

Winning Robotics Competition Strategy: Theory of Creating Projects in Robotics Education

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Abstract

The subject of robotics in education has a significant impact on the development of skills of students. Studying the main factors motivating robotics to participate in competitions, project competitions, and win prizes is always relevant. There are many competitions in robotics. In particular, one of the competitions for developing robotics in education is WRO. However, it is essential to know and research several factors that can lead to a place in a competition and support young coaches and participants. Higher education institutions that already have courses in educational robotics can benefit from the proposed approach, which allows them to develop new projects with robotics elements.

Keywords: Education Robotics, Mentor, Competition, Strategy

1 Introduction

The training of future STEM specialists is becoming more relevant every year for teachers and researchers [1] (Amanda Sullivan, Marina Umaschi Bers, 2019). In addition, many national and international competitions are organised in STEM to improve skills in science, technology, engineering and mathematics. Kazakhstan's educational program aims to develop and form a competitive, competent, creative, and educated person. Development of STEM skills is important to maintain competitiveness in the global economy. This is because the number of STEM employees in any country is considered a reliable indicator of the country's ability to generate ideas for innovative products and services [2] (Chew et al., 2014). STEM helps

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students learn using constructive methods to understand the content and application of knowledge [3] (Turner, 2013). As Elbasy (first President) said in his Address to the Nation, “In the New World – New Kazakhstan”, we can see the success of the education reform in our country only if every citizen of the country has a qualified professional by their education and meets the requirements of the world. Therefore, in order to develop STEM skills, it is necessary to effectively use robotics in education in primary, secondary and higher education. That is why robotics in education is an indispensable tool for teaching STEM, which allows you to conduct laboratory experiments [4] (Henry Goh, Mohamad Bin Bilal Ali, 2014).

At the same time, when it comes to the learning process, there is always the issue of motivating students. An excellent, motivating way is to participate in competitions and project competitions [5]. The role of a mentor is vital in preparing students for the Olympics. The study, based on an experiment conducted for senior students of the Nazarbayev Intellectual School and students of Computer Science at the *L.N. Gumilyov Eurasian National University*, identified strategies for success in preparing for Olympic robotics and developed a model of the main functions of mentoring. There will be presented practical work of students who participated in international project competitions and were awarded prizes.

This research paper consists of the following research topics:

- winning strategies for the development of competitive robots;
- skills developed by students in the learning process through robotics.

Competitions in robotics. Currently, competitions in robotics are organised from the preparatory group to the university level. The most famous of these competitions are the World Robot Olympiad (WRO) , FIRST Robotics, and VEX Robotics competitions [1].

In general, Olympic robotics is divided into two areas:

- the first is sports robotics (Competitive robotics) - robots are created to perform a specific task;
- second – project robotics projects allow students to study different areas of science and technology to acquire different knowledge and skills, respectively.

In the project work, students learn various environmental or social issues and different science components, think critically, and offer solutions to problems by solving non-standard tasks. Thus, they obtain a wide range of skills in addition to knowledge.

The WRO is an international robotics competition for pupils and students between the ages of 10 and 21. More than 23,000 students from 74 countries participate yearly in the competition. Competitions are held based on LEGO MINDSTORMS Education EV3 constructors in four categories for sports and design robotics:

- main;
- creative;
- robot football;
- advanced Robotics Challenge.

Annually the state organises the Olympic task within the project category.

2 Course Design

Mentoring.

Some studies have found that male and female mentors have different experiences. This shows that male mentors pay more attention to practical work and have well-developed design skills [1] (Amanda Sullivan, Marina Umaschi Bers, 2019). The peculiarity of the discipline of robotics requires attention to practical knowledge. That is, mentors must constantly improve their knowledge and be able to work on the content of the subject in the following languages and laboratories: LegoMindstorms EV3, Arduino, Raspberry pi, Machine learning, Python, Java, C++, 3D printing, etc. The primary function of the mentor is to identify team members and guide them in developing project work [6]. However, at each stage of project development, there is a need to determine the role of the mentor. During the experiment, a series of lessons for LegoMindstorms EV3, Arduino, and Machine learning was developed for the graduates of the Eurasian National University named after L.Gumilyov, the structure of the project work was determined and the role of the mentor at each stage was determined.

Methods overview.

