth grade and with Chemistry and Physics in seventh grade. In eighth grade they have formed attitudes toward natural science subjects and can report their grades in these subjects obtained at the end of previous year.

Five schools from urban areas of Koprivnica-Križevci County were included in the study. One county and urban areas were chosen in order to minimize differences in teaching quality and equipment of the schools needed for teaching natural science subjects. Schools and two intact classes from each school were randomly chosen. The total population of eighth-grade students in this county is around 1200, so the sample size is big enough to represent students from urban areas.

Instruments and Procedures

The Scale of student attitudes towards subjects in the natural sciences (Biology, Chemistry, and Physics) by Jugović (2010) was modified for the purpose of this study. The original scale consisted of 11 items for each subject. Students were asked to assess the interestingness, importance, and usefulness of each subject using a 5-point scale (from 1 – I completely disagree to 5 – I completely agree). An exploratory factor analysis using the principal components method with varimax rotation was conducted for each scale of each subject. All three factor analyses resulted in a two-factor structure, in which two items were excluded from further analysis due to their loading on both factors. The final scale resulted in two factors. The first consisted of five items about how interesting the subject is (e.g., *I find Biology very interesting*), and the second consisted of four items about the importance of the subject (i.e., *It is very important to me to get a good grade in Biology*). Cronbach **α** coefficients were .87 and .84 for interestingness and importance of Biology, .92 and .87 for interestingness and importance of Physics and .91 and .88 for interestingness and importance of Chemistry.

The Learning strategies scale is a subscale of the questionnaire *Components of self-regulated learning* (Niemivirta, 1999) translated and adapted by Rijavec et al., (1999). It has been widely used in Croatia with students attending lower secondary school (i.e., Rijavec & Brdar, 2002; Šimić Šašić & Sorić, 2011). The questionnaire consists of 10 items for each subject, in which the students express their agreement with each item using a 5-point scale (from 1 – I completely disagree to 5 – I completely agree). Five items are related to deep learning (e.g., *When I study Biology, I often go back to sections that I didn't understand or that were unclear*), and five to surface learning (e.g., *When I study Chemistry, I try to concentrate only on what the professor might ask*). Cronbach **α** coefficients were .79 (deep learning) and .68 (surface learning) for Biology, .86 (deep learning) and .78 (surface learning) for Physics and .86 (deep learning) and .78 (surface learning) for Chemistry.

Students received oral instructions and explanations of how to fill out the questionnaire. It was stressed that all questionnaires were anonymous, that there were no right or wrong answers, and that they could withdraw at any time during the study. Students had 30 minutes to fill out the questionnaires.

Data Analysis

Before analysis, the data were screened with respect to missing data, outliers, and violations of assumptions for the planned analysis. Values of skewness and kurtosis were in an acceptable range. Differences in the level of interestingness and importance of subjects were tested using repeated measures ANOVAs with different subjects as a within-subject factor. A linear regression analysis was used to assess the interestingness and importance of subject, as the predictor variable, and the grade achieved in this subject. Mediation analysis was performed using PROCESS macro for SPSS (Hayes, 2018).

Results of Research

Descriptive Results

The descriptive statistics and correlations of all variables are shown in Table 1.

The arithmetic means of the variables showed that the assessment of subject interestingness was around the average, while the assessment of subject importance was somewhat higher. The assessments of deep and surface approaches to learning were somewhat above average, but still somewhat lower for the surface approach. Grades were above average in all three subjects.

Table 1.
Descriptive Results and Correlations Among the Study Variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
B – i	-	**.40**	**.19**	**.60**	**.31**	**.18**	**.51**	**.29**	**.27**	**.17**	.10	.06	.36		
C- i				-	.65	.22	.29	.45	.22	.04	**.19**	.01		.46	
P – i					-	**.60**	***.13***	.08	**.42**	.03	-.05	**.16**			.14
B – I				-	**.61**	**.41**	**.56**	**.44**	**.40**	**.25**	**.21**	***.13***	.33		
C – I					-	.46	.49	.61	.40	**.25**	**.35**	.10		.48	
P - I						-	.24	.28	.50	***.13***	.09	**.30**			.28
B – DA							-	.61	.61	**.59**	**.37**	**.35**	.26		
C – DA								-	.56	.35	.65	.29		.34	
P – DA									-	.36	.35	.65			.22
B – SA										-	.56	.49	-.09		
C – SA											-	.49		.09	
P – SA												-			-.03
B – g	.36			.33			.26			-.09					
C – g		.46			.48			.34			.09				
P – g			.14			.28			.21			-.03			
M	3.37	3.05	3.35	4.05	3.79	3.81	3.68	3.70	3.77	3.49	3.52	3.57	3.83	3.70	3.83
SD	0.99	1.22	1.03	0.93	1.19	1.11	0.92	1.04	1.02	0.94	1.00	0.99	1.04	1.10	1.07
Range	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	2-5	2-5	2-5
Cronbach alpha	.87	.92	.91	.48	.88	.87	.78	.86	.86	.68	.78	.78	n.a	n.a	n.a

B – Biology; C – Chemistry; P - Physics
M – mean; SD – *SD* - standard deviation; n.a. – not applicable
i – interestingness; I – importance; DA – deep approach, SA – surface approach, g – grade
italics – *p* < 05; **bold** - *p* < 0.01

The correlations among the variables were in the expected direction. All correlations (except one) between the interestingness and importance of the subject and the deep learning approach were positive, as were the correlations with subject grades. However, the correlations between surface approach were not significant for subject interestingness, while contrary to expectations, they were positive for the assessment of subject importance. Also, the correlation between the deep learning approach was positive with grades, while the correlation between the surface approach and grades was not significant.

