

# A study on pupils' motivation to pursue a STEM career

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**Abstract**—The industry is facing with the increasing lack of STEM graduates every year. It is of vital importance to motivate pupils for technical schools or schools in the STEM fields. This paper analyzes data from 693 pupils about their interest in a STEM career as well as their attitude towards STEM in general. Within this study, we also analyze the influence of the participation in robotics workshops. The method is a quantitative survey with questionnaires. Results show what mostly influenced the pupils to pursue a STEM career as well as the influence of robotics on them. Finally, the paper presents three STEM-related projects, which we also analyzed in regard to their impact on the pupils.

**Keywords**—STEM Careers, Out-of-school-activities, Educational Robotics, Technical High School, Interest in STEM

## 1 Introduction

Most EU countries are facing a low number of students interested in the STEM career [1]. Although, some economic projections forecast that demand for STEM-skilled labour is expected to rise and there will be around 7 million job openings until 2025 in the European Union [2]. Austria, like many other EU countries, lacks students interested in pursuing degrees in STEM fields [3, 4]. Already today, eight out of ten industrial companies in Austria have problems to find qualified personnel in the fields of engineering, production, research and development [5]. Based on the calculation of the Federation of Austrian Industries, there is a shortage of around 1000 graduates in the STEM fields every year, which results in about every 6<sup>th</sup> job position unfilled [6]. Besides the increasing demand, an insufficient supply of graduates of vocational-technical schools is regarded as one of the reasons for skills shortages [7]. Considering the fact of several research studies pointing out that high school and early school grades are critical times for motivating young people to pursue STEM careers [8, 9], it is of vital importance to focus on their motivation at this stage. These facts are further underlined with findings, which show that the pupil's career interests when entering high school is the strongest predictor of their career interest when leaving high school [10]. Research findings also report that pupils in middle school have limited knowledge

about STEM careers, related to the subject requirements as well as kind of activities these careers integrate [11].

Further studies also indicate that school science practices are constrained to memorizing and replicating science content, and there is a need to redesign and reshape science learning with the purpose of improving STEM learning [12]. To improve perceptions about STEM, more awareness and direct contact opportunities are needed to ensure pupils have enough knowledge to make informed career choices [13]. It is of vital importance to investigate key factors such as family influences, teachers and school curricula, or out-of-school activities that can motivate young people to target STEM careers [14]. In this context, Guzey et al. developed the STEM career interest survey for measuring STEM career interest, and Kier et al. focused additionally on the evaluation of the effects of STEM programs on changes in the interest in STEM subjects and careers [15, 16]. Several literature studies identified and addressed different factors to be influential for motivating pupils towards STEM, such as parents, teachers, and practical activities (laboratory, hands-on, experiments), out-of-schools activities (e.g. open days, lectures at a university, workshops, summer camps), as well as role models and mentoring programs [17, 18, 19, 20, 21]. Studies show that on the one hand, parental involvement could be an influencing factor in their children's career path [22], but also role models, such as teachers, can significantly influence students in pursuing STEM careers [23]. On the other hand, students tend to be more motivated if they participated in STEM-related out-of-school activities such as after-school events, field trips, summer camps, competitions or mentoring programs [24].

Moreover, research has also identified positive relationships between math club participation and STEM major selection [25]. Besides, the results of several studies point out that self-efficacy along with knowledge of STEM careers are essential factors in whether or not young people are going to pursue a STEM career [26]. Considering that there has been only limited research regarding the influence of robotics, the focus of this paper will be to investigate how the participation at robotics programs as well as robotics attitude in general correlate to the interest in STEM and the motivation for pursuing a STEM career. Moreover, the influence of out-of-school activities will also be investigated. Finally, the study will present as good practices the results of three STEM-related projects to increase the interest in a STEM career.

The paper is structured as follows: The following section briefly introduces the method of the study. Section 3 gives an analyses of a few key factors for pursuing STEM careers. Section 4 presents evaluation results from three STEM-related projects. Finally, a conclusion is given in Section 5.

