ROBOT DESIGN
TEAM ÖÖKULLID #23

FIRST® LEGO® League Challenge 2022-2023 SuperPowered℠

Tallinn 2023

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Team Öökullid

We are a team of Öökullid from Tallinn Kristiine Gymnasium (TKG). We come from Estonia. Our name translates to the Owls. Our team started in TKG, and since the TKG logo is an owl, the first generation of the team decided to name the team Öökullid (Owls). Over the years, the team's name and logo have stayed, the latter of which is also inspired by the TKG logo. All the team members have changed over the years, and this year are already younger members from the seventh generation.

1.2 Base robot Beast

Our main robot Beast got its name in 2014. The name arose when the older generation introduced robotics to smaller classes during the Future Class season to spark interest in them. At that point in time, our robot did not yet have a name, the only ideas were: Rally Car, Breaker and Speed.

1.3 Short summary of Beast, equipment, and robot game

Beast has a built-in motion sensor and two color sensors. The wheels of the robot are rotated by two large motors, and the other two medium motors turn the motorized solutions on our rides.

Our entire equipment consists of a basic robot and rides, which we place on top of the Beast.

2 MISSION STRATEGY AND THE DISCOVERY OF BUILDING AND CODING SKILLS

2.1 Mission strategy in the preliminary round eelvoorus

2.1.1 First run

Our first ride collects two looped waters and thee the energies from the solar farm. In addition, we load three fuel units into the fuel truck.

2.1.1 Second run

Our second ride lifts our field's orange smart grid connector and solves the power plant mission.

2.1.1 Third run

Our third ride pushes up the television set, grabs the rechargeable battery, loads the hybrid unit into the hybrid car and releases the car from its ramp. In addition, we collect three energies from the windmill and leave them in the rechargeable battery target circle.

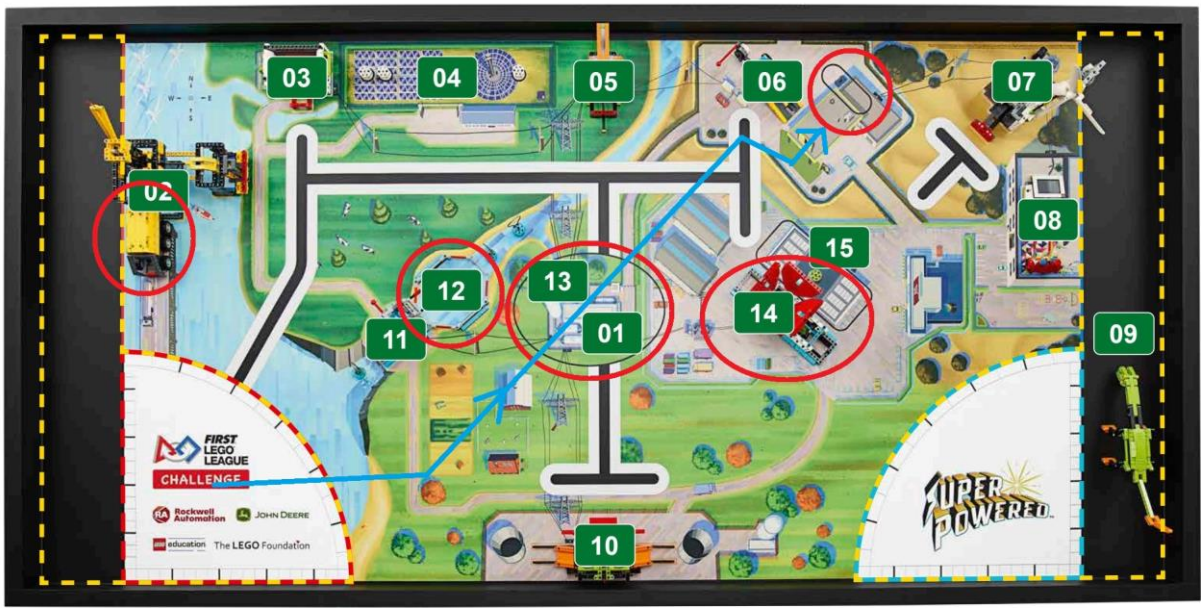
2.1.1 Fourth run

Our fourth ride dumps the dinosaur toy loaded with a rechargeable battery, two energy units and two looped water units collected by the previous rides into the other home area. In addition, it collects the looped water unit in front of the hydroelectric dam and solves the dam as well. It then delivers three energy units into the energy storage mission and grabs the tray from beneath the storage mission.

2.1.1 Fifth run

Our fifth ride collects the fuel truck.

2.1.1 Sixth run



Our sixth and last ride uses the same ride as the firth ride. Our sixth ride delivers the three looped water units into the target, placing two looped water units on the red hooks, and one into the reservoir. In addition, it delivers two energy units and our innovation project model into the hydrogen plant target circle. After that we drop two energy units into the toy factory's red hopper. We finish our ride and robot game by parking the robot over the fuel station target in a way that part of the fuel truck is in it.

2.2 Robot game strategy in national final

2.2.1 Run zero

Ride zero – maximum 70 points. The robot fits in the inspection area and does not lose precision discs on the table.

2.2.1 First run

First ride – maximum of 45 points – We collect three looped water units and three energies by solving the hydroelectric dam and power plant.

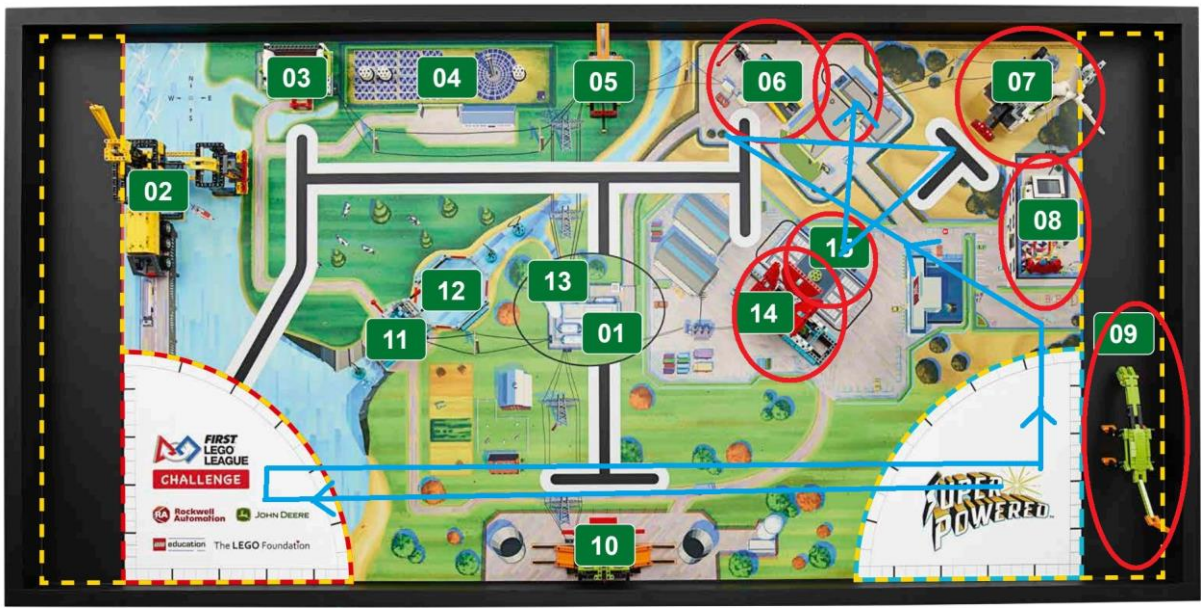
2.2.1 Second run

Second ride – maximum of 60 points – we load three oil units into the fuel truck, we deliver three energy units into the energy storage. In addition, collect the tray and grab two energy units form the solar farm. At the end of the ride, we ram the fuel truck into left home area.

2.2.1 Third run

The third ride – maximum 110 points – We raise our fields smart grid connector, grab the last energy of the solar park, deliver two waters onto the red hooks, and drop water into the reservoir circle. In addition, we will take the innovation project model and two energy units to Power-To-X circle, drop one energy into the toy factory and grab the rechargeable battery.

2.2.1 Fourth run



Fourth ride – maximum 135 points – We drive the dinosaur to another base and bring a fuel truck from the second base. We solve the TV, the hybrid car, and pick up three energies from the wind turbine. We take these energies to the target circle of the battery and drop two more energies into the toy factory. We end the ride and the game by parking above the target circle of the fuel station.

1. ROBOT FUNCTIONS, RIDES AND SENSORS

2.3 Robot

2.3.1 SPIKE Description of the main robot Beast

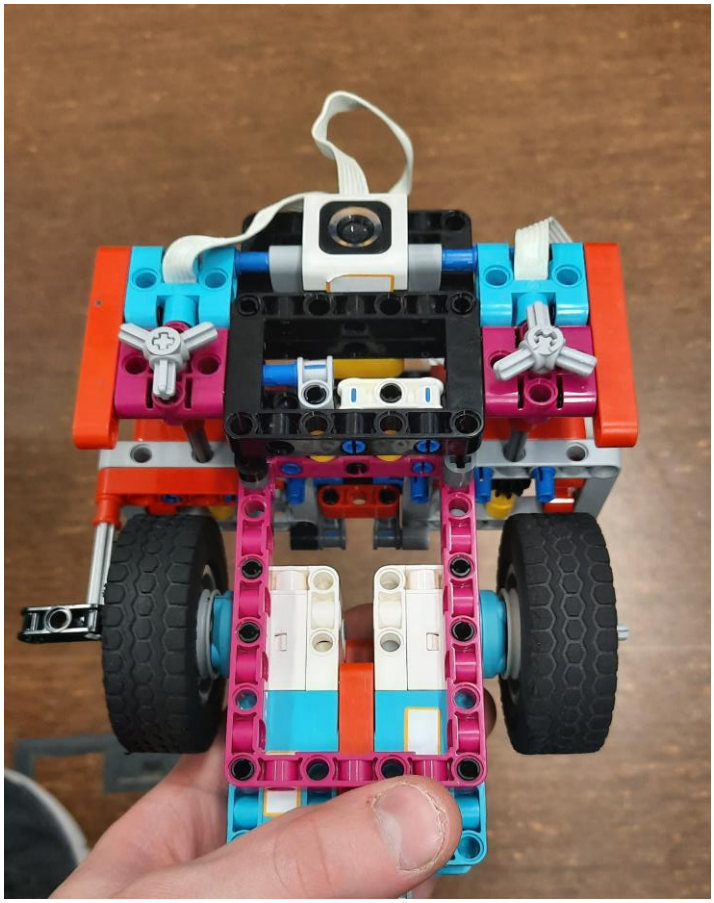
The main robot (hereinafter referred to as the main robot) has two color sensors and a motion sensor built into the brain. The main robot is propelled by two large SPIKE Prime motors. The two medium SPIKE Prime motors are for mission solving, should a solution require the use of a motor. We decided to document the construction of the entire robot. The process of developing our robot began from the first parts. From the very beginning, we had plans to build a new SPIKE PRIME based robot as we found some flaws in our last year's robot. We stayed on the SPIKE platform because the gyro sensor, as a robot built on SPIKE is more reliable and its motors are more powerful. In addition, we also document the principle of operation of each base, as well as the construction process.

2.3.2 Development of the main robot Beast

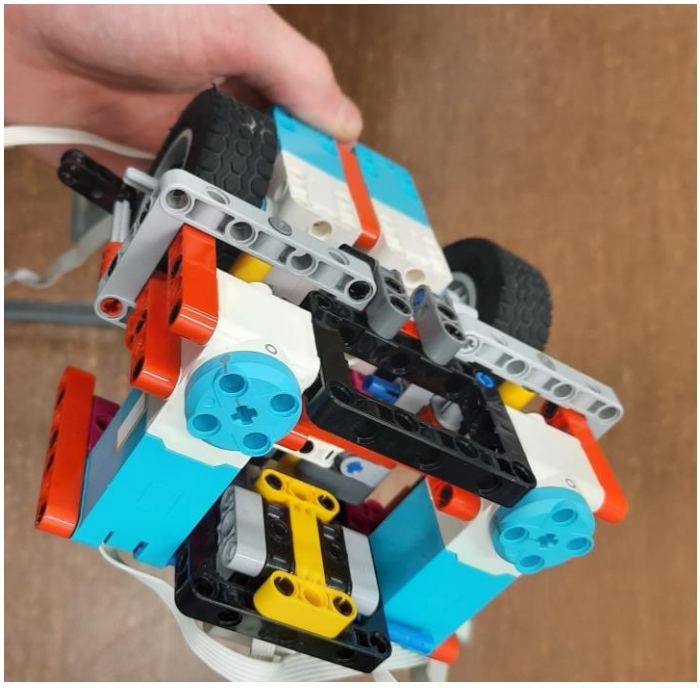
The construction of the main robot began with the first details on the date of March 31, 2022. We based the construction of the robot on the best features of our robots of the last six years, from last year's robot we wanted to keep a large gap between servo motors, good flat wheels and the stability of the robot that came from them. The biggest strength of the RePlay season robot was its small size, the goal was to build a smaller robot than the one we used during the Cargo Connect season. One of the very good design elements of its Hydrodynamics/Orbiting robot of the season was the easy interchangeability of its battery, four pieces and the battery, or even the entire brain, had been replaced. The goal then became a small and stable robot, which has a large frame between the servo motors and whose battery is very easily replaced. In addition, we wanted one color sensor on top of the robot to start the right ride with it in a large program. We got a summary of such a list that we need from a robot:

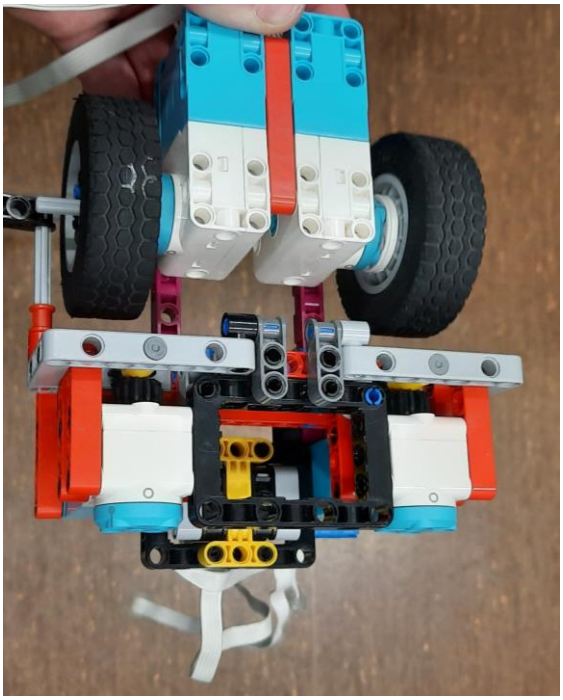
Feature	Previous example	Importance:
Easily replacable battery	2017-19 a. robot	I
Small and compact	2020/2021 a. base robot	II
Color sensor on top	2021/2022 a. base robot	I
Enough space between servo motors	2017-20 ja 2021/2022 a. base robots	I
No up/down wobble	2021/2022 a. base robot	I
The good and flat tires	2017-19 ja 2021/2022 a. base robot	I

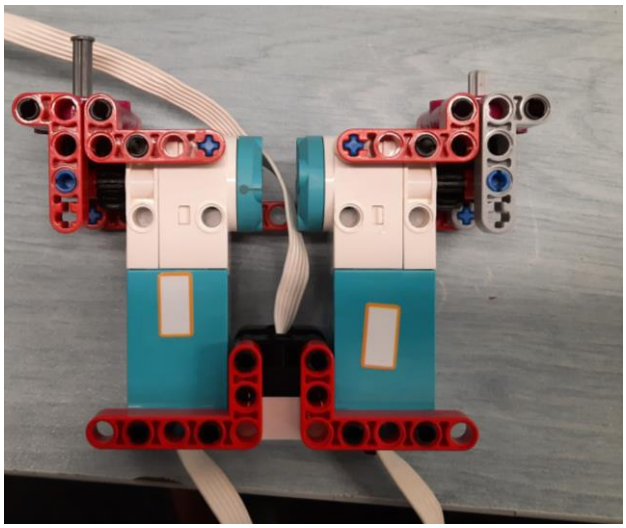
1. Development of the main robot Beast in the Cargo Connect season

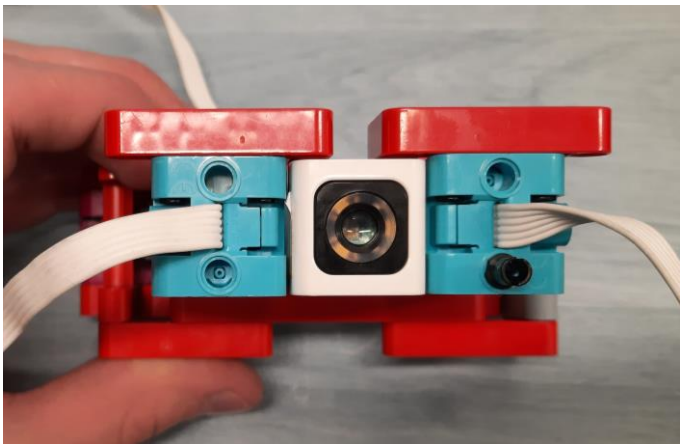


The beginning of the construction of the main robot was simple. We got something put together initially, and then started thinking about what needs to be changed to fit all the planned goals into one robot.