Differences in Attitudes Towards Biology, Chemistry, and Physics

To test the differences in the level of interestingness and importance of subjects, we used repeated measures ANOVAs with different subjects as a within-subject factor with three levels (Biology, Chemistry, Physics). For pairwise comparisons Bonferroni test was used.

For the interestingness of a subject, a significant effect ($F = 8.122$; $p <.001$) of the subject was found. As seen in Table 1, students assessed the interestingness of all three subjects to be somewhat above average. They equally and positively assessed Biology ($M = 3.37$; $SD = 0.99$) and Physics ($M = 3.35$; $SD = 1.03$) and there was no statistically significant difference ($p > .05$) between the assessments of these subjects, while the least positive attitude was found towards

Chemistry (*M* = 3.05; *SD* = 1.22), and this was significantly lower than the attitude towards Biology (*p* < .001) and towards Physics (*p* < 0.05).

In assessing the importance of subjects, there was also a significant effect of the subject (F = 9.227; p < .001). Students placed the highest importance on Biology (*M* = 4.05; *SD* = 0.93) and this was significantly higher than for Physics (*M* = 3.81; *SD* = 1.11; *p* < .001) and Chemistry (*M* = 3.89; *SD* = 1.03, *p* < .001), while there was no significant difference between the latter two (*p* > .05).

Generally speaking, it can be concluded that students found Biology and Physics more interesting than Chemistry, and Biology to be more important than the other two subjects. These results partly confirmed the first hypothesis.

Correlations Between Attitudes Towards Subjects and Grades in Those Subjects

A linear regression analysis was used to assess the interestingness and importance of Biology, as the predictor variable, and the grade achieved in Biology, as the criteria variable, and showed that both components of attitude were significant predictors of the grade. The beta coefficient for interestingness was 0.253 (*t* = 3.417; *p* < .001), and for importance was 0.174 (*t* = 2.344; *p* < .05). Both components together explained 15% of the variance of grades.

For Chemistry, the assessments of interestingness and importance were also significant predictors of the grade. The beta coefficient for interestingness was 0.269 (t = 3.622; p < .001) and for importance was 0.293 (*t* = 3.955; *p* < .001). Both components explained 26% of the variance of grades.

For Physics, only the assessment of importance proved to be a significant predictor of grades. The beta coefficient for importance was 0.306 (*t* = 3.936; *p* < .001). The assessment of the interestingness of Physics was not a significant predictor of grades. The beta coefficient was -0.046 (*t* = 0.595; *p* > .05). Both components explained 8% of the variance of grades.

These results confirmed the second hypothesis about the positive correlation between an attitude towards a subject and the grade achieved in that subject. The assessment of interestingness (except for Physics) and the importance of a subject were positive predictors of grades for all three subjects. These components of attitude best explained the grades in Chemistry and least in Physics.

Correlations Between Attitudes Towards Subjects and Learning Strategies for Those Subjects

Linear regression analysis was performed with the assessments of the interestingness and importance of Biology as a predictor variable, and a deep learning approach as the criteria variable. The analysis showed that both components of attitude were significant predictors of deep learning. The beta coefficient for interestingness was 0.283 (*t* = 4.383; *p* < .001), and for importance 0.380 (*t* = 5.895; *p* < .001). Both components explained 35% of the variance of the deep learning approach. With regard to the surface learning approach, interestingness was not a significant predictor for Biology, while importance was a positive and significant predictor for Physics. The beta coefficient for interestingness was -0.035 (*t* = 0.454; *p* > .05), and for importance 0.314 (*t* = 4.052; *p* < .001). Both components of attitude explained 6% of the variance of the surface learning approach.

For Chemistry, the importance of the subject was a significant positive predictor for the deep learning approach, while the interestingness of the subject was not a significant predictor. The beta coefficient for interestingness was 0.090 (*t* = 1.338; *p* > .05), and for importance was 0.550 (*t* = 8.290; *p* < .001). Both components explained 38% of the variance for the deep learning approach. For the surface learning approach, the interestingness of Chemistry was not a significant predictor, while its importance was. The beta coefficient for interestingness was

0.034 ($t = 0.437$; $p > .05$), while importance was 0.231 ($t = 2.979$; $p < .01$). Both components of attitude explained 9% of the variance of the surface approach to learning.

For Physics, both components of attitude were significant predictors of the deep learning approach. The beta coefficient for interestingness was 0.173 ($t = 2.512$; $p < 0.05$), and for importance was 0.404 ($t = 5.877$; $p < .001$). For the surface learning approach, the interestingness of Chemistry was not a significant predictor, while importance was a positive and significant predictor. The beta coefficient for interestingness was -0.035 (t=0.454; $p > .05$), while for importance it was 0.314 ($t = 4.052$; $p < .001$). Both components explained 9% of the variance of grades.

These results only partly confirmed the third hypothesis, in which attitude is positively correlated with the deep learning approach and negatively with the surface learning approach. The interestingness of a subject proved to be a significant predictor of the deep learning approach in Biology and Physics, while contrary to expectations, the importance of a subject also proved to be a significant and positive predictor for surface learning for all three subjects.

Correlation Between Learning Strategy of a Subject and the Grade Achieved in That Subject

The linear regression analysis of the assessment of deep and surface learning approaches to Biology as a predictor variable, and the grade achieved in Biology as the criteria variable, showed that both learning strategies were significant predictors of the grade. Deep learning was a positive predictor of the grade, while surface learning was a negative predictor of the grade. The beta coefficient for deep learning was 0.475 ($t = 6.504$; $p < .001$), and for superficial learning was -0.373 ($t = 5.108$; $p < .001$). Both components together explained 16% of the variance of the grade.