## **2 Method**

The online survey consisted of 50 questions grouped in four categories of variables: (A) pupil demographics, (B) family context, (C) participation in STEM-related activities outside school, and (D) pupils' science and learning preferences. The approach was focused on understanding different factors that have an influence on the decision to attend a technical high school. In this context, we analyzed the impact of some out-of-school activities on the attitude towards a STEM career. Our main focus

was to investigate if possible contact with educational robotics had some influence on the later career pipeline. In order to get a broader overview of students preferences, we also examined their attitude towards engineering and science within the frame of three different projects.

Each of this factor was encompassed with a different set of questions. Considering an inscription to a technical high school as one of the first steps in a STEM career, we formulated several questions that cover the reasons to make such a choice. The questions should evaluate the influence of the family, peer group and robotic workshops. Furthermore, we asked about the influence of some other STEM-related school activities such as Open Days, School Visit Programs or Career Days, which support the young people with relevant information about STEM careers and STEM activities. In order to evaluate the learning style favoured by the pupils when attending a technical high school, we investigated their preferred learning and teaching methods. The final set of questions was dedicated to review the pupils' intentions related to their future career. This part of the survey was done with 249 pupils from three technical high schools in Vienna, Austria, carried out in the frame of the project iBridge (see also Section 4.2). In order to analyze the attitude towards engineering and science by young people in general, we performed an online survey within the frame of the European Researchers' Night (see Section 4.1) with 271 technical high school pupils. Besides, 173 pupils filled out questionnaires in the frame of the STEM-related project Makers@School (see Section 4.3). Overall, answers of 693 students were analyzed regarding the likelihood to pursue a STEM career.

### 3 The key factors for pursuing a STEM career

This part of the study contains the results from analyzing the answers from 249 pupils of the three technical high schools. The age group range is from 14 to 22 years. Almost 27,4% of these pupils had migration backgrounds speaking a total of 30 different native languages. As can be seen in Figure 1, most of the pupils attended an Academic Secondary School Lower Cycle (AHS: 58%) or a New Secondary School (NMS: 34%) before attending the technical high school.

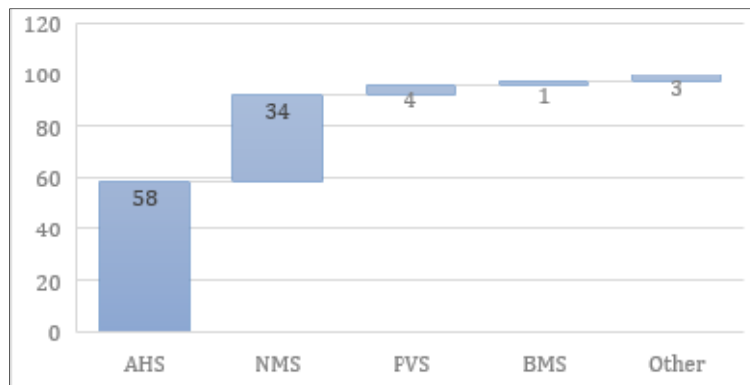


Fig. 1: The school attended before the technical high school [%]

Regarding the reason for pursuing a STEM Career, we analyzed the following statements: “I get support from my parents to register to the school”, “I must persuade my parents to register to the school”, “My choice for the technical high school was because of my friends”, and “My choice for the technical high school was due to a robotic workshop”. The pupils answered to the statements with a 5-Likert-scale with 1 representing “strongly agree” and 5 representing “strongly disagree”. A significant result of the test group is that the students were supported by their parents (mean=1,74; SD=1,245) and did not have to persuade their parents to choose a technical high school (mean=4,33; SD=1,281). The other significant result is that the students did not choose their STEM career because of their friends (mean=4,02; SD=1,425).

Nevertheless, the analysis shows that 21 (8,5%) of the pupils said that they chose a technical high school because of the participation in a robotic workshop by selecting “strongly agree” or “agree” as answer to the statement “My choice for the technical high school was a robotic workshops”. Our next step was to compare the results between a group A, which chose the STEM career because of a robotic workshop, and a group B, which did not chose the STEM career because of a robotic workshop. The results are seen in Table 1.

Groups	Group A		Group B	
	Mean	SD	Mean	SD
I get support from my parents	2,57	1,748	1,65	1,158
I must persuade my parents	2,62	1,884	4,57	0,992

**Table 1:** Comparison between group A and B

The comparison of the two tables shows that group A had to persuade their parents more than group B. Respectively, group B got more support from their parents than group A. It seems that the participants of a robotic workshop confronted their parents to get a chance for pursuing a STEM career. This result is very significant and has to be analyzed with a larger example. But already these results with small numbers show that robotic workshops can influence pupils and encourage them to pursue a STEM career, although this is sometimes not in the main focus of their parents.

