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Perceived Ability and Value of Integrated English and STEM Disciplines: A Perspective from Primary Learners in Serbia

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Abstract

The study aimed to measure primary learners' perceived ability and value of integrated English and STEM, drawing from their experience in STEM Day activities. Being an innovative approach that integrates content from four disciplines in inquiry-based, learner-centred, collaborative, meaningful and purposeful classroom activities, STEM lends itself perfectly to integration with English as a foreign language. Studies show that learners' attitudes affect the effectiveness of the approach, and that age may be a significant factor for its success. To determine how participation in STEM Day activities was viewed by learners in terms of perceived ability and value for STEM and English integrated learning, the purposive sample of 40 primary school learners (distributed into two age groups: AG1, 11-year-olds; AG2: 13-year-olds) from a state school in Serbia was asked to rate their experience on a five-point attitude scale with 20 closed items and 5 open-ended questions. The results showed that perceived ability and value varied across disciplines and learner ages. Both age groups rated their self-confidence higher than their skills for English and STEM disciplines, but younger learners expressed consistently positive attitudes in terms of perceived ability and value, while the older age group regarded the experience valuable only for developing their English and science skills, seeing no value for engineering, technology and mathematics. It is concluded that STEM and English integration should be more explicit and supported for the learners, and should begin early in primary education. The implications for STEM curriculum and teacher professional development are suggested.

Key Words: primary language learners, English and STEM integration, STEM-Day activities, learners' perceived ability and value, age factor.

Introduction

In the area of interdisciplinary approaches in education, STEM stands out as a political and social initiative closely tied to industry and economic development (Chesky & Wolfmeyer, 2015). European Commission (2007) highlights the importance of strengthening science education in European countries as a needed response to the decline of young people's interest in mathematics and science, believed to be mainly the result of the way science is taught in schools. STEM refers to interdisciplinary teaching that integrates Science, Technology, Engineering and Mathematics, as the key STEM content areas, in the way that requires learners to transfer knowledge and skills among the disciplinary areas. The benefits of STEM education have made the approach attractive for teaching other school subjects, such as foreign languages, social sciences, fine arts and physical education, resulting in broadening the science areas with humanities, and consequently changing the acronym to STEAM (with art component added) and STREAM (both art and reading added to te key areas). The English language, which is considered as a non-STEM subject area, has increasingly been integrated with STEM (Banerjee, 2016; Sultana et al., 2021; Tang et al., 2021). This is in line with the shift towards socially oriented view of learning English as a foreign language (EFL) that sees language learning as a means of communication and a medium for acquiring information and knowledge through purposeful and meaningful language use in social interaction.

However, in spite of the increased interest in providing learners with experiences that foster mastery of integrated content knowledge and English, there is still not enough information on how STEM integration can be best practised, especially with primary learners. Moreover, little is known about the effectiveness of primary STEM to "increase student learning, interest, retention, achievement, or other valued outcomes" (Honey et al., 2014, p. 2), or about the role of EFL in primary STEM education and how it is viewed by primary learners. Research suggests that learners' perceptions on introducing integrated English and STEM education may play a key role in the success of STEM education (Tang et al., 2021; Trott & Weinberg, 2020). Still, there is a dearth of research on how primary learners' attitudes are affected by their experience of EFL integration with STEM education, and how learners' age and gender influence their attitudes. STEM experience may be provided by a STEM curriculum, or by STEM activities embedded in traditional curriculum. The main aim of the paper is to reveal how STEM Day activities held in a state primary school in Serbia shaped learners' attitudes related to EFL and STEM education, and how learners' age influenced these attitudes in terms of perceived ability and value.