For Chemistry, both the deep and surface learning approaches were significant predictors of the grade. As with Biology, deep learning was a positive and surface learning was a negative predictor of the grade. The beta coefficient for deep learning was 0.483 ($t = 6.160$; $p < .001$), and for surface learning was -0.217 ($t = 2.761$; $p < .01$). Both components together explained 14% of the variance of the grade.

The results for Physics showed the same pattern, with deep learning as a positive and surface learning as a negative predictor of the grade. The beta coefficient for deep learning was 0.416 ($t = 5.155$; $p < .001$), and for surface learning was -0.306 ($t = 3.792$; $p < .001$). Both components together explained 10% of the variance of grades.

This fully confirmed the hypothesis of a positive correlation between the deep learning approach to a subject and the grade achieved in that subject, and a negative correlation between the surface approach to learning and the grade achieved in that subject for all three subjects.

Mediation Analysis

Table 2 shows the results of the mediation analysis for Biology with attitudes as independent variables, grades as dependent variables and learning strategies as mediators.

Table 2
Mediation Role of Learning Strategies in the Relationship Between Attitudes Towards Biology and the Grade Achieved in Biology

Independent variable	Interestingness of Biology		Importance of Biology	
Dependent variable	Grade		Grade	
	β	*SE*	*β*	*SE*
Total effect (c)	0.363***	0.063	0.354***	0.071
Direct effect (c')	0.261***	0.071	0.248**	0.081
Indirect effect (ab)	0.102*	0.042	0.201*	0.057
Deep learning approach	0.157*	0.048	0.296*	0.079
Surface learning approach	-0.055*	0.028	-0.095*	0.032

In Table 3. the mediation analysis for Chemistry is presented with attitudes as independent variables, grades as dependent variables and learning strategies as mediators.

Table 3
Mediation Role of Learning Strategies in the Relationship Between Attitudes Towards Chemistry and the Grade Achieved in Chemistry

Independent variable	Interestingness of Chemistry		Importance of Chemistry	
Dependent variable	Grade		Grade	
	β	*SE*	β	*SE*
Total effect (c)	0.412***	0.051	0.472***	0.057
Direct effect (c')	0.331***	0.074	0.410***	0.071
Indirect effect (ab)	0.078*	0.029	0.062	0.046
Deep learning approach	0.108*	0.039	0.121*	0.058
Surface learning approach	-0.029*	0.018	-0.058*	0.029

The mediation analysis for Physics is presented in Table 3.

Table 4
Mediation Role of Learning Strategies in the Relationship Between Attitudes Towards Physics and the Grade Achieved in Physics

Independent variable	Interestingness of Physics		Importance of Physics	
Dependent variable	Grade		Grade	
	β	*SE*	*β*	*SE*
Total effect (c)	0.149**	0.056	0.280***	0.062
Direct effect (c')	0.047	0.061	0.221***	0.071
Indirect effect (ab)	0.102*	0.031	0.059*	0.041
Deep learning approach	0.147*	0.040	0.148*	0.052
Surface learning approach	-0.045*	0.024	-0.088*	0.037

The tables above show that the results for all three subjects indicate the same pattern. For each subject, there is a significant total indirect effect of learning strategy as a mediation variable in the relationship between the assessment of interestingness and importance of a subject and the grade achieved in that subject. The total indirect effect was insignificant only for the assessment of the importance of Chemistry, though the individual mediators were significant. Generally, it can be concluded that there is a significant relationship between the assessment of interestingness and importance of a subject and the grade achieved in that subject and that this association is partly mediated by learning strategies. Students who found the subject more interesting and important were more inclined to use the deep learning approach, and less often the surface learning approach, which resulted in higher grades. In both cases, this was a partial mediation, indicating that there is a direct association between the interestingness and importance of a subject and the grade, or that there are other mediators that were not examined in this study.

These results confirm the fifth hypothesis on the mediation role of learning strategies in the association between the attitude towards a subject and the grade achieved in that subject.

Discussion

This study examined the differences in students' attitudes towards Biology, Chemistry, and Physics, and the relationship between the attitudes towards those subjects, learning strategies, and the grades achieved. It was assumed that students would have a more positive attitude toward Biology than towards Chemistry or Physics. It was also expected that students' attitudes towards particular subjects would be associated with their learning strategy (deep or surface approach), which would then lead to different educational outcomes. Specifically, it was presumed that students with more positive attitudes towards a given subject would be more inclined to apply the deep learning approach and less the surface learning approach, resulting in a higher grade in that subject.

Differences in Attitudes Towards Biology, Chemistry, and Physics

The results partially confirmed the first hypothesis (H1), that the attitudes toward Biology would be statistically significantly more positive than the attitudes toward Physics and Chemistry. Specifically, Biology was assessed as being significantly more important than Physics and Chemistry. Also, Biology and Physics were rated as equally interesting, significantly more than Chemistry.

Positive attitudes toward Biology correspond to the previous research in Croatia (Jokić, 2013; Marušić, 2006), and in the world (Hussaini et al., 2015; Martin et al., 2000, 2008; OECD, 2007) which also found that students positively assessed Biology. Several studies have shown that students find Biology more relevant to their daily life, and due to topics, such as the human body and overall health, they view Biology as capable of increasing the quality of life (Christidou, 2006; Dawson, 2000; Lamanauskas et al., 2004). Contrary to the expectations, students rated Biology and Physics as equally interesting. This result is surprising since research in Croatia over the past 15 years has found that Physics is one of the least liked subjects (Jokić, 2013; Marušić, 2006; Šimičić & Pešut, 2021), while in the world, students most often assess it to be difficult, hard to understand, and overly abstract (Institute of Physics, 2001; Spall et al., 2004; Stefan & Ciomoş, 2010). Therefore, in interpreting such results, one must certainly consider the personality, professional capabilities, and enthusiasm of Physics teachers, which can largely improve students' attitudes towards Physics (Barmby et al., 2008; Reid & Skryabina, 2003). It is important how well the classroom is equipped, and whether Physics class includes doing experiments, and students are guided using examples associated with daily life and taught the benefits that a career in Physics can bring (Brewe et al., 2009; Dilek Eren et al., 2015; Perkins et al., 2005; Reid & Skryabina, 2003). It is possible that this sample included schools with better equipment for Physics teaching than the average, or with better-educated teachers, resulting in Physics being just as interesting to students as Biology. This, however, is an assumption that should be further examined.