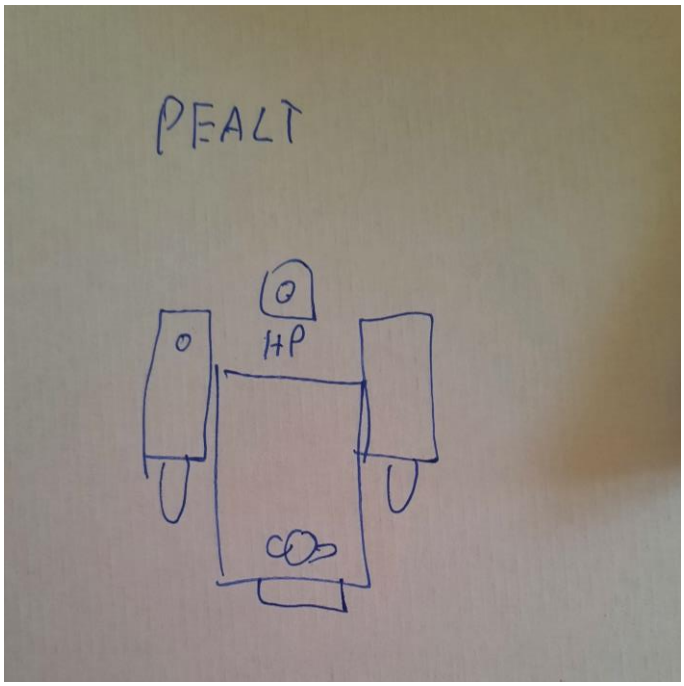


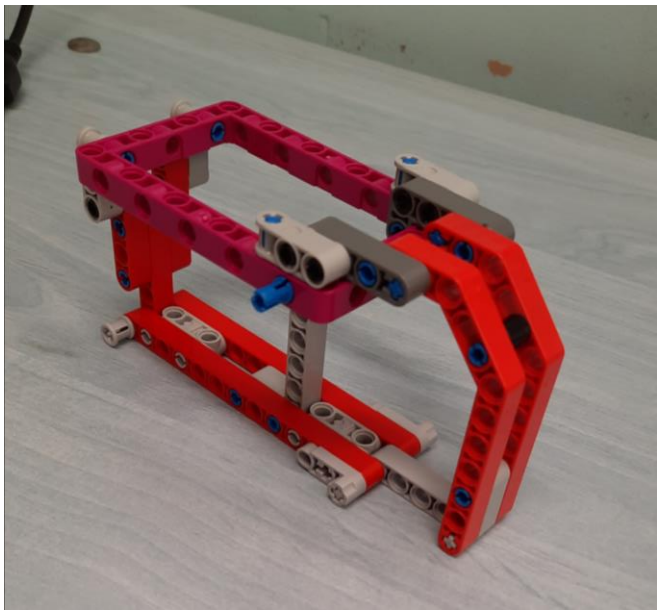


We looked at ways to make the servo motor part more compact. In many ways, the mouth of the Cargo Connect robot was due to the position of the servos.

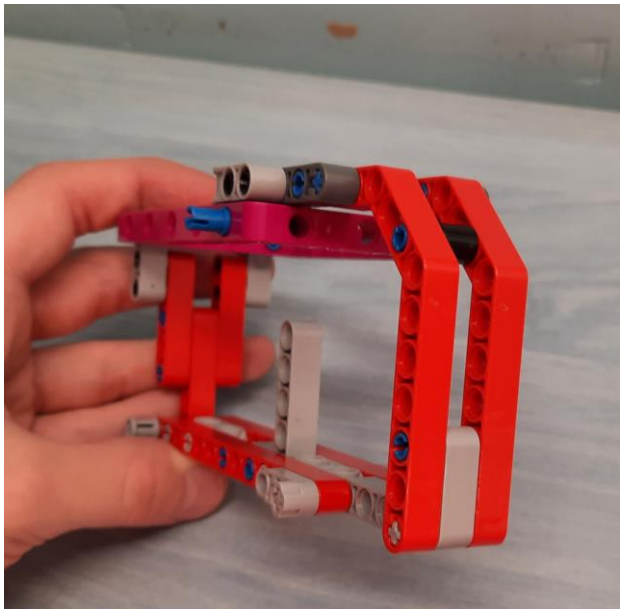
The construction of the main robot continued with the idea that the battery must be replaceable very easily. The most logical way to achieve this was by a robot that could split in half.

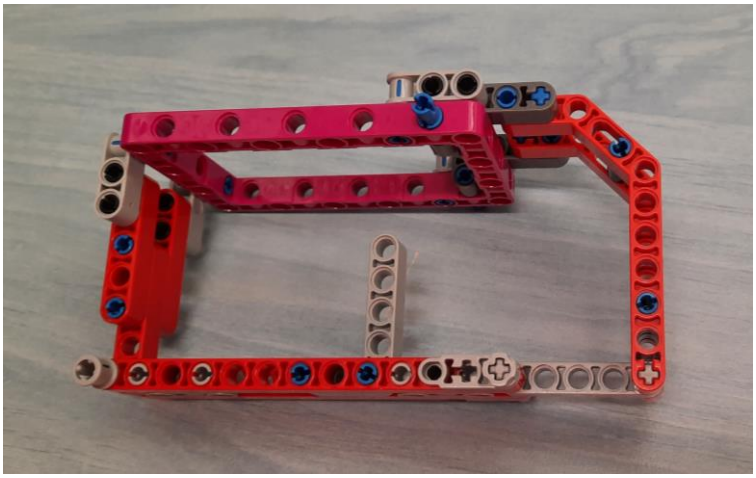
A quick drawing of what the robot's top might look like was made.

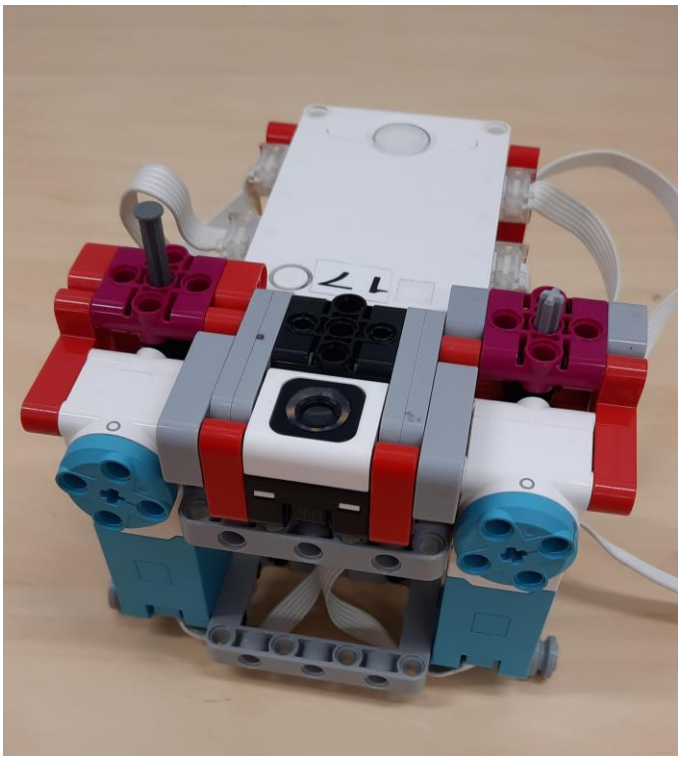




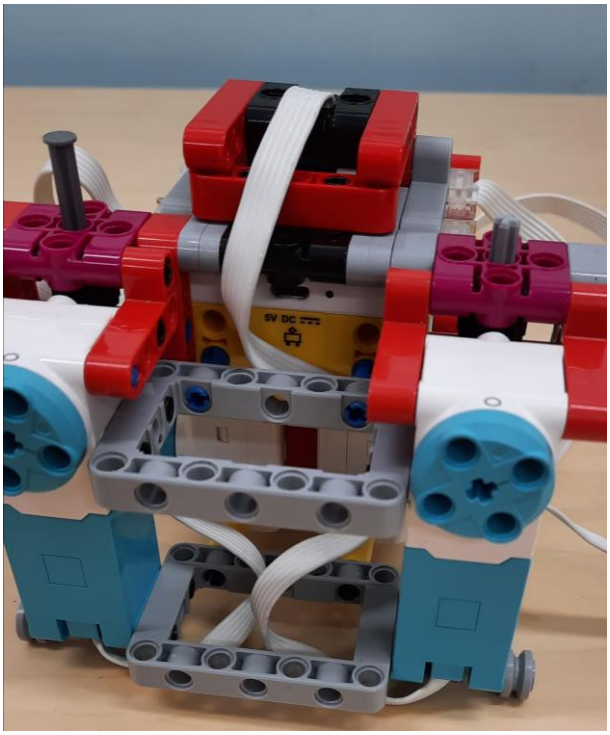
We continued to develop the hinge system that could allow the robot to open up.

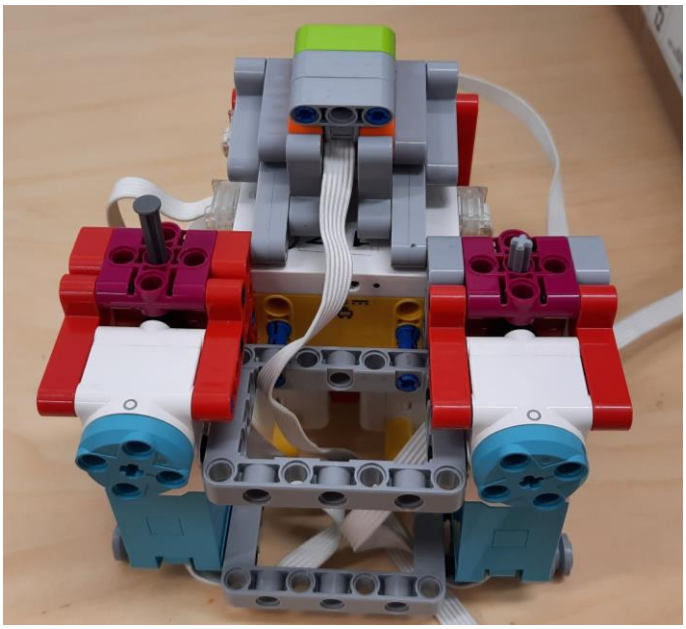




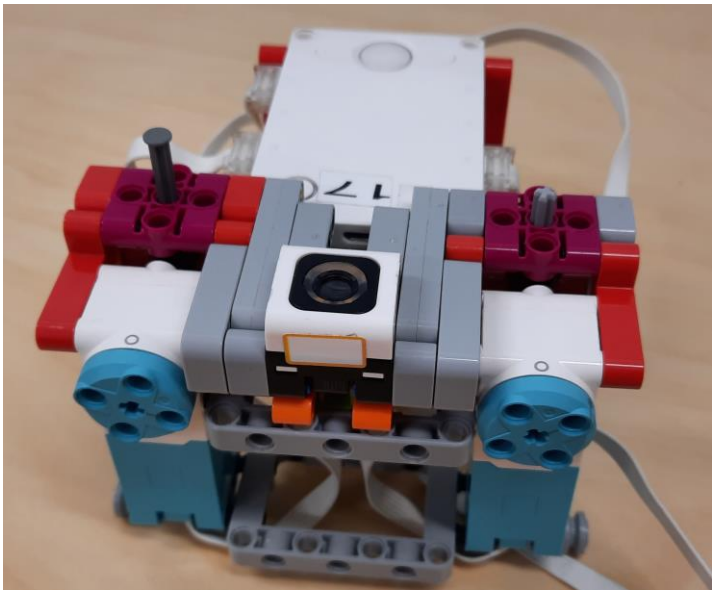


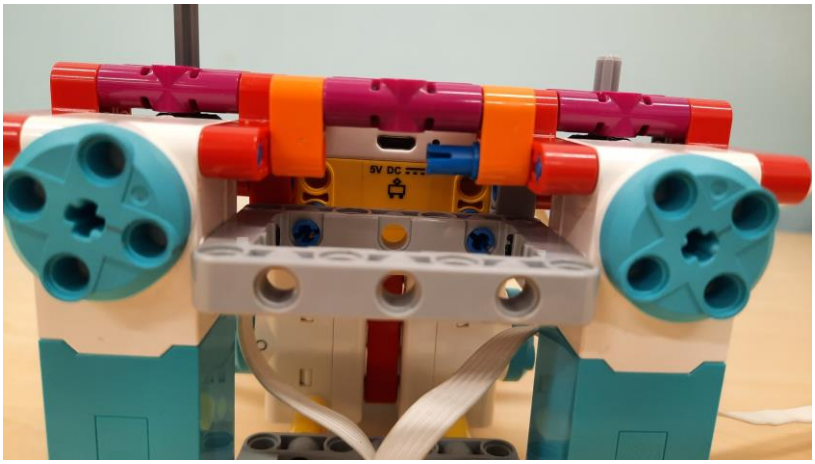
We took what we learned during the experiments and, based on that, we began to again build the robot. With this prototype, the original plan was to make the color sensor with the mounting point of the bases into a type, thus allowing access to the robot's charging slot.



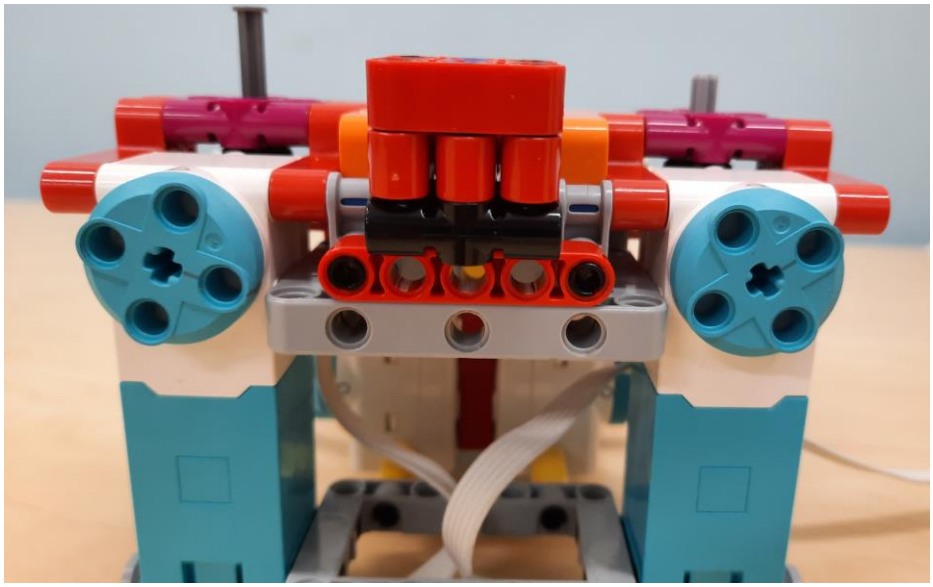


We slightly changed the design of the moving color sensor to allow it to be locked to the robot.

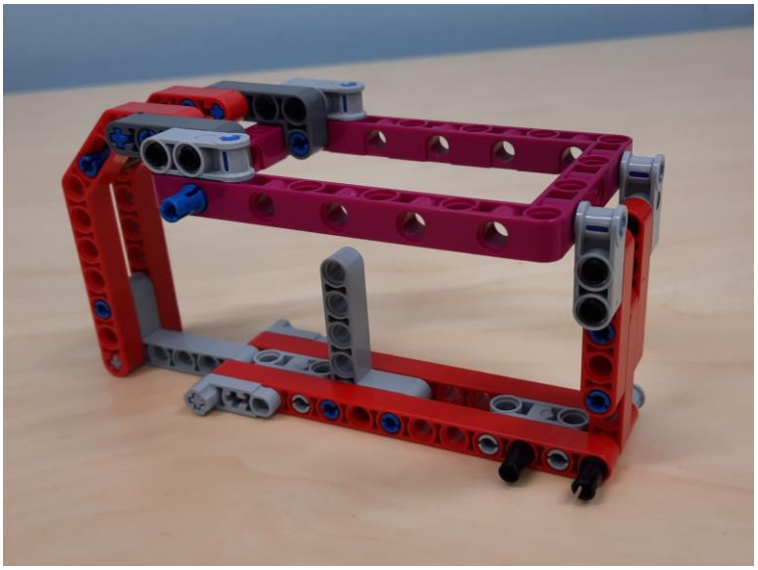




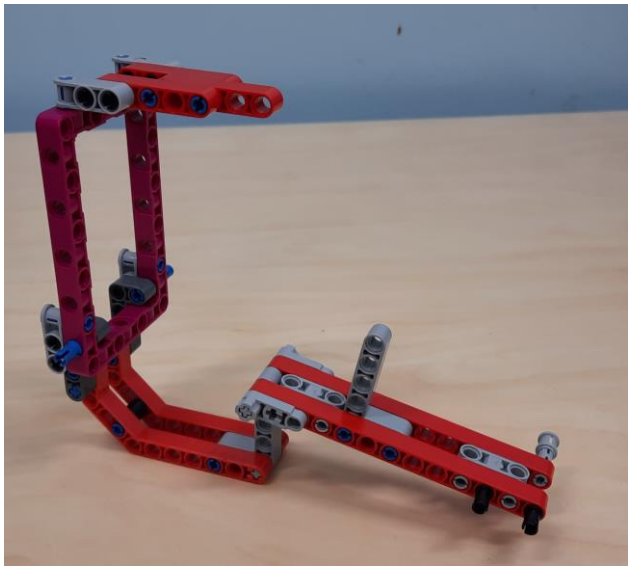
To achieve compactness, we also tested the idea of leaving an empty space for the charging cord under the mounting point of the bases.

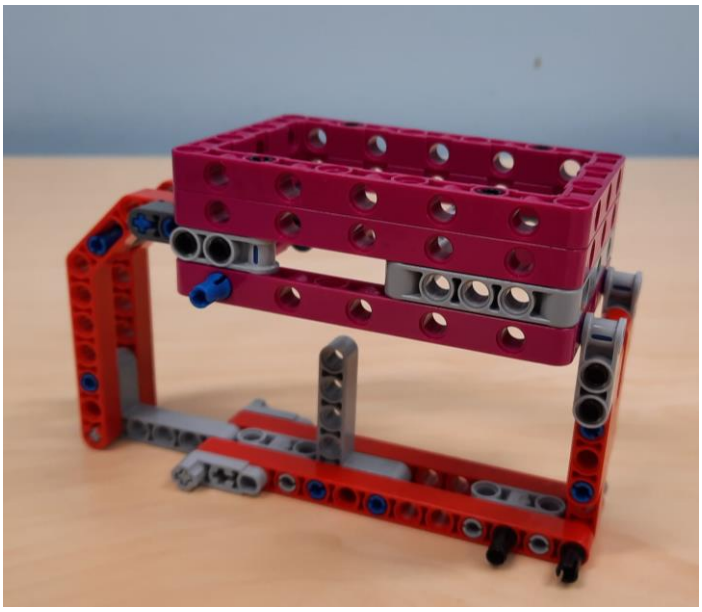


In this design, the color sensor would have been easily removed for charging.

