BUILDING A BICYCLE ROBOT WITH LEGO EDUCATION WITHIN THE FRAMEWORK OF STEM EDUCATION: CHALLENGES AND OPPORTUNITIES IN THE PRIMARY EDUCATION STAGE

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Abstract: *This article discusses the construction of a bicycle robot using LEGO Education within the framework of STEM education, focusing on the challenges and opportunities involved in implementing such a project at the primary education level. The process of building and programming a robot that can move like a bicycle provides students with the opportunity to apply knowledge from physics, engineering, mathematics, and technology. Through active participation in building the robot, students encounter various engineering problems that require critical thinking, experimentation, and problem-solving. The article also discusses methodological approaches to integrating STEM concepts into education through project-based learning, teamwork collaboration, and the use of digital resources. The use of LEGO Education offers the possibility of practically applying abstract scientific and engineering concepts, encouraging active participation and innovation*

Keywords: *LEGO Education, bicycle robot, STEM education, engineering challenges, programming, mathematics, scientific principles, technology, project-based learning, balance and stability, teaching methods.*

I. INTRODUCTION

The modern educational model places emphasis on developing skills related to science, technology, engineering and mathematics (STEM), which have an important role in preparing students for future professional challenges. One of the main methods of integrating STEM concepts into education is the use of hands-on learning through technology, such as LEGO Education, which offers innovative approaches to building skills and knowledge in these areas. In this context, the construction of a robot cyclist provides a unique opportunity to apply theoretical principles through practical tasks that stimulate the development of critical thinking and creativity in students.

This article examines the challenges and opportunities that accompany building a robot with LEGO Education in the initial educational stage, as well as methodological approaches for the effective inclusion of STEM training in school practice.

STEM education is an integrated approach that encourages students to consider science, technology, engineering, and mathematics not as separate disciplines, but as interrelated fields. The ability to use LEGO Education to build a robotic model in the classroom provides learning in the context of real and actionable tasks. The process of building a robot cyclist with LEGO is an example of an active and exploratory form of learning, in which students not only acquire theoretical knowledge, but also apply it, solving real engineering problems.

The example of a robot cyclist is relevant because it requires students to put into practice knowledge from physics (balance, motion and inertia), engineering (planning and building stable mechanisms) and mathematics (measuring speed and distance).

Constructing a robot cyclist with LEGO Education is useful for STEM learning purposes (science, technology, engineering and mathematics). This project provides opportunities for students to develop and apply various skills and knowledge in these disciplines through the active construction and programming of the robot. Here are a few ways this process can be used in a STEM context:

1. Science

A robotic cyclist can be designed to demonstrate basic physical principles such as friction, centrifugal force, equilibrium and inertia. For example, the robot must be stable on different surfaces and show how the different components of the wheel interact with the environment.

By experimenting with different wheels or mechanisms, students can study the effects of different materials on the robot's performance, exploring how the rubber, weight, or design of the wheel affect speed and stability.

2. Technology

The robot cyclist must be programmed to follow a certain route, react to obstacles or adapt to changing conditions. This includes the use of programming languages such as Scratch or Python (via LEGO Mindstorms). Students will learn how to use motion sensors, light sensors, distance sensors, and program the robot's behavior in different situations.

The process of designing and adjusting the robot includes technological solutions related to the selection of components and sensors, as well as optimization of movement mechanisms.

3. **Engineering**

Designing a robotic cyclist requires research on engineering principles such as balance, sustainability, and mechanics. Students will have to draw up a plan for building the robot, choose the right parts and combine them so as to achieve a functional and stable result.

Production Processes: Students can learn about the design and prototyping processes using LEGO Education and various technological tools. They will learn how to build and test their physical models before they start programming.

4. Mathematics

Students can become familiar with mathematical concepts related to speed, acceleration, and time while working on the robot's program and tracking its motion. Calculations can be performed related to the optimization of the cyclist's trajectory or the speed he can achieve on different types of terrain.

