ROBO STEAM - INCLUSIVE TECHNOLOGIES

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Abstract
This article presents developmental a cost-effective robot - TELE-ROBKO and a robot-based platform for education - ST(R)EAM IT.
An autonomous mobile robot (and the required software) will to provide virtual presence visits of museums, as a part of the teaching curriculum or as an extracurricular activity for classes of students (pupils) and their teacher. This is a high-tech solution, which will allow the visiting class to easily remote visit ("tele - visit") the museum exhibitions regardless of the distance separating them form the location of the museum (for example – in another city or even in other county).
Students will be able to view in real time the exposed national treasures, cultural values, historical artifacts, art and so on exhibits and participate interactively in the exhibition tour, conducted by the museum expert-guide (including asking questions and receiving answers trough the robot's audio system).
64 teachers and trainers will be trained on how to use the ST(R)EAM IT platform. They will become the backbone of a teacher and trainer community, which will operate as informal group and provide sustainably of the project results in the future.

Keywords: *mobile robot, education, STEM, platform, tele–visit, COVID-19.*

1. INTRODUCTION

Education is provided in formal and private institutions in Bulgaria and is managed by the local authorities. Today we all talk about the big technology changes after the last big health pandemic COVID-19. The pandemic brought changes in the Bulgarian education and education in whole world. The COVID-19 crisis once again outlined the importance of digitization of the social interaction. One of the most vulnerable groups are the students who had to explore the vast world of knowledge by spending long hours in front of their computer screens.

Digital transformation goes beyond the limits of the desktop computers, laptops and tablets. Robots are the logical next generation of digital tools, that can be utilized to speed up the digital transformation of the educational systems.

2. PRELIMINARY NOTES

Bulgarian education has two mandatory stages: Primary and Secondary. Pre-primary, upper-secondary and higher education are optional. Primary and secondary education in Bulgaria are free in the public schools. There are primary schools (first through fourth grade), basic schools (first through eighth grade), secondary schools (eighth through twelfth grade) and general-secondary schools (first through twelfth grade). Elementary stage includes children first – fort grade (7-10 age) or its elementary school,

presecondary stage is fifth – eighth grade (11 – 14 age). Secondary education is secondary stage. Students are ninth – twelfth grade (15 – 18 age). Educational system in Bulgaria - Fig.1. Basic education can be obtained at state, municipal and private schools. It is free of charge with the exception of private schools. There is a single curriculum for primary education which is compulsory for all pupils from years 1 to 4; more-over, in these years teachers work with one class. After successful completion of year four, a certificate is issued. The certificate includes the annual score in the subjects studied in year four, as well as the score obtained in the chosen/optional subjects. [5] Lower secondary education (years 5 to 8) lays the foundations for studying the basics of different sciences and at the end of this education pupils should have acquired such skills. A certificate of basic education is issued after the successful completion of year eight. The certificate includes the annual score obtained in the subjects studied in year eight, as well as the scores obtained in the chosen subjects. A pupil passes from basic school to secondary school without having to pass an entrance examination, by using the basic school certificate. Entry into profile-oriented schools (e.g. mathematic or language oriented school) after completing their course in year 7 or 8 (language schools, school of mathematics, technical schools, etc.) is on the basis of entrance examinations. [5] Secondary general education covers pupils from years 9 to 12 (13) and is again free of charge with the exception of private schools. Holders of secondary school leaving qualifications (Diploma of Secondary Education) are entitled to continue their education on a higher educational level (university), without restriction as to the choice of a higher education establishment.