The study was attended by participants and mentors of the WRO Olympiad and students of the University majoring in computer science, STEM. The study included an online survey of questions related to the program's content, which teaches robotics in education. The survey was conducted for mentors and students with experience. The results of the WRO Robotics Olympiad for the last 5 years were analysed, and strategies for victory were identified. As a result of this research, training software and a unique model for the work of the mentor were developed.

Data collections.

Data were collected through two questionnaires (mentor questionnaire and student questionnaire). University students answered both questionnaires. This is because future professionals need to answer questions about their interests and beliefs as a student and as a mentor. Students were asked questions related to their participation in sports and project competitions. Accordingly, questions were asked about the general team experience, and the satisfaction of the mentor's experience, which tests the knowledge of each category of the Olympiad. 237 out of 390 Nazarbayev Intellectual Schools students who participated in the WRO competition responded to the survey. Mentors with 20 experiences who mentored these students participated, and 69 bachelor's and 28 master's of university students also participated.

Sports robotechnics.

The main category of the WRO Olympiad is a challenge-based competition. Students must design, build, and program robots to solve specific field problems over time. Points are awarded for completing tasks. The total number of points of the team is based on the time spent collecting points.

3 Research Results

Victory strategy №1-Decomposition

According to the results of the survey: “Do you decompose in solving Olympic problems?”
47% – “yes”, 35% – “no”, 18% – “I do not know what the decomposition”.

However, when performing any complex task, it is better to decompose first. That is, the first strategy for victory is to classify a complex task into several small tasks Figure 1 [7] (John R. Frederiksen Barbara Y. White).

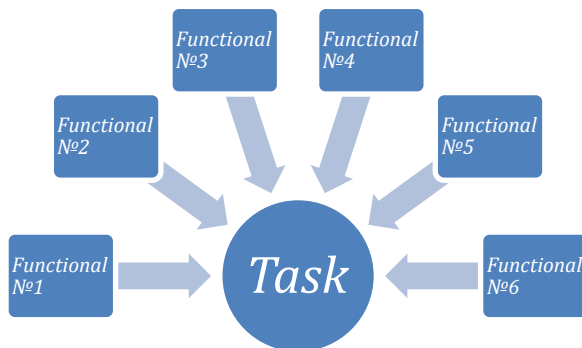


Fig. 1: Model of decomposition.

Students were asked to decompose the following task (Figure 2). In Lego mindstorms EV3, you can build your own block for decoding program code: It has the following advantages:

- easy to understand code;
- errors can be detected quickly.

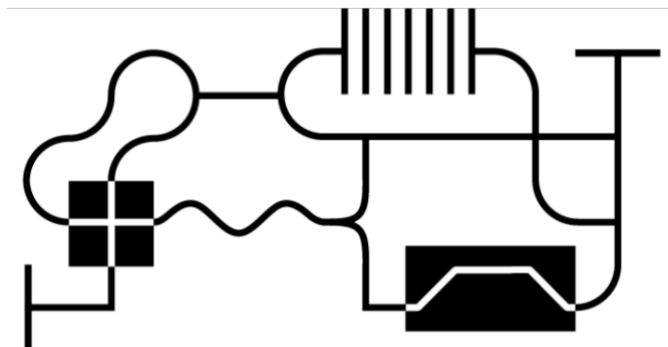


Fig. 2: Game field for line following

As a result of:

- optimal geometry of the kinematic scheme for the task;
- line movement on the PD-regulator on two sensors;

- zebra: Direct movement with synchronization of engines;
- exit from the cycle (movement along the line) on the event;
- my block (procedure): movement along the line to the cross, to the assigned encoder;
- turn left, turn right;
- search G-shaped turn;
- search for a T-shaped cross;
- search inversion;
- inversion ride;
- search for inversions.

Victory strategy №2-algorithm of exact alignment (exact alignment)

Accurate alignment is essential for the robot to perform the task correctly. Therefore, we use the following algorithms from the SeparateAlignment and PID procedures for the robot to move straight. The SeparateAlignment procedure allows you to use a separate proportional regulator (PD) for each motor. If the two wheels are equal, we run an algorithm (Figure 3) for the proportional integral differential regulator (PID).