As part of the robot's testing process, students can collect data on the time it takes to go through different sections or complete different challenges, and analyze this data using graphs and charts.

5. Teamwork and critical thinking

Students will have to work in teams to plan, build and program the robot. This develops communication and collaboration skills.

When the robot does not work as expected or encounters difficulties in completing tasks, Students will need to engage in the process of critical thinking and problem-solving by performing tests and adjustments.

6. Integration of disciplines

The project with the robot cyclist Legocycle is an example of the integration of all four disciplines (STEM) into one joint activity. This helps students understand how these areas are interconnected and how each of them plays a role in creating innovations and technological solutions.

Thus, by building and programming a robot that can move like a cyclist, students have the opportunity to learn and apply important concepts from physics, mathematics, technology, and engineering, while developing teamwork and innovation skills.

II. CHALLENGES IN BUILDING THE ROBOT CYCLIST

1. Balance and stability problems

Building a robot that can move like a cyclist and maintain balance is one of the main challenges. The issue of stability is especially important, as the robot must be designed so that it can pass through different terrains without falling. This requires careful selection of components and experimentation with different weight placements.

Example: Often, when students start building, their robot may fail to maintain balance, which is a common problem in the practical part of the lesson. These difficulties can arise from incorrect wheel placement or inadequate choice of motors. Students will need to experiment and analyze the robot's design to identify and correct these problems by changing the design or choosing new components.

2. Programming and Automation

Although LEGO Education offers intuitive programming platforms, students still encounter difficulties in setting up the motors and sensors that control the robot's movement. Programming the robot to follow a trajectory, recognize obstacles and move smoothly requires not only basic programming knowledge, but also logical thinking skills and advanced conceptualization.

Example: During the tests, students may find that the robot does not respond correctly to the set trajectory. This is a signal that programming may be inadequate, and students need to revise their codes, such as adjusting speed, motion, or barrier sensors.

3. Testing and Optimization

The testing process is not only part of the engineering approach, but also an important means of acquiring self-correction skills. When the robot does not function as expected, students must take steps to optimize the structure by changing weight distribution strategies or revising the program code.

Example: Students may face problems when passing through obstacles or when the wheels are stationary. They need to analyze data on the robot's movement and make adjustments. This not only develops engineering skills, but also strains their ability to think critically and solve problems.

III. METHODOLOGICAL APPROACHES FOR EFFECTIVE INCLUSION OF STEM IN PRIMARY EDUCATION

1. Project-based learning

Project-based learning is an effective method of integrating STEM concepts into primary education, giving students the opportunity to apply what they have learned in a practical situation. Building a robot cyclist with LEGO offers the opportunity for active participation and stimulates students to think like engineers and programmers. Through this approach, students solve real-world engineering problems and become familiar with the process of planning, creating, and testing.

2. Interactive and collaborative methods

STEM learning in the initial stage can be significantly enriched through collaboration and group work. The projects, which involve building and programming a robot, provide opportunities for students to exchange ideas, work together in teams, and develop communication and coordination skills. The ability to collaborate in groups allows students to solve problems together by combining their knowledge of different disciplines.

3. Use of technology and digital resources

The programmable platforms provided by LEGO Education offer an intuitive interface for students and can be easily integrated into the initial stage of education. It is important for the teacher to provide support in navigating through these platforms, to train students in basic programming concepts, and to encourage them to experiment with different approaches to the task.

IV. STEM LESSON PLANNING FRAMEWORK WITH LEGO EDUCATION – "BUILDING A ROBOT CYCLIST"

Lesson purpose: Students will learn the basic principles of STEM by building a robot cyclist with LEGO Education, developing skills in planning, constructing, testing and optimizing robotic systems.

1. Objectives of the lesson:

Scientific objectives: Understanding basic physical principles: balance, movement, center of gravity. Understanding how the robot interacts with the environment (wheel movement, friction).