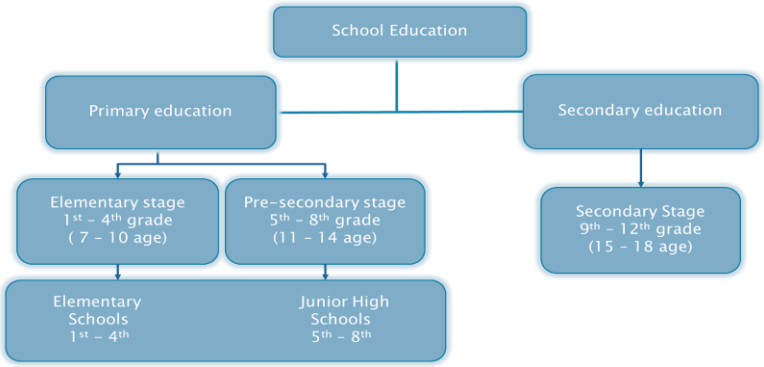

Fig.1 Educational system in Bulgaria

Education is separated in two parts, based on the childrens abstract eye vision. The child's vision gets stronger each year. This improved vision is needed as the child explores the world more fully and begins attending school. The developing eye is learning to do many things better, such as: seeing things in 3D (three dimensions). This is known as depth perception, tracking, which helps the eyes follow a moving target and etc. Around the age of 11 or 12, children learn to think about abstract concepts. It's the pre-secondary stage. They complete what Piaget termed the concrete operational period and enter the formal operation period. There are two major aspects to this theory: the process of coming to know and the stages we move through as we gradually acquire this ability. [13] Piaget was interested in how an organism adapts to its environment. That he described intelligence. He explained behavior. Behavior is controlled through mental organizations called schemes that the individual uses to represent the world and designate action. This this adaptation is driven by a biological drive to obtain balance between schemes and the environment. [13] Piaget described two processes used by the individual in its attempt to adapt: assimilation and accommodation. Both of these processes are used throughout life as the person increasingly adapts to the environment in a more complex manner. Piaget identified four stages in cognitive development: Sensorimotor stage (7 months of age); Pre-operational stage (toddler and early childhood); Concrete operational stage (elementary and early adolescence) and Formal operational stage (adolescence and adulthood).

Concrete operational stage. In this stage (characterized by 7 types of conservation: number; length, liquid, mass, weight, area, volume), intelligence is demonstrated through logical and systematic

manipulation of symbols related to concrete objects. Operational thinking develops (mental actions that are reversible). Egocentric through diminishes. [13]

Many pre-school and primary programs are modeled on Piaget's theory, which, as stated previously, provides part of the foundation for constructivist learning. Discovery learning and supporting the developing interests of the child are two primary instructional techniques.it is recommended that parents and teachers challenge the child's abilities, but not present material or information that is too far beyond the child's level. It is also recommended that teachers use a wide variety of concrete experiences to help the child learn e.g., use of manipulatives, working in groups to get experience seeing from another's perspective, field trips, etc. [13] The hallmark achievements of concrete operations are that children display logical thinking. They begin to think abstractly. Children this age are able to demonstrate abstract thinking. For example, they can understand shades of gray, wrestle with abstract concepts like love or justice, and formulate values based on thinking and analyzing as opposed to only by feeling or experiencing. This means that children in primary education need to see, to touch everything they hear doesn't mother of the education field – math, history, geography. Today we called this practice STEM(STEAM). STEM is an educational program developed to prepare primary and secondary students for college, graduate study and careers in the fields of science, technology, engineering and mathematics (STEM). STEM integrates multiple disciplines and trains students to use cross-disciplinary knowledge to solve problems. STEM programs promote a learn-by-doing approach. Students participate in real-world projects with real-world consequences. STEM in education teaches students to think critically, prepares them for careers and creates professionals that can work across scientific disciplines to solve challenging problems. STEM education make the connection between theory and practice.

Students' satisfaction is an important measurement for the education success.

Teachers through proper guidance and social support can define and design the future of the children. Teachers act as promoters of motivation and engagement of students. Positive teacher-student relationships will ensure students' satisfaction with their schooling experience, while Vieno et al (2007) identified that psychologically motivating and caring teachers could enhance the effectiveness of school for children. When classroom learning is organized in a cooperative environment by teachers, students will feel increased efficacy. Students become more engaged in the learning process when they find teachers attending to their social and academic needs. Generally, children studying away from their home countries are more observant of their teachers and rate them on factors including their commitment to the profession, and attitude towards students, that could subsequently influence students to see teachers as role models for their adult lives. Also, the school experiences of expatriate children help them to develop their abilities through the influence of friends and extra-curricular activities. Such studies suggest it is reasonable to assume that teachers' support would enhance student satisfaction with their schools, which in turn would result in better student engagement. [2]

The following hypotheses are proposed(Fig.2):

H1: Teachers' support will have a positive impact on the school satisfaction of students.