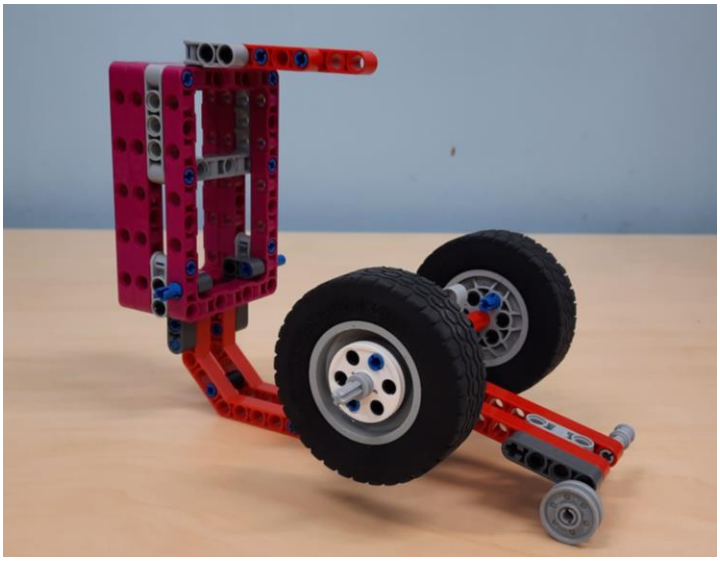


We took a prototype of our initial hinge system and started thinking about how to attach the brain to it.



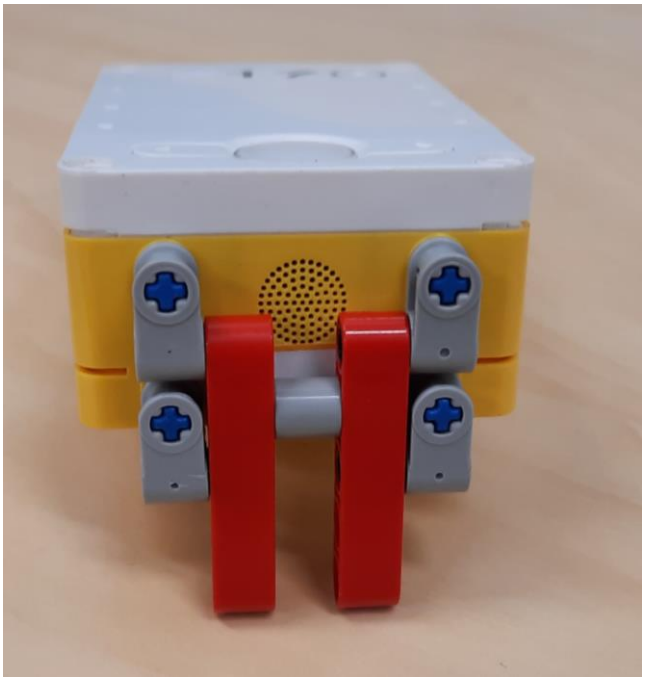


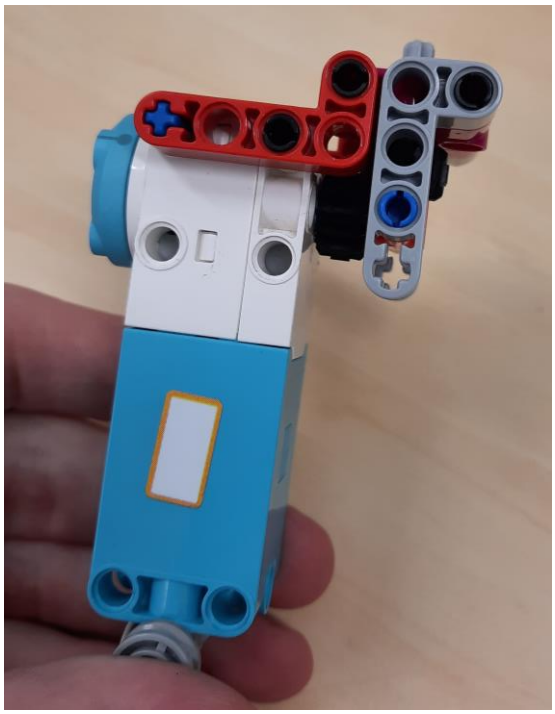
Since the SPIKE brain was in use elsewhere at the time, it had to be replaced with pink frames.



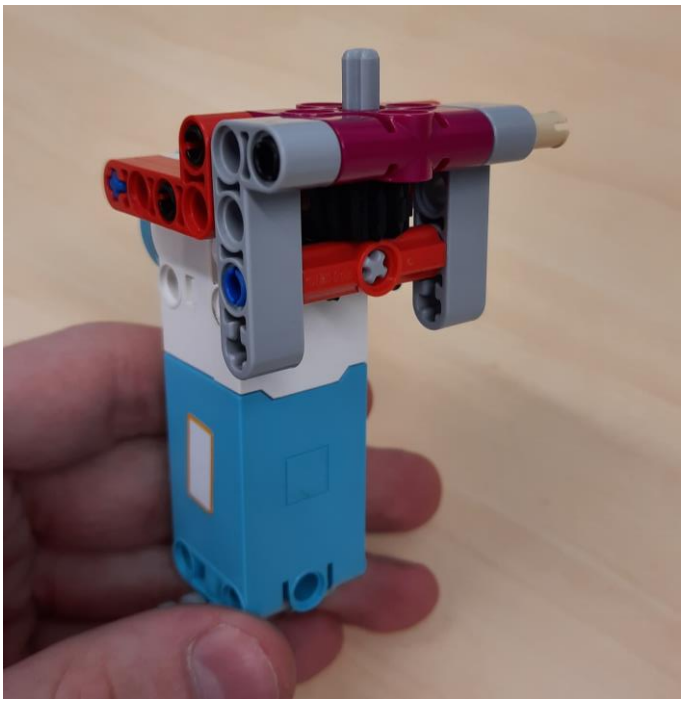
We started thinking about where the big and small wheels would be.

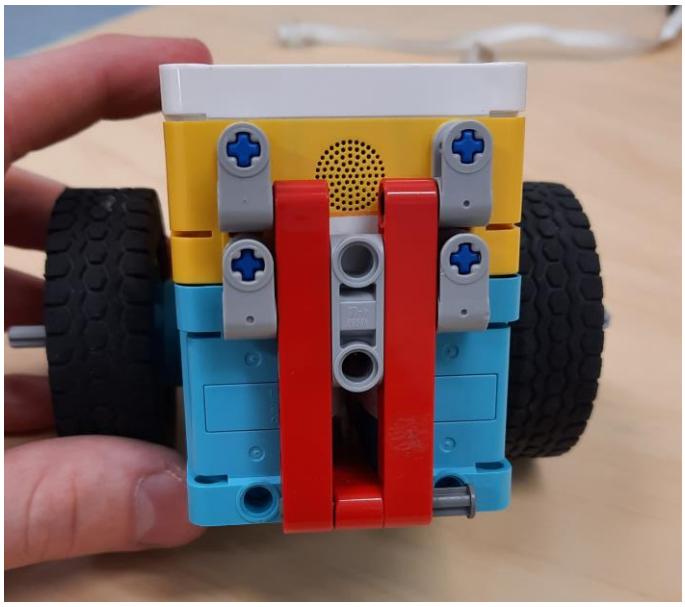
Having got the wheels more or less in place, we started over.



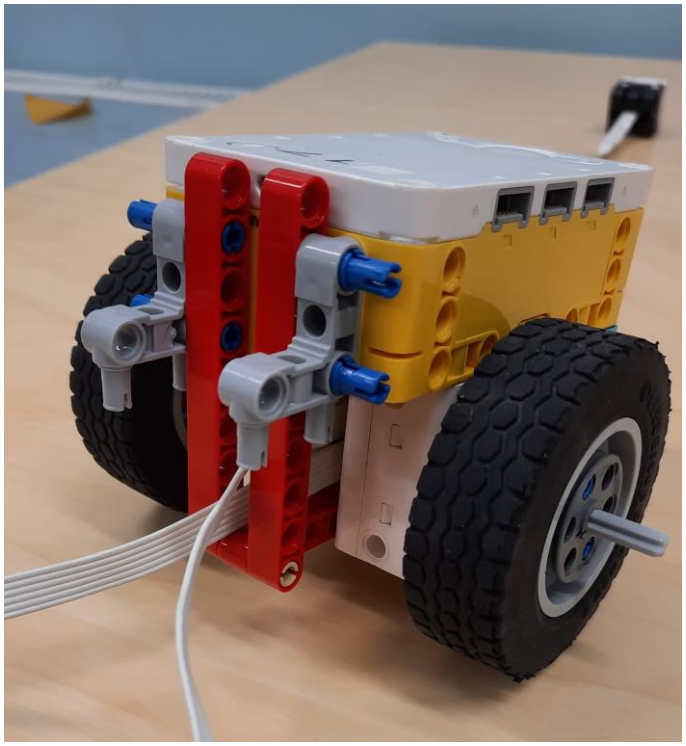


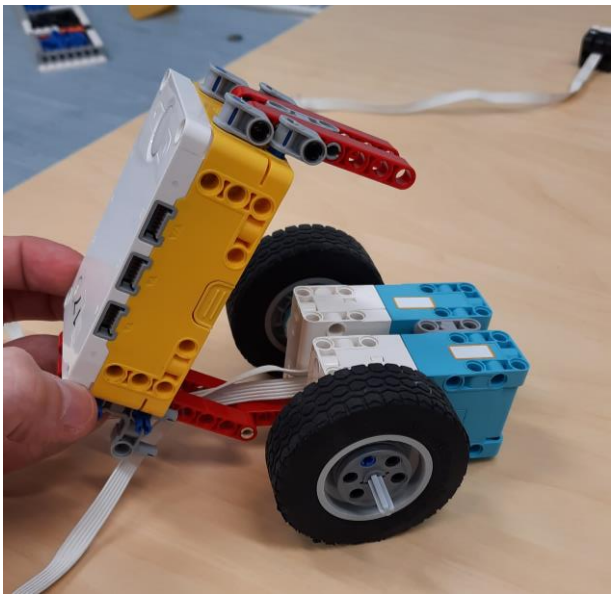
We began to think of a working transmission for small motors.



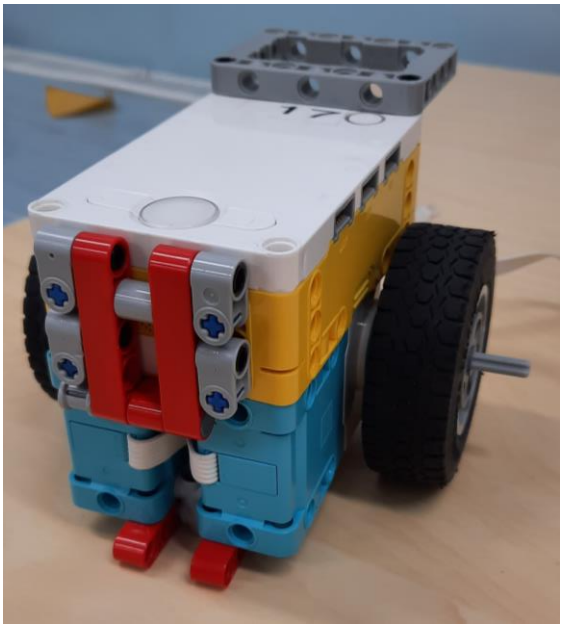


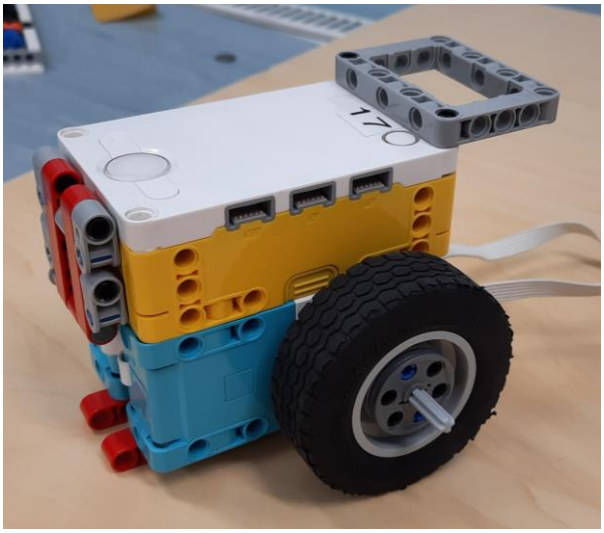
We built an initial locking and hinge mechanism on the brain.



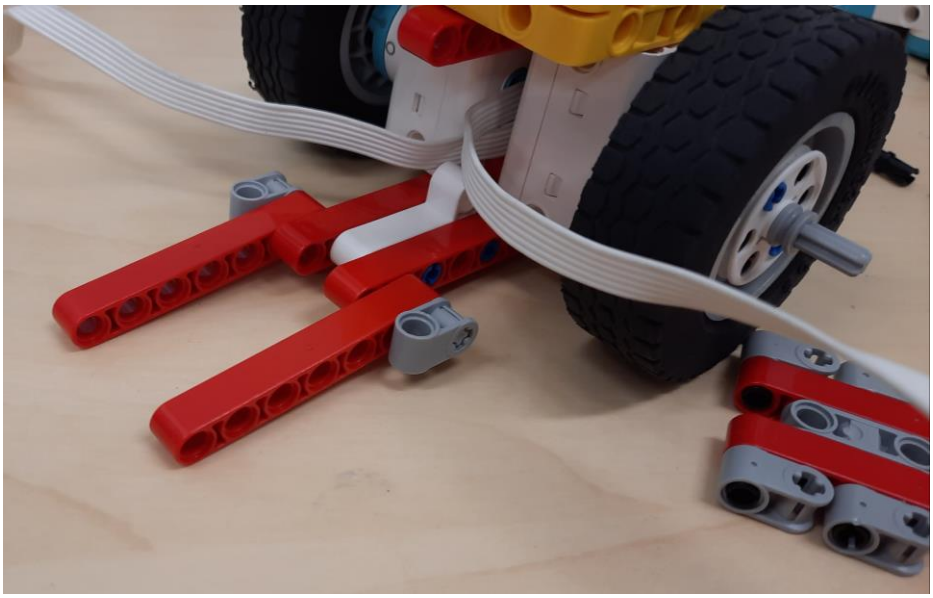


We tested such a design and found places for improvement.

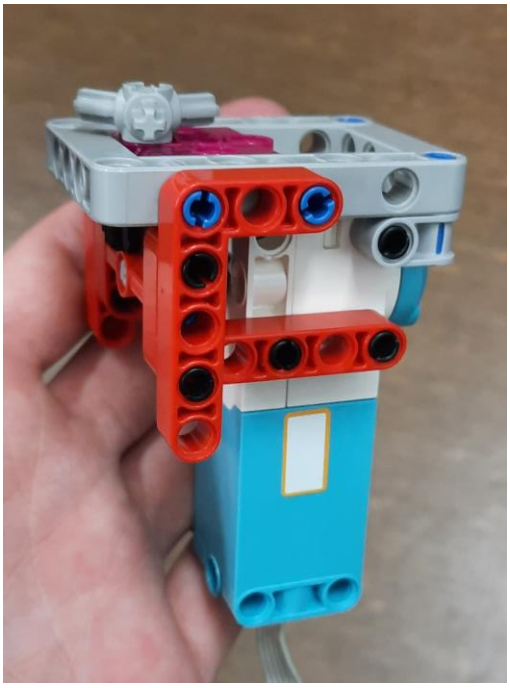
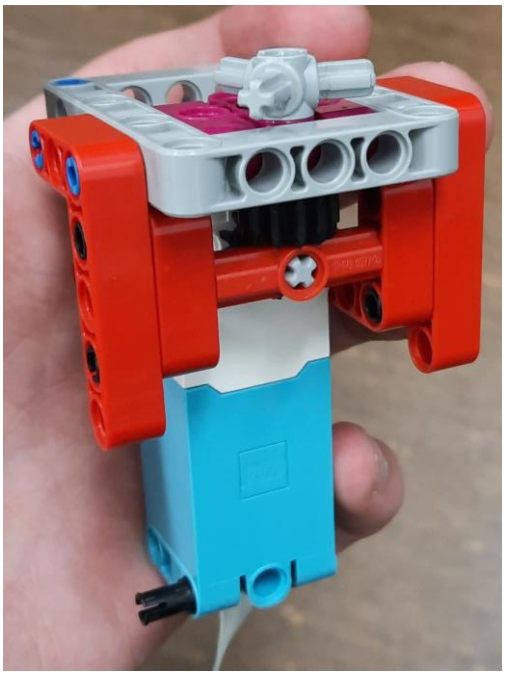
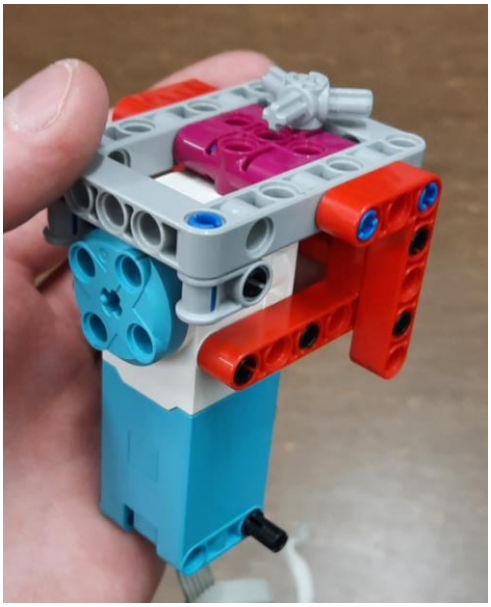




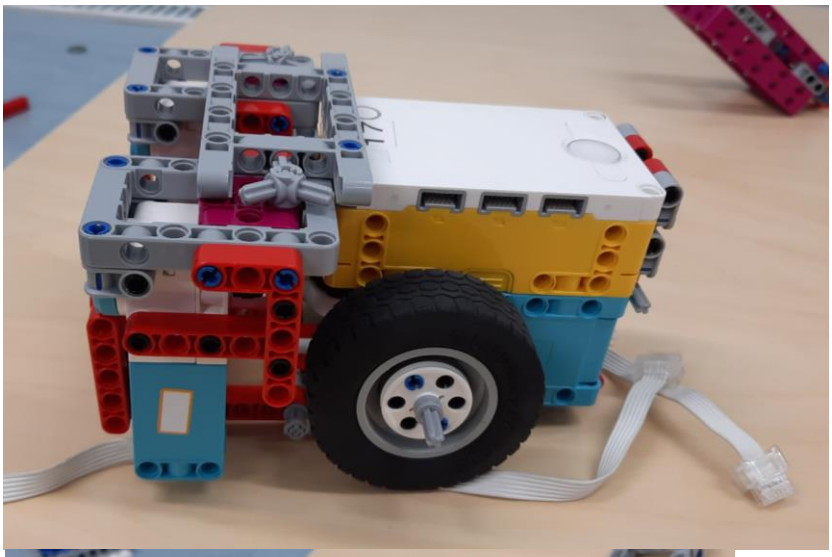
We started all over again. We decided use axle length 4 with stopper as part of the locking mechanism.