Technological Goals: Using LEGO Education to build a robot. Introduction to motors, sensors and their operation in the context of robotic systems.

Engineering goals: Design and build a robot that can move and maintain balance. Select and adjust components to achieve optimal movement.

Mathematical objectives: Measuring the time and distance that the robot travels. Speed analysis and optimization of the robot's trajectory.

2. Dividing a class into groups:

Group size: 3-4 students per group.

Role in the group: Designer: Responsible for planning the robot's construction and selecting components.

Constructor: Builds the physical part of the robot by mounting the components.

Testers: They test the robots after they are built and check if they can move without problems.

Programmer: Works on programming the robot for movement and optimizing its functions.

Method of separation: Students are divided into teams of 3-4, with each team receiving a LEGO Education set. Each team will work on an individual robot, but will have to collaborate and exchange ideas with the other teams.

3. Introduction to STEM Components (10 minutes):

Science. Balance and Movement Explanation: The teacher explains the principles of physics that are essential for the movement of a cyclist, such as inertia, center of gravity, friction.

Question to students: "How can we make sure that the robot remains stable while moving? How can we ensure the balance of the robot?"

Technology. Introduction to LEGO motors and sensors: The teacher demonstrated how LEGO motors and sensors work and how they can be used to control the robot.

Question to the students: "How will we use the motors to move the wheels? Which sensor can help us detect obstacles on the road?"

Engineering. Constructing a robot: The teacher explains how to create a robot that is stable by correctly placing the weight, selecting the parts and taking care of balance.

Question to students: "How will you ensure that the wheels will rotate evenly? What components should we use for balance?"

Mathematics. Motion measurement: The teacher explains how to measure the distances that the robot travels and monitor the speedQuestion to students: "How can we measure how fast the robot is moving? What will happen if we accelerate the bike?"

4. Planning and Building the Robot (20 minutes):

Design stage: The groups begin to plan the design of their robot. They design basic mechanisms and decide how they will arrange the parts so that the robot is stable and can move like a cyclist.

Students have to decide how they will install the motors and how they will use the sensors to optimize movement.

Construction stage: Students start assembling the robot using the LEGO Education sets. They need to make sure that all components are properly placed so that the robot does not fall and can move along the correct trajectory.

The teacher offers assistance in the assembly process and reminds students to test the robot and make adjustments if necessary.

5. Testing & Optimization (10 minutes):

Testing the robot: Each team puts their robot on a path and tests it. The goal is for the robot to move steadily and not fall.

Students have to measure the time the robot travels for a certain distance and analyze its speed.

Optimization: After the test, the student will discuss what can be optimized in the design. Possible adjustments include moving the motors, adding additional parts for stability, or adjusting the speed.

Question to students: "What did you do to make the robot more stable? How can we change the design to move faster or more balanced?"

6. Summary and Feedback (10 minutes):

Discussion of results: Students present their robots to the class. They explain how they achieved balance and how they decided to build and program their robot.

Teacher feedback: The teacher gives feedback on each group, noting the strengths of the projects and suggesting ideas for future improvements.

Reflection: The teacher asks a question: "What did you learn about the balance and movement of the robot? What part of the process was the most interesting?"

7. Additional tasks and extension of the lesson (Optional for future lessons):

Engineering challenges: Students can try to add new sensors to their robots to automatically adjust speed or avoid obstacles.

V. DETAILED LESSON SCENARIO AT THE INITIAL EDUCATIONAL STAGE: "PLANNING AND BUILDING A ROBOT CYCLIST WITH LEGO EDUCATION"

1. Introduction to the lesson (10 minutes)

The teacher begins with an introduction to the topic: "Good morning, students! Today we will create not just a robot, but a robot that will be able to move like a cyclist. We will understand what balance, movement and how different parts of the robot will work together to move forward without falling."

The teacher asks a question: "What do you think it takes for a robot to ride a bicycle? What should we do to provide him with a balance?"