H2: School support will have a positive impact on the school satisfaction of students.

H3: Peer support will have a positive impact on the school satisfaction of students.

H4: School satisfaction will lead to a positive impact on the engagement of students.

H5: Location of the school will moderate the relationship between school satisfaction and student engagement for students.

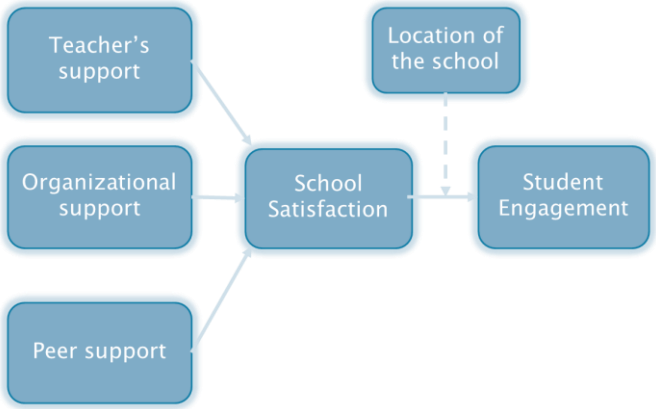

Fig.2 Students satisfaction

Teachers' Support

1. My teachers make my learning interesting and joyful.
2. My teachers & other staff treat me with respect.
3. I get feedback about my performance from my teachers.
4. My teachers help me to improve whenever I perform poorly.
5. My teachers encourage me.
6. My teachers recognize my good works in public.
7. My teachers really care about me.
8. When I have a problem I know whom to approach for help.
9. I feel comfortable about approaching teachers/counselors for discussing my troubles.

Organizational Support

10. My school provides opportunities for getting involved in sports, clubs, and other activities outside the class.
11. The grounds, buildings and outdoors are kept in clean & good condition.
12. I find classrooms at school excellent & well equipped with learning & teaching resources.
13. I find computer laboratories at school excellent & well equipped with learning & teaching resources.
14. I find science laboratories at school excellent & well equipped with learning & teaching resources.
15. I find library at school excellent & well equipped with relevant books.

School Satisfaction

16. I am happy at school.
17. I feel that the discipline in school is adequate.
18. I feel safe in school.
19. I feel proud of my school.

Peer Support

20. Students in my school treat others with respect.
21. My friends in school are mostly cooperative and work in teams.
22. My friends help me in completing my assignments.

Student engagement

23. I am actively involved in extra-curricular/co-curricular activities.
24. I am actively involved in sports activities.

In the organizational support we see 3 points connected with classroom, resource and equipped. This is the STEM education.

We have students and schools and it looks like everything is organized and properly working - We are managing the school system. But life has challenges for our education system. Some of those

challenges are: children living abroad; children living out of capital (Sofia); disabled people and health pandemic.

Provoked by the challenges of distance learning, that all students and teachers in EU faced during COVID-19 lock-down , the partners started a series of brainstorm sessions on how the technology can be utilized to provide relieve during social lock-down.

COVID 19 is not first health pandemic, but it's the first which provoked a big technology progress. We talked long time ago for new technology, new generation – technology generation, but our education only talked about preparation, but not realized any changes. Same private schools started to integrate technology in education, but in government schools it was a just a mirage.

The COVID-19 crisis once again outlined the importance of digitization of the social interaction. The most vulnerable groups are the students who have to explore the vast world of knowledge spending long hours in front of their computer screens. But the digital transformation goes beyond the limits of the desktop computers, laptops and tablets. Robots are the logical next generation of digital tools that can be utilized to speed up the digital transformation of the educational systems all over EU and even all over the world. This key enabling technology introduces new digital capacity and opens new horizons for educational institutions on all educational levels.