Literature Review

STEM Pedagogy and Language Learning

Since the 1990s, when the acronym STEM was developed in the USA, there have not been any fixed definitions of the term STEM. The main reason is the multitude of interpretations of both STEM education and STEM integration (English, 2016). Nevertheless, the interdisciplinary teaching of science, technology, engineering and mathematics is presently widely understood as providing integrated experiences in which learners are working "in the context of complex phenomena or situations on tasks that require students to use knowledge and skills from multiple disciplines" (Honey et al., 2014, p. 52). Primary curriculum may embed STEM through project-based learning, problem-solving activities, inquiry-based activities, gamification, and hands-on activities applied in real-world situations. Solving real-life problems in and out of the classroom can make STEM fields alive, meaningful and authentic for the learners, inspire their engagement, and increase their motivation. Being learner-centred, STEM activities encourage learners to transfer their disciplinary knowledge and skills to new situations and to connect concepts from different areas. Such integration has been found effective "because basic qualities of cognition favor

connected concepts over unconnected concepts so they are better organized for future retrieval and meaning-making" (Honey et al., 2014, p. 2).

In formal school environments, STEM activities are usually organised as teamwork with learners working collaboratively on problem-solving. The inquiry-based approach in group activities facilitates the construction of understanding in social interaction. Adding English as a tool for interaction, information gathering, and presentation and discussion of results, aligns with "developmental and learning sciences research to better support children's learning" (Bermudez et al., 2023, p. 213) advocating purposeful and meaningful use of a foreign language in authentic life-like environments (Shin et al., 2021). For example, creating a school garden may provide a rich integrated, experiential, and collaborative context for STEM and English learning. However, the cognitive load learners experience may shape their perceptions of the role of English in learning multi-disciplinary content and affect their persistence in STEM education (Sultana et al., 2021). It is therefore crucial to monitor and assess learners' progress, provide adequate scaffolding when needed, and reflect on the learning process. How learners view their own STEM experience may be a key to the success of integrating English and STEM teaching and learning.

Language Learners' Attitudes to STEM Education

Measuring the effectiveness of STEM programmes has focused on identifying the key factors that contribute to success in STEM education, with learners' attitudes being of key importance. STEM attitudes consist of cognitive and affective components related to STEM and English integrated curriculum, some of them being learners' proficiency in English and their interest in learning (Trott & Weinberg, 2020). Research has found a variety of primary and secondary learners' attitudes related to their gender, age, grade, learning interest, proficiency in English, classroom climate, pedagogical approach and cultural diversity: for example, younger learners and boys seem to hold more positive attitudes to specific STEM disciplines (Mahoney, 2010; Puška et al., 2023), supportive classroom climate was found to enhance comprehension (Tang et al., 2021), while proficiency in English was reported to contribute to learners' engagement and self-confidence in participating in integrated activities (Tang et al., 2021).

Mahoney (2010) specifically focused on learners' attitudes as affective indicators of successful STEM programmes and set out to develop an instrument capable of measuring learners' response to a change caused by STEM integration in school settings. The process led to the identification of three key components related to the construct of attitudes: interest, perceived ability, and value. Interest was seen to relate to awareness and curiosity, perceived ability referred to capability and confidence, while value was associated with usefulness and significance (Mahoney, 2010). For each of the components the author developed a series of statements and a four-level scale for measuring learners' attitudes, such as *I am good at science/ technology /engineering/ maths* for perceived ability, and *Learning science/ technology/ engineering/ maths will help me*, for measuring value. The author used this scale with different age groups of learners in two types of secondary schools to measure the learners' attitudes toward all STEM content areas. The results showed statistically significant more positive attitudes of the younger learners only for mathematics. However, while some other studies have also shown that younger learners exhibit more positive attitudes to STEM-integrated learning (Puška et al., 2023;), there has been research that did not find any differences in aspirations of learners of different ages (Archer et al., 2012). Some studies showed that sustained STEM experience significantly enhanced learners' attitudes toward science (Erkut & Marx, 2005), and that learners' connected their value of STEM disciplines to their own perception of the usefulness of each STEM area in everyday life and future career (Leonidas de Oliviera et al., 2022). Obviously, exposure to STEM activities can be a powerful way of improving learners' attitudes to integrated teaching and to the effectiveness of STEM programmes, but it is still not conclusive if attitude to STEM becomes less positive with learners' age.

