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INTEGRATING STEM INTO EFL CURRICULUM THROUGH STEM DAY ACTIVITIES: LEARNERS' AND TEACHERS' PERCEPTIONS

Vera M. Savić*
Faculty of Education, University of Kragujevac, Jagodina, Serbia

Ana Z. Živković
Čegar Primary School, Niš, Serbia

Abstract: Primary English Language curriculum is increasingly focusing on developing competencies beyond language skills and knowledge. Studies show that integrating English as a foreign language with STEM has been found beneficial for developing learners' cognitive academic L2 proficiency and interest in STEM disciplines. The paper aimed to study how STEM Day activities affected learners' perceptions of integrated English and STEM disciplines, and how the experience of planning and organizing STEM activities shaped teachers' perceptions of the approach. The study applied a phenomenographic approach, and a purposive sample involving a total of 40 fifth- and seventh-grade primary learners (aged 11 and 13 respectively) and seven teachers was selected from a state school in southern Serbia on the basis of their experiences in STEM Days. The data were collected using two online questionnaires with both closed- and open-ended questions. The data of *Learner STEM Survey* reported in this chapter aimed to measure interest in integrated English and STEM as a key component of learners' STEM attitudes. The results indicate that a majority of learners developed a positive interest in English and STEM disciplines, but the STEM Day experience was perceived differently by two sample age groups: younger learners expressed significantly higher interest in all STEM areas and for integrated English and STEM, being statistically significant for the area of technology. Moreover, there were statistically significant differences in perceptions resulting from gender differences, boys expressing higher interest in technology and mathematics. The teachers highlighted STEM benefits for learners and pointed to some organizational challenges. The findings support the integration of STEM into the primary EFL curriculum and indicate an advantage of an early start for developing learners' positive interest in key aspects of STEM.

Keywords: English and STEM integrated curriculum, primary learners' interest in STEM, primary teachers' perceptions of STEM, STEM Day activities.

* verasavic035@gmail.com

INTRODUCTION

STEM is an innovative approach that has become one of the main foci of educational reforms today (Chesky & Wolfmeyer, 2015). It focuses on the integration of the content areas of science, technology, engineering, and mathematics, and it can be applied at all levels of formal education, from pre-primary to secondary education. In primary education, STEM's educational value is primarily seen in deeper content learning and in the development of 21st century skills of primary learners, well-documented by a vast body of research (Bertrand & Namukasa, 2022; Erkut & Marx, 2005; Guzey et al., 2016; Honey et al., 2014; Hudson et al., 2015; Mahoney, 2010; Puška et al., 2023; Rosicka, 2016; Sultana et al., 2021). Relevant learning theories that support STEM are constructivism, experiential learning, and learning by doing in social interaction, while being supported by a more able peer or a more knowledgeable adult (Vygotsky, 1986). Some studies show that STEM can be very beneficial for enhancing interest of low-income students in STEM disciplines and for encouraging their future careers in STEM fields (Hansen et al., 2023). Moreover, studies indicate that early exposure to STEM activities can enhance marginalized children's learning and literacy development (Bermudez et al., 2023). Applied in developing countries, STEM education can contribute to the economic advancement of these countries by providing learners with quality education in science, maths, technology, and engineering, by popularising STEM disciplines in education, and by narrowing the gender gap in STEM fields and careers (Chesky & Wolfmeyer, 2015; Nawaz et al., 2023; Trott & Weinberg, 2020).

Although STEM has been spreading worldwide to ever younger learners, its application is still limited globally. The approach is generally considered to be challenging to apply due to a number of requirements, some of which relate to teachers' competencies, professional support, and teaching resources, while the others may result from the learning environment and learners' cognitive abilities (Boice et al., 2021; Honey et al., 2014; Tang et al., 2021). Furthermore, in teaching contexts where English as a foreign language (EFL) is integrated with STEM, the requirements also involve EFL proficiency of both learners and STEM teachers, STEM content knowledge of English teachers, and learners' readiness to engage in STEM activities in English. Teachers' perceptions have been found to play a crucial role in accepting and applying innovation in education, and also in determining its success (Savić et al., 2020). To determine how integrated English and STEM experience may shape learners' perceptions, the chapter studies primary learners' interest for English and STEM disciplines upon their participation in STEM Day activities, while teachers' perceptions are examined through levels of their engagement in preparing and teaching the STEM Day activities.