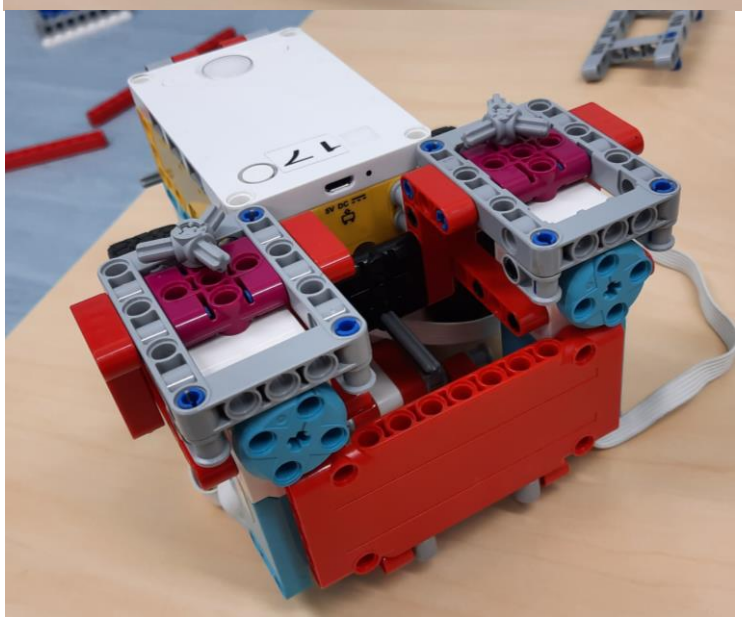
We set out to build a stronger articulation point.

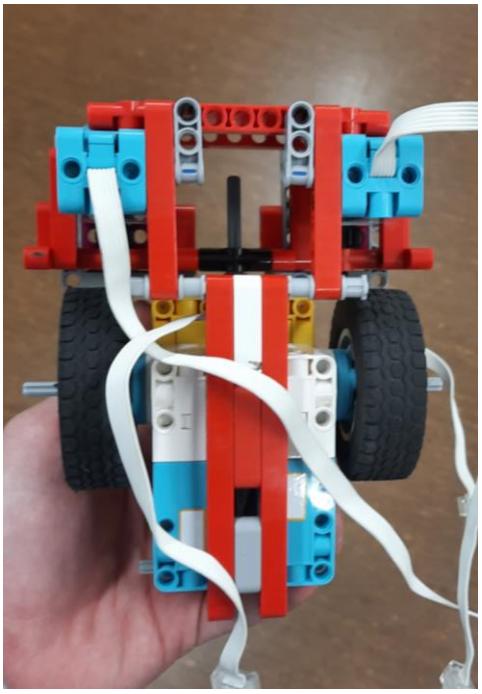
We modified the servo motor transmission, making it stronger.

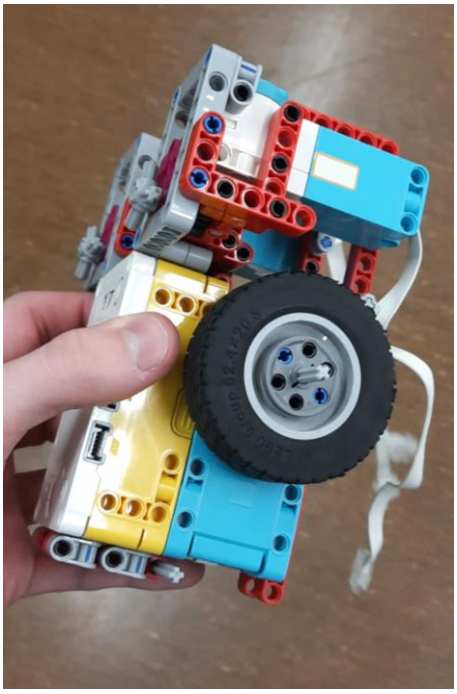


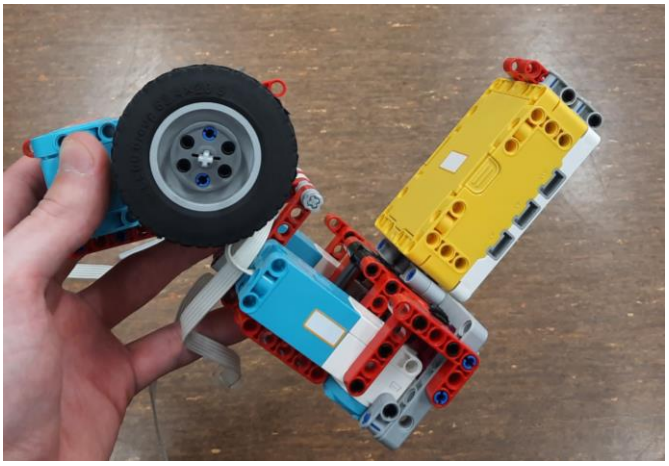
We built servos on a robot.

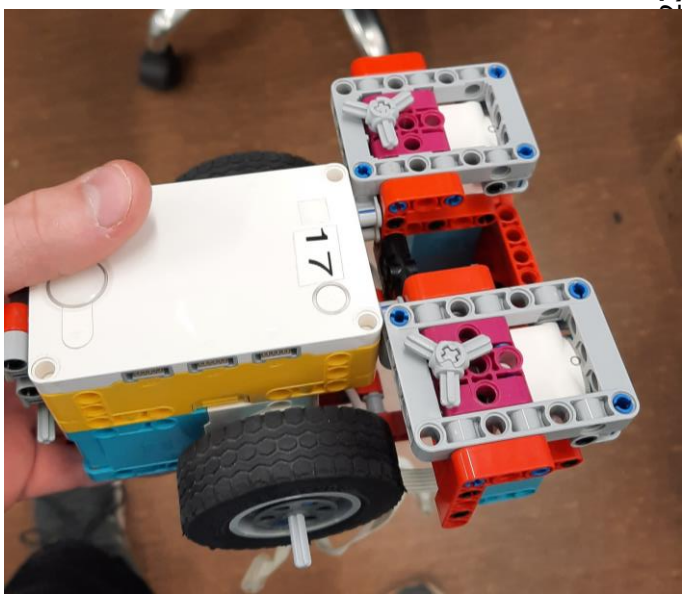


We added a red plate in front of the robot.





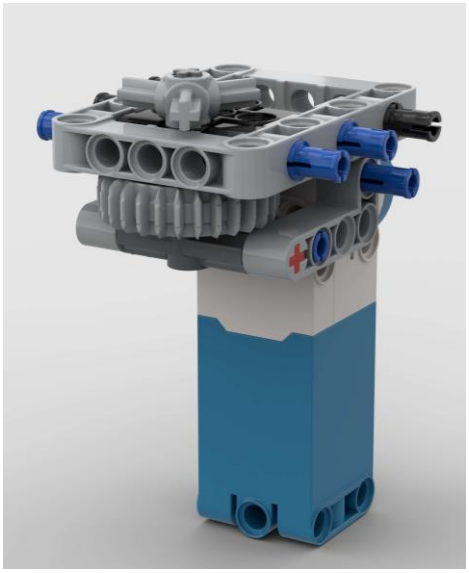




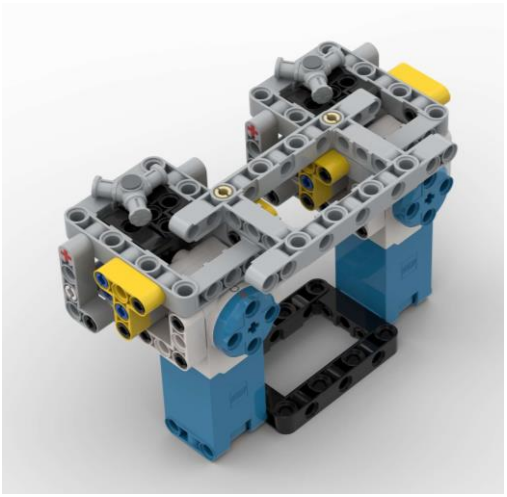
We took a bunch of pictures of the robot and went on summer break.

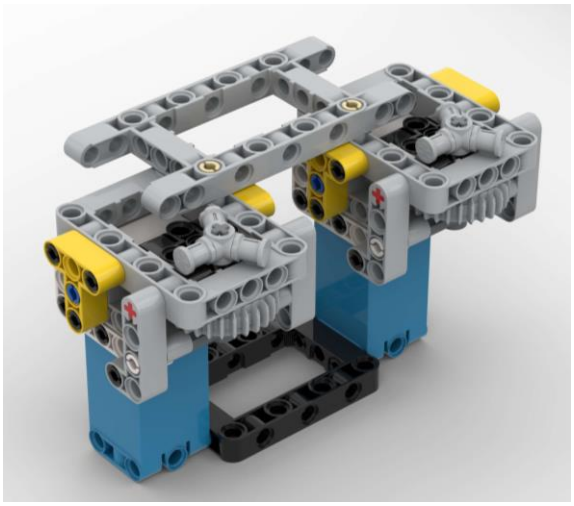
2.3.3 Development of the main robot Beast during the summer break

As an innovation this year, the main robot was partly developed using computer modeling. To do this, we used the BrickLink Studio 2.0 software, which also made it possible to engage in the development of the main robot in the summer, when the school building is closed to students.



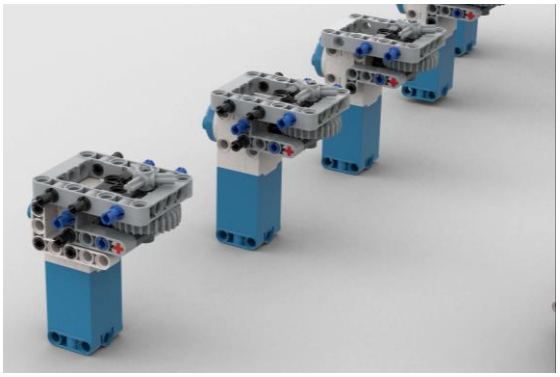
We had decided that the next robot would have to be smaller than the previous one. Basically, the only way to achieve this was to create a ninety-degree transmission on the servo motors by allowing the servos to be located vertically.

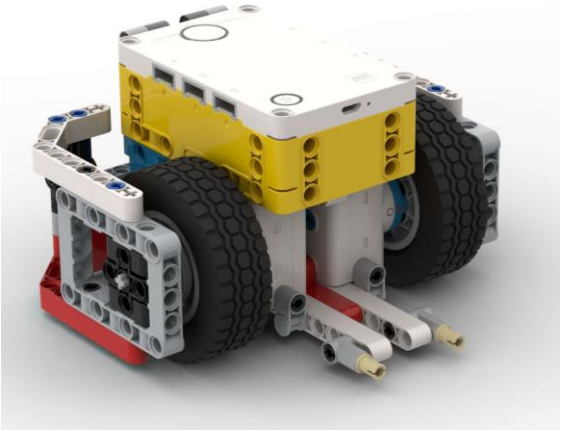




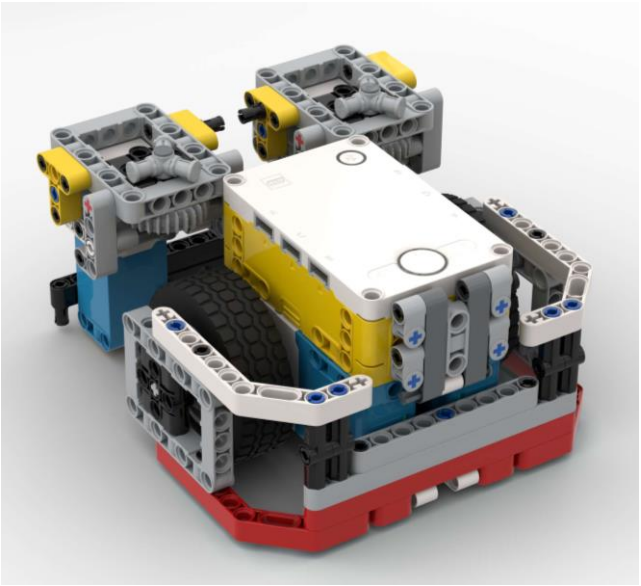
This design seemed to be the best in theory. It wasn't until we went back to the school that we learned its flaws in practice. It was not possible to turn this transmission into place with the ride, this made it unusable on the table.

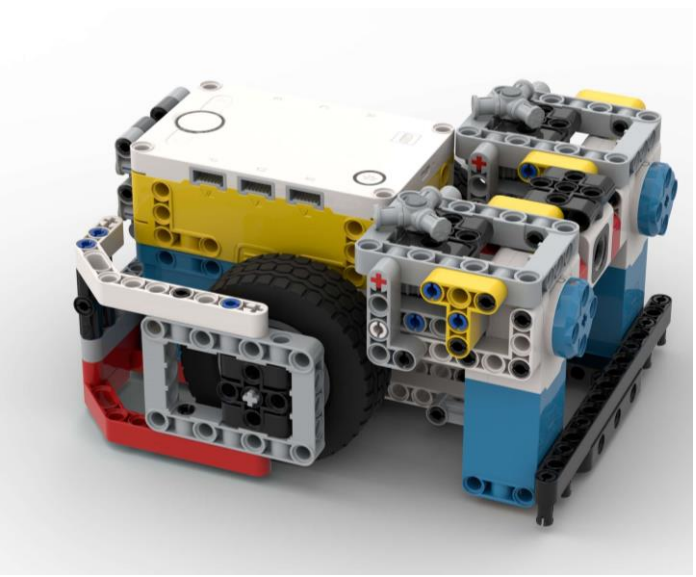
Prototypes of motor transmissions came in many different designs. Each had their own advantages and flaws.



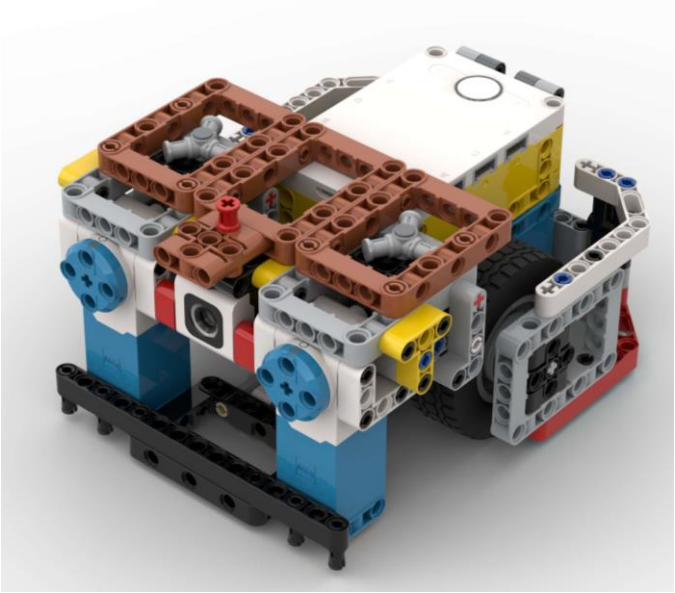


Having completed some kind of transmission, we were able to start designing the rest of the robot and, more fundamentally, the articulation site that allows for very fast battery replacement.



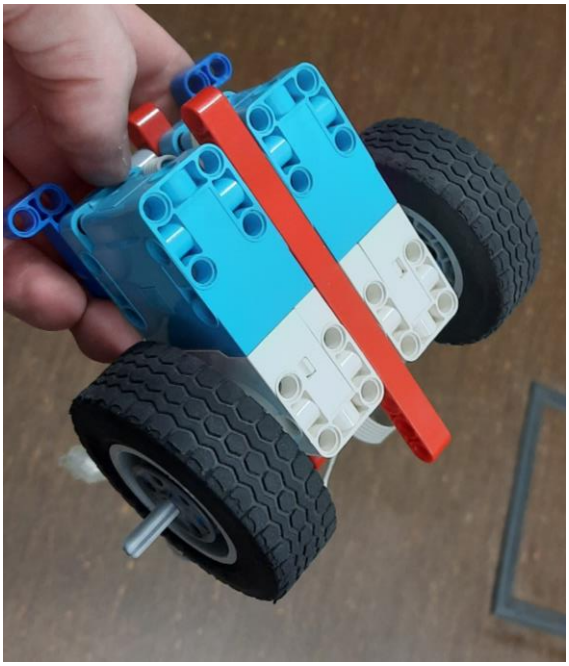


We added servos to the front of the robot and were able to start thinking about how to support the robot's wheels so that the robot still unfolds.