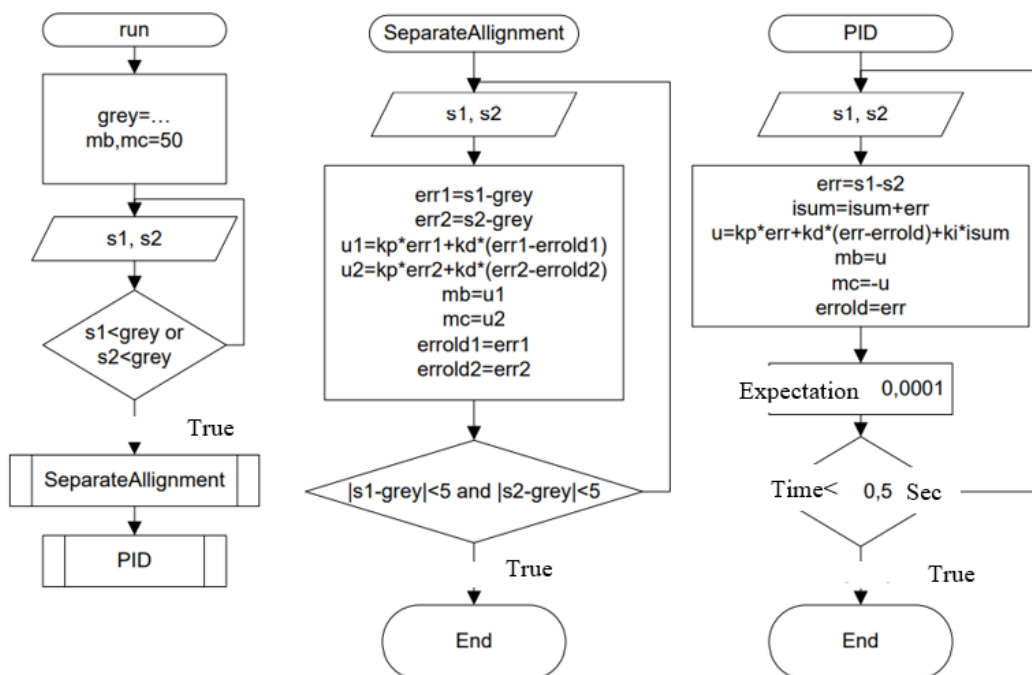


Fig. 3: Algorithm of exact alignment

The survey found that the two algorithms are often used separately to align the robot accurately. As a result of the experiment, the students determined the optimal coefficient of the PD and PID algorithms for the lego mindstorms EV3 robot when moving along the black line.

Project robotecnics. The method based on project work is relevant in the teaching of robotics. There are also competitions among project works in the Olympiads aimed at STEM

robotics. Over the years, the work of the creative category of the WRO Olympiad has been analysed and the following winning strategy has been developed:

1. The most important thing is to choose a particularly relevant topic;
2. The most difficult is the high level of technical implementation;
3. The easiest way is to follow the other points on the evaluation sheet.

To describe the structure of this victory strategy in more detail, we propose the following project development structure model (Figure 4).

