THE PART PLAYED BY ROBOTICS CLUBS IN HIGH SCHOOL STUDENTS` CAREER GUIDING

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ABSTRACT: *the goal of this work is to show the manner according to which the activity of robotics clubs influences high school students' career guiding through a study upon the students who are members of five robotics teams in the Jiu Valley. The results of the methodology, which consisted in applying an on-line questionnaire, show that the option of the students participating in robotics clubs is to attend a career in the STEM field. These results match the studies in the domain set forth by specialized literature. As a consequence, the work pinpoints the need and the positive effects of training the students for this field, which is of primary importance in the context of the nowadays development of technology and has major consequences upon high school students' future.*

KEY WORDS: *robotics teams, career guiding, STEM.*

JEL CLASSIFICATIONS: *A20, O30.*

1. INTRODUCTION

At present, the labor force market undergoes constant and profound changes determined by the economic reforms, the technological evolution, and the social or political circumstances having a direct effect on the quality and quantity of the human factor. An important component of the economic system, labor market represents an accurate barometer of the internal and international evolutions, while the increase of competitiveness in today society increases the importance of the manner we train and prepare labor force (Zirra, 2006).

Under such circumstances and on a long term, human capital is considered to be the most important resource of a country, while the correlation between the educational factors and labor demand represents a priority. Considering that the progress of society

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is continual and the profile of the future specialist is difficult to predict, the educational trajectory of a specialist requires the constant up-dating of the knowledge and abilities with a view to cope with the changing demands of the labor market. As a result, labor force becomes more and more flexible in terms of responsibilities, a fact that is influenced not only by the educational system but also by personal development.

We go through a period when labor market begins to be increasingly impacted by the evolution of technology and operationalization through robotics, artificial intelligence, 3D printing, cloud computing, and the analysis and processing of data bases not only regard engineering domains, but increasingly enter the fields of architecture, medicine and other fields in the society. In addition, the responsibilities of the human factor begin to be gradually taken over by technology, a fact that shows that a labor force trained and adapted to the present informational society is required.

The context previously mentioned has deep implications upon the process of training labor force, while the psycho-social and individual factors that influence young people's career guiding are increasingly important. The educational system, as a main factor of career guiding, supports young people through a portfolio of instruments that stimulate students' interest and influence their vocational decisions.

With a view to help high school students face such a change, teachers support them through debates, in-depth discussions, project-relying learning, and interactive teaching methods in all subjects. The use of the traditional teaching methods is no more enough for developing students' skills, and more and more high schools extend their preoccupations to include a diversity of extracurricular activities that are correlated with the tendencies on the labor market and adapted to the evolution of society.

A large number of publications have cited the decrease of young people's option for a training of their abilities in science, technologies, engineering, and mathematics (STEM), while Intel Corporation has discovered that one of the most important barriers preventing young people entering the field of engineering is the lack of exposure to engineering, although there is a critical and continual need for improving scientific education, mainly among high school students (Wallace & Freitas, 2016).

Under such circumstances, an important segment of extracurricular activities is represented by robotics clubs, whose number is growing owing to the fact that a lot of youngsters and educators associate their technical, design and creativity practices to authentic STEM learning. During the last decade, a growing number of school units founded such teams that attract children and teenagers owing to their clear relation with science fiction (Jojoa, et al., 2010), while stimulating young people's passion for technology.

Starting from the preoccupations of the authors of the hereby work and considering the evidence already displayed, this analysis intends to set forth the manner according to which robotics teams in the Jiu Valley influenced the preoccupations of high school students and their decision to attend a specific higher education domain. In accordance, the paper is structured as follows: the introductive part that displays an image of the bidirectional relation between the dynamics of labor market and career guiding; STEM education literature review and the part played by robotics clubs in training high school students for a vocational career; the research methodology involving

the application of an online questionnaire filled-in by the members of the robotics clubs, the interpretation of the results and proposals for a future research.

2. LITERATURE REVIEW

The innovative element robotics clubs bring to young people's education results in the training and development of technical creativity. The experience accumulated in such clubs helps high school students take a look into the future and imagine, on the one hand, the manner they might use modern technologies, and, on the other hand, the manner they might develop the abilities required for becoming the 21st century generation of innovators (Welch, 2010). The use of robotics as part of the educational system is an efficient instrument for training young people in scientific and technological subjects, while giving them practical experience with robots that become more and more present in society (de Rezende Freitas, et al., 2023).