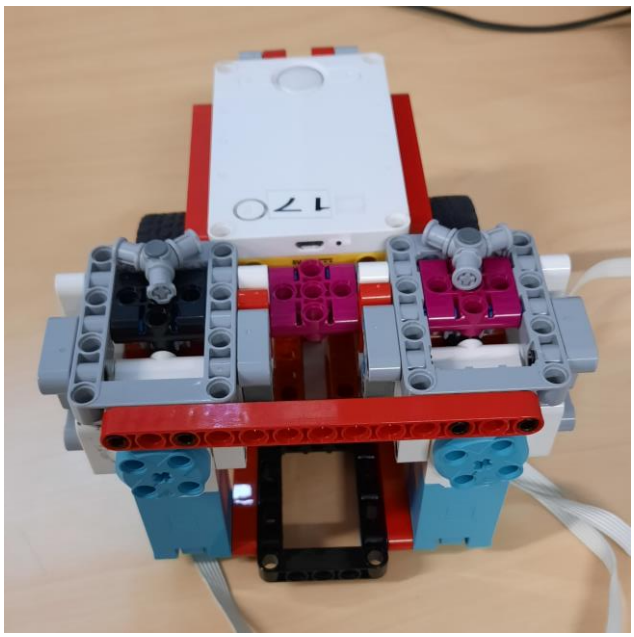


We also slowly began to think about the shape of the rides and the way they were attached.

2.3.4 Development of the main robot in the SuperPowered season

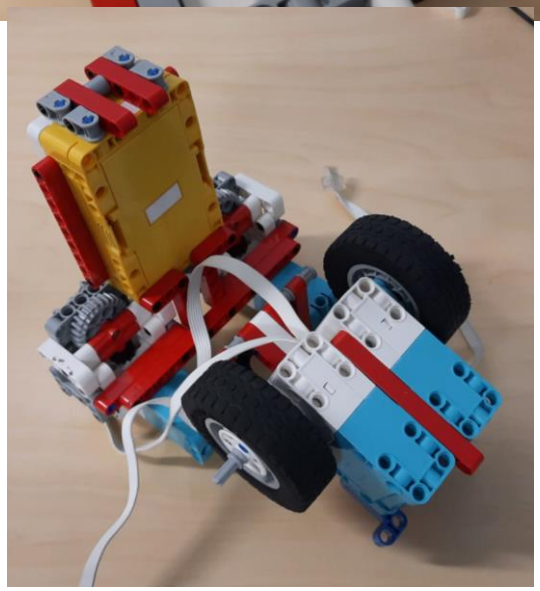


We took our plans made during the summer break as a basis and started over.

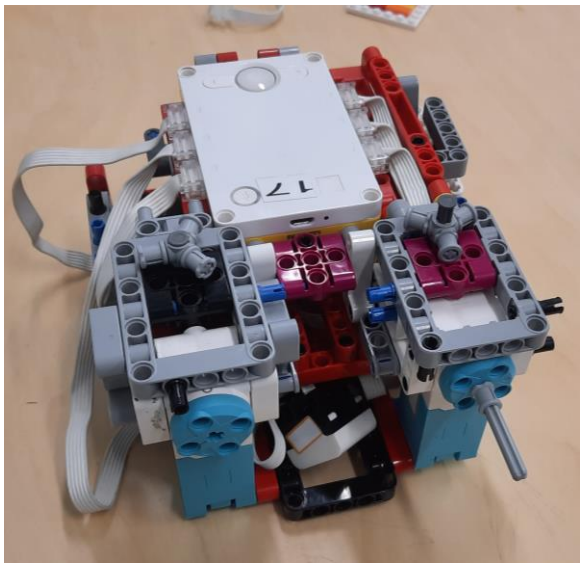


We built the servos on the robot and left a void in front of the charging port.

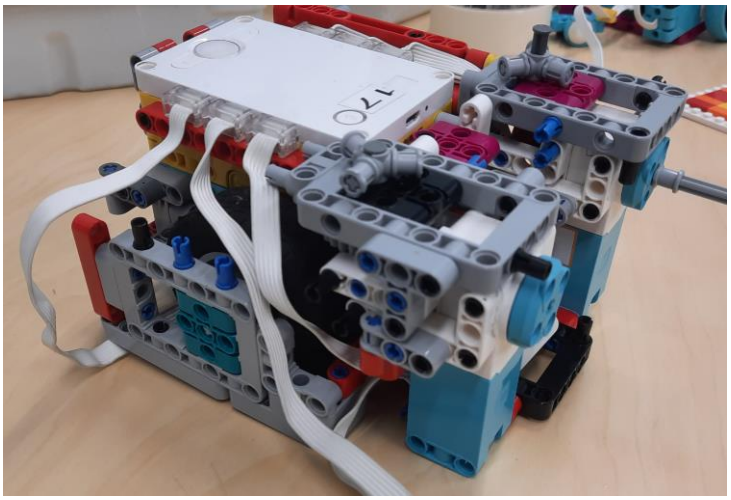
We removed the location of the bases attached to the robot.

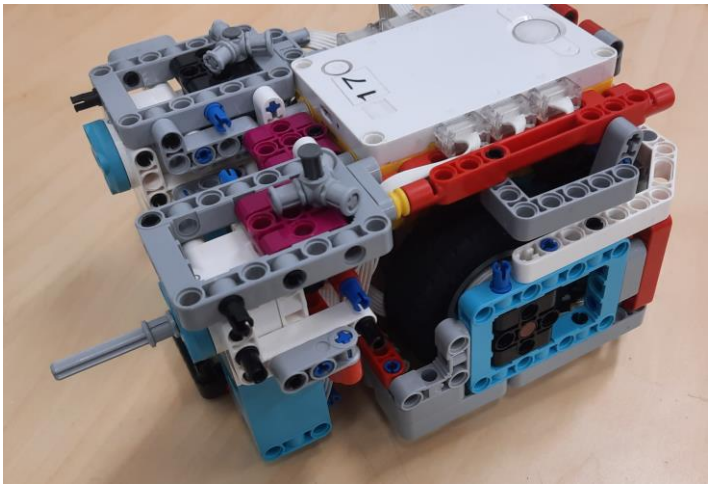


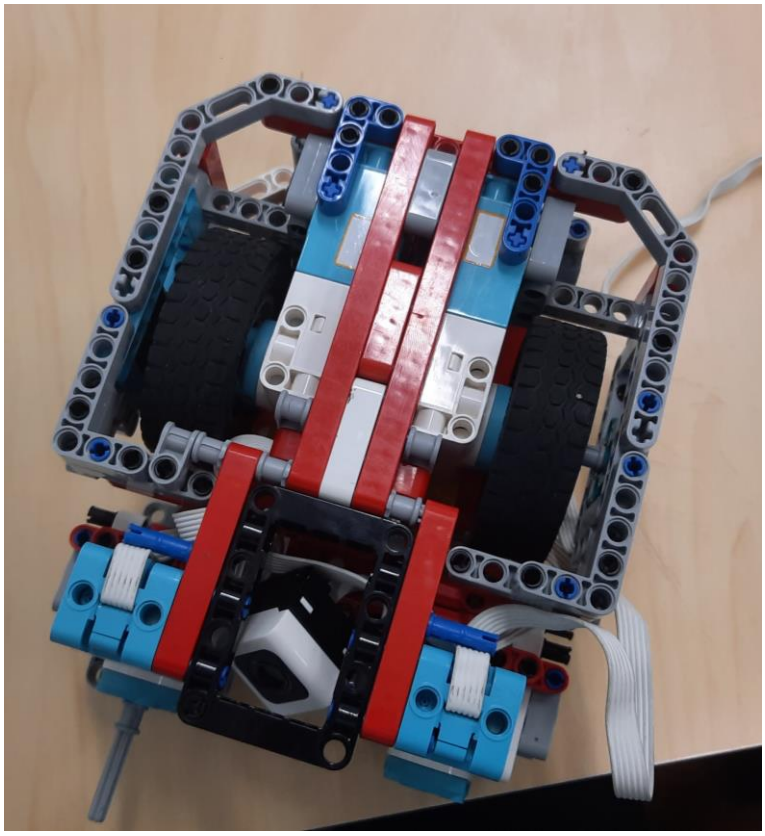
We supported a moving spot that allows for fast battery changes.



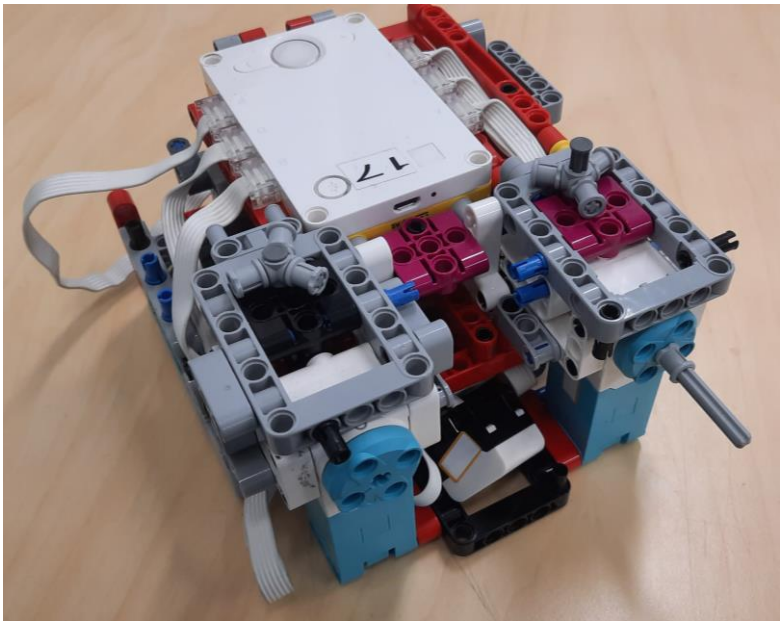
Next, we had to think about how to manage the wires of the robot so that they would not be left in the way. We decided to collect the wires on top of each other for aesthetic and reliability reasons. At the bottom left you can see how it was and, on the right, how it was done when finised.



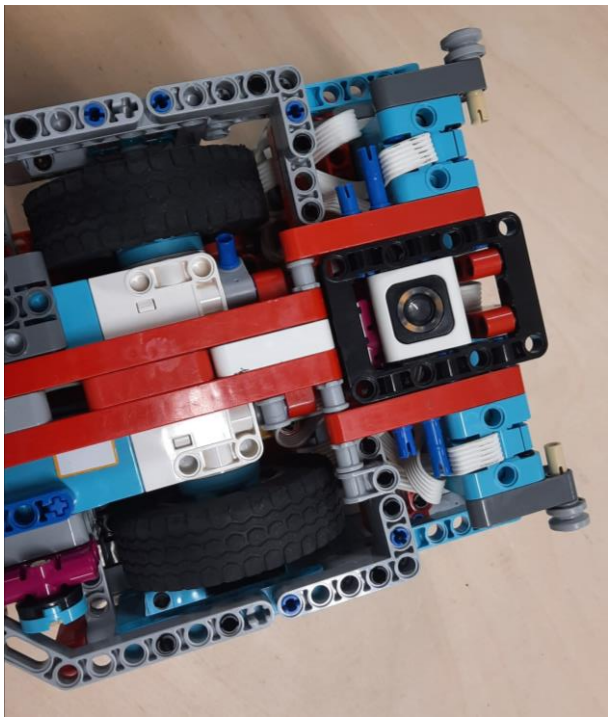


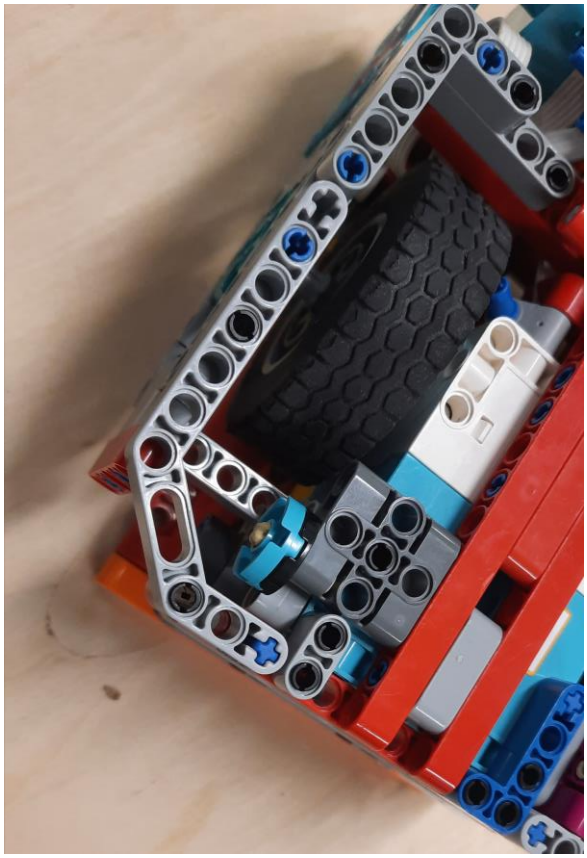


We reinforced the lower part of the robot.

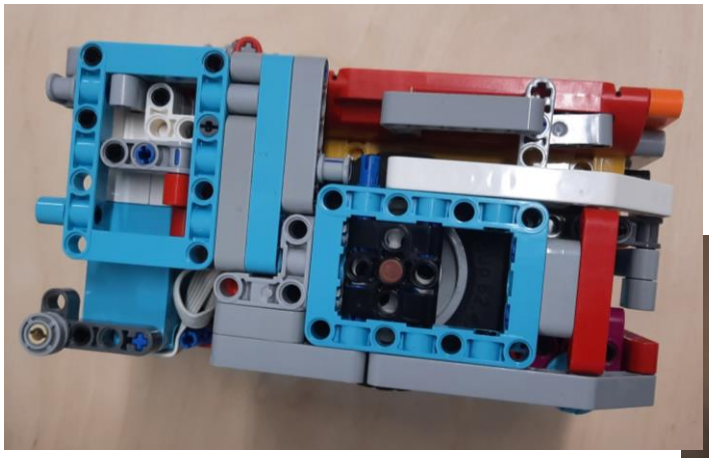


We added a mounting point for the robot to fasten the bases.

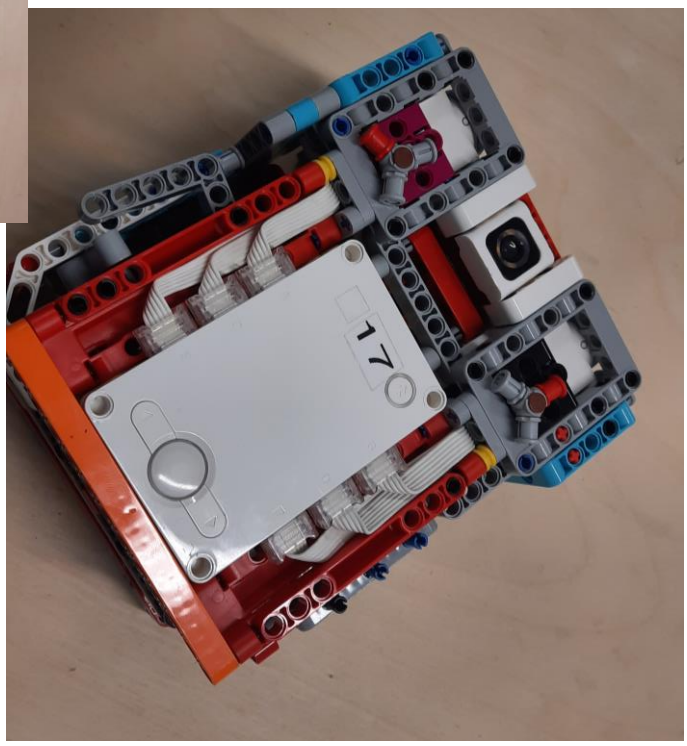


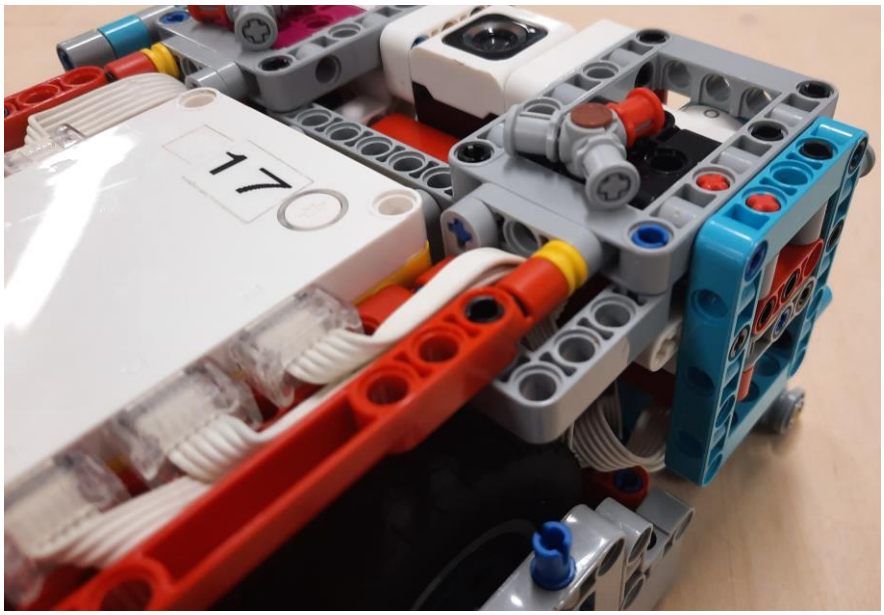


We tested wheels of different sizes in different locations with the aim of reducing the robot's shaking in the up-down direction.

