Analysis of Interest in STEM Among Primary School Children According to Gender and Age

Nikolina Ribarić[1], Daniela Novoselić[2]
[1]Faculty of Science, University of Split, 21000 Split, Croatia
[2]Faculty of Science, University of Split, 21000 Split, Croatia

Abstract— *The aim of this study was to examine the development of interest in STEM (Science, Technology, Engineering, and Mathematics) among primary school children, with particular emphasis on gender- and age-related differences. The analysis of the collected data included descriptive representations, violin plots, scatter plots, and diagnostic graphs of the regression model. The results indicate significant differences in the distribution of interest by gender, with girls at certain ages demonstrating a higher level of motivation for STEM fields. Violin plots reveal a stronger orientation toward higher interest values among girls aged 10 and 11, whereas boys' interest remains more broadly distributed. Scatter plots provide visual support for developmental patterns, while the confidence interval graph confirms statistically significant differences between specific groups. The diagnostic assessment of the regression model suggests the need for further adjustments and a more careful evaluation of assumptions. Despite methodological limitations, the study offers valuable insight into the dynamics of STEM interest among children and calls for continued longitudinal analysis.*

Keyword *- Children: Confidence Interval: Gender Differences: Motivation: Primary Education: Regression Analysis: STEM: Violin Plot*

I. INTRODUCTION

STEM education encompasses the integration of science, technology, engineering, and mathematics, and its importance in contemporary society is increasingly recognized as a foundation for fostering innovation, critical thinking, and digital literacy [1]. In the context of primary education, early exposure to STEM-related content can have long-term effects on children's academic motivation and professional aspirations [2].

Children's interest in STEM is shaped by a range of factors, with age and gender identified as key demographic predictors. Children are naturally curious and inclined to explore, but the way this curiosity develops and directs itself toward STEM fields can vary significantly depending on developmental stages and social expectations.

According to socio-cognitive development theory [3], children form interests through interaction with their environment, wherein age plays a crucial role in shaping confidence and identity. Between the ages of 8 and 12, children transition from the concrete-operational to the formal-operational stage of thinking [4], which enables them to engage in abstract reasoning and problem solving—skills that are essential for STEM. [5] and [6] emphasize that STEM interests begin forming in primary school, while secondary school represents a critical period for their consolidation. [7] demonstrated that STEM interests may begin to differentiate in the early grades of primary education depending on exposure to content and environmental support.

Gender stereotypes may influence children's perceptions of STEM as suitable for their gender. Studies show that girls often internalize societal messages that associate STEM with a male identity, which can diminish their motivation and self-efficacy [8], [9]. However, when exposed to encouraging environments free from stereotypes, girls demonstrate equal or greater interest in STEM compared to boys [10]. According to [9], gender differences in STEM interest are not due to ability but to societal expectations and stereotypes. [11] and [12] confirm that girls achieve equal or better results in STEM subjects but are less likely to perceive them as part of their identity. [13] highlight the importance of scientific identity and self-efficacy in predicting STEM interest among girls.

The Croatian context: In Croatia, numerous initiatives aimed at promoting STEM among children have been launched, such as the STEM Academy and the STEM Ambassadors Network initiative [14], which emphasize the value of non-formal education and early encouragement of scientific interest. The Ruđer Bošković Institute also conducts evaluations of STEM program impacts on students [15].

These findings underscore the need for systematic monitoring of children's STEM interests, taking into account age and gender differences, in order to develop educational approaches that foster equal participation of all students in STEM fields.

Research into students' interest in science has revealed that engagement can be fostered through various dimensions of instruction. These dimensions encompass the general appeal of science and technology, the specific content within individual science subjects, the context in which new concepts are introduced—such as environmental protection versus technological application—and the teaching methods employed, particularly the integration of information and communication technologies [16],[17],[18]. Student`s interest is also shaped by gender, developmental stage, and the perceived relevance of the subject—both by the student and their immediate environment—especially in relation to future career prospects. In addition to teaching quality, the amount of effort invested or expected, as well as the achieved and anticipated level of competence, play a significant role [19].

Some students exhibit extrinsic motivation toward science, such as passing exams or achieving academic success [20] [21]. Boys are more often driven by career-related goals, while girls tend to show intrinsic interest [22]. Nevertheless, students

generally perceive scientific knowledge as an essential component of their education [23], [21].