LITERATURE REVIEW

Integration of English and STEM

Supported by research, traditional views on teaching EFL that focused mainly on mastering the linguistic forms are being replaced by approaches striving to develop the necessary skills for understanding STEM disciplines and finding solutions to real-life problems (Sultana et al., 2021). STEM education combines teachers' discipline knowledge and pedagogical content knowledge when creating integrated English and STEM tasks that require learners to utilize inquiry-based learning and scientific language in classroom interaction, thus simultaneously acquiring STEM multi-disciplinary content knowledge and English. As Banerjee (2016: 16) argues, "although focus of language learning is not on the content, language learning experience for learners may be made more effective and interesting by making connections to other disciplines" as a real-world experience.

As a result, STEM education lesson plans usually differ from traditional EFL lesson plans in a number of aspects: first, they may adopt engineering design process with six stages, i.e. ask, imagine, plan, create, test, improve (Nawaz et al., 2023), or 5E lesson design, i.e. engage, explore, explain, elaborate, and evaluate (Moran et al., 2021); second, to guide learners in the process of solving problems, STEM lesson plans often combine concepts from different disciplines that learners need in order to better understand the problems; third, they usually require learners to collaborate in small groups, and to communicate and make decisions together; fourth, ideally they provide authenticity by linking the problems to real-world issues and making them more interesting and relevant to learners' lives; fifth, they require the use of technology in problem solution; sixth, they involve hands-on experiential activities which are learner-centered and provide fun for learners; finally, rather than expecting the solution of the problem, this approach to language teaching sees failures as learning opportunities (Nawaz et al., 2023). The younger the learners are, the more scaffolding with scientific language, engineering design, and statistical representations they will need from teachers.

Learners' Perceptions of STEM

Learners' perceptions have been considered reliable measures of STEM program success because they have been found to affect learner engagement and participation in STEM activities (DeJarnette, 2012; Erkut & Marx, 2005; Friday Institute for Educational Innovation, 2012; Mahoney, 2010; Puška et al., 2023; Tang et al., 2021; Trott & Weinberg, 2020; Zhang et al., 2021). Tang et al. (2021)

have found five factors affecting primary learners' engagement in STEM activities and their success in learning: proficiency in English, teacher's pedagogical approach, learners' learning interest, classroom climate, and learners' cultural diversity. The more proficient in English the learners are, i.e. the more comprehensible input and output, the more positive effects are seen in STEM academic outcomes. Some studies further indicated that age may have an effect on attitudes (Mahoney, 2010; Puška et al., 2023).

Students' STEM attitudes have so far been measured with several instruments (Erkut & Marx, 2005; Friday Institute for Educational Innovation, 2012; Mahoney, 2010). Aiming to increase the number of girls in science in the United States, a group of experts developed a project involving science units for 8th-grade students and questionnaires for measuring and comparing students' attitudes toward science, mathematics, and engineering before and after teaching the new science units (Erkut & Marx, 2005). Pre- and post-intervention scores indicated that all students' attitudes toward science improved, but not toward mathematics and engineering. The study also found statistically significant differences in attitudes between male and female students, with male students having more positive attitudes for the content areas of technology and engineering, but there was no statistically significant difference based on gender for the content areas of science and mathematics (Erkut & Marx, 2005). Mahoney (2010) describes a complex process of designing and validating a student attitudinal instrument through the collaborative efforts of a number of experts. Interest, perceived ability, and value were thus found to be the main elements of the cognitive and affective response of learners to STEM. The application of the instrument with secondary school students showed some statistically significant differences between groups of older and younger students, the latter group expressing statistically significant higher levels of attitudes for mathematics, while there was no statistically significant difference in age groups' attitudes towards content areas of science, technology and engineering (Mahoney, 2010). Learners' age seems to play a significant role in how learners perceive STEM disciplines, documented by some more recent studies with primary learners, while gender does not consistently cause such differences (Leonidas de Oliveira et al., 2022; Puška et al., 2023).

Teachers' Perceptions of STEM

Teachers' beliefs about STEM and their teaching strategies play a crucial role in the success of STEM education (van Driel et al., 2018), especially with English language learners (ELLs) who may struggle to master mathematics and science concepts (Min et al., 2023). To make STEM content accessible to all learners, teachers need to acquire STEM discipline knowledge and develop and

apply effective STEM education pedagogy (Collier et al., 2016). Interviews with pre-service primary school teachers revealed their anxiety related to teaching ELLs in linguistically and culturally responsive ways and put forward the need for developing effective scaffolding strategies, such as multimodal extralinguistic support through visual and auditory aids, body movements, and hands-on activities that rely on learners' senses and aid comprehension through different channels (Min et al., 2023). Additionally, García-Carrillo et al. (2021) found out that pre-service primary teachers had positive attitudes toward STEM education in spite of the number of challenges experienced when teaching coding and robotics in the classroom, viewing STEM as a beneficial approach both for the learners and the teachers.