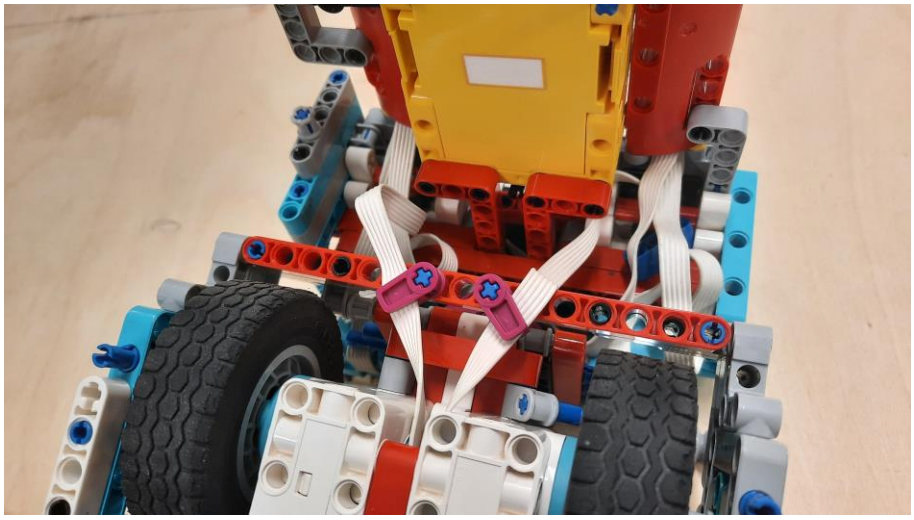


We built the wires in place and then all that was left was to build the sides. We also added a bar to which we attach the bases. This bar is gray in color and is located between the color sensor and the brain.

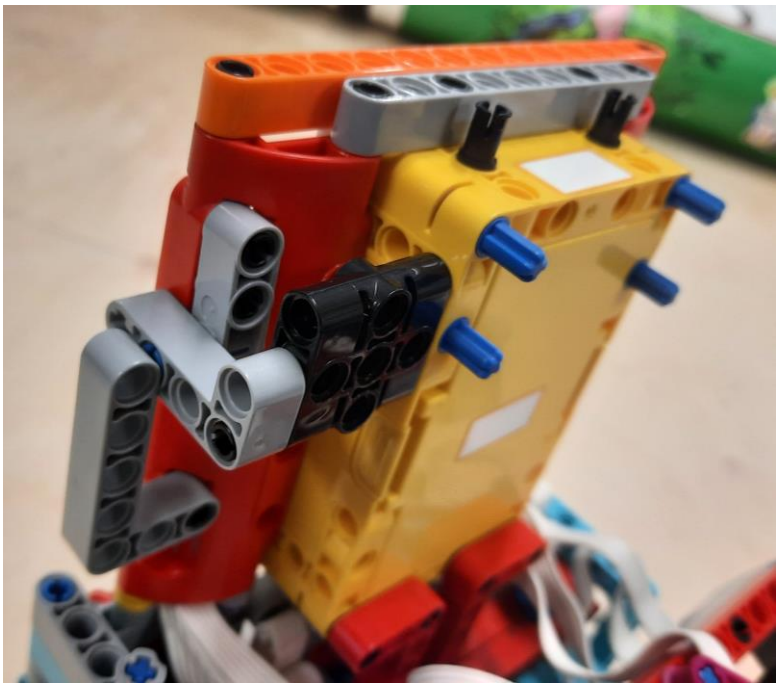




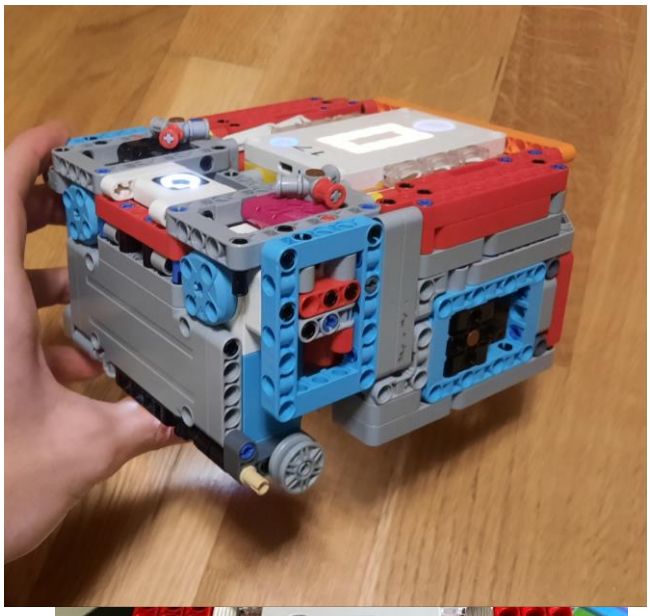
We started to build the side walls, with the first pieces, the servo motor part was strongly attached to the brain.



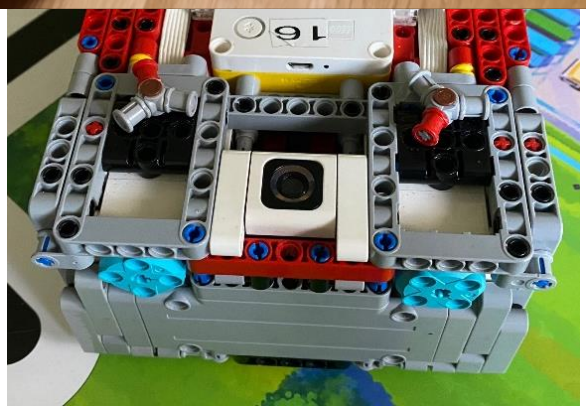
We attached the motors moving the robot firmly so that the wires wouldn't move or be in the of the battery changes.



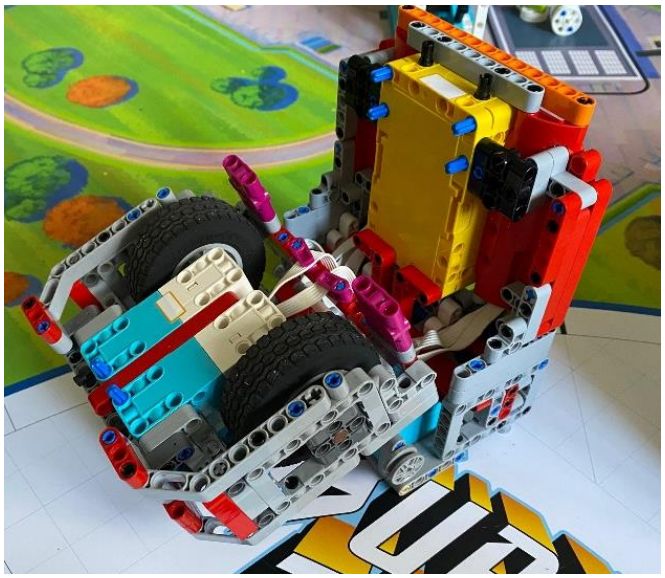
We added a support under the red cable channel to support the rides on top of it.



A couple more pieces were added and both the side walls and the robot were ready.

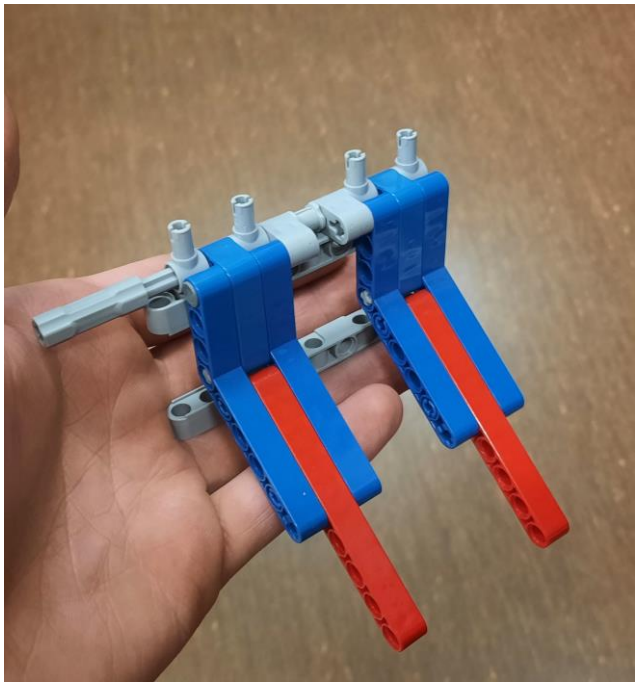


The finished main robot Beast.

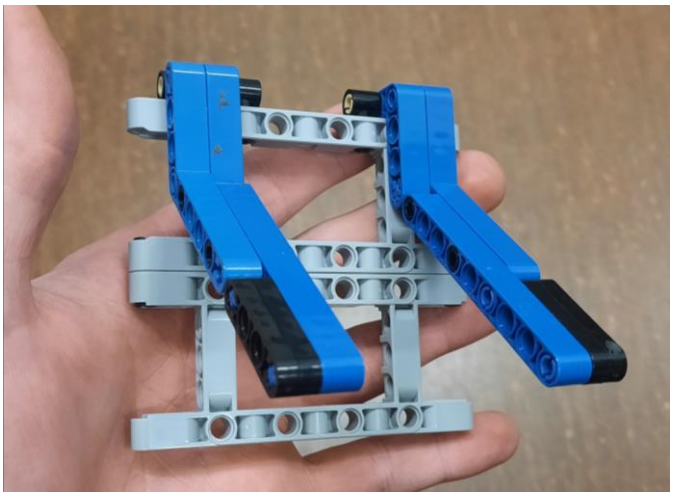


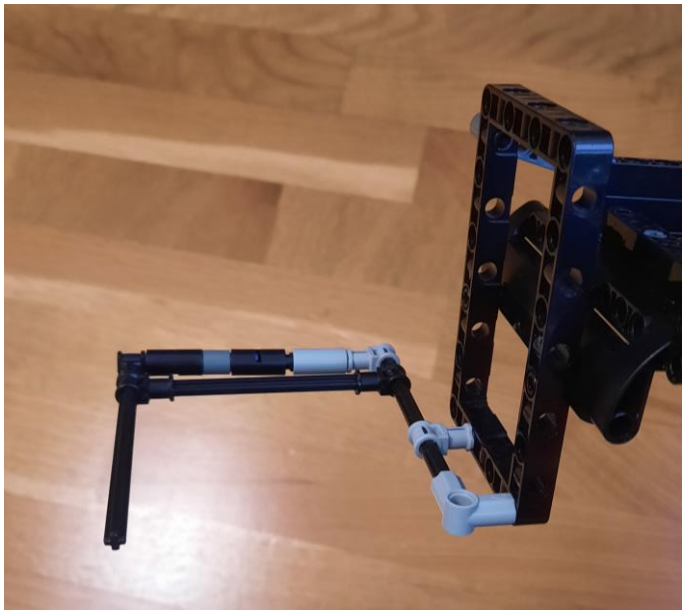
The completed main robot, Beast, opened.

2.3.5 Development of the first ride

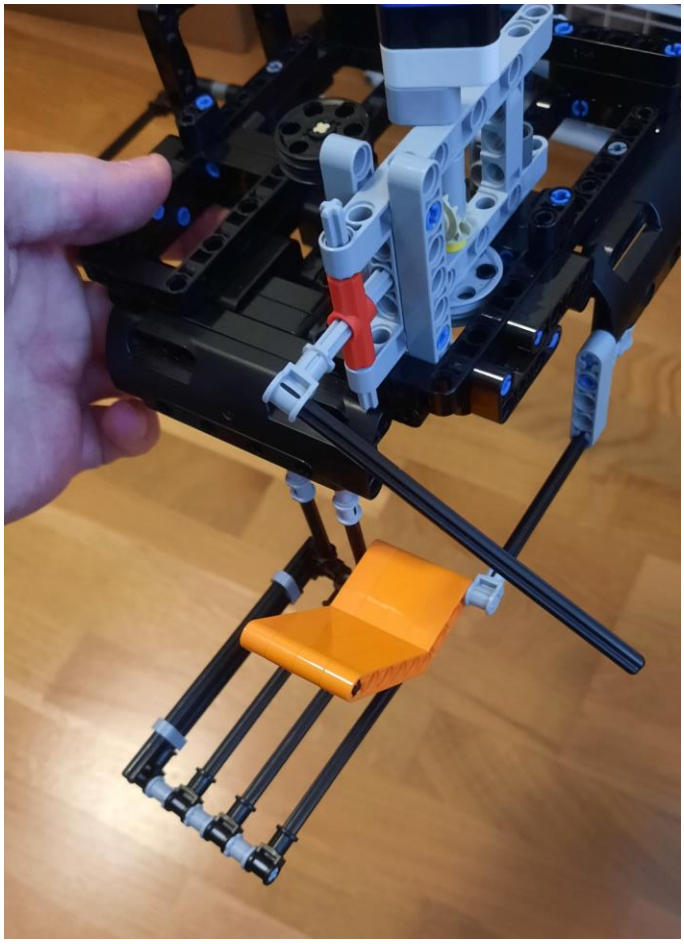


The construction of the first ride began with the construction of various ramps. With the ramp, the plan was to solve the task of loading oil into the fuel truck.

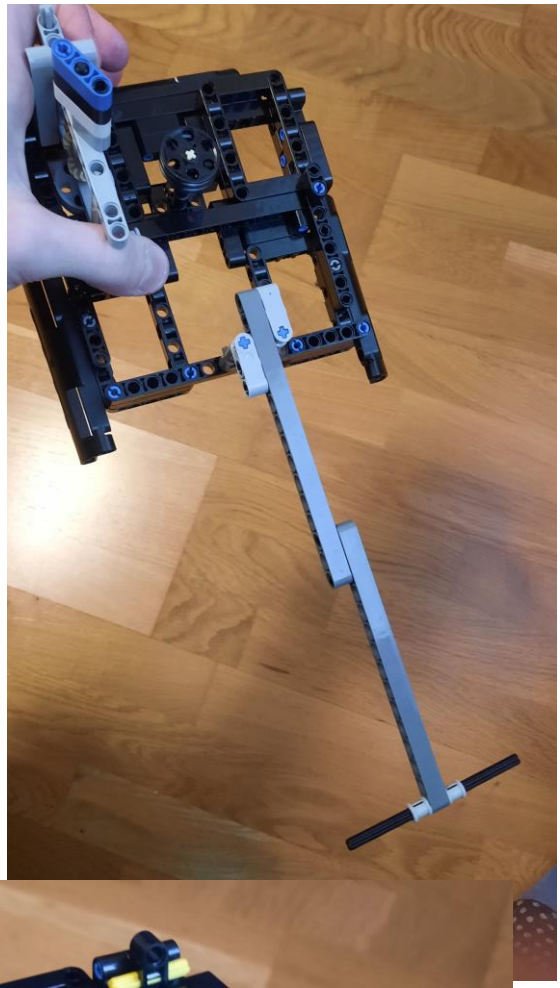




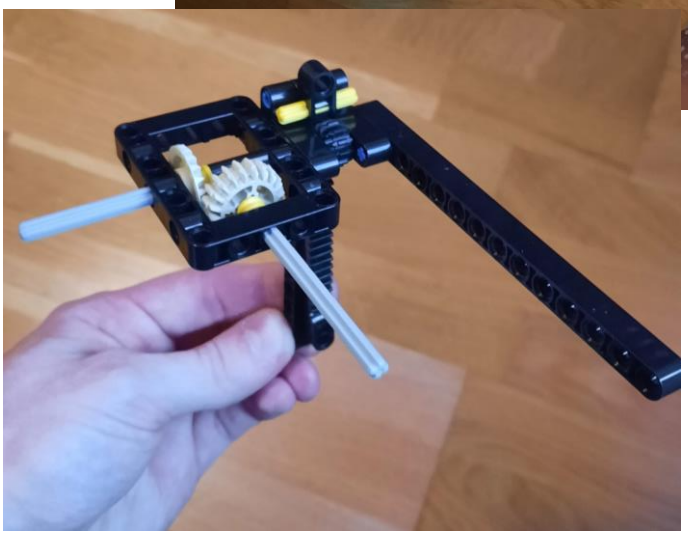
We added a simple collector to the side of the robot with which to collect two looped water from behind the dam.



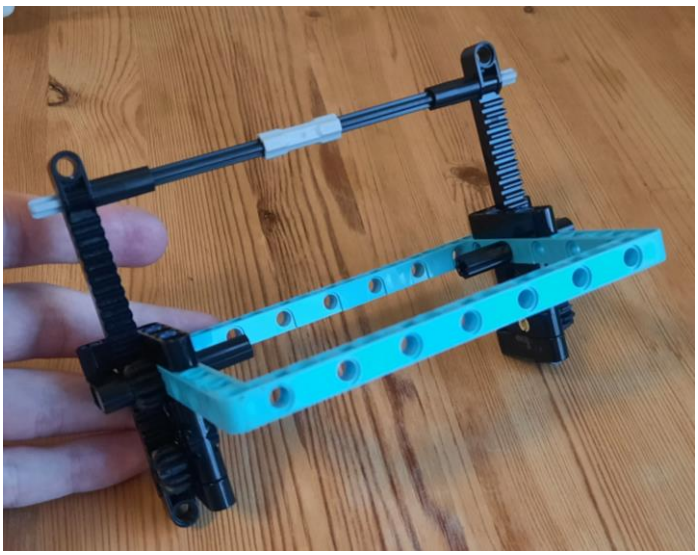
We added a collector, ramp, and rotating axle to the front of the robot. With them, we solved the power plant and collected the average energy with us.