A large-scale study by [22] on Scottish students found that boys' preferences shift from biology-oriented topics toward physics-oriented ones as they age, whereas girls' interest in biology remains relatively high and less influenced by age. These findings suggest that research into student interest and attitudes should consider both gender and age, as results may vary across different scientific disciplines.

Numerous studies emphasize the critical role of learning context in stimulating interest in science content. [23] found that topics linked to everyday life or presented through familiar phenomena generate significantly more interest than abstract scientific concepts—for example, rainbows and sunsets are more engaging than light and optics. [24] similarly demonstrated that identical physics concepts elicit varying levels of interest depending on the context in which they are presented.

The way scientific content is introduced is crucial in shaping students' attitudes and interests. Context-based learning directs students toward scientific concepts embedded in familiar or personally relevant situations, demonstrating the practical value of science in everyday life, further education, or future employment [25].

II. Participants, Materials, and Methods

The study was designed to be conducted across all counties of the Republic of Croatia. As part of the project, an educational program titled With STEM We Grow (Sa STEMom raSTEMo) was developed and validated, and implemented in a total of 22 primary schools—at least one in each county. A custom-designed and validated questionnaire was also used to examine children's interest in STEM fields at the age of ten.

Prior to the commencement of research activities, official approvals were obtained from all participating educational institutions. Special attention was given to the ethical acceptability of the research design, as well as the competencies and resources of the research team to ensure professional execution and enable reliable conclusions.

Participation in the study was voluntary—each respondent had the opportunity to independently decide on involvement. Given that participants were minors, informed consent was signed by their legal guardians (parents or caretakers). At the beginning of the study, participants were informed about the objectives and methodology, and following the data collection, they were briefed on the results and their interpretation.

The research aimed to examine differences in interest in STEM among primary school children, taking into account gender (boys vs. girls) and age (8 to 12 years). A total of 2,572 respondents participated, including 1,295 boys (50.35%) and 1,277 girls (49.65%). The age distribution included children from 8 to 12 years old, with the largest proportion being 11 years old (40.81%).

To measure interest in STEM, a child-friendly survey was administered within the With STEM We Grow program in 22 primary schools (at least one per county).

Data analysis was conducted using the R programming language. The following analytical methods were applied:

Two-Way ANOVA to examine the effects of gender and age on STEM interest

Linear regression analysis with interaction terms (Gender × Age)

Tukey HSD post-hoc test for detailed comparison of group differences

Data visualization through violin plots and regression curves

Diagnostic model checking (residual analysis, variance assessment, normality testing). Ethical approval was ensured through formal institutional consent, participant and guardian agreement, and authorization by the Ethics Committee of the Faculty of Science, University of Split. Participation was voluntary and transparently explained to all respondents.

The statistical analysis was conducted using the R programming language. The following methods were applied:

Two-Way ANOVA to examine the effects of gender and age on interest in STEM

Linear regression analysis including interaction terms (Gender × Age)

Tukey HSD post-hoc test to explore specific group differences

Data visualization through violin plots and regression curves

Diagnostic model checking, including residual analysis, variance stability, and normality testing

These procedures ensured both statistical robustness and comprehensive interpretation of the data patterns.

III. Results

Data analysis reveals significant differences in interest in STEM based on gender and age of the participants, while the interaction between these two factors did not show statistical significance (Figure 1).
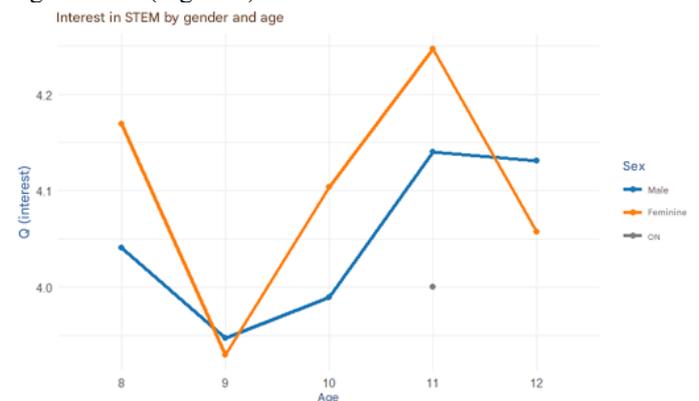

Fig. 1. Graphical representation of STEM interest by gender and age among participants aged 8 to 12 years.