Teachers' perceptions of STEM are shaped by the challenges related to its application, the biggest being crowded classes, lack of infrastructure, inadequate teacher qualification and training, low teacher motivation to introduce change and STEM innovation, outdated curriculum, obsolete standards, and textbooks that lack interesting content (Nawaz et al., 2023). To teach the STEM integrated curriculum effectively teachers need to develop pedagogical strategies for the successful incorporation of hands-on and inquiry-based activities that can help children understand abstract concepts in STEM disciplines, the key skill being "pedagogical expertise in scientific inquiry and technological design" (DeJarnette, 2012: 80). Besides developing the skills for successful collaboration with colleagues, STEM teachers need professional skills that support deep learning (Fullan & Langworthy, 2013). Teachers' engagement in STEM, from collaborative planning of STEM events to reflecting on their teaching effectiveness, provides opportunities for them to enhance their own scaffolding strategies and confidence to apply STEM regularly and thus nurture positive learners' perceptions of STEM.

Best Practices in STEM Teaching in Serbia

Although the Serbian Primary Curriculum does not explicitly give instructions about STEM teaching, a document titled Framework for Elective Activities (Eurydice Unit Serbia, 2022; MoESTD, 2021) instructs primary teachers to provide a variety of opportunities for upper-primary grades learners (ages 11 – 14) to develop lifelong learning skills and autonomy needed for thriving in life and career. Considering the suggested themes and types of learner and teacher involvement described in the Framework, many of the STEM principles are applied. Planning and realizing the program according to the Framework is determined as the responsibility of schools and teachers. This means that teachers' cross-curricular pedagogical skills and their positive perceptions of STEM innovation are keys to successful application of the Framework.

One of the researchers in the present study has designed and implemented a number of STEM activities aligned with the Framework, designed with a specific thematic focus, integrating English with STEM subjects in STEM Days for upper-primary grades. The activities aimed to contribute to learners' linguistic development while simultaneously providing opportunities for content knowledge acquisition. Two STEM Days will be briefly described (see also Savić & Živković, 2024).

1*. Maths Pirates and the Lost Treasure.* This STEM Day scenario integrated English with the school subjects of Mathematics, Computer Science, and Home Economics, and comprised four consecutive STEM Day sessions lasting 225 minutes. The scenario, designed by one of the authors of this chapter, is available online in European Schoolnet Academy MOOC *STEM Out-of-the-box* as an example of the best practice in teaching STEM in Europe (European Schoolnet Academy, 2023). This STEM Day theme was a treasure hunt in which English was used as the language of all activities, aiming to develop learners' literacy in English (writing a description), their financial literacy (counting money, converting different currencies, saving, spending and donating money, and understanding new economic concepts), and digital literacy (coding and computational thinking for navigating a map). The activities involved real-life situations that required solving maths problems and navigating a map, making decisions, negotiating opinions, asking and answering questions, and thinking critically and creatively. STEM Day ended with a visit by a guest speaker, an economics expert, who answered learners' questions about earning, spending, and saving money. To create the materials and activities the teachers used a number of online applications, such as Ginzy for teachers, Wordwall, Wakelet, Mentimeter, Bookcreator, QR code generator, and currency converter. Teacher-designed materials comprised a glossary of new words, a pirate word search, a pirate vocabulary quiz, a financial literacy quiz, interactive game-like maths activities, and money notes maths problems. Learners worked in groups, collaborated and supported each other, created maths problems for each other, gave feedback to each other, investigated the problem of finding a hidden treasure, proposed solutions, and asked and answered questions. Teachers applied the formative assessment procedure to monitor learners' progress, while learners participated in an anonymous poll on Mentimeter to evaluate the difficulty of specific activities and their own STEM Day experience.

2. *Aerospace in Class*. This STEM Day activity implemented a flipped classroom method. The theme was space and the design of a moonbase/house on the Moon within the Airbus Foundation Discovery Space project. Learners were given materials and tasks online dealing with concepts and vocabulary in English related to life on the Moon characterized by low gravity and the absence of atmosphere. STEM content areas explored were the subjects of

Science, Mathematics, and Engineering. The main task was to design a house on the Moon, to make a 3D model of it, and to describe it in English. The English teacher collaborated with class teachers to design tasks and select teaching materials by using applications such as Quizlet for reviewing vocabulary, and videos created by Airbus Foundation Discovery Space for explaining the conditions on the Moon and the qualities of materials needed to build a house there. The science content included types of building materials and their qualities, while the math content dealt with different shapes and calculations of angles in them, and engineering content involved both creative design and 3D model building. Working individually, learners designed and created 3D models of their houses on the Moon, took photos of them and shared photos with the teachers together with detailed descriptions of the house. The 3D models were created from cardboard, paper, LEGO blocks, plastic boxes, plastic bottles, plastic glasses, paper plates, paper rolls, and aluminum foil, in a number of shapes, from a ball, rectangular box, and sphere, to rather unique shapes and designs.