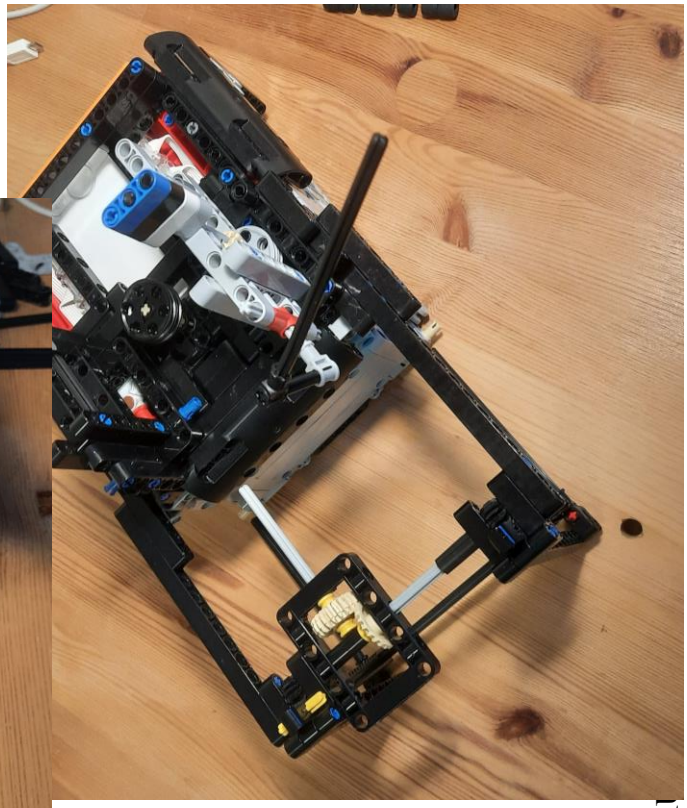


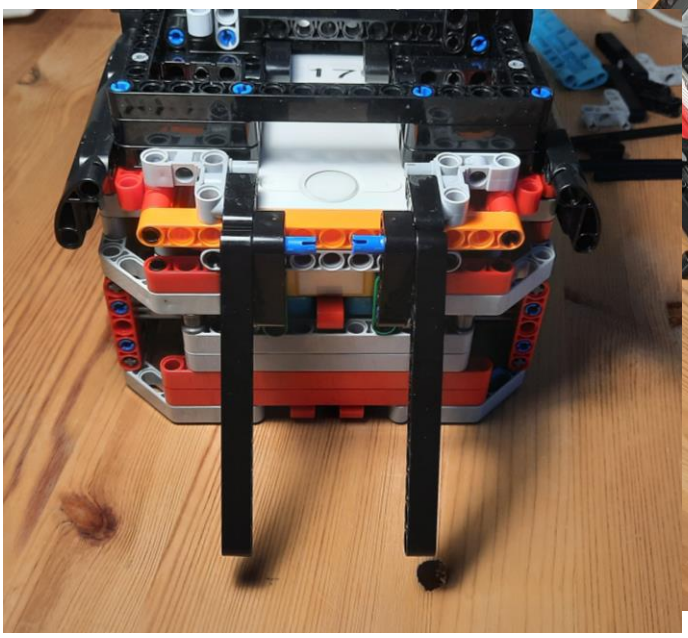
We added a liftarm to the ride that could solve the smart grid, simply by pushing the connector up.

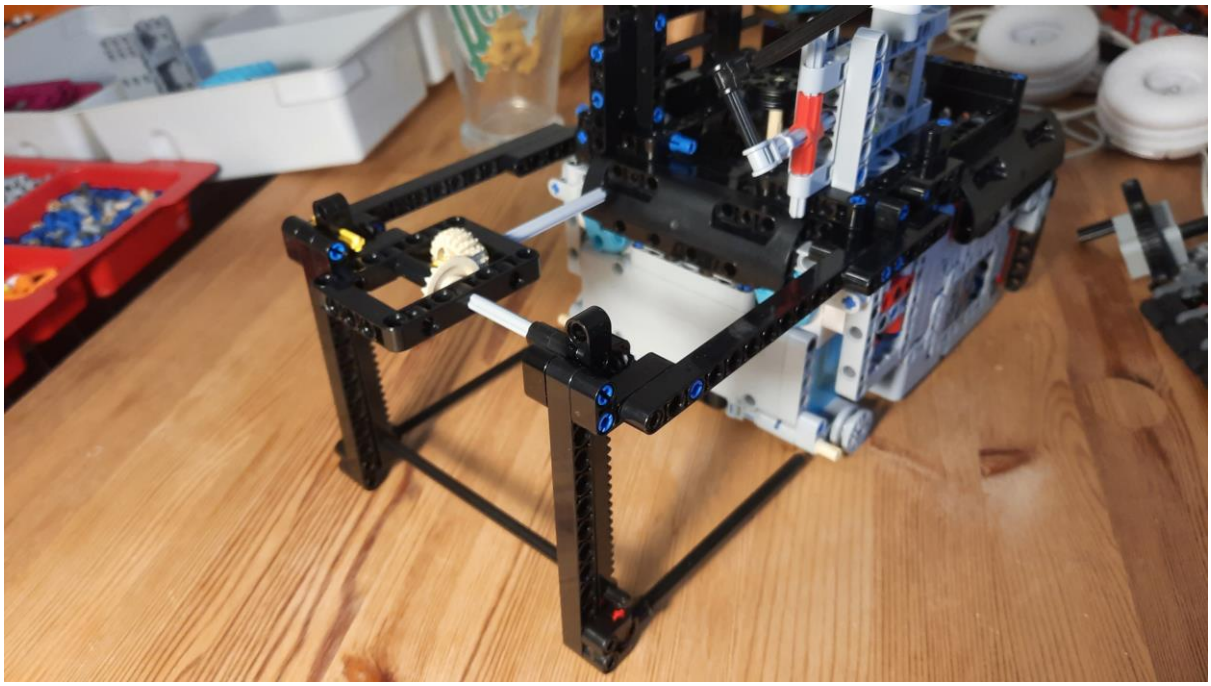


We decided to build a moving gate to our first ride. The plan was to use that gate to collect things from the game field.

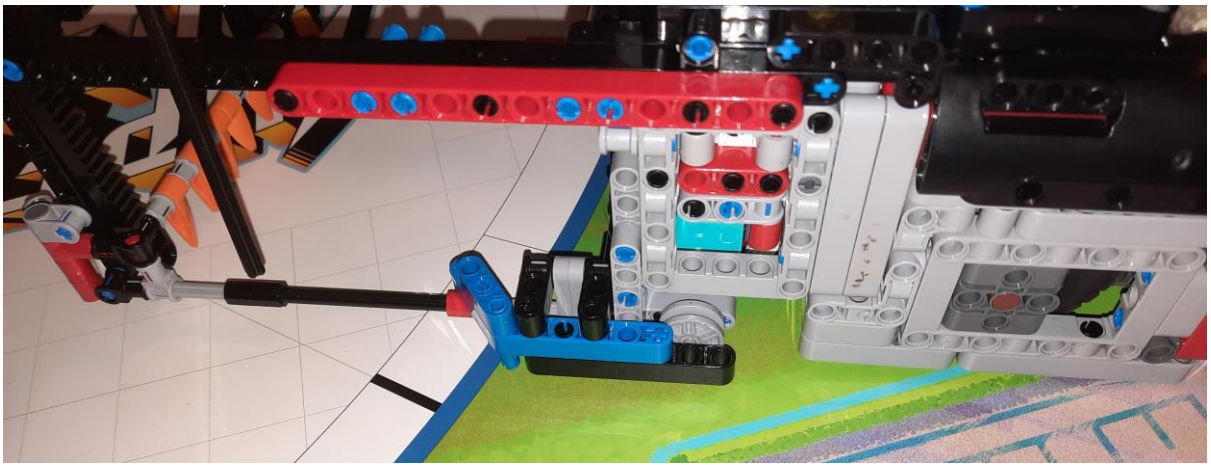




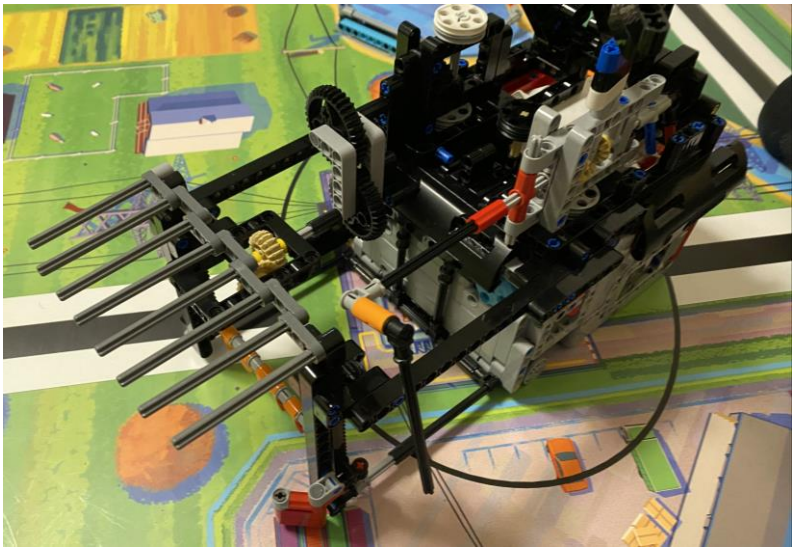




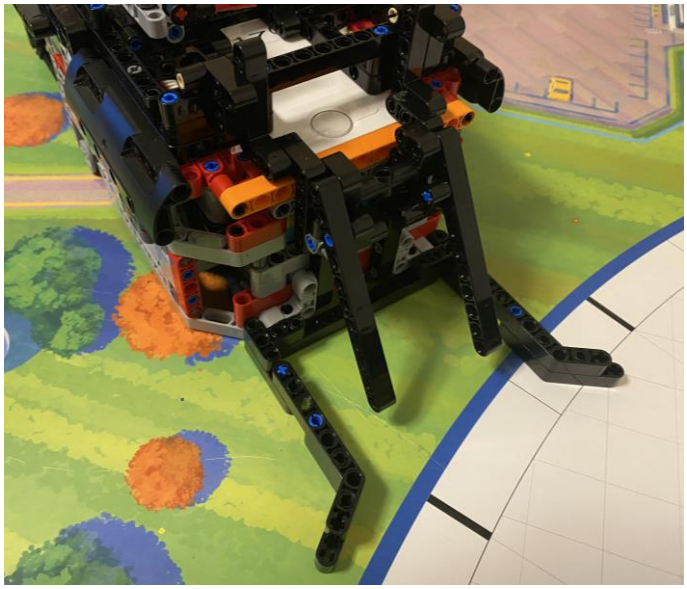
We added a ramp to the rear end of the robot again to solve the oil with it.

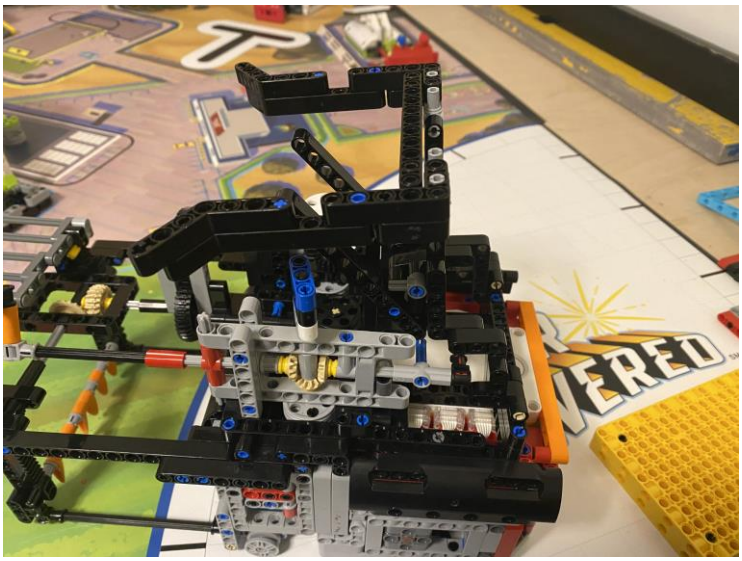


Since the robot tended to get stuck at the circle behind the dam, we added a deflector to avoid it.

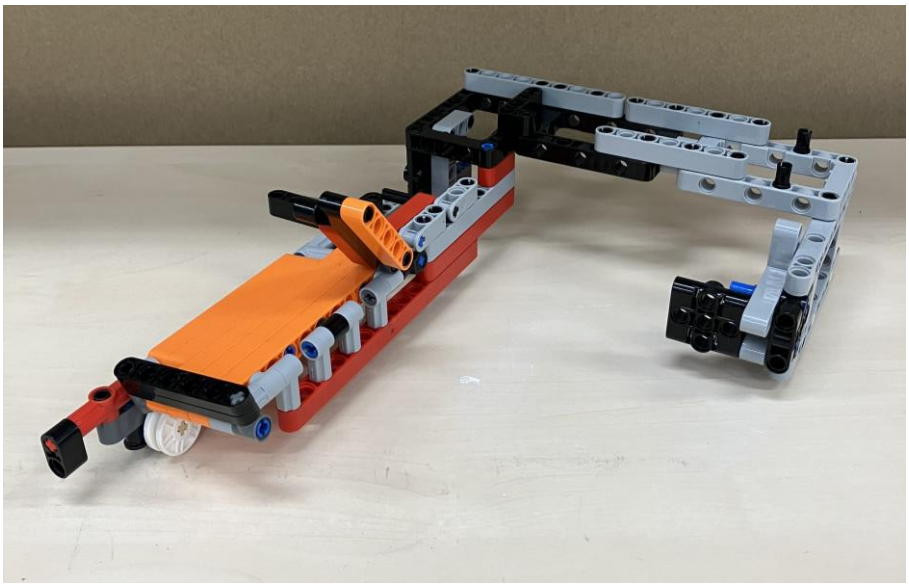


We tested a fork from axles, the goal was to pick up two loops of water behind the dam.





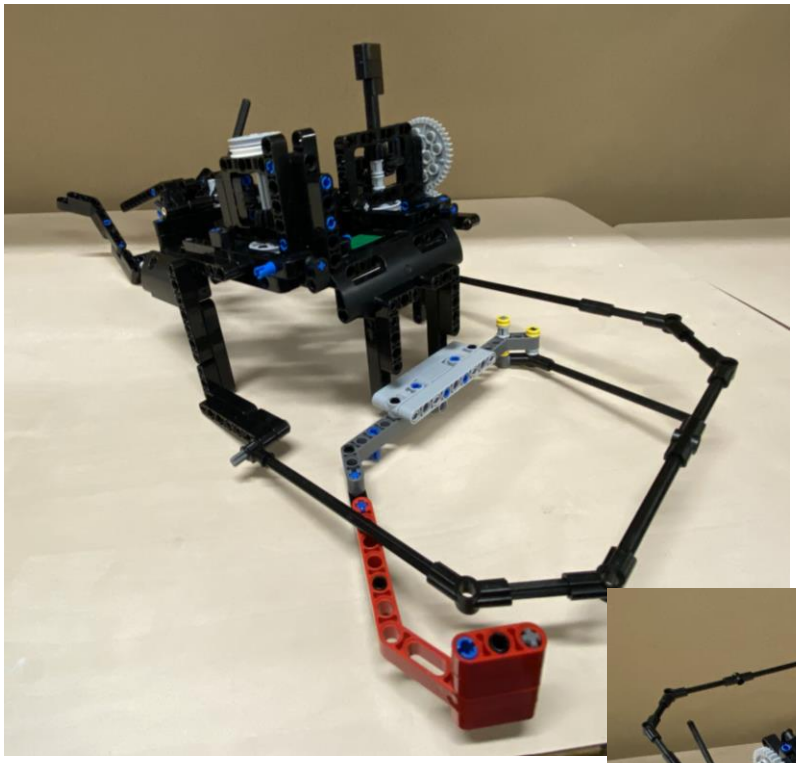
We rebuilt the ramp behind the robot so that it would take up less space when starting and moving around on the table.



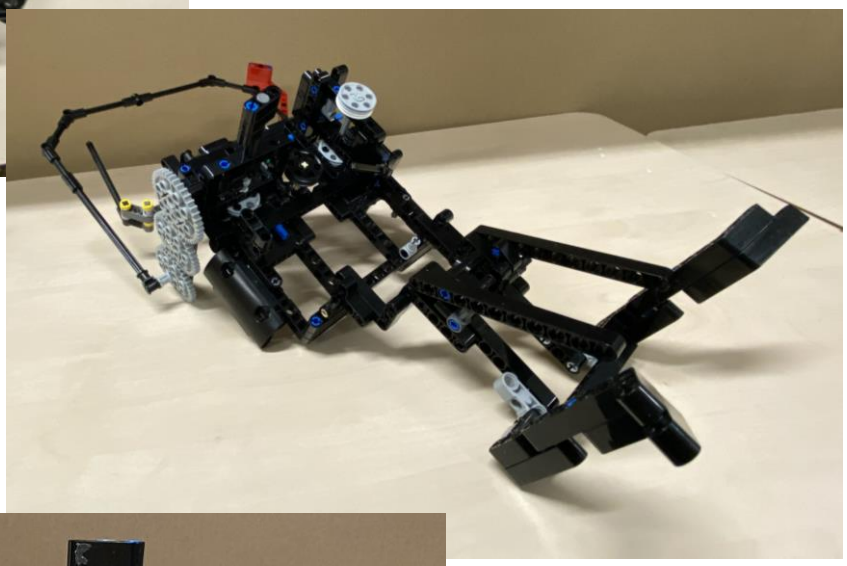
To solve the power plant, the built received insane support. The plan was that at the beginning of the ride, the robot would drive against the wall, leaning on it. This support would also help solve the power plant.