The figure displays a line chart illustrating changes in interest in STEM fields among primary school children. The horizontal axis shows age groups from 8 to 12 years, while the vertical axis represents the intensity of interest (Q-value). Two curves are shown— the blue line indicates interest among boys, and the orange line among girls. It is evident that girls' interest increases sharply between ages 9 and 11, whereas boys show a more gradual rise. Individual data points represent the distribution of respondents' answers. A grey "NA" label denotes missing data. The chart visually confirms the presence

of gender differences in STEM interest as well as developmental changes related to age.

Two-way ANOVA results (Table 1) indicate that:

• There is a significant difference in STEM interest between boys and girls ($F = 7.01$; $p = 0.008$), with girls expressing higher interest in STEM fields.

• Age has a statistically significant effect on the level of interest ($F = 12.81$; $p < 0.001$), suggesting developmental changes in STEM motivation.

• The interaction between gender × age is not statistically significant ($F = 1.30$; $p = 0.269$), implying that the age-related dynamics of STEM interest do not vary substantially by gender.

TABLE 1. Results of the two-way ANOVA analysis

Variable	F	p-value
Gender	7.01	0.00818
Age	12.81	< 0.001
Interaction	1.30	0.269

Linear regression analysis further confirms that gender is a significant predictor ($p = 0.00679$), with girls showing a greater level of interest compared to boys (+0.074). Additionally, age variables (9–12) did not show significant differences compared to the reference age (8 years), suggesting that the development of interest is not linear. The overall model quality is limited ($R^2 = 0.022$), which is expected in research dealing with social phenomena, as interest in STEM is likely influenced by numerous external factors (environment, educational content, parental attitudes, etc.). Residual analysis indicates symmetry and model stability, with a standard error of 0.6945. Although certain observations deviate, the model is not critically compromised and satisfies basic statistical assumptions. The graphical representations (violin plots in Figure 2 and regression analysis in Figure 3) visually confirm these findings.
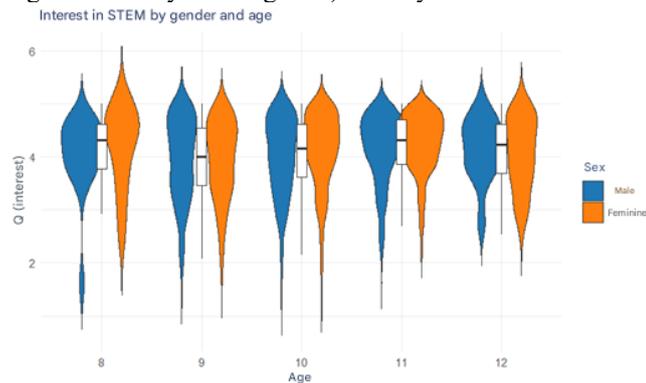

Fig. 2. Violin plot of STEM interest by gender and age among children aged 8 to 12 years.

The violin plots presented in Figure 2 offer a detailed view of the distribution of STEM interest across gender and age. A visual inspection of the violin shapes reveals several important patterns. Among girls, the orange violins show a pronounced density of interest around higher Q-values—particularly at ages 10 and 11—suggesting increased motivation during those years. The wider shapes at higher values indicate that a larger number of respondents reported elevated levels of interest. In contrast, the blue violins for boys reveal a more even distribution of interest, with lower concentration in higher

values. In certain age groups (e.g., ages 9 and 12), a broader range of values is visible but without a distinct peak in density, possibly indicating heterogeneity of interest within the male group. The gender comparison indicates that girls at specific ages express a stronger and more focused interest in STEM than boys, pointing to developmental dynamics and potential gender differences in motivation. These findings highlight the importance of examining data distribution—not just means—as the shape of the violins uncovers broader patterns that may be critical to understanding children's interest in STEM. Regression analysis (Figure 3) further supports the findings from the ANOVA test.
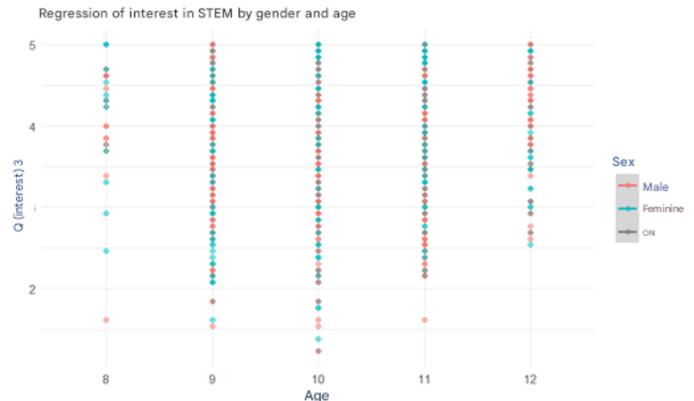

Fig. 3. Regression analysis of STEM interest among children aged 8 to 12 years by gender.