In terms of importance, students consider that both Chemistry and Physics are less important for life than Biology. This is in line with previous studies (Angell et al., 2004; Hobson, 2003; Sert Çıbık & Yalçın, 2011) showing that students are less able to perceive the importance of Chemistry and Physics in daily life unless the teacher explicitly outlines this, and uses methods based on activities, simulation methods, and performs experiments that are necessary to understand the abstract teaching content in this subject. The reasons for not perceiving the importance of Chemistry and Physics are also due to a large number of facts, the difficulty for students to connect different concepts and processes that are presented to them and that they should be able to practically apply (Ćosić, 2015; Jokić, 2013; Osborne & Collins, 2001), as well as a lack of integrated animation that aids in the teaching of such concepts in Physic (Su & Yeh, 2014). Therefore, certain authors have recommended that the teaching of Chemistry and Physics should start with simpler concepts, with checks to determine whether students have truly mastered them, before moving on to more complex relationships and processes. ICT technology can play an important role in this process (Su & Yeh, 2014; Tuan Soh et al., 2010). Learning should start with the concrete and move towards the abstract, to avoid forming negative attitudes of students at their very first contact with these subjects, which in Croatia starts in the seventh grade.

Association Between Attitudes, Learning Strategies, and Subject Grades

According to the second hypothesis (H2), it was expected that the attitudes toward Biology, Chemistry, and Physics would be positively associated with the school grades in those subjects, which was generally confirmed. For both Biology and Chemistry, interestingness and importance were both significant predictors of grades, while for Physics the only significant predictor was the assessment of importance. Students with more positive attitudes toward Biology, Chemistry, and Physics show greater attention in class, participate more in scientific activities, and are better able to learn scientific concepts and skills in those areas, which lead to their better academic success in the form of grades (Baram-Tsabari & Yarden, 2007; Hidi & Harackiewicz, 2000; Jarvis & Pell, 2005; Yager, 1996). It remains unclear as to why only the importance of Physics was associated with grades, while its interestingness was not.

According to the third hypothesis (H3.1), it was expected that the students' attitudes toward all subjects would be positively correlated with a deep learning approach to these subjects, and negatively with a surface learning approach (H3.2). The results partly confirmed this hypothesis.

As expected, for all three subjects, the assessments of the interestingness and importance of the subject were associated with deep learning. However, contrary to expectations, the assessment of subject importance was also positively associated with surface learning, though to a lesser extent. It is obvious that students who find natural science subjects interesting and important will prefer to learn with understanding (deep learning) rather than just learn by memorizing (surface learning). This is in line with previous research, though very sparse, which also showed such associations in the field of Mathematics (Alkhateeb & Hammoudi, 2006; Zakariya et al., 2020). However, the question arises of why subject importance is associated also with a surface learning approach, as also seen in some other studies (Hacieminoglu, 2016). A possible explanation is that some teachers require reproduction of facts, and so the students take a surface approach to learning because the subject is important to them, and they want to obtain a better grade.

Research has confirmed the expectations that deep learning approach is positively (H4.1), and surface learning negatively associated with grades (H4.2). This is in line with research in Croatia (Putarek et al., 2016; Rijavec et al., 1999; Vrdoljak, 2016; Vrdoljak & Vlahović-Štetić, 2018), and elsewhere (BouJaoude, 1992; Cavallo et al., 2003; Hacieminoglu et al., 2009; Hacieminoglu, 2016). A surface approach to learning is based primarily on memorization. Students are focused only on what they expect the teacher will ask, they ask no additional questions, and do not highlight important sections but instead only repeat until they feel they have learned the content. This strategy finally results in lower grades.

As presumed, the results have shown that learning strategies are a mediator between the attitude towards subjects and the grades achieved in that subject (H5). For all three subjects, students who assessed the subject as both interesting and important were more inclined to take a deep learning approach, and less to take a surface learning approach, which ultimately resulted in higher grades in that course.

Limitations of the Study

This research is a correlation type study, therefore any conclusions about causality cannot be drawn from the findings. It is possible that attitudes towards natural science subjects influence the grades obtained in those subjects through the learning strategies, as presumed here. However, this association can also go the opposite way, for example, the learning strategy influences the grade, which then consequentially influences the attitude towards the subject. Therefore, future studies should include longitudinal research that would allow confirming possible cause and effect relationships between the variables tested in this study. Also, the research was conducted only in one county in Croatia, and therefore, we cannot generalize to the entire elementary school population. Since attitudes towards subjects change in relation to the situation in the school, particularly equipment in the classroom and education of teachers, research in other parts of Croatia would contribute to a better overall generalization of the obtained results.

Conclusions and Implications

Research involving natural science subjects in school has shown that students with positive attitudes towards these subjects also earn better grades. However, studies that try to investigate the mechanisms underlying this association are rare. In other words, we know that positive attitudes contribute to better grades but the reasons why this happens are still unclear. Results of this study point to learning strategies as a mediator between attitudes and grades. Students who have positive attitudes toward Biology, Physics and Chemistry more often use the strategy of deep learning while working to master the content in these subjects, which in turn leads to better grades. This finding, in addition to theoretical contribution, has practical implications suggesting educators and teachers to pay more attention to helping students develop positive attitudes towards natural science subjects as early as possible.