STEM in Serbian Primary Education

STEM is important for learners in a country such as Serbia, whose economy is still developing slowly. However, STEM as a concept is not mentioned in Serbian legal documents regulating primary education (law and bylaws). Nevertheless, the need for a cross-curricular approach to teaching and the requirement for developing learners' cross-curricular competencies is explicitly stated both in legal documents and in school programmes and plans. Since the 2022-2023 school year learners in the upper-primary grades (5th to 8th, ages 11-14) can choose elective activities offered by schools within the new Amendments to the Bylaw document comprising the Framework for Elective Activities (Eurydice Unit Serbia, 2022; MoESTD, 2021). These activities are cross-curricular in nature and are not attached to any specific subject content area. They comprise 36 lesson periods of 45 minutes a year and are compulsory for all learners. As clarified by the Bylaw document (MoESTD, 2021), the elective activities are to be realised according to a specifically designed school plan and timetable, so that learners from different classes and grades can join, collaborate, interact, communicate, share ideas and learn from each other. Significantly, the Framework for Elective Activities maps aspects of STEM education, such as inquiry-based, problem-based and project-based learning, and the focus on developing the 21st-century skills.

Changes in education often depend on teachers' readiness to introduce innovative approaches. Significantly, "effective and sustainable change happens when there is a consensus among all stakeholders that the new goals are a moral imperative" (Fullan & Langworthy, 2013, p. 7). This often requires teachers "to quickly acquire new pedagogical skills, to effectively introduce novelty into their classrooms, and to transform their attitudes and abandon some of their practices" (Savić et al., 2020, p. 251). The process can be made easier if there is targeted professional development for preparing teachers to manage change with confidence and success. That was the path one of the coauthors of this paper had taken before she introduced STEM and English-integrated activities as STEM Day projects. As a practising primary EFL teacher, she completed an international STEM professional development programme offered as an online MOOC by the European Schoolnet Academy. In collaboration with subject teachers of physics, technology, geography, and English, and two class teachers, all working in the same state primary school in Serbia, she conducted two STEM Days with two learner groups: 1. Maths Pirates and the Lost Treasure, a STEM Day in which English was integrated with mathematics, home economics and technology, with a series of STEM activities of total duration of 225 minutes, including the learners' discussion with a bank manager (European Schoolnet Academy, 2023); 2. Aerospace in Class, a STEM Day integrating English with science, mathematics and engineering as a flipped classroom method, involving the individual design of a moonbase or a house on the Moon within the Airbus Foundation Discovery Space project. The learners who participated in these STEM activities were invited to take part in the present study.

Aim of the Study and Research Questions

Although the above mentioned STEM Day activities have not been the only opportunities for learners in Serbia to experience STEM education related to the Framework for Elective Activities, there is a complete absence of studies documenting the effectiveness of this practice. Moreover, there have been no studies on primary learners' attitudes related to STEM content integration or to integration of English and STEM disciplines. The only study dealing with cross-curricular English language teaching in primary education in Serbia we are aware of focused on primary English language teachers' attitudes of and practices in theme-based language instruction in lower primary grades, conducted by Savić et al. (2020). To fill in the research gap in this area and to gain an insight into how primary learners view their STEM experiences, the present study aimed to measure learners' perceived ability and value of integrated English and STEM, based on their experience in STEM Days conducted by one of the authors of the paper. Two research questions were designed:

RQ1: What is Serbian primary learners' perceived ability of integrated English and STEM disciplines and how does age affect it?

RQ 2: What is Serbian primary learners' value of integrated English and STEM disciplines and how does age affect it?

Based on previous research (Erkut & Marx, 2005; Mahoney, 2010), it was expected that sample learners would exhibit varied, but positive, perceived ability and value ratings in relation to integrated English and STEM disciplines and that learners' age would have a slight impact on the ratings.

Research Methods

Research Design

We hereby report part of the results collected in an extensive study that focused on a number of aspects of the STEM experience. Specifically, this paper reports and discusses the results related to learners' perceived ability and value of integrated English and STEM-related subjects. We employed a mixed-method design and collected both quantitative and qualitative data in the survey. Quantitative results helped us to measure the levels of the learners' perceived ability and value, and to compare the results from two age groups, while content analysis of qualitative data provided more insight into reasons behind perceived ability and value results.