The figure displays a scatter plot illustrating the relationship between children's age (8–12 years) and their level of interest in STEM fields, by gender. The horizontal axis represents participants' age, while the vertical axis shows Q-values reflecting the intensity of interest. The distribution of data points provides insight into individual responses, with denser areas indicating concentrations of interest at specific ages. The results show a statistically significant difference in STEM interest between girls and boys, with girls demonstrating a higher level of interest. Furthermore, STEM interest appears to change with children's age. However, no interaction between gender and age was observed. The Tukey HSD post-hoc test confirms that, although both gender and age were significant factors in the ANOVA models, their interaction—as gender × age combinations—did not produce statistically significant differences (Figure 4). The graphical depiction supports the statistical result: the gender × age interaction is not significant ($p = 0.27$).

Based on the confidence intervals presented (see Figure 4), it is evident that differences in average STEM interest between some groups of children are statistically significant. For example, among girls aged 10 years, the confidence interval does not include the value zero, indicating a significant difference compared to the reference group. In contrast, among boys aged 8 years, the interval crosses zero, suggesting that the difference is not statistically significant. These results suggest that gender and age may play a key role in shaping STEM interest, with more pronounced shifts observed among girls during the early years of primary education.
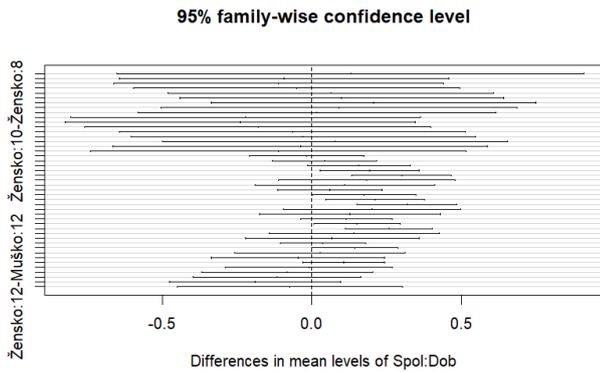
Fig. 4. Confidence interval plot of differences in average STEM interest by gender and age (8–12 years).

IV. OTHER RECOMMENDATIONS

The diagnostic analysis of the regression model (shown in Figure 5) indicates certain challenges regarding the statistical validity of assumptions. Mild curvatures observed in the residual plots may suggest the presence of nonlinear relationships between age and interest in STEM, which the current linear model does not fully accommodate. In addition, deviations in the Q-Q plot imply that the error distribution may diverge from normality, particularly at the extremes, which could affect the reliability of p-values and the interpretation of intervention effects.
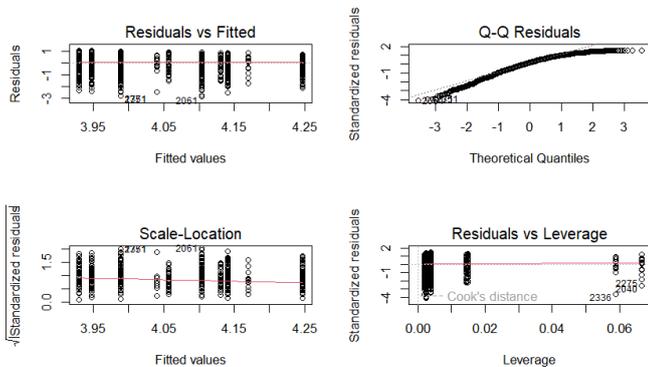

Fig. 5. Diagnostic plots for evaluating the regression model of STEM interest among children aged 8 to 12 years.