The present study of sample learners' and teachers' perspectives of STEM is mainly based on their experience in the above two STEM Days.

Aim of the Study and Research Questions

The aim of the study was to determine sample primary school learners' and teachers' perceptions about the integration of English with STEM disciplines in STEM Day activities, based on their participation in STEM Days described in the above sub-section. Being an innovative approach in Serbia, STEM is gaining the attention of enthusiastic teachers, but has so far not been researched in the Serbian primary teaching context. This gap asks for studies of all aspects of introducing the innovation, even on a small scale. In line with international studies dealing with learners' and teachers' attitudes to STEM, we focused on the construct of interest of STEM disciplines and English integration, on how it is shaped by learners' age and gender, and on teachers' perceptions of their STEM experience. Together with perceived ability and value, interest is a component of STEM attitudes which refers to learners' awareness, i.e. their initial interest in STEM disciplines, their internal motivation in STEM disciplines, and their long-term commitment to participating in activities that involve STEM disciplines (Mahoney, 2010). We posed the following four research questions:

RQ1: What is the sample learners' interest in integrated English and STEM?

RQ2: How does age affect sample learners' interest in integrated English and STEM?

RQ3: How does gender affect sample learners' interest in integrated English and STEM?

RQ4: What are sample teachers' perceptions of integrating English and STEM disciplines?

Considering the results of the previous studies of learners' and teachers' perceptions of STEM (Erkut & Marx, 2005; García-Carrillo et al, 2021; Mahoney, 2010; Nawaz et al., 2023; Puška et al., 2023), we expected generally positive attitudes of both groups.

METHODOLOGY

Research Design

This cross-sectional survey applied a phenomenographic approach with purposive samples of learners and teachers who responded to the survey issues. We performed a phenomenographic examination of the participants' experiences in STEM Day activities (Velasco & Hite, 2023). The aim of the study was twofold, i.e. to reveal sample learners' perceptions of STEM disciplines and English, in terms of interest, and how they are affected by learners' age and gender, and to analyze teachers' experiences of STEM Day activities and their conceptions of STEM. The study was extensive and a part of the results dealing with learners' perceived ability and value of STEM has already been published (see Savić & Živković, 2024), while the present chapter aimed to investigate learners' interest in English and STEM disciplines, interest regarded as an attitudinal component (Mahoney, 2010). We applied a mixed-method design and performed the analysis of quantitative and qualitative data to measure learners' and teachers' perceptions.

Sample

Participants were 40 primary school learners (*learner sample*) and seven primary school teachers (*teacher sample*) from a state primary school located in a city in southern Serbia. The sampling was purposive and only the learners and teachers who had participated in at least one STEM Day held in the school within the regular curriculum were invited to take part in the study. A total number of 40 primary learners participated in the study, representing the learner sample, distributed into two age/grade groups (AG, see *Table 1*).

Table 1: Demographic characteristics of the learner sample.

Learner Sample AGs	N	Girls N (%)	Boys N (%)	Age	Grade	Started EFL at preprimary N (%)	Started EFL in Grade 1 N (%)
AG1	23	13 (56.5)	10 (43.5)	11	5	11 (47.8)	12 (52.2)
AG2	17	8 (47.1)	9 (52.9)	13	7	9 (52.9)	8 (47.1)
Total	40	21 (52.5)	19 (47.50)	-	-	20 (50.0)	20 (50.0)

The teacher sample (see *Table 2*) comprised two class teachers (T2 and T3) and five subject teachers (one of them being a researcher in this study), with mean age of 49 years and teaching experience ranging from 10 years to more than 25 years. Their experience with STEM Day organization and teaching was diverse, from one STEM Day to more than 10 STEM Days.

Table 2: Demographic characteristics of the teacher sample.