Participants

The study involved 40 primary school learners (termed 'learner sample') drawn from two classes in a state school and distributed into two age groups (AG) (see Table 1): 1. AG1 involved 23 learners aged 11, all in the 5th grade, 56.5% were girls; 2. AG2 had 17 learners aged 13, all in the 7th grade, 47.1% were girls. The sampling was purposive and only the learners who had participated in STEM Day activities held in the school in English within the regular curriculum were invited to take part in the study.

Table 1 *Demographic characteristics of the learner sample distributed into two age/grade groups (AG)*

Learner Sample AG	N	Girls N (%)	Boys N (%)	Age	Grade
AG1	23	13 (56.5)	10 (43.5)	11	5
AG2	17	8 (47.1)	9 (52.9)	13	7
Total	40	21 (52.5)	19 (47.50)	-	-

As the English primary curriculum prescribes two lessons of English a week throughout primary education, from grade 1 (age 7) to grade 8 (age 15), all sample learners' English language study involved a total of 72 lessons per school year, starting from grade 1 (Eurydice, 2023).

Instrument

The attitude scales were designed by the authors of the paper drawing on several sources (Erkut & Marx, 2005; Mahoney, 2010). The perceived ability and value scales were adapted from Mahoney (2010) scales for English and four STEM content areas to finally comprise four items for each of the five areas, i.e. a

total of 20 items, 10 referring to perceived ability (skills and self-confidence), and 10 to value (career and improved understanding of content areas). The statements for assessing perceived ability were: a) *[subject] is easy*; b) *I am good at [subject]*; the statements for measuring value were: c) *Knowing [subject] will help me in my future career*; d) *Participation in STEM Day activities helped me improve my [subject]*. All the items were given in area clusters (titled English, Mathematics, Technology, Science. and Engineering) as positively phrased statements, ranked on a five-point Likert scale: 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree. The survey also comprised five open-ended questions asking learners to illustrate and interpret their STEM experiences in terms of their contribution to enhanced understanding of English academic language and concepts in the areas of science, mathematics, technology and engineering related to STEM Day activities. The survey had a separate section with questions for collecting demographic information. To ensure full understanding of the items and questions, the survey was in Serbian, i.e. in the learners' native language, and the answers to open-ended questions were also given in Serbian.

Data Collection Methods

The survey was created as a Google Form to be filled in online. One of the researchers distributed the survey links to the participants as QR codes and collected responses in regular classes she taught on school days in February 2024. Ethical requirements for doing research with children and teenagers were met by providing a detailed textual explanation of the study at the beginning of the Google Form survey, preceded by the authors' general oral introduction. Before accessing the survey, the respondents were asked to give an informed consent regarding the free decision to participate in the study. Each participating learner responded to 20 items and additionally answered five open-ended questions. In the course of doing the survey, the researcher provided clarifications to the learners in relation to the survey items, when needed.

Data Analysis Techniques

The collected data were analysed quantitatively and qualitatively. Statistical analysis of attitude scale results was carried out with SPSS for Windows, version 23.0, and the results were shown as percentages and comparable median (M) and standard deviation (SD) values. Medians related to the agreement with the items were interpreted using the following group boundary values of a five-point Likert scale (Narli, 2010): 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. These group boundary values were used to compare sample learners' perceived ability and value among different STEM disciplines, and between age groups at three levels: 1. low, median being $1.00 < M < 2.60$; 2. moderate, median being $2.61 < M < 3.40$; and 3. high, median being $3.41 < M < 5.00$. Low ratings were considered negative, while moderate and high ones were interpreted as positive. The responses to open-ended questions were analysed by applying thematic analysis of the content. The themes that emerged from the analysis were: 1. types of activities the learners experienced success in; 2. value of individual STEM activities for learners' future careers. These answers provided explanations to support the quantitative results.