The Scale-Location plot indicates potential heteroscedasticity—unequal variance of residuals—which suggests that errors may vary depending on predicted values. This may require model corrections such as the use of robust regression or variable transformations. In the Residuals vs. Leverage plot, points with higher Cook's distance were identified, indicating potential disproportionate influence on the model. Further analysis of these cases is recommended to assess whether they are justified or represent outliers that could distort the results. To improve the model, it is advisable to introduce nonlinear components (e.g., polynomial terms) for better alignment with actual patterns, and to apply transformations to the dependent variable or predictors to stabilize variance. Alternative regression approaches such as robust regression or mixed-effects models may also be considered, along with examining influential data points and,

where appropriate, removing or analyzing them separately. Despite certain statistical deviations, the model still offers valuable insights into the development of STEM interest among children; however, interpretation of the results should be cautious and supported by additional analyses. Given the limitations of the current regression model, it is recommended to apply nonlinear statistical approaches and longitudinal analyses that could enable tracking changes in interest over time. Additionally, incorporating qualitative methods (e.g., interviews with students and teachers) may provide deeper understanding of the motivational mechanisms at play.

V. CONCLUSION

The findings of this study build on existing knowledge of gender and developmental differences in motivation for STEM fields. Girls' interest in STEM may emerge strongly during early adolescence, as shown by patterns of interest that are consistent with the literature [9], [8]. Violin plots visually confirm that girls show a pronounced tendency toward higher values of interest, aligning with the assumption that their motivational patterns may be more sensitive to contextual factors such as teacher influence and family support [12]. Boys display a more dispersed pattern, which may indicate heterogeneity in motivational drivers or the influence of external factors. Scatter plots point to a potential developmental trend, particularly among girls aged 10–11 years, although in the absence of regression lines, conclusions remain qualitative. The confidence interval plot enabled the assessment of statistically significant differences, emphasizing the importance of age as a component. However, diagnostic plots suggest certain departures from statistical assumptions (e.g., heteroscedasticity, deviation from normality), and future research is advised to expand the model by including nonlinear components and robust regression approaches [26]. The sustainability of children's interest in STEM calls for further investigation involving a longitudinal approach and evaluation of educational interventions that specifically foster scientific motivation—particularly among girls who frequently face societal barriers in STEM careers [8]. In Croatia, programs such as the JOBSTEM project [2] explore how academic achievement, self-beliefs about competence, and parental influence shape interest in STEM. These results highlight the need for a systematic approach involving teachers, parents, and educational institutions in creating an inclusive STEM environment. Emerging educational models advocate for connecting STEM with social sciences and humanities (so-called post-STEM), thereby fostering the development of emotional intelligence, creativity, and communication skills [1]. This approach enables children to perceive STEM not merely as a technical domain but as a tool for solving real-world societal challenges. When examining the overall findings on student interest in science, a prominent trend emerges: interest tends to decline as student's progress through their schooling. Interests that are notably high and diverse in grades 5 and 6 of primary education appear to diminish over time. This phenomenon has been documented by several researchers [27] [28], [29] suggesting that students in our educational system follow a pattern consistent with international observations.

Younger students generally exhibit broad and non-selective curiosity, showing interest in nearly all topics. This can be attributed to the natural developmental drive of children aged 10 to 12 to explore and make sense of the world around them, as well as to establish their place within it. The shift in interests with chronological age is a well-recognized and extensively described phenomenon in educational literature [27], [28], [29].

[19] emphasize that overly complex or developmentally inappropriate content can negatively affect students' interest and motivation to learn. A contributing factor to the decline in interest may lie in curriculum design, which often fails to adequately consider the developmental characteristics and evolving interests of students at different ages. In a study on students' attitudes toward biology across age groups, [29] found that the content taught at a particular grade level has a direct impact on students' interest and perception of the subject. Engaging material fosters positive attitudes, whereas overly challenging content tends to diminish enthusiasm and interest.