Future research should address other possible mediators between attitudes towards subjects and grades achieved in that subject. Coping with stress and test anxiety may be a promising line of research. Students with positive attitudes towards subjects experience positive emotions, which are known to improve cognitive functioning, which could help students to better cope with oral and written exams and achieve better grades.

Ethical approval

All procedures performed were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Declaration of Interest

The authors declare no competing interest.

References

Adejimi, S. A., Nzabalirwa, W., & Shivoga, W. A. (2022). Enhancing students' attitudes toward biology using consensus and cooperative reflective journal writing educational strategies. *Problems of Education in the 21st Century*, *80*(2), 242-255. https://doi.org/10.33225/pec/22.80.242

Akpınar, E., Yıldız, E., Tatar, N., & Ergin, Ö. (2009). Students' attitudes toward science and technology: An investigation of gender, grade level, and academic achievement. World Conference on Educational Sciences 2009. *Procedia - Social and Behavioral Sciences, 1*, 2804-2808. https://doi.org/10.1016/j.sbspro.2009.01.498

Albert, O. O., Yungungu, A. M., Ahmed, O., & Ogolla, B. (2015). The relationship between students' attitude towards biology and performance in Kenya Certificate of secondary education biology in selected secondary schools in Nyakach, Kenya. *Research Journal of Educational Studies and Review, 1*(5), 111-117.

Alkhateeb, H., & Hammoudi, L. (2006). Attitudes toward and approaches to learning first-year university mathematics. *Perceptual and Motor Skills, 103*(1), 115-120. https://doi.org/10.2466/pms.103.1.115-120

Angell, C., Guttersrud, Ø., Henriksen, E. K., & Isnes, A. (2004). Physics: Frightful, but fun. Pupils' and teachers' views of physics and physics teaching. *Science Education, 88*(5), 683-706. https://doi.org/10.1002/sce.10141

Aziz, A. A., Yusof, K. M., & Yatim, J. M. (2012). Evaluation on the effectiveness of learning outcomes from students' perspectives. *Procedia - Social and Behavioral Sciences, 56*, 22-30. https://doi.org/10.1016/j.sbspro.2012.09.628

Baram-Tsabari, A., & Yarden, A. (2007). Interest in Biology: A developmental shift characterized using self-generated questions. *The American Biology Teacher, 69*(9), 532-540. https://doi.org/10.1662/0002-7685(2007)69[532:IIBADS]2.0.CO;2

Barmby, P., Kind, P., & Jones, K. (2008). Examining changing attitudes in secondary school science. *International Journal of Science Education, 30*(8), 1075-1093. https://doi.org/10.1080/09500690701344966

Beaton, A., Martin, M. O., Mullis, I., Gonzalez, E. J., Smith, T. A., & Kelley, D. L. (1996). *Science achievement in the middle school years: IEA's Third International Mathematics and Science Study.* Boston College.

BouJaoude, S. B. (1992). The relationship between students' learning strategies and the change in their misunderstandings during a high school chemistry course. *Journal of Research in Science Teaching, 29*(7), 687-699.https://doi.org/10.1002/tea.3660290706

Braš Roth, M., Markočić Dekanić, A., & Markuš Sandrić, M. (2017). *PISA 2015. Prirodoslovne kompetencije za život* [*Science competencies for life*]. National Center for External Evaluation of Education - PISA center.

Brewe, E., Kramer, L., & O'Brien, G. (2009). Modeling instruction: Positive attitudinal shifts in introductory physics measured with CLASS. *Physical Review Special Topics - Physics Education Research, 5*, 1-5. https://doi.org/10.1103/PhysRevSTPER.5.013102

Çalişkan, S., Selçuk, G. S., & Erol, M. (2007). Development of Physics self-efficacy scale. *AIP Conference Proceedings*, *899*, 483-484. https://doi.org/10.1063/1.2733247

Cavallo, A. M., Rozman, M., Blinkenstaff, J., & Walker, N. (2003). Students' learning approaches, reasoning abilities, motivational goals, and epistemological beliefs in differing college science courses. *Journal of College Science Teaching, 33*, 18-23. https://doi.org/10.1007/s10648-022-09661-w

Cavallo, A. M., Potter, W. H., & Rozman, M. (2004). Gender differences in learning constructs, shifts in learning constructs, and their relationship to course achievement in a structured inquiry, yearlong college physics course for life science majors. *School Science and Mathematics, 104*(6), 288-300. https://doi.org/10.1111/j.1949-8594.2004.tb18000.x

Christidou, V. (2006). Greek students' science-related interests and experiences: Gender differences and correlations. *International Journal of Science Education, 28*(10), 1181-1199. https://doi.org/10.1080/09500690500439389

Coutinho, S. A., & Neuman, G. (2008). A model of metacognition, achievement goal orientation, learning style and self-efficacy. *Learning Environment Research, 11*, 131-151. https://doi.org/10.1007/s10984-008-9042-7

Ćosić, A. (2015). *Analiza stavova učenika osječkih srednjih škola o nastavi fizike i informatike (Diplomski rad)* [*Analysis of Osijek high school students' attitude towards education in physics and informatics (master thesis)*]. Osijek: Josip Juraj Strossmayer University.

