Junior Botball experience at HTL St. Pölten

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***Abstract*—JBC is a competition for young students to motivate and encourage to learn more about robotics. With five schools workshops were done and some students were exited to form a JBC-Team. The parts of a robot were explained and basic C knowledge was taught. Simple programming tasks were executed on prepared robots. Apart from the technical robotic part, questionnaires were conducted before and after the workshop. The results were analyzed and categorized. Analyzing all pre-post questions boys are more interested in technical topics and robots than girls. Females increased their robot-handling skills by about 0.4 of a point which is way more than the males with 0.1 out of a 1-5 point scale. 85 % think that they have now a better understanding of technic and 78 % would like to attend additional workshops with a robotic theme.**

Keywords— JBC, Robotics, Programming, STEM

I. Introduction

Welcome to the world of STEM education! The mission is to spark the interest and skills of young learners in Science, Technology, Engineering, and Mathematics (STEM). Initiatives such as Botball and the Junior Botball Challenge (JBC) have been developed to enhance comprehension and enthusiasm for STEM among primary and secondary school students. Botball provides practical robotics experiences, while JBC offers an engaging introduction to robotics and programming for younger learners. Botball, geared towards older students, entails more advanced tasks, nevertheless both programs share the goal of inspiring future innovators and problem solvers.

II. Process of Project

A. Inviting classes

The aim was to enhance the STEM skills of at least 100 pupils aged 10 to 14. schools in the vicinity of St. Pölten were contacted to visit the HTL St. Pölten for robotics workshops. As the HTL St. Pölten conducted similar workshops in 2023, those teachers were contacted in order to make appointments.

B. Making appointments

Appointments for dates and times were scheduled with interested schools. The duration of each workshop was tailored individually for each school based on their timetables and travel time. The objective was to allocate approximately five hours of dedicated working time for each workshop.

C. Preparation of the Workshop room

Robots and batteries need to be prepared and charged. Any faulty components such as servos, motors, sensors, Lego parts, and metal parts must be replaced or repaired. The most common fault was loose screws, which could be fixed easily. Prior to the lesson commencing, all PCs should be booted, and the pre-questionnaire was opened. The projector and teacher's PC should be connected, and the JBC presentation should be displayed.

III. Junior Botball Challenge

A. ECER and JBC

The ECER (European Conference on Educational Robotics) is a 5-days conference including technical presentations of students and researchers. Another main part of ECER is the robotics-competition between teams from different schools. It has the three disciplines Botball, Open and Aerial. In addition since 2023 the JBC (Junior Botball Challenge) is also part of the ECER. It only takes place on one day and the students are aged between 10-14. The students work with a JBC-Surface (**Fehler! Verweisquelle konnte nicht gefunden werden.**) and they have to program the robot to solve small independent tasks.

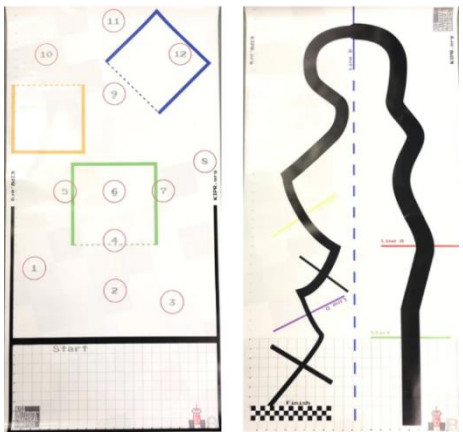

Fig. 1 JBC Surface A and B

B. Parts of the robot-set

1) Metal-Parts

The set includes perforated metal sheets, facilitating easy and sturdy assembly. These sheets are provided in long strips, suitable for constructing arms or grabbers, as well as a large sheet serving as the primary chassis. With pre-drilled

perforations, screws can be easily inserted at any desired location. The mounts for servos and motors are meticulously designed to securely hold them in place. When utilizing servos and motors, the option to utilize a servo horn is available. Notably, the servo horn features small teeth to prevent slippage during operation.