Teacher Sample	Gender	Qualification	School Subject	Years of Teaching Experience	STEM Day Experience
T1	female	BA English Language and Literature	English Language	19	10+ STEM Days
T2	female	BA Class Teaching	Class Teacher	22	Several STEM Days
T3	female	BA Class Teaching	Class Teacher	24	Several STEM Days
T4	female	BA Physics	Physics	25	One STEM Day
T5	female	MA English Language and Literature	English Language	25 +	Two STEM Days
T6	male	MA ICT	ICT	10	Several STEM Days
T7	female	MA Geography	Geography	10	Several STEM Days

Instruments

Two instruments were applied in the study: the *Learner STEM Survey* and the *Teacher STEM Survey.* They were designed by the researchers drawing on several sources (Erkut & Marx, 2005; Friday Institute for Educational Innovation, 2012; Guzey et al., 2016; Mahoney, 2010). *Learner STEM Survey* was a comprehensive questionnaire with five perception scales, from which we are hereby

reporting the results collected with 15 items (three statements for each of the five subject areas) of the scale for measuring sample learners' interest in integrated English and STEM disciplines: a) [*subject*] *is fun;* b) *I love* [*subject*]; c) *I like it when on STEM Day we do* [*subject*] *in English.* For clarity and understanding the statements were given in Serbian, sample learners' native language, and phrased positively. *Teacher STEM Survey* was a questionnaire with two perception scales, comprising a total number of 19 items about the cross-curricular approach on STEM Days and four open-ended questions about the benefits and challenges of planning and realizing STEM Days. All statements in both instruments were ranked on a five-point scale: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*.

Procedure and Data Generation and Analysis

The attitudinal instruments were designed as Google Forms: The links were distributed as QR codes, filled out in regular classes (*Learner STEM Survey*) and in school premises (*Teacher STEM Survey*) on school days in February 2024. The informed consent was obtained by all participants at the beginning of each survey. The data collected were analyzed quantitatively using the SPSS tool for Windows, version 23.0 so that the results appeared both as percentage, median (M) and standard deviation (SD) values. To compare and interpret median values the following group boundaries were used: *very low:* 1.00 - 1.80; *low:* 1.81–2.60; *moderate:* 2.61–3.40; *high:* 3.41–4.20; and *very high:* 4.21–5.00 (Narli, 2010). Only *moderate*, *high*, and *very high* scores (M > 2.61) were considered positive attitudes. To interpret the responses to open-ended questions collected with the *Teacher STEM Survey* thematic analysis was carried out.

RESULTS AND DISCUSSION

Findings are organized into three sub-sections related to the study's research questions. The learner sample's interest results are presented in *Table 3* and *Table 4*, while teacher sample's results are shown in *Table* 5. All scores are given as M and SD values. Additionally, the learner sample's interest scores for English and STEM subject areas run in parallel for two age groups to enable easy comparison (see *Table 3*).

Table 3: Sample learners' interest scores of integrated English and STEM disciplines per individual subjects and per two age groups (AG1 & AG2, see Table 1) (on a scale 1 – 5, from strongly disagree to strongly agree).

No.	Item	Age Group	M	SD
English Language Learning				
1.	English is fun.	AG1	4.30	1.063
		AG2	3.18	1.551
2.	I love English.	AG1	4.09	1.083
		AG2	3.59	1.326
3.	I would like to have STEM Day in English more often.	AG1	3.91	1.311
		AG2	2.76	1.251
Mathematics				
4.	Math is fun.	AG1	2.70	1.608
		AG2	2.41	1.372
5.	I love math.	AG1	2.91	1.443
		AG2	2.71	1.572
6.	I like it when on STEM Day we solve interesting math problems in English.	AG1	3.39	1.672
		AG2	2.24	1.251
Technology				
7.	Technology is fun.	AG1	4.43	.945
		AG2	3.06	1.478
8.	I love Technology.	AG1	4.26	1.251
		AG2	2.88	1.219
9.	I like it when on STEM Day we use Technology with English.	AG1	4.00	1.279
		AG2	2.29	1.404
Science				
10.	Science is fun.	AG1	3.91	1.164
		AG2	3.47	.943
11.	I love science.	AG1	3.70	1.259
		AG2	3.47	1.007
12.	I like it when on STEM Day we do science in English.	AG1	3.61	1.469
		AG2	2.82	1.286
Engineering				
13.	Engineering is fun.	AG1	3.96	1.261
		AG2	2.82	1.551
14.	I love engineering.	AG1	3.61	1.373
		AG2	2.88	1.409
15.	I like it when on STEM Day we do engineering in English.	AG1	3.43	1.308
		AG2	2.53	1.328

Sample Learners' Interest in Integrated English and STEM

The results indicate that the affective category of interest varied in different STEM areas and English. Generally speaking, all sample learners expressed positive interest in English and individual STEM subjects. The highest interest was expressed for English (see scores for items 1&2, M between 3.18 – 4.30) and science (items 10 & 11, M between 3.47 – 3.91), while the lowest was shown for mathematics (items 4 & 5, M between 2.41 – 2.91). Although the scores for technology and engineering ranged from *moderate* (items 7, 8, 13, & 14, M between 2.82 – 3.06) to *high* and *very high* (items 7, 8, 13, & 14, M between 3.61 – 4.43), sample learners' motivation and awareness for these two STEM areas appeared to be lower than for English and science.