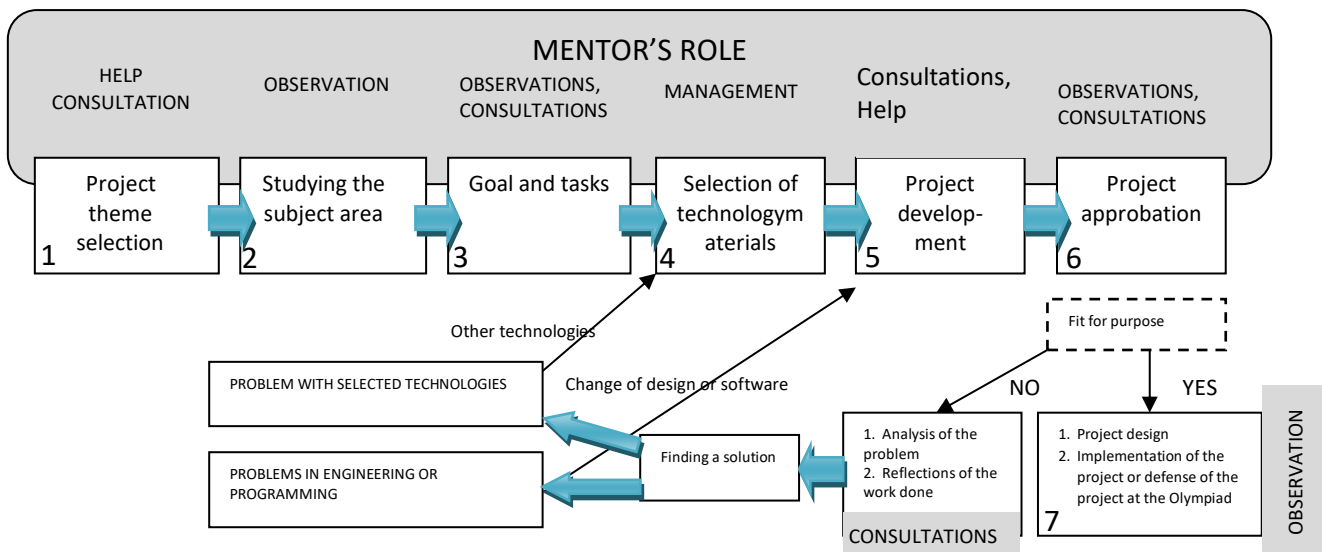


Fig. 4: Project development structure model

Project work consists of 7 stages: selection of the project topic, study of the industry, setting goals and objectives, selection of materials technology, project development and testing of the project, preparation for project defense. If we consider the research work that focuses on each stage:

The following criteria were used to select the topic of the project:

- the project must be practice-based and robotic (includes project prototype, device development, as well as the use of artificial intelligence);
- the project should be relevant to today's trends in science and technology;
- the project must be useful for economic, social or other development;
- it is necessary to use cross-cutting areas, mixed with different sciences.

At this stage, students study the problem to be solved, determine the relevance and novelty of this problem.

1. Study of the subject area:

- detailed study of the problem (detailed description of the problem to be solved by the project) or a detailed description of the research problem;
- analyze other solutions to the problem or other methods of conducting this research.

This information allows you to see the need for project work and formulate its goals and objectives.

2. Setting goals and objectives. On the basis of the subject area and other methods of solving this problem, students:

- defines the main objectives of the project;
- clearly defines the vision of the final result of the project;
- defines in detail all the tasks for project development.

3. Selection of technologies and materials. It is a very crucial stage because many students make mistakes at this stage, as a result of which, at the end of the work, they do not achieve their goals due to insufficient technical capabilities of the selected technology.

Today, there are many laboratory kits for the study of robotics. Each collection can be selected and analysed according to the age of the students (Table 1), as well as the difficulty level, capabilities, and price.

Lego WeDo Primary school	The simplicity of construction and design No special knowledge is required; everything you need is taught in the classroom.
Lego Mindstorms EV3 Education Primary and secondary school	average complexity of construction and design logical thinking skills
Arduino High school	high complexity of construction and design logical thinking skills, physics (electronics, mechanics)
Raspberry Pi, STM32, machine learning, neural network High school, and university students	very high structural complexity and complex programming Good knowledge of C ++, Java, and Python programming knowledge of physics (electronics, mechanics)

Table 1: Result of analyzing according to the age of the students, level of difficulty, capabilities, and price

4. Project development:

- at this stage, students create a design (layout) of the project;
- develop a robot or project concept;
- model models and mechanisms;
- print models from a 3D printer;
- write program.

4 Conclusions

Students test and analyze the design of the robot in accordance with the goals and objectives of the project. Determines whether the robot is working properly.

If the robot is working following the planned purpose, it is prepared for the external decoration of the project, the implementation of the project in production or defence in competitions. Conversely, if the goal is not met, the problem is searched, analyzed and returned to the fourth and fifth stages.

Today, research shows that robotics affects many aspects of education and profoundly affects students' abilities and skills. In the discipline of robotics 21st Century Skills, including Learning, Creativity, Research, Collaboration and Teamwork, Self-Governance, Communication, etc. Skills are described in several studies (Khanlari, 2013; Hussain et al., 2006; Nugent et al., 2010; Arlegui et al., 2008; Demetriou, 2011).

Therefore, an in-depth study of robotics in STEM education and training of students will increase its relevance. In addition, the organisation of Olympic competitions has contributed to the formation of skills. During the experiment, mini-competitions were held within the group. In developing a competitive robot, it was observed that students had developed the necessary skills for the 21st century. In other words, the team developed communication, teamwork, critical thinking, and project presentation, i.e. leadership skills. The best projects were nominated for national and international competitions. The following works were submitted to the international competition, and the best team was included in 10 projects.

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