2) Screws, bolts and nuts

There is a wide variety of screws and nuts in the set. In the set are 3 different length-types of black screws. They can be matched with the black normal and security nuts. There are also special mounting screws for the caster wheel. In plastic bags are also screws for attaching the grabber on the servos.

3) Lego-Parts

The Lego Technic parts in the Junior Botball Challenge set encompass a variety of essential components. Beams offer sturdy structural support, while axles provide rotational capabilities. Gears facilitate power transmission and manipulation, allowing for precise control of movement. Connectors ensure secure and stable assembly.

4) Controller

The central controller of the robot, known as WOMBAT, comes pre-installed with a fundamental program to facilitate programming tasks. Crafted and refined by the skilled team at KIPR, WOMBAT units are also available for purchase through their online store. This controller enables manual control of servos, motors, and sensors, as well as the execution of programs.

5) Sensors, Motors and Servos

Sensors are vital components that enable robots to interact with their environment. Infrared sensors emit infrared light and measure their reflection to determine distance. Light sensors detect ambient light levels, facilitating responses to changes in brightness. Touch sensors register physical contact, enabling robots to react to touch or collisions.

Motors are essential for converting electrical energy into mechanical motion. Their speed and direction of rotation can be controlled by varying the voltage supplied by the WOMBAT-controller. Positive voltage will move the motor forward and negative will turn it backward.

Standard servo motors act as rotary actuators, allowing precise control of angular position. Consisting of a motor, gearbox, and control circuitry, the used servos offer a limited range of 180 degrees. Standard servos are used in JBC to control moving the arm and the gripper.

C. Building of the workshop-robots

The robots are pre-built to save significant time and minimize the likelihood of parts being damaged. Students require additional time for assembly and may lack the expertise to assemble the pieces correctly. Goal of these workshops was to show the students fast results. So the focus was set to the programming of the robots.

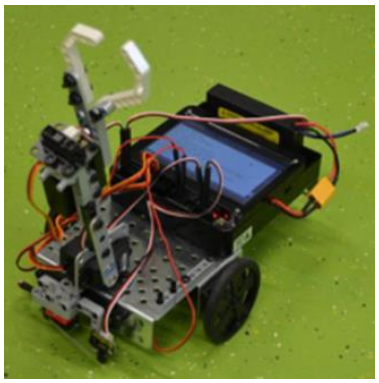

Fig. 2. JBC-Robot

IV. Structure of the Workshop

The workshop, comprising small groups of two to three students, commenced with an informative presentation showcasing the school's profile and its representatives. Following this introduction, a comprehensive overview of the workshop's objectives and structure was provided through a PowerPoint presentation, setting the stage for productive engagement.

Fig. 3. Working on Robot

A. Timetable

In most cases, the class arrived at 8 am, and students sat down at their PCs, waiting for the presenters to begin. After the introduction, all students started with the questionnaire before the workshop. Most classes took about 10 minutes to finish the pre-questionnaire. Following that, the theoretical and practical part began as shown in the following bullet points.

- The first section of the lesson was about presenting the school and the introduction of the tutors who were leading the lesson.
- In the second part it was talked about the mechanical parts of a robot and what their functions were because most parts may be new to the pupils.

- After the Human vs. Robot Quiz the theoretic programming segment started. Because most young leaners haven't used a programming language before it was focused on how to program functions and how the students should later program the robots.
- Once students have acquired a foundational understanding of programming concepts, each team was provided with a robot. They were taught how to establish connections with PCs and navigate the KIPR programming interface.
- After all groups were successfully connected, initial steps were demonstrated and explained. Basic commands in the programming language C were provided on a reference sheet for easy consultation in case of forgetfulness.
- The first program "Hello World" was explained step by step for easy understanding. If pupils couldn't follow, the tutors explained everything face-to-face.
- The second task involved instructing the robot to move forward for 1 second. Subsequent tasks became progressively more challenging. These tasks showed the students how easy it is to get first success which is very important to get the students enthusiastic.
- After mastering movement, students learned about sensor functionality and applications. Programming tasks involving both movement and sensor integration were assigned. This was designed to show how robots can interact with their environment and they might understand the different actions from their daily life sensorized machines.
- JBC mats were spread across the floor to provide an additional challenge. The usage of servos was explained and practice material (bottles or aluminum cans) was handed out so they could learn how to move objects with their robot.
- Before they left the HTL the second questionnaire needed to be answered and the teachers wrapped up the lesson.