By expressing mainly *high* and *very high* interest in English, the sample learners indicated their high awareness (item 1) and motivation (item 2) for studying this foreign language. On the other hand, their preferences for mathematics were lower when compared to other STEM disciplines. These findings are contrary to the results of some previous studies (Mahoney, 2010) and may have been caused by their low mathematical proficiency and/or the way mathematics was taught in their teaching/learning context. On the other hand, both age groups' high interest in science may be the result of their shared curiosity in this area and the way science was taught in the particular context at both grade levels (Savić & Živković, 2024).

In reference to the long-term interest in integrating English with STEM Day activities, sample learners expressed *moderate* to *high* interest (item 3, M between 2.76-3.91). Regarding the integration of English with individual STEM disciplines, the interest was positive only for science (item 12, M between 2.82 – 3.61), while for the other three disciplines, it varied a lot depending on sample learners' age, being positive for AG1 (items 6, 9, & 15, M between 3.39 –4.00) and negative for AG2 (items 6, 9, & 15, M between 2.24 – 2.53). This aspect of research will be discussed in relation to RQ2.

The Effects of Age on Sample Learners' Interest for Integrated English and STEM

To answer the question related to the effect of age on sample learners' perceptions, their interest was measured for all five areas in the form of separate scores per two age groups (see *Table 3*). The findings show that younger sample learners (AG1) were more interested in English and STEM disciplines than the older ones (AG2), the largest interest gap between them being for technology (items 7 & 8), where AG1 expressed *very high* interest, while AG2 showed only *moderate* interest. Regarding motivation for English (item 1), AG1 expressed *very high* motivation, while AG2 indicated *moderate* motivation. Noticeable

differences in motivation between the two age groups were also reported for engineering (items 12 & 13) and science (items 10 & 11), with AG1's motivation being consistently *high*, and AG2's motivation *moderate*, approaching *low* (negative) interest for engineering. Both groups expressed *moderate* motivation (item 5) for mathematics, while their awareness (item 4) differed, being *moderate* for AG1, but *low* for AG2. The higher preferences for STEM disciplines of younger learners are in line with previous studies (Mahoney, 2010; Puška et al., 2023; Zhang et al., 2021) and may have been the result of less complex STEM content in grade 5 curriculum as compared to grade 7 STEM subjects curriculum, especially for mathematics, that fostered younger sample group's self-confidence (Savić & Živković, 2024).

AG1 also expressed a highly positive interest for integration of English with technology, science and engineering (items 9, 12 & 15), while AG2's interest was negative for technology and engineering (items 9 & 15), and moderate for science (item 12). Mathematics received the least interest of all STEM areas, which was *moderate* for AG1 (items 4, 5 & 6), and negative, i.e. *low,* for AG2 (items 4 & 6). Generally, the younger sample group expressed more positive interest regarding language-integrated STEM than the older sample group, with the largest interest gap expressed for engineering. These findings are partly in line with previous studies documenting STEM age-related differences in learner attitudes (Puška et al., 2023; Zhang et al., 2021). They indicate that younger learners may have been more open to STEM education and the use of English in STEM activities, or that their experience in STEM Day activities was more favorable (Savić & Živković, 2024).

Mann-Whitney test showed that there was a statistical significance concerning age only in scores on interest towards technology (U=79.500, Z= -3.311, p=.001), while the difference in interest toward English, mathematics, science, and engineering was not statistically significant. This is in contrast to some previous studies that found statistically significant more positive attitudes of younger learners only for mathematics (Mahoney, 2010), but corroborates some other studies (Puška et al., 2023).

The Effect of Gender on Sample Learners' Interest for Integrated English and STEM

To answer the third research question, we measured differences in sample learners' interest in English and STEM disciplines in terms of gender. Table 5 shows the mean values and standard deviations of scores in all five areas for girls (1) and boys (2) in the whole sample and for two separate age groups (AG1 & AG2).

Table 4: Differences in means of scores on interest in English and STEM disciplines for girls (gender 1) and boys (gender 2) for the whole learner sample (N=40) and for two age groups (AG1, N=23; AG2, N=17) (on a scale 1 – 5, from strongly disagree to strongly agree).