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REFERENCES

[1] Bermanec, V., Burušić, J., & Vlahović-Štetić, V. (2018). *Post-STEM: integracija društveno-humanističkih i STEM područja u obrazovanju.* Institut za društvena istraživanja.
[2] Burušić, J. (2019). JOBSTEM projekt: Interesi i motivacija učenika za STEM područja. Institut za društvena istraživanja.
[3] Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Prentice-Hall.
[4] Piaget, J. (1972). The psychology of the child. Basic Books.
[5] Lindahl, B. (2007). A longitudinal study of students' attitudes towards science and choice of career. Science Education, 91(3), 371–394. https://doi.org/10.1002/sce.20198
[6] Sadler, P. M., Sonnert, G., Hazari, Z., & Tai, R. H. (2012). Stability and volatility of STEM career interest in high school: A gender study. Science Education, 96(3), 411–427. https://doi.org/10.1002/sce.21007
[7] Potvin, P., Hasni, A., & Roy, R. (2009). Interest, motivation and attitude towards science and technology at K-12 levels: A systematic review. International Journal of Science and Mathematics Education, 7(3), 377–393. https://doi.org/10.1007/s10763-008-9170-9
[8] Cheryan, S., Ziegler, S. A., Montoya, A. K., & Jiang, L. (2017). Why are some STEM fields more gender balanced than others? Psychological Bulletin, 143(1), 1–35. https://doi.org/10.1037/bul0000052
[9] Wang, M.-T., & Degol, J. L. (2017). Gender gap in science, technology, engineering, and mathematics (STEM): Current knowledge, implications for education, and future directions. Educational Psychology Review, 29(1), 119–140. https://doi.org/10.1007/s10648-015-9355-x
[10] Eccles, J. S. (2009). Who am I and what am I going to do with my life? Journal of Adolescence, 32(1), 9–16. https://doi.org/10.1016/j.adolescence.2008.07.003
[11] Hyde, J. S., Fennema, E., & Lamon, S. J. (1990). Gender differences in mathematics performance: A meta-analysis. Psychological Bulletin, 107(2), 139–155. https://doi.org/10.1037/0033-2909.107.2.139
[12] Riegle-Crumb, C., Moore, C., & Ramos-Wada, A. (2011). Who wants to have a career in science or math? Exploring adolescents' future aspirations by gender and race/ethnicity. Science Education, 95(3), 458–476. https://doi.org/10.1002/sce.20431
[13] Hazari, Z., Sonnert, G., Sadler, P. M., & Shanahan, M.-C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. Journal of Research in Science Teaching, 47(8), 978–1003. https://doi.org/10.1002/tea.20363
[14] Likić, R., Kovačević, A., & Šimunić, M. (2022). Razvoj mreže STEM ambasadora u Hrvatskoj: Evaluacija učinka na učenike. Revija za obrazovanje i društvo, 14(2), 45–60.
[15] Institut Ruđer Bošković. (2025). Evaluacija učinka STEM programa na učenike: Nacionalni pregled rezultata. Zagreb: IRB. https://www.irb.hr/stem-evaluacija-2025
[16] Simon S. Beyond the science classroom: The role of informal science education. *International Journal of Science Education*. 2000;22(9):1027–1039.
[17] Hoffman L. Promoting girls' interest in physics: The impact of context-related learning. *International Journal of Science Education*. 2002;24(6):665–678.
[18] Osborne J. Towards an agenda for research in science education. *Studies in Science Education*. 2003;40(1):1–47.
[19] Lavonen J, Byman R, Juuti K, Meisalo V, Uitto A. Students' interest in physics: A survey in Finland. *Nordic Studies in Science Education*. 2005;1(1):21–43.
[20] Carlone HB. The cultural production of science in reform-based physics: Girls' access, participation, and resistance. *Journal of Research in Science Teaching*. 2004;41(4):392–414.
[21] Osborne J, Collins S. Pupils' views of the role and value of the science curriculum: A focus-group study. *International Journal of Science Education*. 2001;23(5):441–467.
[22] Gardner P. Students' interests in science and technology: Gender, age and cultural effects. *Research in Science & Technological Education*. 1985;3(1):1–20.
[23] Jenkins EW. School science, citizenship and the public understanding of science. *International Journal of Science Education*. 2005;27(7):703–719.
[24] Häussler P, Hoffmann L. A curricular frame for physics education: Development, comparison with students' interests, and impact on students' achievement and self-concept. *Science Education*. 2000;84(6):689–705.
[25] Bennett J, Lubben F, Hogarth S. Bringing science to life: A synthesis of the research evidence on the effects of context-based and STS approaches to science teaching. *Science Education*. 2003;87(1):1–14.
[26] Field, A. (2013). Discovering statistics using IBM SPSS statistics (4th ed.). Sage Publications.
[27] Barmby P, Kind P, Jones K. Examining changing attitudes in secondary school science. *International Journal of Science Education*. 2008;30(8):1075–1093.
[28] George R. A cross-domain analysis of change in students' attitudes toward science and the impact of constructivist teaching practices. *International Journal of Science Education*. 2006;28(6):571–589.
[29] Prokop P, Tuncer G, Chudá J. Slovakian students' attitudes toward biology. *Eurasia Journal of Mathematics, Science and Technology Education*. 2007;3(4):287–295.