B. Human Body and Robot Components

1) Comparing Humans with Robots

In their presentation, the tutors drew parallels between the components of the robot and those of the human body. They likened the robot's skeleton to the bones and joints of an organic skeleton. Furthermore, they equated the sensors to human senses, such as comparing the touch sensor to fingers and the light sensor to a simplified version of the human eye. When discussing motors or servos, they highlighted their resemblance to muscles, while the battery serves as the energy source akin to how animals require food for energy replenishment. Through the integration of these components, the robot gains the ability to interact with its environment and respond accordingly.

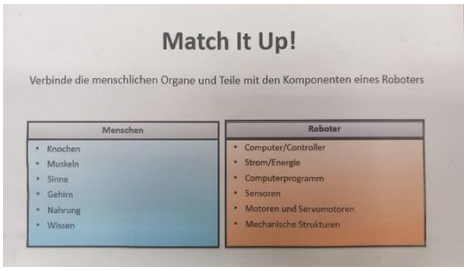

Fig. 4. Human vs. Robot Quiz

Knochen = bones	Computer/Controller = controller
Muskeln = muscles	Strom/Energie = electricity/energy
Sinne = sense	Computerprogramm = PC-program
Gehirn = brain	Sensoren = sensor
Nahrung = food	Motoren und Servomotoren = motors & servos
Wissen = knowledge	Mechanische Strukturen = mechanical structure

2) Human vs. Robot Quiz

Each student received a paper-based quiz shown in Fig. 4. They had a few minutes to complete it. The quiz requires students to match words on the left side with their corresponding counterparts on the right side. Prior to the quiz, the presenters discussed the relevant subject matter, emphasizing its importance. The quiz reveals which students have engaged with the material and paid attention to the presentation.

C. Questionnaire

Two questionnaires were provided for completion, one at the beginning and one at the end of the workshop. On average, students spent 10 minutes for each of these questionnaires. Further details regarding the results will be explained in chapter V.

D. Proceedings after workshops

If a group of motivated students was interested, they had the opportunity to visit the HTL-St. Pölten one or two additional times between the workshop and the ECER to acquire the necessary knowledge to participate in the JBC. During these visits, they would receive instruction on utilizing analog sensors. After the sessions the team could borrow a robot and JBC-Surfaces for further preparation for the competition.

V. Statistic Analysis of the Questionnaire

A. Methods for analysis

The data was initially processed using '*Pandas*', a '*Python*' data analysis library. This processing involved translating and renaming the columns to more usable names as '*Pandas*' is easier to work with column names not containing any spaces. Furthermore, the data values were translated into English or transformed to boolean values. For example, German words such as "Ja" and "Nein" were converted into boolean values.

After getting a brief overview over the data, graphs were plotted using '*Seaborn*', a '*Python*' library for statistical data visualization. The '*Python*' code performing the preparations and drawing the plots was written in '*Jupyter Notebook*' files using '*JetBrains IDE DataSpell*'.

B. Analysis

Four NMS (secondary school) and one AHS (grammar school) attended the workshop at HTL St. Pölten from surroundings. At total there were 102 students. Two couldn't take part in the questionnaire because of lack of German language skills and three post-questionnaires were not stored in the formular for some technical reasons. Out of the 97 students were 76 boys, 19 girls, one not specified gender and one diverse.