A lot of authors, among whom Galino&Tanaka, 2021, consider that the use of robotics increases the creative thinking of young people and helps them understand technical concepts. Ngugi asserts that robotics makes students feel like "scientists during the process of learning", influencing their future career choices, while Galino considers that the most frequent result is that the use of robotics prepares pupils for a STEM-related career (Nguci, 2023; Galino&Tanaka, 2021). Nugent asserts that, although the training process is complex, it is also captivating, as pupils are able to manipulate robots directly, which results in a handcrafted, self-directed learning, guided towards mind (Nugent et al., 2016). As a result and with a view to successfully complete robotics activities, grouped in small teams and coordinated by teachers, high school students learn concepts and principles through authentic experiments and problems that are specific to technology and engineering (Nugent, et al., 2016). As an initiator of a successful robotics team in Romania, Ciontescu D. considers that interdisciplinary and applied approaches lead to a visible progress of students' development on several plans (AlphaBit-RO137).

Although robotics is the program with the highest impact on modeling high school students' attitude to domains of STEM, the curriculum considers it an extracurricular activity organized after school (Ozis, et al., 2016). Such circumstances are analyzed in the study carried out by Le, 2023, showing that younger teachers with experience in robotics are aware of the fact that robotics is an essential learning activity that should be included in the regular curriculum.

Nonetheless, in time, the opportunities for young people to be part of a robotics club have increased especially thanks to the informal learning environments and to the fact that it proposes "semi-formal" learning spaces; as a result, the option of introducing robotics in the curricula, if only for technical specializations, seems not to always have followers.

Another factor that accelerated the increase of the number of robotics clubs and of high school students participating are the competitions these students were engaged in (Ozis, et al., 2016).

Created in 1989 by Dean Kamen, an entrepreneur and inventor, in collaboration with Woodle Flowers, a physician and MIT Professor, FIRST competitions made history in increasing young people's enthusiasm for science and technology. FIRST

competitions (FIRST LEGO League Discover, FIRST LEGO League Explore, FIRST LEGO League Challenge and FIRST Tech Challenge FIRST Robotics Competition) (https://stiintescu.ro) reported a positive impact upon stimulating creativity among teams (Galino, Tanaka, 2021) and an increase of students' enthusiasm and commitment, while being an example from the real world, outside the school environment (Ozis, et al., 2016).

In accordance, Kamen considers, while using sports paradigm, that an attractive milieu has been created, but "instead of jump-jump-jump-throw – the content is electrical engineering, mechanical engineering, system engineering, controllers, sensors and software". The activities in the robotics clubs are attractive for the young people; these clubs are "after schools, not at school. They are aspirational, they are not compulsory…, you are not given tests, you enter competitions and get trophies, you do not have teachers, you have coaches" (https://en.wikipedia.org); Kamen's vision as a the founder of FIRST competitions shows that it is important *"To transform our culture by creating a world where science and technology are celebrated and where young people dream of becoming science and technology leaders."*

The competition spirit and students' feelings of being part of such teams should be disseminated and transmitted with a view to become positively contagious. This conclusion has also been reached by those who study the psychology of competition participants. Let's notice the fragment written by Wallace and Freitas: "It is a rainy Friday afternoon in Washington and, while a lot of high school teens went to the mall, a team of exuberant and focused teenagers gathered in a former garage to handle glue guns and electrical tools. They gather in small groups to also discuss the designing issues of their under-water robots that should become functional within a few weeks for a regional competition. Emotion is tangible. This scene requires a question: why such opportunities are so infrequent?"

Under such circumstances, robotics competition is a show that should be lived, and FIRST represents the dream of an increasing number teenagers. FIRST Robotics Competition is a yearly international competition for high school students, who, within six weeks, assemble robots capable to carry out certain tasks. In accordance, during this period, the teams work intensely, frequently until midnight and on weekends, take part in a lot of designing and testing meetings so that, finally, the robot participates to a regional event. This is the time when the high school students effectively implement theoretical knowledge closely working with their technical mentors (Welch, 2010). The goal of the competition does not only concern the technical part, but also facilitates the assessment of creativity, design, presentation, communication, etc., a fact that increases its attractiveness and teams' coherence. As a result, FIRST represents a complex process dedicated to STEM after school (Burack, 2019); the reputation of such competitions resulted in over 80,000 high school students and 25,000 mentors, grouped in 3,225 teams from 26 countries, participating in 58 regional competitions, 90 district qualification competitions and 11 district championships, in 2022 (https://www.slashgear.com). The training and participation for and in these competitions develop and improve not only the technical knowledge of the students but also multiple abilities, such as motivation, perseverance, autonomy and increased reasoning (de Rezende Freitas, et al., 2023) and,

according to Muntean G., a passionate mentor of a robotics team, "FIRST experience is complete and brings added value to the community" (AlphaBit-RO137).