Dawson, C. (2000). Upper primary boys' and girls' interests in science: Have they changed since 1980? *International Journal of Science Education, 22*(6), 557-570. https://doi.org/10.1080/095006900289660

Dilek Eren, C., Karadeniz Bayrak, B., & Benzer, E. (2015). The examination of primary school students' attitudes toward science course and experiments in terms of some variables. *Procedia - Social and Behavioral Sciences, 174*, 1006-1014. https://doi.org/10.1016/j.sbspro.2015.01.1245

Diseth, Å. & Kobbeltvedt, T. (2010). A mediation analysis of achievement motives, goals, learning strategies, and academic achievement. *British Journal of Educational Psychology, 80*, 671-687. https://doi.org/10.1348/000709910X492432

Drury, C., & Allen, A. (2002). *Task force on the physical sciences - Report and recommendations.* Ireland: Department of Education and Science.

Duff, A., Boyle, E., Dunleavy, K., & Ferguson, J. (2004). The relationship between personality, approach to learning and academic performance. *Personality and Individual Differences, 36*, 1907-1920. https://doi.org/10.1016/j.paid.2003.08.020

Durrani, M. (1998). Students prefer to mix and match. *Physics World, 11*(6), 9. https://doi.org/10.1007/978-3-319-58515-4_24

Ebele, U. F., & Olofu, P. A. (2017). Study habit and its impact on secondary school students' academic performance in biology in the Federal Capital Territory, Abuja. *Educational Research Review, 12*(10), 583-588. https://doi.org/10.5897/ERR2016.311

Edomwonyi-Otu, L., & Avaa, A. (2011). The challenge of effective teaching of chemistry: A case study. *Leonardo Electronic Journal of Practices and Technologies, 10*(18), 1-8.

Eidelman, R. R., & Shwartz, Y. (2016). E-Learning in chemistry education: Self-regulated learning in a virtual Classroom. *3rd international Conference on Cognition and Exploratory Learning in Digital Age (CELDA 2016).* Israel: Weizmann Institute of Science.

Ekici, G. (2010). Factors affecting biology lesson motivation of high school students. *Procedia Social and Behavioral Sciences, 2*, 2137-2142. https://doi.org/10.1016/j.sbspro.2010.03.295

Gadelrab, H. F. (2011). Factorial structure and predictive validity of approaches and study skills inventory for students (ASSIST) in Egypt: A confirmatory factor analysis approach. *Electronic Journal of Research in Educational Psychology, 9*(3), 1197-1218. https://doi.org/10.25115/ejrep.v9i25.1501

Hacieminoglu, E. (2016). Elementary school students' attitude toward science and related variables. *International Journal of Environmental & Science Education, 11*(2), 35-52. https://doi.org/10.12973/ijese.2016.288a

Hacieminoglu, E., Yilmaz-Tuzun, O., & Ertepinar, H. (2009). Investigating elementary students' learning approach, motivational goals, and achievement in science. *Hacettepe University Journal of Education, 37*, 72-83.

Hidi, S., & Harackiewicz, J. M. (2000). Motivating the academically unmotivated: a critical issue for the 21st century. *Review of Educational Research, 70*(2), 151-179. https://doi.org/10.3102/00346543070002151

Hobson, A. (2003). Physics literacy, energy, and the environment. *Physics Education, 38*(2), 109-114. https://doi.org/10.1088/0031-9120/38/2/301

Hussaini, I., Foong, L. M., & Kamar, Y. (2015). Attitudes of secondary school students towards biology as a school subject in Birninkebbi Metropolis, Nigeria. *International Journal of Research & Review, 2*(10), 596-600.

Institute of Physics. (2001). *Physics – building a flourishing future. Report of the inquiry into Undergraduate Physics.* Institute of Physics.

International Council for Science [ICS] (2006). *Strategic Plan 2006-2011. Strengthening international science for the benefit of society.* ICS.

Jarvis, T., & Pell, A. (2005). Factors influencing elementary school children's attitudes toward science before, during, and after a visit to the UK National Space Centre. *Journal of Research in Science Teaching, 42*(1), 53-83. https://doi.org/10.1002/tea.20045

Jokić, B. (2013). *Science and religion in Croatian elementary education: pupils' attitudes and perspectives.* Institute for Social Research.

Jugović, I. (2010). Uloga motivacije i rodnih stereotipa u objašnjenju namjere odabira studija u stereotipno muškom području [The role of motivation and gender stereotypes in the choice of study in a stereotypically male domain]. *Journal Sociology and Space, 186*(1), 77-98.

Lamanauskas, V., Gedrovics, J., & Raipulis, J. (2004). Senior pupils' views and approach to education in Lithuania and Latvia. *Journal of Baltic Science Education, 1*(5), 13-23.

Lyons, T. (2006). Different countries, same science classes: Students' experiences of school science in their own words. *International Journal of Science Education, 28*(6), 591-613. https://doi.org/10.1080/09500690500339621

Martin, M. O., Mullis, I. V., & Foy, P. (2008). *TIMSS 2007 International Mathematics Report: Findings from iEA's Trends in international Mathematics and Science Study at the Fourth and Eighth Grades.* TIMSS & PIRLS International Study Center, Boston College.

Martin, M. O., Mullis, I., Gonzalez, E. J., Gregory, K. D., Smith, T. A., & Chrostowski, S. J. (2000). *TIMSS 1999 International Science Report Findings from iEA's Repeat of the Third International Mathematics and Science Study at the Eighth Grade.* Boston College.

Marušić, I. (2006). Nastavni programi iz perspektive učenika [Teaching program from students' perspective]. In B. Baranović (Ed.), *Nacionalni kurikulum za obvezno obrazovanje u Hrvatskoj - različite perspektive* [*National Curriculum for Compulsory Education in Croatia: different perspectives*] (pp. 175-213). Institute for Social Research.