The most wanted professions today did not exist fifteen years ago. In another five years, robots will do 65% of the work we do today. The EU Industrial Policy Strategy defines robotics as an integral part of the Key Enabling Technologies (KETs) with the most important share in the growth of the European industries. Therefore, greater attention must be focused on how robots can be better integrated into the lives of young people and their education.

3. MAIN RESULTS AND DISCUSSIONS

Unlike the traditional digitization approach using stationary computers and cameras, the robots provide independent mobility, thus overcoming the physical barriers imposed by the need of social distancing, socioeconomic disadvantages or special needs. They combine the advantages of a computer system with the excitement of human-robot interaction which inspires the imagination of all students thus promoting by example the benefits of STEM. The robot will be used to provide all students involved with access to the treasures of the cultural heritage, under the supervision of their teachers and the professional researchers from the partner museums. It will show-case how the technology can be used to overcome limitation and imposed boundaries in order to provide high quality educational experience, inclusion and non-discrimination via innovation. Robots have great potential in being utilized as an educational technology they add brand new digital capacity to the educational system. They can be used as a powerful edutainment platform - combining the traditional and innovative didactic methods and the educational content in mathematics, physics, computers, electronics, mechanical engineering, and even artificial intelligence, with the experience of gamified learning. The robot-based system can be powered by clean energy sources (sun-energy) and promote by example climate change awareness and prevention.

The consensus was reached that the dire need for new type of high quality educational content, innovative didactic approaches, and reliable means to provide students with cultural and educational experiences under the restriction of social distancing can be addressed with the help of robotics. Robots can't be infected by COVID-19 or other infectious diseases. They can be used as avatars of teachers and pupils so they can experience the excitement of the museum visits. Also they can support the museum researchers during the onsite guided tours, or during a distance class-room lesson.

The COVID-19 crisis fast-forwarded the process of digitization and emphasized the need of distance education, or rather the need of providing all students with high quality learning experience outside the confront of the classroom.

Tele-ROBCO robot will be created - an autonomous mobile robot (and the required software) for providing virtual presence visits of museums, as a part of the teaching curriculum or as an extracurricular activity for classes of students (pupils) and their teacher.

This is a cost oriented autonomous mobile robot consists of mobile robot platform of differential type, PC and controllers, electro-actuating system including two 12V LiFePo batteries and recharging station and sensory system including: infrared, ultrasound, laser scanner, 3D sensor - “Real Sense” and integrated accelerometer, gyroscope and inertia sensor (Fig. 3)

Fig. 3 TELE-ROBKO

One robot functionality is School class telepresence mode (Fig. 4):

- Museum “Tele-visit” guided tour– The robot will collaborate with the museum tour expert - guide and will provide an avatar of the visiting class (students), by following the thematic presentation of the museum expert. In front of each exhibit, the expert guide will conduct a talk, prepared and didactically in accordance with the curriculum for the subject. A tour is composed of a predefined sequence of exhibits, linked by a common theme. The robot will go from one exhibit to another, as directed from the museum tour guide (by a remote control, or through the WEB interface), based on his/her presentation. The robot will position itself at a predefined position in front of the exhibit which provides the best view of the exhibit.
- Teacher defined and controlled tele-visit tour – Prior to this type of visit, the teacher, using the WEB interface, creates a list of exhibits (from the ones available in the database). When the tour starts, the robot autonomously goes to the best viewing spot in front of the first exhibit, when requested by the teacher (over the WEB interface) goes to the next exhibit in the list.
- Teacher controlled “go to exhibit” tele-visit – In this type of visit, the teacher, in real time, dispatches the robot in front of an exhibit of his/her choice. The selection of the exhibit is made through the WEB interface, from the list of exhibits in the database.