The impact of STEM-related school activities were analyzed through multiple-choice-questions. Twenty pupils (24%) visited the high schools in the frame of a School Visit Program, where classes from lower grade schools get a tour to a high school for obtaining information about its offers. However, it is significant that 82 pupils (42,1%) visited the school as a guest before they officially registered to this school. From this number, 72 pupils visited the school during an Open Day activity, during which the young people have the opportunity to visit the school privately with parents or friends. On such an Open Day, the guests are guided through the school and can visit the laboratories, classrooms and workshop rooms as well as get information about study topics and curricula.

We also analyzed the pupils’ learning habits and preferences. As presented in Figure 2, most of the high school pupils like to do research and showed interest to understand technical things. However, it is interesting that 53% of them “strongly agree” or “agree”

to learn rather alone than learn with others, Moreover, 58 % “strongly agree” and 25 % “agree” to choose how to learn on their own.

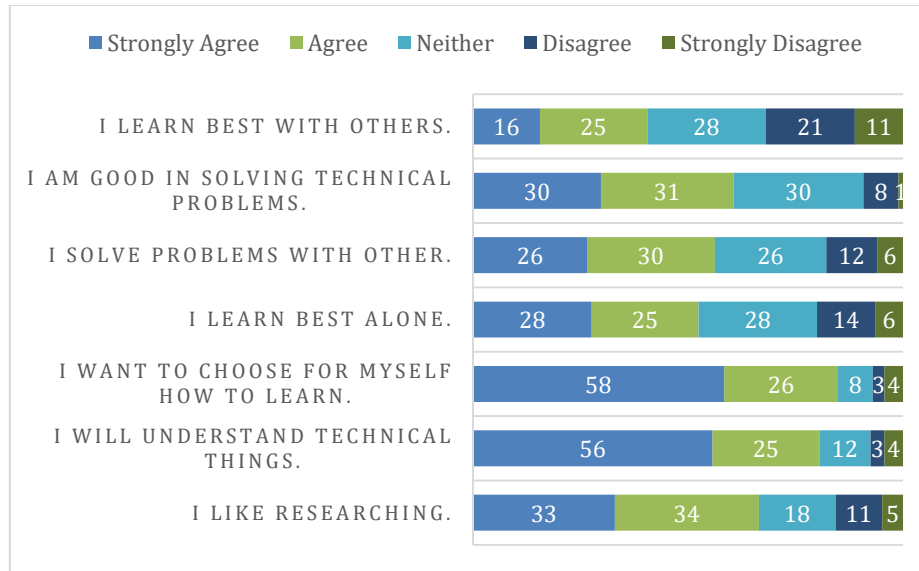


Fig. 2: Learning habits and preferences of the pupils

## 4 Best Practice Examples

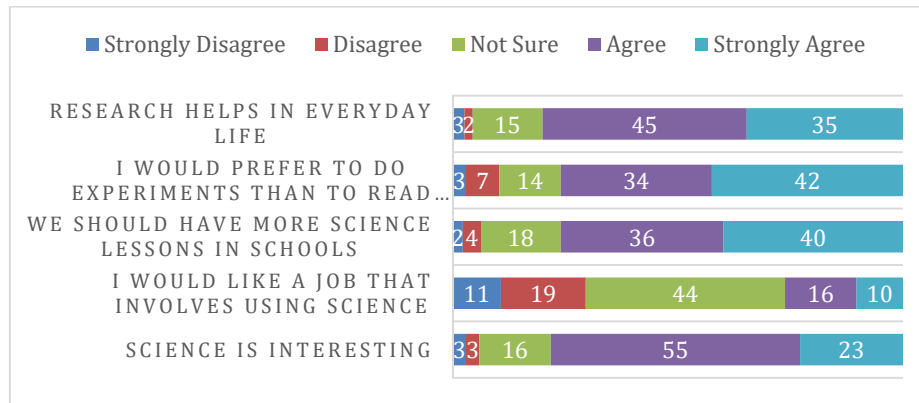
Within this section, evaluation results are shown how the participation in three different STEM-related projects influence the pupils’ motivation to pursue a STEM career.