Marušić, I. (2013). Uloga ličnosti, samopoimanja i motivacije u odabiru kognitivnih strategija učenja. *21. Dani Ramira i Zorana Bujasa – sažeci priopćenja.* Filozofski fakultet u Zagrebu

Marušić, M., & Sliško, J. (2009). Postoje li »muški« i »ženski« stavovi o učenju fizike, o fizici kao znanosti i fizici kao struci? [Are there "male" and "female" attitudes towards learning of physics, physics as a science, and physics as a profession?] *Metodički ogledi, 16*(1-2), 87-111.

Mazana, Y. M., Suero Montero, C., & Olifage, C. R. (2019). Investigating students' attitude towards learning mathematics. *International Electronic Journal of Mathematics Education, 14*(1), 207-231. https://doi.org/10.29333/iejme/3997

Niemivirta, M. (1999). Individual differences in motivational and cognitive factors affecting self-regulated learning: A pattern-oriented approach. In P. Nenniger, R. S. Jäger, A. Frey, & M. Wosnitza (Eds.), *Advances in Motivation* (pp. 23-42). Verlag Empirische Pädagogik.

OECD - Organisation for Economic Co-operation and Development. (2007). *PISA 2006: Science Competences for Tomorrow's World, Volume 1: Analysis.* OECD Publications.

Olakanmi, E. E., & Gumbo, M. T. (2017). The effects of self-regulated learning training on students' metacognition and achievement in chemistry. *International Journal of Innovation in Science and Mathematics Education, 25*(2), 34-48.

Osborne, J., & Collins, S. (2001). Pupils' views of the role and value of the science curriculum: A focus-group study. *International Journal of Science Education, 23*(5), 441-467. https://doi.org/10.1080/09500690010006518

Osborne, J. F., & Dillon, J. (2008). *Science Education in Europe: Critical Reflections.* Nuffield Foundation.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education, 25*(9), 1049-1079. https://doi.org/10.1080/0950069032000032199

Oxford. (1990). *Language learning strategies: What every teacher should know.* Boston Heinle & Heinle Publishers.

Partin, M. L., & Haney, J. J. (2012). The CLEM model: path analysis of the mediating effects of attitudes and motivational beliefs on the relationship between perceived learning environment and course performance in an undergraduate non-major biology course. *Learning Environment Research, 15*, 103-123. https://doi.org/10.1007/s10984-012-9102-x

Perkins, K. K., Adams, W. K., Pollock, S. J., Finkelstein, N. D., & Wieman, C. E. (2005). Correlating student beliefs with student learning using the Colorado Learning About Science Survey. In J. Marx, P. Heron, and S. Franklin (Eds.), *AIP Conference Proceedings Vol. 790: 2004 Physics Education Research Conference* (pp. 61-64). American Institute of Physics. https://doi.org/10.1063/1.2084701

Pintrich, P. R. (1999). The role of motivation in promoting and sustaining self-regulated learning. *International Journal of Educational Research, 31*, 459-470. https://doi.org/10.1016/S0883-0355(99)00015-4

Potvin, P., & Hasni, A. (2014). Interest, motivation, and attitude towards science and technology at K-12 levels: A systematic review of 12 years of educational research. *Studies in Science Education, 50*(1), 85-129. https://doi.org/10.1080/03057267.2014.881626

Prokop, P., Tuncer, G., & Chudá, J. (2007). Slovakian students' attitudes toward biology. *Eurasia Journal of Mathematics*, *Science* and *Technology Education., 3*(4), 287-295. https://doi.org/10.12973/ejmste/75409

Putarek, V., Rovan, D., & Vlahović-Štetić, V. (2016). Odnos uključenosti u učenje fizike s ciljevima postignuća, subjektivnom vrijednosti i zavisnim samopoštovanjem [The relationship between engagement in physics, achievement goals, subjective values, and self-worth contingencies]. *Društvena istraživanja, 25*(1), 107-129. https://doi.org/10.5559/di.25.1.06

Reid, N., & Skryabina, E. A. (2003). Gender and physics. *International Journal of Science Education, 25*(4), 509-536. https://doi.org/10.1080/0950069022000017270

Rijavec, M., & Brdar, I. (2002). Coping with school failure and self-regulated learning. *European Journal of Psychology of Education, 12*(2), 177-194.

Rijavec, M., Raboteg-Šarić, Z., & Franc, R. (1999). Komponente samoreguliranog učenja i školski uspjeh [Self-regulated learning components and school success]. *Društvena istraživanja, 8*(4), 529-541.

Sadi, Ö., & Uyar, M. (2013). The relationship between cognitive self-regulated learning strategies and biology achievement: A path model. *Procedia - Social and Behavioral Sciences, 93*, 847-852. https://doi.org/10.1016/j.sbspro.2013.09.291

Samikwo, D. C. (2013). Factors which influence academic performance in Biology in Kenya: A perspective for global competitiveness. *International Journal of Current Research, 5*(12), 4296-4300.

Sandi-Urena, S., Cooper, M., & Stevens, R. (2012). Effect of cooperative problem-based lab instruction on metacognition and problem-solving skills. *Journal of Chemical Education, 89*(6), 700-706. https://doi.org/10.1021/ed1011844

Savelsbergh, E. R., Prins, G. T., Rietbergen, C., Fechner, S., Vaessen, B. E., Draijer, J. M., & Bakker, A. (2016). Effects of innovative science and mathematics teaching on student attitudes and achievement: A meta-analytic study. *Educational Research Review, 19*, 158-172. https://doi.org/10.1016/j.edurev.2016.07.003

Sert Çıbık, A. i Yalçın, N. (2011). The effect of teaching the direct current concept with analogy technique to the attitudes of science education students toward physics. *Procedia - Social and Behavioral Sciences, 15*, 2647-2651. https://doi.org/10.1016/j.sbspro.2011.04.163

Sjøberg, S., & Schreiner, C. (2005). How do learners in different cultures relate to science and technology? Results and perspectives from the project ROSE. *Asia Pacific Forum on Science Learning and Teaching, 6*(2), 1-16.