Age	Amount
10	1
11	5
12	28
13	38
14	23
15	2

Table 1 Age-range of students

Most of the students already built a robot at the age of 12-13 (Fig. 5). The older ones had way less robot-experiences yet than the younger ones. That might be because the younger students were part of a robotics-class (Fig. 5). More than a half of the students who already build a robot, have done it at school, 15 % at a workshop and 20 % at home (Fig. 6Fig. 5).

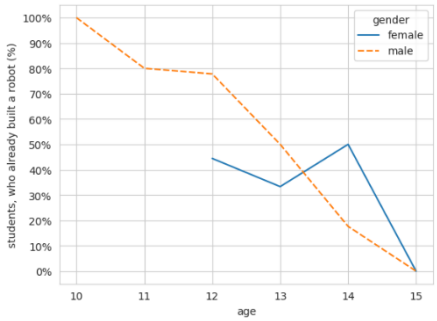

Fig. 5. Students who built a robot

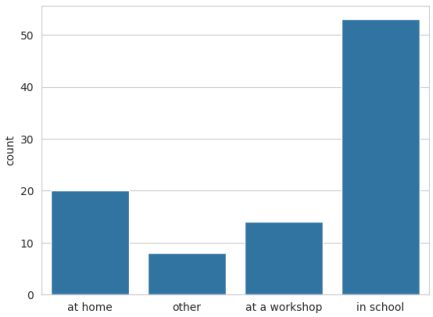

Fig. 6. Building the first robot

The parameters questioned before and after the workshop were compared overall, male and female. As there were only one person diverse and others resulting in too few numbers for statistics, these categories were not implemented in the diagram. Because of the workshop more students were interested in robotics and STEM. The solution-solving skills improved by about 0.2 points out of a 1-5 scale. The knowledge of robots increased at a similar rate. The importance at working with robots decreased for some reason (Fig. 7). The male graph is similar to the overall graph because there are about 80 % boys. Therefore the girl graph is way less significant. Analyzing all pre-post questions boys are nearly a point more interested in technical topics and robots than girls. Females increased their robot-handling skills by about 0.4 of a point which is way more than the males with 0.1 (Fig. 8 & Fig. 9). The question "can develop robot to solve others problems" increased strongly for the girls. This might be because they thought of their daily life and got ideas to solve problems at school or at home with the help of robots.

For future studies some points should be considered. If the study would be conducted with more students even over more years the results will become more accurate. There should be more advanced workshops for students who attended the first one after e.g. one year. It would be notable to collect separate questionnaires from the students who took part in the JBC and compare them to the participants who attended the first time. It will be expected that they improved a lot compared to beginners.