Development of Methodology and Teachers’ Toolkit. The academic institutions will provide additional expertise for the development of teachers' guides, videos, tutorials, and case-studies, while the schools will validate and adapt the content to the needs of the teachers, students and their parents. The WP demands understanding of the needs of a newcomers in the field of robotics, as well as profound knowledge in didactic methods.

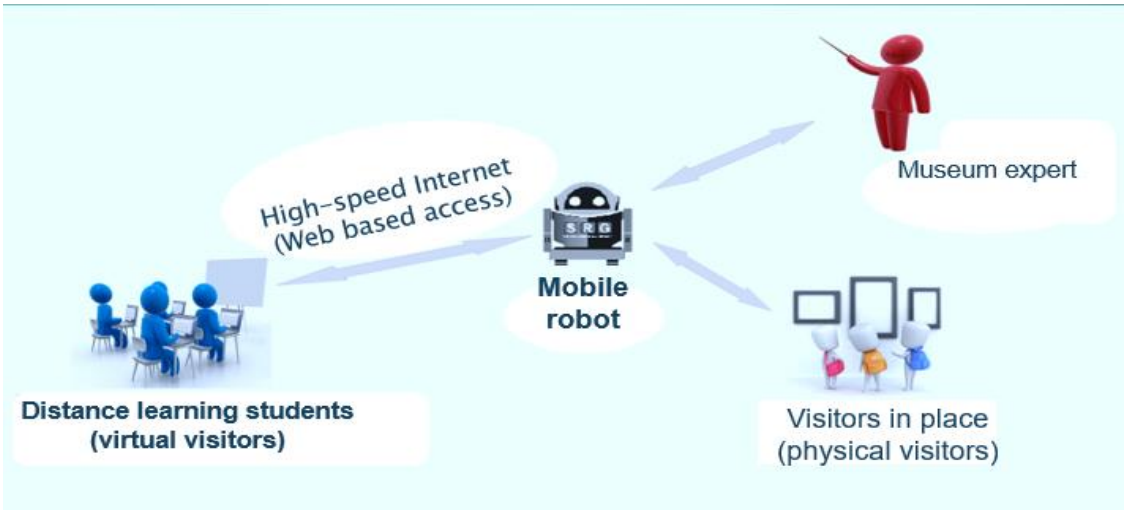

Fig. 4 School class telepresence mode

Education innovation:

- Introducing new interactive learning tool in Bulgarian educational institutions
- Innovative exploitation of museum exhibits
- Creating the possibility of remote access to cultural institutions (museum exhibitions, etc.)
- Development of a robotic system for "tele-visits" of cultural institutions (museum expositions, galleries, exhibitions and other objects) "TELE-ROBKO“
- Development of a unique, web-based graphical user interface for managing the Robotic System for tele-visits - "TELE-ROBKO“

4. CONCLUSIONS

ST(R)EAM IT project will result in a robot-based hardware platform TELE-ROBKO for tele-visits (telepresence) and its pilot integration in the partner institutions. The hardware platform will be equipped with robot-control software sub-system (based on ROS - open-source Robot Operating System). The platform educational capacity will be enhanced by an add-on software package for robot-behavior, tuned to cultural events, guided tours, and museum exhibitions.

Inter-institutional cooperation, co-creating, knowledge sharing, and team building, all enhancing the cooperation and interaction between the partner institutions.

Strong multidisciplinary transnational diverse project team focus on closer institutional integration and cooperation for innovation.

TELE-ROBKO will contribute to the innovation in the VET education and training by implementing and piloting a robot-based tele-vision hardware system that will provide VET institutions with additional digital readiness and enhanced digital resilience by providing means for distance observation, interaction, and research. This high-tech approach will be piloted in our partner VET and secondary schools, universities, and cultural institutions, be it can be used in all educational levels for teaching natural science, technology, engineering. It will provide full indiscriminatory tele-presence access to events (sports, education, culture) and places, thus boosting the inclusion of large socioeconomic groups, overcoming the barriers imposed by disabilities, health problems, cultural differences.

5. ACKNOWLEDGMENTS

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