No.	Content area		Learner sample N=40		AG1 N=23		AG2 N=17	
		Gender	M	SD	**M**	**SD**	**M**	**SD**
1.	English	1	3.52	1.365	3.77	1.235	3.13	1.553
		2	**4.26**	.872	**4.50**	.707	**4.00**	1.000
2.	Mathematics	1	2.48	1.436	2.23	1.235	**2.88**	1.727
		2	**3.21**	1.475	**3.80**	1.229	2.56	1.509
3.	Science	1	**3.62**	1.203	**3.77**	1.235	3.38	1.188
		2	3.58	1.121	3.60	1.350	**3.56**	.882
4.	Technology	1	3.19	1.436	3.77	1.481	2.25	.707
		2	**4.21**	1.182	**4.90**	.316	**3.44**	1.333
5.	Engineering	1	**3.48**	1.470	**3.62**	1.446	**3.25**	1.581
		2	3.11	1.370	3.60	1.350	2.56	1.236

It can be seen in *Table 4* that sample boys expressed more positive perceptions of English and technology in all three measures, while girls had more positive attitudes toward engineering in all three measures. Mann-Whitney test for the whole sample showed that the difference in interest towards technology was statistically significant (U=115.500, Z= -2.373, p=.018). In the younger sample, statistical difference based on gender was significant for interest toward mathematics (U=25.000, Z= -2.549, p=.011) and technology (U=30.000, Z= -2.494, p=.013), boys expressing more positive interest in these two disciplines, which corroborates previous studies (Erkut & Marx, 2005). Regarding the older group, Levene's Test for Equality of Variances and the t-test for Equality of Means showed that there was a statistically significant difference in attitudes towards technology between girls and boys (t(15)= -2.261, p=.039). It can be concluded that although there were differences in attitudes towards all four STEM areas and for English between girls and boys, the gender difference proved to be statistically significant only for technology and mathematics. These findings corroborate some earlier studies (Erkut & Marx, 2005; Mahoney, 2010), but are contrary to some other studies (Puška et al., 2023), asking for more research in the area.

Sample Teachers' Perceptions of Integrating English and STEM Disciplines

Teacher STEM Survey provided two sets of data: I. sample teachers' perceptions of the effectiveness and benefits of integrating English with STEM disciplines in STEM Day activities (see *Table 6*, items 1 – 11); II. sample teachers' perceptions of the challenges of planning and organizing STEM Day activities (see *Table* 6, items 12-19). As all items were positively phrased, the higher the score on a five-point scale (ranked 1 – 5, from *strongly disagree* to *strongly agree),* the higher agreement of the sample. The participants evaluated three aspects of STEM Day activities *very high* (M>4.21): integrating English and science at appropriate grade level, and encouraging learners to communicate in English while doing activities and working on tasks. These data support sample learners' highly positive attitudes to science and the integrated English and science curriculum described above. The other aspects were evaluated *high* (3.41<M<4.20): integrating mathematics at appropriate grade level, encouraging learners to use English to express their opinion, ask questions, communicate science and mathematics concepts, express engineering thinking, and find information on the internet. It can be concluded that sample teachers rated their experiences in STEM Day activities and the role of English rather positively, which is in line with the findings of studies of teacher STEM perceptions (Boice et al., 2021).

Regarding sample teachers' rating of their experiences of planning and organizing STEM Day activities, the participants' agreement was *very high* (M>4.21) about the following requirements: collaboration of teachers of different STEM and non-STEM school subjects (item 12); a lot of extra time and engagement (item 14); and co-teaching by the English teacher and STEM teachers (item 16). Their agreement was *high* (3.41<M<4.20) in relation to the need for the English teacher to learn concepts from STEM school subjects and to design new teaching materials. They also agreed that an extra budget for STEM Day activities was not needed, as the activities were inexpensive and did not require a large space with computers and the internet. These findings are in line with studies about successful STEM programs in low-resourced learning and teaching environments (Nawaz et al., 2023) and indicate sample teachers' highly positive attitudes to STEM Day experiences.

Table 5: Results from Teacher STEM Survey (N=7) on a scale of 1 – 5, from strongly disagree to strongly agree).