Results

The findings are organised into two sub-sections related to the study research questions. Table 2 shows the results of sample learners' perceived ability and value scores (expressed as M and SD scores) of integrated English and STEM disciplines per two age groups. Items 1, 2, 5, 6, 9, 10, 13, 14, 17 and 18 refer

to perceived ability in English, mathematics, technology, science and engineering, while all the other items refer to value in the same areas.

Table 2 *Learners' perceived ability and value scores (M and SD) of integrated English and STEM disciplines per two age groups (AG1 & AG2) (on a scale 1-5, from strongly disagree to strongly agree)*

No.	Item	Age Group	M	SD
	English Language Learning			
1.	English is easy.	AG1	4.17	1.072
		AG2	3.71	1.213
2.	I am good at English.	AG1	4.22	1.085
		AG2	3.76	1.091
3.	Knowing English will help me in my future career.	AG1	4.57	.896
		AG2	4.00	1.225
4.	Participation in STEM Day activities helped me improve my English.	AG1	3.70	1.259
		AG2	2.71	1.448
	I. Mathematics			
5.	Mathematics is easy.	AG1	3.48	1.310
		AG2	2.88	1.364
6.	I am good at mathematics.	AG1	3.91	1.125
		AG2	3.41	1.583
7.	Knowing mathematics will help me in my future career.	AG1	3.26	1.630
		AG2	3.18	1.380
8.	Participation in STEM Day activities helped me understand mathematics better.	AG1	2.83	1.497
		AG2	1.94	1.249
	II. Technology			
9.	Technology is easy.	AG1	4.17	834
		AG2	2.65	1.320
10.	I am good at using technology.	AG1	4.52	.947
		AG2	3.35	1.272
11.	Knowing Technology will help me in my future career.	AG1	4.48	.994
		AG2	3.18	1.468
12.	Participation in STEM Day activities helped me understand Technology better.	AG1	3.57	1.590
		AG2	2.18	1.185
	IV. Science			
13.	Science is easy.	AG1	3.39	1.118
		AG2	3.35	.862
14.	I am good at science.	AG1	4.30	.822
		AG2	3.82	.951
15.	Knowing science will help me in my future career.	AG1	3.48	1.344
		AG2	3.53	1.179
16.	Participation in STEM Day activities helped me understand science better.	AG1	3.13	1.517
		AG2	2.82	1.425

No.	Item	Age Group	M	SD
V. Engineering				
17.	Engineering is easy.	AG1	3.87	1.254
		AG2	2.47	1.231
18.	I am good at engineering.	AG1	3.83	1.154
		AG2	2.88	1.364
19.	Engineering skills will help me in my future career.	AG1	3.48	1.563
		AG2	2.47	1.068
20.	Participation in STEM Day activities helped me understand engineering better.	AG1	3.26	1.544
		AG2	2.41	1.326

RQ1 - Serbian primary learners' perceived ability of integrated English and STEM disciplines and the age factor

Perceived ability was measured in each of the five areas, showing high scores of all sample learners only for English (M between 3.71-4.22). In STEM areas the perceived ability varied and was moderate to high for mathematics (M between 2.88-3.91), technology (M between 2.65-4.52), and science (M between 3.35-4.30), and from low to high for engineering (M between 2.47-3.87). The findings also show that AG1 rated their self-confidence and skills in English and all four STEM disciplines much higher than AG2, the largest gap between age groups being for technology (item 10 - AG1: M = 4.17, AG2: M = 2.65), and the smallest gap shown for the skills in science (item 13 - AG1: M = 3.39, AG2: M = 3.35), with less dispersion seen in responses of AG2 (SD=.862) for this area. Overall, both groups reported higher ratings for their self-confidence (items 2, 6, 10, 14 and 18) than for their skills (items 1, 5, 9, 13, and 17) for the five areas. In terms of perceived ability, AG1 found science the most challenging, while for AG2 engineering was the most challenging STEM discipline.