Irrespective of region, number of members or age, specialized literature displays a series of benefits determined by students' participation in the robotics teams, especially upon their STEM education. Several authors, among whom Rezende Freitas and Ngugi, assert that robotics projects increase students' critical thinking and creativity and also determine significant effects upon students' judgment and decision capacity, socializing and team-work skills as well as upon STEM process abilities (Ngugi, et al., 2023; de Rezende Freitas, et al., 2023) On a long term, let's notice the positive aspects of robotics clubs on the education of high school students, as these practical training experiences develop essential skills for a future job or freelancer position, such as the manner of solving problems, project management or computational thinking, considered part of engineering education (Burack, 2019; de Rezende Freitas, et al., 2023).

In conclusion, robotics clubs positively change high school students' perception on robots, humans and society, while increasing their scientific creativity abilities and scientific process abilities (de Rezende Freitas, et al., 2023).

Consequently, robotics activities can be beneficial for young people in many ways (Galino & Tanaka, 2021) and there are countries that invest in educational programs with a view to increasing the number of young people who attend STEM careers owing to the fact that it is necessary to provide the labor opportunities that are going to come out in the field of engineering, a domain that requires innovative specialists and entrepreneurs on a labor market that will be different from the nowadays one (Ngugi, 2013).

3. GOOD PRACTICES OF THE ALPHA BIT-RO137 ROBOTICS TEAM

Organized by Association Nation for Education and financially supported by BRD, FIRST competitions in Romania have awakened the competition spirit of over 13,000 pupils passionate by robotics, during the season 2022-2023 of BRD FIRST Tech Challenge Romania only, including 173 teams from 76 towns. In order to show their abilities and creativity in building and programming robots, in the Jiu Valley, the members of the AlphaBit-RO137 team of Mihai Eminescu National College in Petrosani and of the Waffy team of Constantin Brancusi Technical College in Petrila took part in this competition.

AlphaBit-RO137 team, founded in October 2018 as an extracurricular activity intended to put into practice the knowledge acquired from high school courses, has become a symbol of Mihai Eminescu National College in Petrosani and has opened the road for robotics among the high school students in the area. Owing to the enthusiasm of the students and the engagement of their mentors, the team took part in all the editions of the BRD FIRST Tech Challenge, to several meetings specific to robotics and, in time, through networking, it collaborated with several other teams and initiated a series of local and regional events.

A highlight of this activity was the collaboration with Wafy team of *Constantin Brancusi* Technical College in Petrila, with the Association Valea Jiului Engaged, the Association Nation for Education and the University of Petrosani, partners with whom

they founded the robotics hub located at the Cultural Exploitation in Petrila, whose activities were financially supported by the County Council of Hunedoara and the Town Hall of Petrila. This collaboration also resulted in the participation in the final round of the awards New European Bauhaus Brussels and the show called Kingdom of Lions. The results obtained by these teams were published and one of the objectives of the teams was to provide help to the community of high school students passionate by robotics to discover FIRST values and to inspire other students in discovering the opportunities STEM education offers. In accordance, irrespective of generations, through enthusiasm and engagement, results come out, and Szedlacek R., a remarkable mentor of AlphaBit-RO137 team, showed that "new members came to the team, others left the team, but a powerful core, ready to overcome all obstacles, already came into being" (AlphaBit-RO137).

4. METHODOLOGY

Our research consisted in applying an on-line questionnaire, which is a rapid research method through which data are automatically collected and the results of the research are accessible at any moment. The questionnaire was distributed and filled-in during the period October 1st - October 30th, 2023, in five high schools in the Jiu Valley that own a robotics team. We considered it appropriate to also distribute the questionnaire among teams that do not have remarkable results at competitions or are at the beginning of their journey, owing to the fact that high school students have this common passion and have common pursuits, especially STEM-oriented.

The questionnaire resulted in seventy-two valid answers. The questionnaires were answered by the students of Mihai Eminescu National College in Petrosani (47.2%), Carmen Sylva National Informatics College in Petrosani (22.2%), Constantin Brancusi Technical College in Petrila (25%), other high schools (5.6%), mainly including students in the mathematics – informatics profile (63.1%), sciences of nature (27.8%) or philology and social sciences (9.1%), who were predominantly male (55.5%).