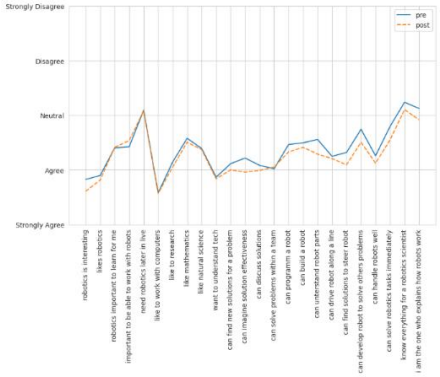

Fig. 7. Overall results

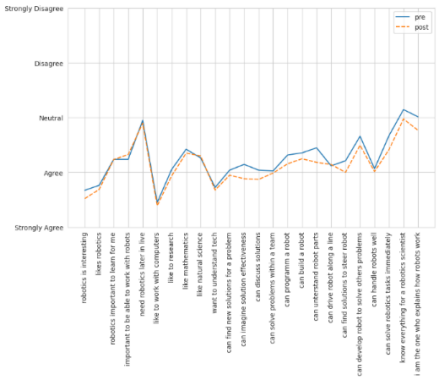

Fig. 8. Male results

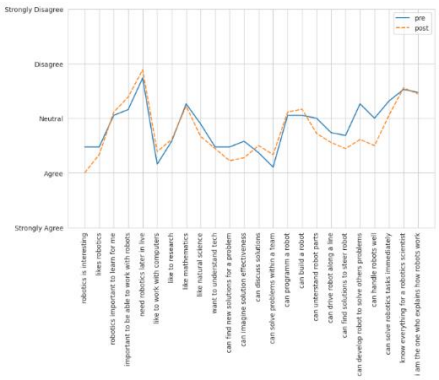

Fig. 9. Female results

Above figures and analyses only describe overall statistics with average graphs. When considering some cases there are students whose attenuation regarding to robotics improved more and some even decreased. In one positive case the pupil increased his programming skills for robots and could handle them more easily after the workshop. Even the problem solving and discussing skill improved (Fig. 10). But for some individuals it didn't work out as planed and they realized that it might be more difficult to control a robot than they thought. Maybe this has to do with his team, because the working in a team skill decreased, and the problems derive of this (Fig. 11).

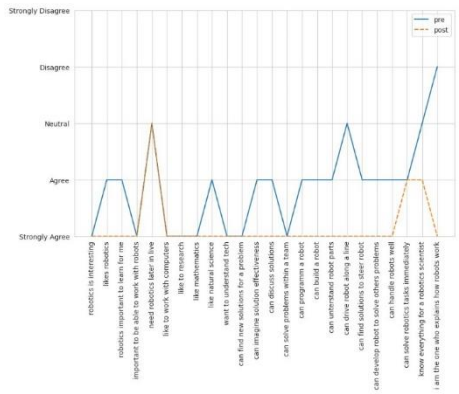

Fig. 10 Student with positive changes

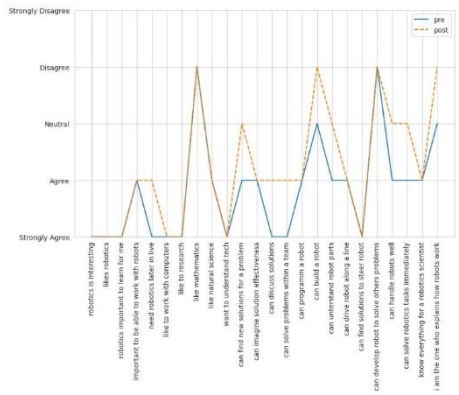

Fig. 11 Student with negative changes

VI. What did the kids learn

The students delved into the realm of robotics, exploring topics such as programming and the mechanisms through which robots interacted with their surroundings. They also explored the intriguing parallels between human anatomy and robotic components, gaining insights into the fascinating world of technology and wanting to investigate more in this direction (Table 1). This educational journey not only broadened their understanding but also provided them with valuable insights into potential career paths. Following their visit to the higher school, students were better equipped to chart their future endeavors upon completing their education and now knew how important engineering was (Table 2). We as tutors saw the enthusiasm of some students and thought that they had gotten a glimpse of STEM-topics.

A. Development of students through robotic workshops

As discussed above these workshops were held to improve a wide range of skills the students may need in their future. Another study " The Effects of Robotics Club on the Students' Performance on Science Process & Scientific Creativity Skills and Perceptions on Robots, Human and Society" used Lego Mindstorm robots and took place with 23 students from different classes, aged between 12 and 13, in a school in Turkey. Like the autors pointed out, the pupils enhanced their problem solving skill and see the importance of robots in the daily live. Even if their carrer-path should not involve engineering they might increase their creativity through such projects like JBC. [1]

Evaluation-questions after the workshop	**%**
I am now more interested than before in understanding how things work.	78
I now better understand the importance of engineering.	85
I would like to build and/or program robots in the future.	48
I would like to use robots to learn new things in the future.	46
I would like to learn more about programming.	71
I am now more interested than before in studying something with engineering.	47
I am now more interested than before in studying something to do with informatics.	44
I would like to do more workshops like this.	78

Table 2. Evaluation-questions after the workshop

VII. References

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