These findings were supported by responses to open-ended questions. AG1 provided a wide spectrum of types of STEM Day activities they enjoyed and a number of reasons for appreciating them, many of which referred to newly acquired skills and the feeling of success related to doing them. The most popular activities seemed to be coding the map for treasure hunt and the interactive apps applied for quizzes. The reasons provided for enjoying these and other activities were their novelty, learning something new, success in completing the tasks, possibility to support understanding by visually presenting difficult content, having fun, possibility of using English in fun activities, opportunities for using imagination, and experiencing freedom in creating and drawing. On the contrary, AG2 had difficulty to select favourite STEM activities, some of and the participants seemed to be focused on difficult content in chemistry and physics and on a heavy theoretical approach to acquiring skills in technology. They had divided opinions in relation to the integration of English and STEM areas, and while some appreciated the opportunities for learning complex concepts in English, others criticised the approach as ineffective and frustrating. The activities that a small number of participants in AG2 enjoyed included the creative design of the house on the Moon and Scratch design, which they described as interesting. These qualitative data mapped the quantitative results for these two age groups (see Table 2) and supported their rather different attitudes.

RQ2 - Serbian primary learners' value of integrated English and STEM disciplines and the age factor

The component of value that sample learners attached to STEM content areas and to their own experience in STEM Day activities for facilitating understanding of the content and for their future career was rather

varied: it differed a lot for specific STEM areas and age groups (see Table 2 for M and SD values). Regarding the contribution of the integrated English with STEM learning experience for improving the knowledge and skills of the learners, the rating was positive only for English and science and ranged from moderate to high (items 4 and 16) for both age groups, with more positive attitudes expressed by younger sample learners (AG1). Although AG1 learners expressed a general lack of perceived ability in science, they valued science highly for their future careers. Moreover, AG1 also exhibited positive values for the other STEM-related subjects: high value for technology (item 12: M = 3.57), and moderate value for engineering (item 20: M = 3.26) and mathematics (item 8: M = 2.83). On the other hand, AG2 expressed negative, i.e. low, value for engineering (item 20: M = 2.41), technology (item 12: M = 2.18) and mathematics (item 8: M = 1.94). Generally, younger learners viewed their participation in STEM Day activities as valuable for improving their skills in English and STEM-related subjects, while AG2 regarded the experience valuable only for developing their English and science skills, and saw no value for engineering, technology and mathematics. This is contrary to previous studies that showed learners' low perceived ability in science and mathematics, but high value for both disciplines for their future career (Leonidas de Oliviera et al., 2022).

However, when evaluating the prospective use of knowledge and skills in STEM areas and English in their future careers, all the participants expressed rather positive value attitudes (see Table 2). They rated the value of EFL knowledge and skills for their future career as high (item 3: AG1: M = 4.57; AG2: M = 4.00), of science high (item 15: AG1: M = 3.48; AG2: M = 3.53), and of mathematics moderate (item 7: AG1: M = 3.26; AG2: M = 3.18). On the other hand, the age groups exhibited divided opinions in regards to rating the value of technology and engineering for the future career, which AG1 valued as high (item 11: M = 4.48; item 19: M = 3.48), and AG2 as moderate (item 11: M = 3.18; item 19: M = 2.47). Obviously, AG1 had more positive attitudes and enthusiasm for applying English and STEM-related content in the future. Comparison of ratings for perceived ability in and value for individual STEM disciplines for future career showed balanced results for both age groups of sample learners: they rated their perceived ability higher than the value for their future careers for all STEM disciplines, and only rated the value of English higher than their perceived ability in English. This was confirmed by qualitative analysis of answers to open-ended questions: while some learners in AG1 stated they would need the content from mathematics and science in their careers, AG2 expressed doubt that they would need knowledge from STEM disciplines in their careers and considered STEM skills not so relevant for their future life.

In conclusion, sample primary learners' varied perceptions of integrated English and STEM curriculum was age dependent and younger learners expressed more positive attitudes in terms of perceived ability in and value of these areas.

Discussion

The results will be discussed in two subsections related to the subsections in the Results section.