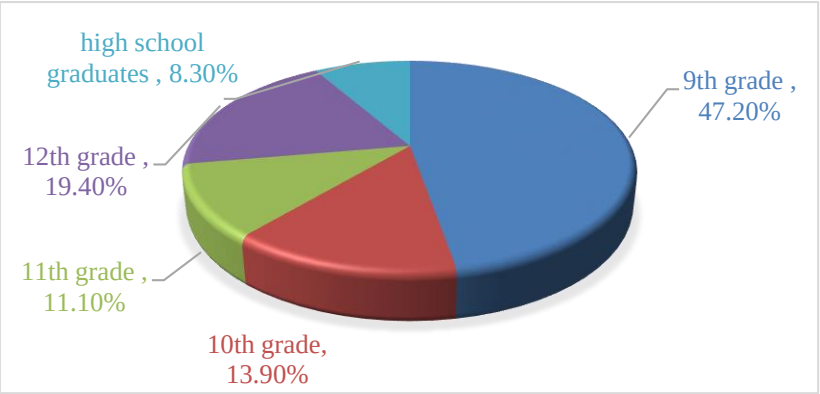

Figure 1. Structure according to grades of the high school students in the interviewed robotics teams

It is fortunate that the present robotics teams include a lot of members in the 9th grade (47.2%), who take over from older generations – 11th grade – 11.1%, 12th grade - 19%, or even from high school graduates who are university students at present but who still collaborate with the teams (figure 1). Let's also notice that over 58% of the students have been members of the club for less than a year, 22.2% between 1 and 2 years, and over 16% of the students have been members for over 3 years; as far as the age structure is concerned, 52.4% are younger than 17, and over 16% are already 18.

A first category of questions regards the "Experience in the robotics team", which set forth questions correlated with the stages covered by the high school pupils or with them being part of the teams. In accordance, a first question refers to the source from where the students learnt about the existence of the robotics club in the high school; the answers gathered show that 72.2% learnt from their friends, 38.9% from teachers, 25% from the social-media networks, and 11.1% from their families; the answers show that most of the students learnt about the existence of the robotics clubs from different sources. The answers to question "Was your move towards the high school you learn at determined by the existence of the robotics club?" show that 58.3% gave a positive answer, which reveals that the media coverage of the results and activities of these clubs had an impact on students' career-guiding.

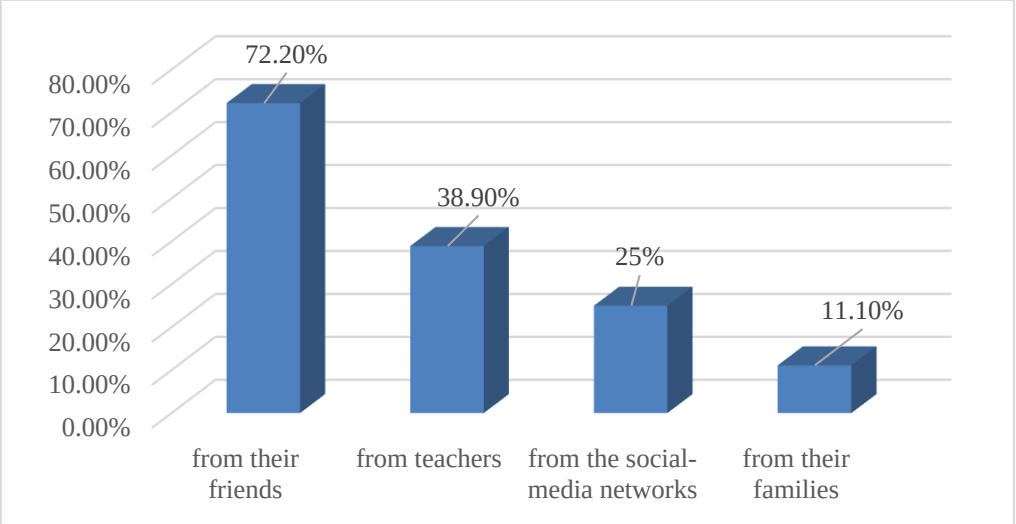

Figure 2. Report on the answers to question "Where from did you learn about the existence of the robotics club at your high school?"