Spall, K., Barrett, S., Stanisstreet, M., Dickson, D., & Boyes, E. (2003). Undergraduates' views about biology and physics. *Research in Science & Technological Education, 21*(2), 193-208. https://doi.org/10.1080/0263514032000127239

Spall, K., Stanisstreet, M., Dickson, D., & Boyes, E. (2004). Development of school students' constructions of biology and physics. *International Journal of Science Education, 26*(7), 787-803. https://doi.org/10.1080/0950069032000097442

Stefan, M., & Ciomos, F. (2010). The 8th and 9th grades students' attitude towards teaching and learning physics. *Acta Didactica Napocensia, 3*(3), 7-14.

Su, K. D., & Yeh, S. C. (2014). Effective assessments of integrated animations - Exploring dynamic physic instructions for college students' learning and attitudes. *The Turkish Online Journal of Educational Technology, 13*(1), 88-99.

Suzuki, A. (2007). *Attitudes of Japanese Students in Relation to School Biology (Master's thesis).* University of Glasgow.

Šimić Šašić, S., Sorić, I. (2011). Kvaliteta interakcije nastavnik-učenik: povezanost s komponentama samoreguliranog učenja, ispitnom anksioznošću i školskim uspjehom [Teacher-student quality of interaction: Relationship with components of self-regulated learning, examination anxiety and school achievement]. *Suvremena psihologija*, *14*(1), 35-54.

Šimičić, S., & Pešut, M. (2021). Stavovi učenika sedmih i osmih razreda osnovne škole o nastavnim predmetima matematika i kemija [Attitudes of Seventh and Eighth Graders Primary School Classes on Teaching Subjects Mathematics and Chemistry]. *Poučak, 22*(85), 32-41.

Tuan Soh, T. M., Arsad, N. M., & Osman, K. (2010). The relationship of 21st century skills on students' attitude and perception towards physics. *Procedia - Social and Behavioral Sciences, 7*(C), 546-554. https://doi.org/10.1016/j.sbspro.2010.10.073

Uitto, A., & Kärnä, P. (2014). *Teaching methods enhancing grade nine students' performance and attitudes towards biology.* University of Helsinki. https://helda.helsinki.fi/handle/10138/230997

Vrdoljak, G. (2016). Važnost strategija učenja za uspjeh u fizici kod srednjoškolaca. [The importance of using learning strategies in achieving success in physics classes for high school students]. Život *i* škola *62*(2), 69-78.

Vrdoljak, G., & Vlahović-Štetić, V. (2018). Odnos ciljeva postignuća, strategija učenja i ocjena u srednjoškolskoj nastavi fizike. [Relations between achievement goals, learning strategies and grades in high school physics class]. *Psihologijske teme, 27*(2), 141-157. https://doi.org/10.31820/pt.27.2.1

Vrkić, M., & Vlahović-Štetić, V. (2013). Learning strategies: Beliefs about learning strategies and academic achievement. *Napredak, 154*(4), 511-526.

Wabuke, J. M. (2013). The role of student related factors in performance of biology subject in secondary schools in Eldoret Municipality, Kenya. *Journal of Emerging Trends in Educational Research and Policy Studies, 4*(1), 64-73.

Ward, H., Roden, J., Hewlett, C., & Foreman, J. (2005). *Teaching Science in the Primary Classroom: A practical guide.* Paul Chapman Publishing.

Weinstein, C. E. (1988). Assessment and training of student strategies. In R. R. Schmeck (Ed.), *Learning Strategies and Learning Styles* (pp. 291-316*).* Plenum Press. https://doi.org/10.1007/978-1-4899-2118-5_11

Yager, R. E. (1996). *Science/technology/society as reform in science education.* State University of New York Press.

Zakariya, Y. F., Nilsen, H. K. Bjørkestøl, K., Goodchild, S. (2020). Impact of attitude on approaches to learning mathematics: a structural equation modelling approach. *INDRUM 2020*, Université de Carthage, Université de Montpellier, Cyberspace (virtually from Bizerte), Tunisia.

Zhang, L. (2000). University students' learning approaches in three cultures: An investigation of Biggs's 3P model. *The Journal of Psychology, 134*(1), 37-55. https://doi.org/10.1080/00223980009600847

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Vol. 80, No. 4, 2022

Received: *June 09, 2022* Revised: *July 09, 2022* Accepted: *August 15, 2022*

Cite as: Maltar Okun, T., Rijavec, M., & Ćaleta, M. (2022). Association between attitudes towards science subjects and grades: The mediation role of learning strategies. *Problems of Education in the 21st Century*, *80*(4), 547-564. https://doi.org/10.33225/pec/22.80.547

Tanja Maltar Okun *(Corresponding author)*	Teacher of Nature and Biology, Elementary School Sveti Petar Orehovec, Croatia. E-mail: tanja_maltar@yahoo.com ORCID: https://orcid.org/0000-0002-1357-1369
Majda Rijavec	PhD, Professor Emeritus, Department of Psychology, Faculty of Teacher Education, University of Zagreb, Savska cesta 77, 10000, Zagreb, Croatia. E-mail: majda.rijavec@ufzg.hr ORCID: https://orcid.org/0000-0001-6361-9968
Marko Ćaleta	PhD, Associate Professor, Department of Biology, Faculty of Science Education & Department of Natural History, Geography and History, Faculty of Teacher Education, University of Zagreb, Savska cesta 77, 10000, Zagreb, Croatia. E-mail: marko.caleta@ufzg.hr ORCID: https://orcid.org/0000-0002-4675-556X