(Students give answers, the teacher directs them to the basic principles of movement and balance.)

The teacher continues: "Today we will look not only at how to build this robot, but also at what happens when the robot moves. We will get acquainted with several interesting physical principles, use technology and solve engineering problems to achieve our goal."

2. Explanation of basic concepts (10 minutes)

The teacher begins with an explanation of basic scientific and engineering principles: "Do you know what balance is? Balance is when something stands stable without falling. When we build our robot, we must make sure that its weight is evenly distributed so that it does not tip over. To achieve this, we will use LEGO parts and motorcycles."

"Then we will program the robot so that it moves like a real cyclist. We will have to understand how the motors work and how we can control them using a program."

The teacher asks the class: "Why do you think balance is important for the cyclist? What other things do we need to know to get the robot to move properly?"

(Students discuss and share ideas.)

The teacher explains: "In order to be able to create a robot that rides a bike, we need to get acquainted with a few basic things: how to position the weight, how to choose the right components and how to set up the robot's program so that it can be used to ride a bicycle.

3. Planning the construction (10 minutes)

The teacher divides the students into groups: "Now we will split into groups of 3-4 students. Each group will work together to create their own robotic cyclist. Each team needs to come up with a plan and start building the robot using the LEGO Education kits." (The teacher distributes the kits and instructions which will serve as guidance, but students will have the freedom to experiment.)

The teacher explains what the groups should do: "You will have to build a robot that has wheels and a motor for movement. You need to make sure it can move forward and maintain balance without falling. Each of you will have a different task, so you must coordinate and work together."

The teacher asks a question: "What LEGO components do you think we will need for the balance of the robot? What wheels and motors can we use?"

(Students begin to think and consider possible solutions.)

The Master continues: "You should also think about how to position the motors. You will use LEGO motors that you will place in the right places so that the robot can move stably. Also, be sure to test the robot throughout the process and fix it if it doesn't work as you expect."

4. Building the Robot (20 minutes)

The teacher supports the groups during the construction: "Okay, let's get started! Each team will start by assembling the basic structure of the robot. There's no right or wrong way to do it, but it's important to think about balance and movement. If the robot cannot move or falls, you will have to turn back and try again."

The teacher asks guiding questions:

- "How did you position the wheels? What do you think, will the robot be stable?"
- "How are you going to use the motor to make the robot move?"

The teacher monitors progress and helps the groups with recommendations.

"Okay, I see that you are starting to build the basic mechanism of movement. Now you will have to make sure that the wheels can rotate smoothly and without locking."

5. Testing & Optimization (5 minutes)

The teacher helps the groups test their robots:

"Now you will start testing your robots. Place them on the floor and see if they can move. If a robot can't ride, think about what can change – maybe you need to move the motors or change the balances."

The teacher asks a question: "What happens when the robot cannot maintain balance? How can you change the design to improve it?"

(Students make adjustments by moving parts or changing the design.)

6. Summary and Feedback (5 minutes)

The teacher summarizes the results of the lesson: "Great! I see that many of you have created great robots that move successfully. What did we learn today? What principles of science, technology, engineering and mathematics did you use to create your robots?"

The teacher asks a final question: "What do you think, what other technologies can we use to improve our robots in the future? What new ideas would you add to your construction?"

VI. CONCLUSION

Constructing the Lego Cycle robot cyclist with LEGO Education in the context of STEM learning is not only an opportunity for students to develop technical skills, but also to acquire critical thinking and problem-solving abilities. This not only prepares students for the future in the technological world, but also provides a holistic approach to learning that integrates science, technology, engineering, and mathematics into collaborative learning. The use of LEGO Education and STEM methodologies in the primary education stage not only facilitates the understanding of abstract scientific and engineering concepts, but also encourages the active participation of students, putting them at the center of the learning process.

Robotics is a bridge to the future of education. It develops key skills in students while inspiring them and opens doors to endless possibilities where anyone can be an inventor.

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