### 4.1 European Researchers Night

The European Researchers’ Night<sup>1</sup> is a mega-event that takes place every year at the same time in many European cities. The main aim of the event is to give every citizen the opportunity to actively participate in science. The focus of the event held in Vienna was to motivate and inspire youth to enhance youth’s understanding of science and research and encourage them to pursue a career in the STEM fields by connecting them with outstanding scientists and innovations. Within the frame of the online survey, we interviewed 271 pupils of the technical high school TGM in Vienna about their career interests and the impressions about the event. Prior to the their participation, 22,9% were not interested, 59% had some interest and 18,1% had a lot of interest in having a career or job in a scientific field. After having participated at the event over 25,8% of the pupils responded that their interest in studying science and becoming scientists

<sup>1</sup> <https://sci4all.eu/>

increased. However, further 70,1% stated that their interest stayed the same and 4,1% even said that interest in the STEM career declined.



**Fig. 3:** Opinion about science [%]

Besides, 62,4% reported to know more about the work of the scientists than before. Further 19,6% improved their opinion about scientists, while 62,4% already had a clear picture. In Figure 3, we summarized their interest and opinion about science in general, where 76% agree with having more science lessons in schools and 78% pupils think that science is interesting. However, only 26% are interested on a career that involves science. It is also interesting that 80% pupils agree that research helps in everyday life. Regarding their interest in participating in future similar events, 42,8% responded that they are very interested and further 48% are somewhat interested.

Asked about their future career more than 35% stated that they are going to search a job after they finish the school, additional to another 33% that still do not know what they are going to do later. 32% of respondents clearly specified that they intend to study after the school. 35% of those that are going to study will probably study STEM, 20% are going to study law, languages, economy or psychology and further 45% are still undetermined with what they are going to study.

## 4.2 Project iBridge

Robotics in education has emerged as a superb tool to learn about STEM enabling pupils to use their individual interests, perspectives and skills to work on interdisciplinary projects [27, 28]. The combination of project-based learning and educational robotics to solve real world challenges can have an impact on the development of pupils' interest in STEM but also on their communication and collaboration skills [29]. In the project iBridge<sup>2</sup>, we combine project-based learning with the application of robotics focusing to improve student skills and their interest in STEM by engaging the students in solving real-world challenges. On the one hand, the

<sup>2</sup> [https://www.sparklingscience.at/en/projects/show.html?--typo3\\_neos\\_nodetypes-page%5Bid%5D=1263](https://www.sparklingscience.at/en/projects/show.html?--typo3_neos_nodetypes-page%5Bid%5D=1263)

project intends to get young people involved in the field of assistive technologies for senior citizens. On the other hand, the students are also concerned with the development of robots for children. In both cases the students have to face the issues that concrete user groups (adults or children respectively) have with technology usage and address their needs, considering their abilities and desires.

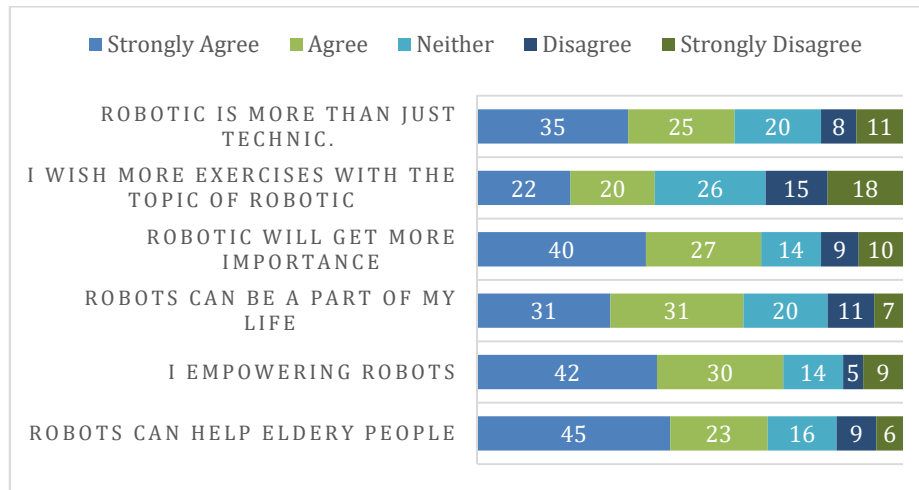


Fig. 4: Impact of robotic on pupils [%]