The reasons for which the students chose to become members of the robotics teams are as follows: to come out of their comfort zone (52.8%), because they are passionate about technology (50%), to learn programming languages and to build robots (41% both), because they had friends who were members of the team (13.9%) and to try a new activity (2.8%).

As far as the knowledge in the field of robotics accumulated owing to this experience is concerned, most students considered that they learnt graphic design (58.3) and how to assembly robots (44.4%); the rest of the information collected have almost similar shares and regarded encoding, robot designing and electrical circuits (22-27%). Besides STEM knowledge, the members of the club learnt to communicate efficiently (80.6%), to be perseverant and find solutions (72.2%), to get used with public speaking (52.8%), to engage in collecting funds (36.1%), to design budgets (30.6%), etc. All this knowledge helped them take part, with the team, in various competitions: equal shares in the case of the students who took part at 2 competitions, at least, or between 2 and 5 competitions. Also equal shares, namely 16.7%, in the case of the students who took part in 5 to 10 competitions and of those who participated in more than 10 competitions.

The responsibilities the students have as part of the teams are diverse, most of them playing multiple roles. Most of the students state that they are mechanics (36.1%), programmers (33.3%), graphic designers (33.3%); let's also notice their roles as fund raisers (22.2%), coaches (13.9%), event planners (13.9%), human players (5.6%), and public relations representatives (5.6%).

Another category of information gathered regards the future plans and the students answered as follows:

- ✓ The answers to question "Was your decision to attend a faculty in the field of STEM influenced by your engagement in the robotics club?" show that over 65% students responded affirmatively;
- ✓ As far as the specialization they want to attend as part of their academic studies is concerned, their options were as follows: computers and information technology (48.7%), mechanical engineering, mechatronics (15.1%), electrical engineering (6.3%), building and architecture (8.3%), other specializations (medicine 8.4%, political sciences 5.6%, economic sciences 2.8%, others 2.8%);
- ✓ When answering the question "Where do you want to study?", 16.7% students responded that they would opt for a university abroad, 80.6% for universities in Romania, and the rest did not decide yet;
- ✓ When answering the question "Do you think of returning to the Jiu Valley in the next 10 years?", 38.3% responded that they want to return, while 36.1% did not decide yet;
- ✓ When answering the question "Did your engagement in the robotics club influence your decision to return or not to return to the Jiu Valley?", 58.3% said that it was indeed a factor that influenced their decision.

The answers gathered show that the experience of the high school students in the robotics teams largely influenced their future and are convergent with the results of other studies. Such answers were expected in consideration of the fact that these students work in highly performing teams and are aware of the fact that the future is connected to performing technology; these facts match the opinions of a series of authors who consider that nowadays youngsters are the first generation that is going to spend their lives living and interacting with robots (Björling, 2020).

5. CONCLUSIONS

Career guiding is an important stage of young people's lives; therefore, the specialists in guiding the high school students, their teachers and families should inform them and make them aware of the tendencies on the labor market and of the tendencies correlated to the technological progress of society. Human resources experts show that the occupations with the most rapid growth in the next years require skills and knowledge in the field of STEM as future occupations demand increased creativity and intelligence. Under such circumstances, the guiding towards STEM is one of the most important future options and, through our research, we show that the behavioral tendencies of the high school students, who were members of the robotics teams and answered the questionnaire, are connected with such preoccupations and their guiding to an academic field belonging to STEM is a reality.

In conclusion, although the goal of the research to offer answers to hypotheses regarding high school students' guiding to a STEM career was carried out, the authors are aware of the fact that the study also has some limitations, especially regarding the number of participants in the questionnaire. In accordance, we intend to continue and extend such researches, both considering the number of robotics teams questioned and their geographic distribution and a qualitative research able to pinpoint the good practices and high school students' behavior during the competitions, whose popularity results in sparking the interest for robotics of more students and possible mentors. In addition, these researches and the dissemination of the results through publications aim at being a step forward in convincing institutions, companies and other possible financing entities to support the robotics clubs in all high schools in Romania.

We consider that the research can be continued and be supplemented with qualitative items in the research questionnaire, which might display high school students' perceptions on the manner a series of extracurricular entrepreneurial activities are carried out. Meanwhile, it would be of interest that the research is also carried out at several universities, for students belonging to the same specialization. All these, owing to the fact that "the challenge that rises before contemporary society does not regard the fact that these young people will be or will not be prepared, but whether they will be prepared in the domains required by future moments" (Pîrgari, 2022).

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