RQ1 - Serbian primary learners' perceived ability of integrated English and STEM disciplines and the age factor

In general, all sample learners had high perceived ability in English, moderate to high in science, mathematics, and technology, but low to high in engineering. Also, they perceived their self-confidence as higher than their skill in all these disciplines, which may be the result of sample learners' positive experiences in STEM activities as opposed to their evaluation of their own mastery of the complex content of STEM disciplines. Considering the fact that AG1 exhibited higher perceived ability for mathematics, technology and engineering than AG2, it can be concluded that this may have been the result of less difficult content of these STEM areas for younger sample learners and/or more enjoyable STEM Day activities they had participated in. Apart from that, it could also be the outcome of the quality

and extent of scaffolding provided by teachers of these STEM-related subjects (van Driel et al., 2018), which corroborates the results of previous research (Mahoney, 2010; Puška et al., 2023). The variations in confidence may have been caused by the difference in required previous knowledge in these STEM areas. Negative perceived ability for engineering expressed by the older group of learners may have been caused by the demanding hands-on task that required not only knowledge in STEM disciplines but also patience and persistence in creating the model of a Moon house.

On the other hand, both age groups rated their knowledge and skills in science as moderate in spite of the difference in difficulty of content for AG1 as compared to AG2, which may indicate that both age groups felt similarly cognitively challenged and in need of some support in mastering the content, which is in line with the results of previous studies on the importance of teachers' STEM pedagogical skills (Tang et al., 2021). Since both age groups rated their skills in English as high, indicating their satisfaction with proficiency in knowing and using the foreign language, this may indicate that the EFL teacher's pedagogical strategies and scaffolding she provided in cross-curricular language use was appropriate (Tang et al., 2021). It can be concluded that learners' perceived ability may depend on age and STEM integration experience and is closely connected to positive or negative experience in school (Leonidas de Oliveira et al., 2022).

RQ2 - Serbian primary learners' value of integrated English and STEM disciplines and the age factor

The experience of integrated English and STEM-related subjects was interpreted differently in terms of value sample learners attached for personal development in each discipline. Generally speaking, sample learners rated the value of individual STEM disciplines higher than their perceived ability in each of them, which indicates that they probably connected their value of each STEM discipline with its usefulness in life and career. However, variations in value attitudes between the two age groups were obvious. While AG1 expressed enthusiasm and positively rated the value of STEM experience for their growth in English and all STEM disciplines, AG2 positively rated the value of STEM Day participation only for their proficiency in English and science, seeing no value for technology, engineering and mathematics. This may be related to the differences in the difficulty of the content in STEM areas for two age groups, but also to the way these disciplines were regularly taught to 7th-grade primary learners in a particular setting in Serbia (European Commission, 2007), or how supportive the classroom climate was (Leonidas de Oliveira et al., 2022; Tang et al., 2021). The STEM and English integrated experience had been a unique one for the participants of the study, not sustained for a longer time to allow the development of needed learning strategies and autonomy, and probably could not be considered by the participants as a practice all the respondents viewed beneficial in terms of value (Erkut & Marx, 2005). The type of STEM activities experienced by AG1 may have been more interesting and rewarding, or the group may have received adequate support while doing the activities, as compared to AG2. Consequently, while younger sample learners viewed the value of integration for their academic growth through a positive lens, AG2 may have considered the STEM activities they had performed too cognitively and/or linguistically demanding and/or may have received too little or no support by the STEM teachers to positively rate the value for mathematics, technology and engineering. Furthermore, sample learners may not have been aware of their own learning that had taken place or able to self-assess their own achievement in collaborative STEM activities.

Considering the career value ratings of integrated STEM and English, sample learners' high value for English proficiency is in line with global trends of using English as an international language of communication in trade and business (European Commission, 2007), and reflects sample learners' awareness of the role of English in the globalised world. Regarding the high or moderate value rating for science, technology, engineering and mathematics for career development expressed by both age groups, this may indicate sample learners' awareness of the universal importance of STEM content

knowledge and skills and of their real-life applicability experienced in STEM Day activities, revealed in AG1's answers to open-ended questions, such as using mathematics and technology to convert different money currencies and discussing home economics with a bank expert. This corroborates previous research highlighting the everyday and career applicability of STEM disciplines (Leonidas de Oliviera et al., 2022). The findings are in line with previous studies (Leonidas de Oliviera et al., 2022; Mahoney, 2010; Puška et al., 2023) and indicate the learners' age as a significant factor for STEM application.