	I. STEM Disciplines		
No.	Item	**M**	**SD**
1.	STEM Day activities integrated mathematics concepts that are grade-level appropriate.	4.14	1.464
2.	STEM Day activities integrated science concepts that are grade-level appropriate.	4.29	1.496
3.	STEM Day activities integrated English skills that are grade-level appropriate.	4.43	1.512
4.	STEM Day activities encouraged learners to use English in communication.	4.29	1.496
5.	STEM Day activities encouraged learners to express their opinions in English.	4.14	1.464
6.	STEM Day activities required learners to ask questions in English to justify their opinions in English.	4.00	1.414
7.	STEM Day activities required learners to communicate science concepts (e.g., oral, written, or using visual aids such as charts or graphs) in English.	3.86	1.676
8.	STEM Day activities required learners to communicate engineering thinking in English.	3.71	1.604
9.	STEM Day activities required learners to communicate mathematics concepts in English.	3.71	1.890
10.	STEM Day activities require learners to use technology to solve a problem.	3.57	1.813
11.	STEM Day activities required learners to use technology to find information in English for the solution of a problem.	3.86	1.952
	II. STEM Day Planning and Organization		
No.	Item	**M**	**SD**
12.	Planning STEM Day activities required teachers of different school subjects to collaborate.	4.43	1.512
13.	Planning STEM Day activities required an English teacher to learn concepts from STEM school subjects.	3.86	1.464
14.	Planning STEM Day activities required a lot of extra time and engagement of the participating teachers.	4.43	1.512
15.	Planning STEM Day activities required designing new teaching materials.	4.00	1.414
16.	Organizing STEM Day activities required co-teaching by the English teacher and STEM teachers.	4.43	1.512
17.	Organizing STEM Day activities required an extra budget.	2.00	1.528
18.	Organizing STEM Day activities was expensive.	1.86	1.464
19.	Organizing STEM Day activities required a large space with computers and the internet.	2.43	1.512

CONCLUSION

Foreign language learning pedagogy advocates for contextual language teaching through the introduction of real-world issues into the language classroom (Shin et al., 2021). STEM education offers highly appropriate conditions for such integration primarily by responding to language learners' variety of interests and their natural curiosity. The study measured primary learners' perceptions towards integrating English and STEM, based on their experiences in STEM Day activities provided in a primary school context in Serbia. The perceptions were evaluated in terms of learners' interest in English and STEM subjects, and for their integration. The results showed that sample learners exhibited mostly positive perceptions, but their level of interest varied greatly in relation to their age. While younger sample learners expressed *very high* and *high* interest in English, science, technology, and engineering, and *moderate* interest in mathematics, older sample learners exhibited *high* interest only in science, *high* to *moderate* in English, *moderate* for technology and engineering, and *low* to *moderate* for mathematics. The interest gap was even broader in measures for integration of English with STEM content areas, being consistently *high* for younger sample learners, but *moderate* to *low* for older ones.

Although in our study statistical significance was detected for two age groups only for the content area of technology, and not for mathematics, science, and engineering, it is important to stress that younger sample learners exhibited higher levels of interest in these content areas and also for integration of English with each of them. Moreover, there were statistically significant differences in perceptions resulting from gender differences, with boys expressing a higher interest in technology and mathematics. It may be concluded that interest in English and STEM disciplines diminishes with age, especially the interest for integration of English with STEM subjects in STEM Day activities, and that gender also plays an important role in shaping primary learners' interest in STEM content areas, with boys expressing statistically significant more positive interest in technology and mathematics, and girls in engineering. The results related to sample teachers' perceptions towards integrating English and STEM disciplines support high interest of the sample in science, but do not reveal any factors responsible for older sample learners' lower levels of interest in STEM disciplines, and English and STEM integrated teaching. It is significant to point out the results regarding sample teachers' positive perceptions of introducing English and STEM, their enthusiastic approach to applying this innovative approach to teaching their respective content areas, and their commitment to organizing STEM Days in the future.

The results of this study cannot be generalized mainly because they are too context-specific and the samples were too small. In the future, larger and more varied primary learner and teacher samples should be surveyed. Also, interest in integrated English and STEM should be studied through primary learners' achievement in English and STEM school subjects to determine the effectiveness of the approach, especially to reveal how English and STEM integration foster language development and STEM content understanding. Moreover, longitudinal studies should be conducted to confirm or disconfirm the influence of age and gender factors on primary learners' interest in English and STEM. The findings of our study call for raising primary teachers' awareness of the positive interest of younger learners in integrated STEM curriculum, and of the need to regularly expose language learners to STEM Day activities so that their positive interest is sustained. Also, teachers should be aware that their encouragement may be crucial for enhancing the levels of older learners' interest in English and STEM integration, and for fostering girls' more positive attitudes toward science, mathematics, and technology. Positive perceptions of both learners and teachers in our study are promising.

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