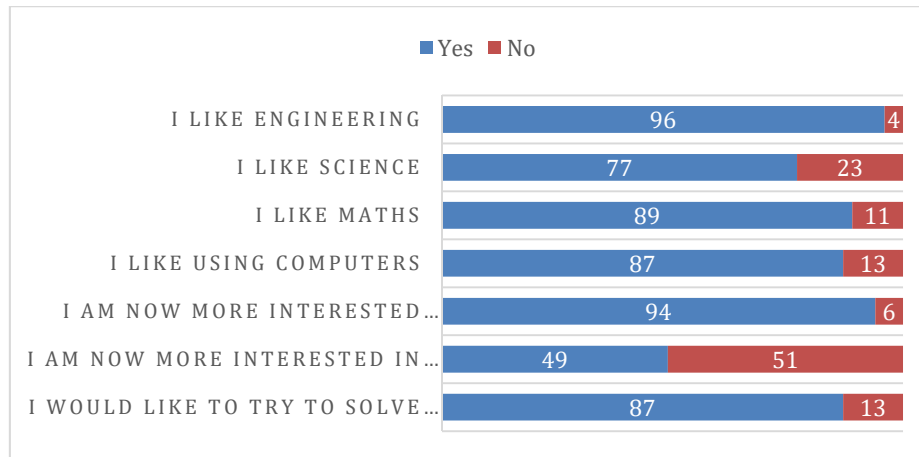
In this context, the pupils have to reflect what functionality a robot or assistive technology has to offer and how it should look like, behave and interact in order to be well accepted by the users. Considering that the challenges are broad enough and offer many different ways to respond to, the pupils have a chance to practice their creativity to develop a possible solution [29, 30]. Within the current stage of the project, the pupils developed different assistive technologies, e.g. “Yeet Bot”, which is a training robot kit for children. Further technologies were developed for elderly people to provide technical support, such as an “unconscious recognition” system, an emergency bracelet, a sensitive cuddly toy denoted as “Paul”, and an intelligent medicine box. Within the frame of this project, we asked 249 pupils about their position towards robotics. As presented in Figure 4, the pupils answered quite positively, stating that they would like to have more contact with it and that they are open to robotics issues in general. They also showed an understanding for the importance of robotics and advantages that it can make in real life, including also the help for elderly people.

### 4.3 Makers@School

Robotic workshops for pupils can increase their interest in STEM from an early age. The Makers@School<sup>3</sup> project aims to communicate a better understanding of the maker-movement and to increase the interest in STEM topics. The project involves a

<sup>3</sup> <https://pria.at/education/makersschool/>

series of workshops for primary and middle school classes as important period in education to introduce pupils in STEM fields. These workshops involve topics such as product development, 3D-printing and robotics. The hands-on activities of the workshops shall encourage the pupils to actively use the provided technologies and to choose a STEM Career. Results of the questionnaire with 173 pupils and administered at the end of the workshops are shown in Figure 5.



**Fig 5:** Impact of robotic on pupils [%]

The number of pupils who liked math increased to 89%, and the proportion who liked science to 77%, showing an increase in interest following the workshops. Nearly all pupils had a positive view of the engineering field after the workshops, and the proportion of pupils who liked to use computers had increased markedly from before the workshops to 87%. Almost half of the pupils were now more interested in studying science, and 87% would like to participate again in such activities like the carried out workshops. It can be concluded that the positive experience of workshops can indeed foster a positive attitude towards STEM, which is one of the main aims of the project Makers@School [31].

## 5 Conclusion

This study investigated several key factors that can motivate pupils to target STEM careers. Besides, their attitude towards STEM was also analysed within this study. Current results show that the impact of parents in choosing the STEM career is much higher than expected and that possible measures in the future should also be oriented to inform the parents about opportunities of STEM careers for their children. Moreover, the students show a preference for having more robotics and science-related topics in regular curricula. In this context, some results show that robotic activities can also influence students to pursue a STEM career. Finally, results from three STEM-related



projects indicate that they can increase STEM interest to some extent. Future work will focus on deeper analysis of the results involving larger number of students.

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