Conclusion

Considering the importance of encouraging primary learners' interest in STEM areas, the study showed how learners in the Serbian primary EFL context viewed the integration of English with STEM-related school subjects in terms of perceived ability and value. Our survey with 40 primary learners exposed to English and STEM integration within STEM Day activities showed generally positive views of the experience and high perceived ability and value for English. Regarding the perceived ability of STEM-related subjects, the two sub-sample age groups' attitudes differed, AG1's ratings being moderate to high, depending on the discipline, while AG2's ratings ranged from low to high, low being for engineering. Generally, younger learners expressed more positive attitudes to integration and higher enthusiasm for STEM education, thus corroborating previous research (Erkut & Marx, 2005; Mahoney, 2010). It can be concluded that STEM innovation was viewed by all learners as rather beneficial for their English language development, but learners' age appeared to be a significant factor in guiding the perceived ability and value for each STEM discipline. Only younger learners saw STEM Day activities as beneficial for the development of knowledge and skills in all STEM-related subjects, while older learners expressed negative attitudes regarding the value of STEM activities for their knowledge and skills in mathematics, technology and engineering. Additionally, in terms of value of STEM disciplines for their future career, younger learners rated the career value of STEM-related areas higher than older learners.

The findings of the study cannot be generalized for several reasons: the sample was small, it represented only one educational context in Serbia, the sample's experience with STEM education was limited to one STEM Day integration of English and STEM disciplines, and teachers' and parents' views were not considered. However, the findings may serve as guidelines in larger studies of primary learners' attitudes to STEM and English integration, learners' strategies and autonomy in STEM education, teachers' STEM pedagogical skills and their planning, organising and evaluating STEM Day activities. The findings show what can be expected in integrated English and STEM teaching in terms of learners' attitudes in similar conditions. Being the first in the field of English and STEM integration in Serbia, the study provides an insight into how primary learners' perceived ability and value for STEM disciplines may vary with learners' age and their STEM experience. Further investigations could indicate how to sustain primary learners' positive attitudes and active engagement in all STEM-related subjects and embed the development of English skills in integrated instruction.

The implications of the findings stem from the points made in the Discussion section of the paper. Most of them refer to primary STEM curriculum and pedagogy applied in English and STEM integration activities. First, it seems that when introduced early in primary education, learners' attitudes to STEM are more positive and integration is better accepted (Mahoney, 2010; Puška et al., 2023). Early exposure allows drawing upon learners' curiosity and openness to new approaches, involving them in the discussion of the applicability of the new knowledge and skills in real-world contexts and situations, and engaging them in solving concrete problems and creating new engineering designs (Açıkay et al., 2023). Additionally, STEM education needs to be sustained to provide learners with opportunities to evaluate the approach's effectiveness in terms of perceived ability and value. Moreover, to be able to monitor and measure their own progress in English and STEM-related subjects, learners should be given ample opportunities for and practice in self- and peer-assessment in collaborative STEM activities. Being affective aspects of

STEM education, perceived ability and value appear to be affected by the level of cognitive challenge and scaffolding provided by STEM and English language teachers, which points to the importance of developing teachers' STEM pedagogical strategies and sensitivity to learners' needs for differentiated and accommodated instruction (Honey et al., 2014; Hudson et al., 2015; Tang et al., 2021). It seems that teachers' strategies for creating an engaging STEM environment and explicitly stressing the connections between disciplines may positively affect learners' perceived ability and value for STEM, and ultimately contribute to their knowledge, skills and understanding (Honey et al., 2014; Hudson et al., 2015). Being a new field in primary education not only in Serbia, but in many education systems worldwide, STEM needs to be investigated further to provide a framework that works best for learners in a particular education context and offers the most opportunities for their development in English and STEM disciplines.

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