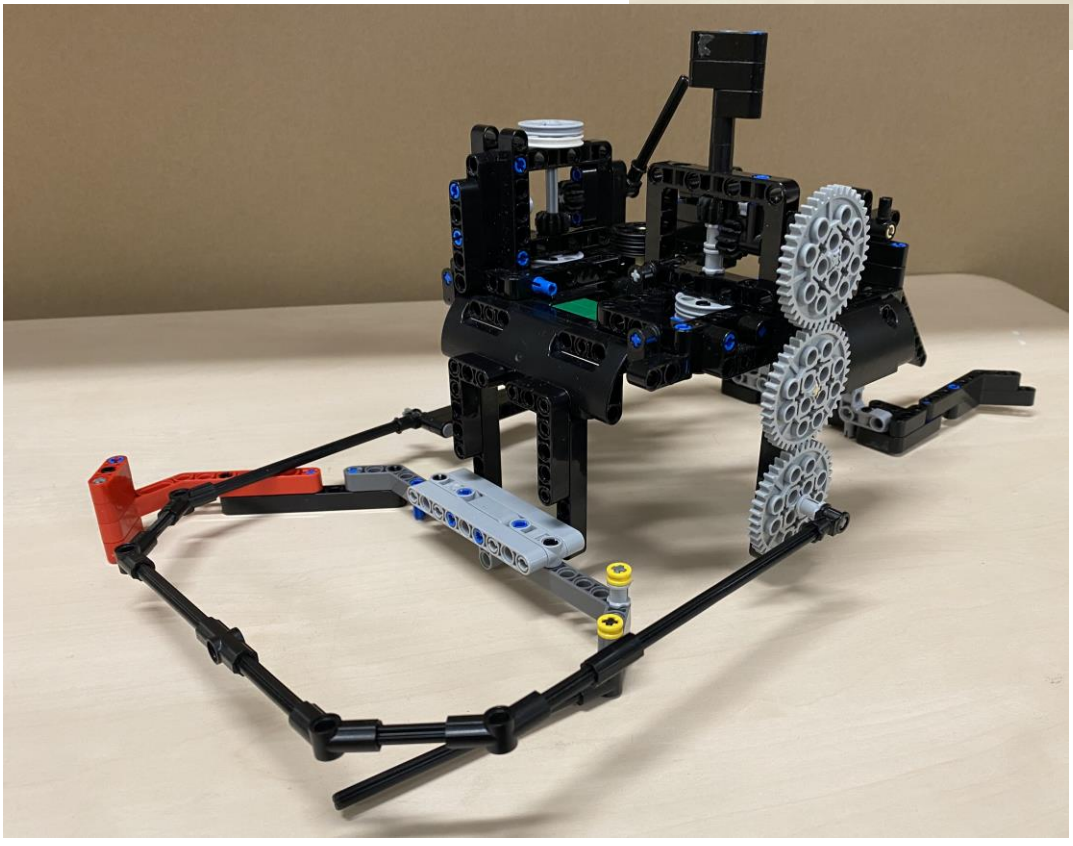
We also considered the idea that the first ride would send out a rubber motor that would solve the task of a toy factory and deliver energy to the battery target circle.

We replaced the complex support and moving gate solution with a much simpler one made from axles and liftsarms. The solution works by collecting things in the gap between them. This gap can also be closed using a motor.



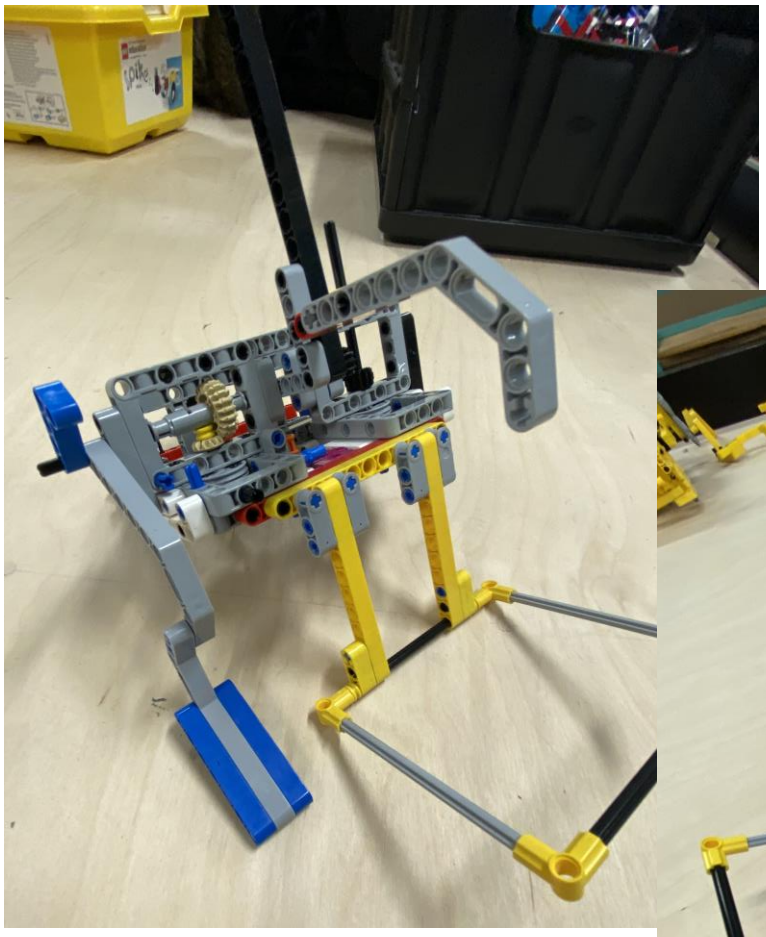
We slightly changed the shape of the shaft arch, and the first ride was ready for the preliminary round.



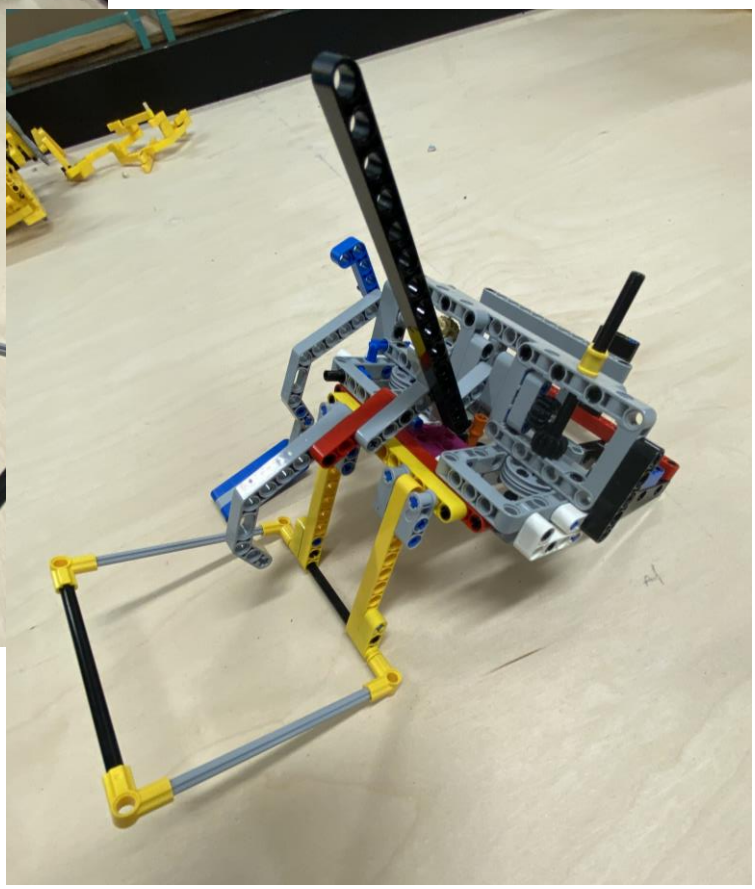


2.3.6 Development of the second ride

The construction of the second ride began with the invention of a solution for solving the power plant.



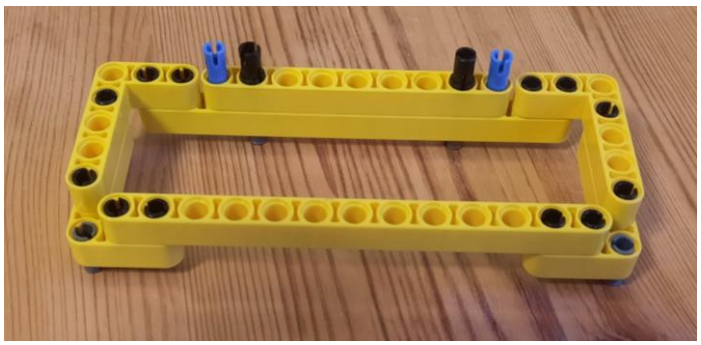
We added an energy-gathering box in front of the ride and a paw to the side with which we push up a frame that holds the energies back. With that, the second race was ready for the preliminary round.



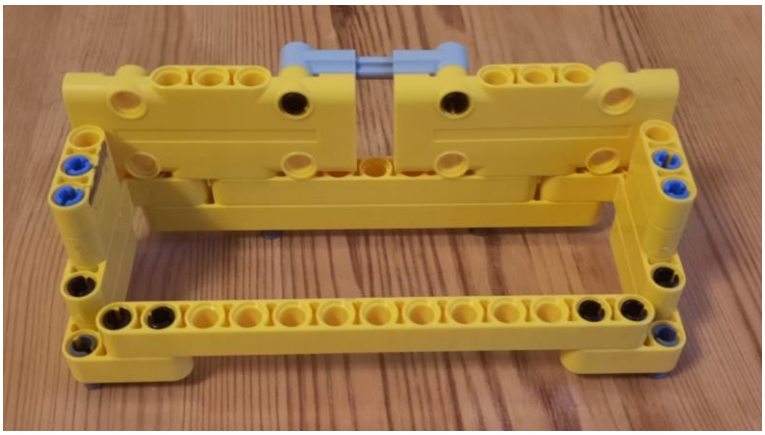
2.3.7 Development of the third ride

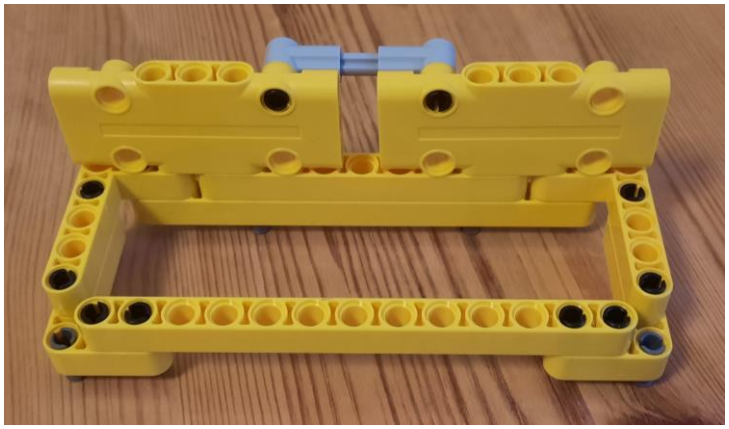
The construction of the third race began with the first pieces of its frame.

We started building a box with something to push the TV and where to pick up the windmill's energies. We decided to motorize the box, allowing the accumulated energies to be left behind in the target circle of the battery.

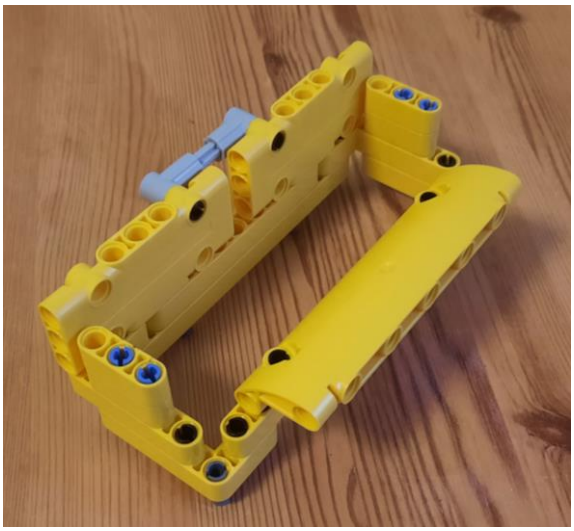


One of us came up with the idea that he would make the ride yellow as a joke. That's why we started over.

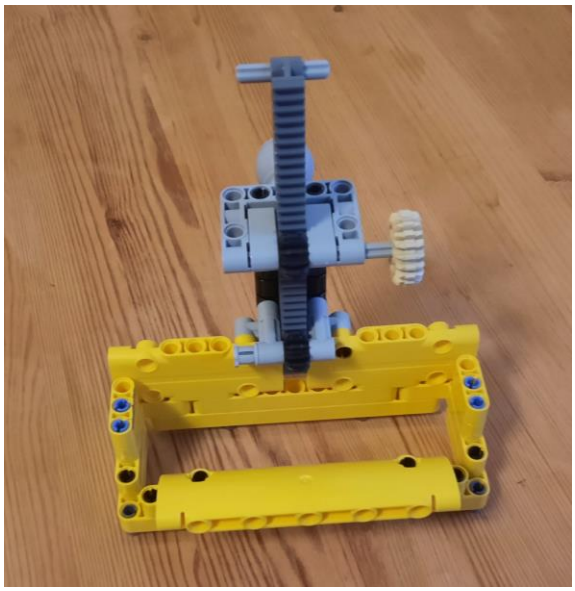




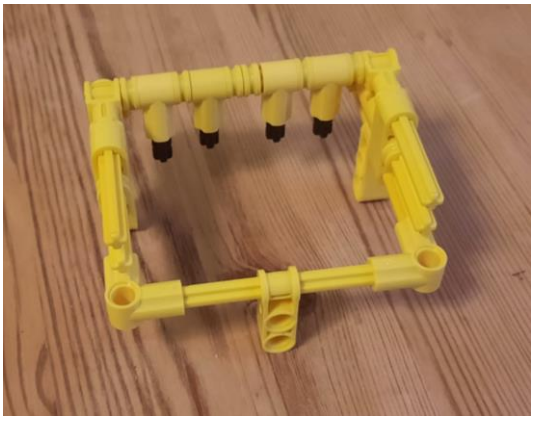
We began to build walls around the box itself.

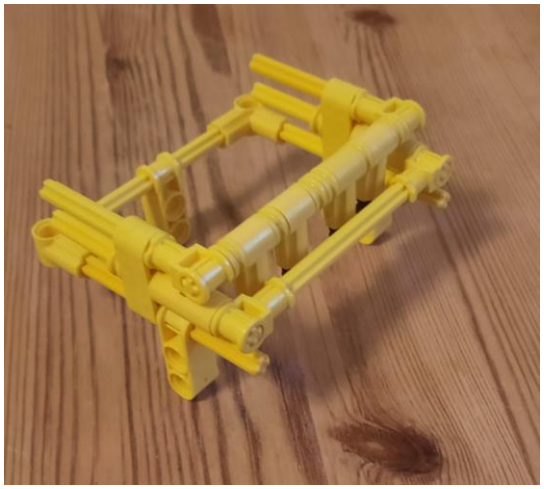


To solve the windmill, we added a sloped plate to the front of the box.

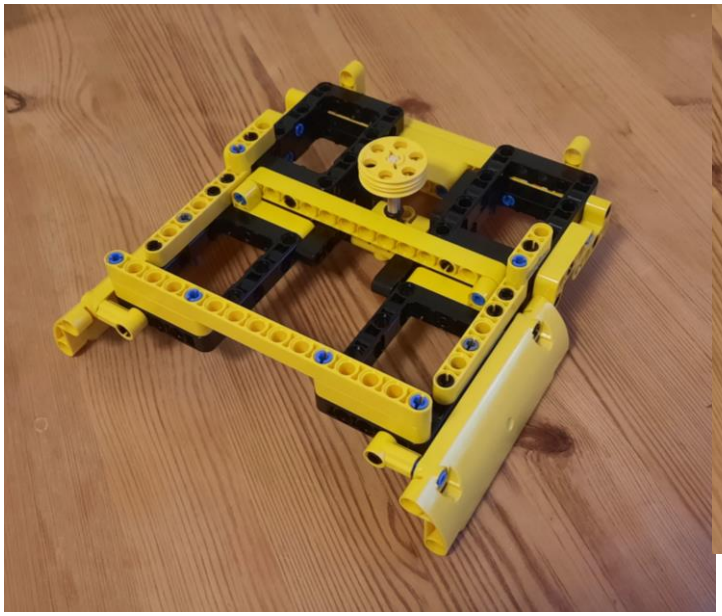


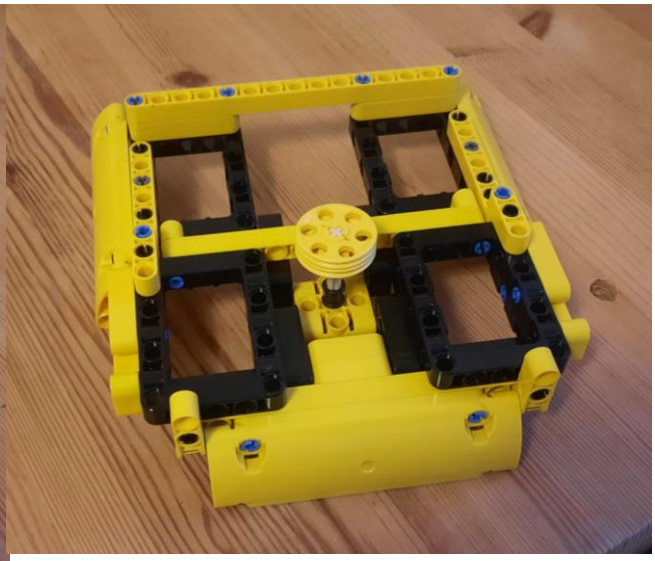
We built a rack on the side of the box, allowing it to be moved up and down with the motor on command.





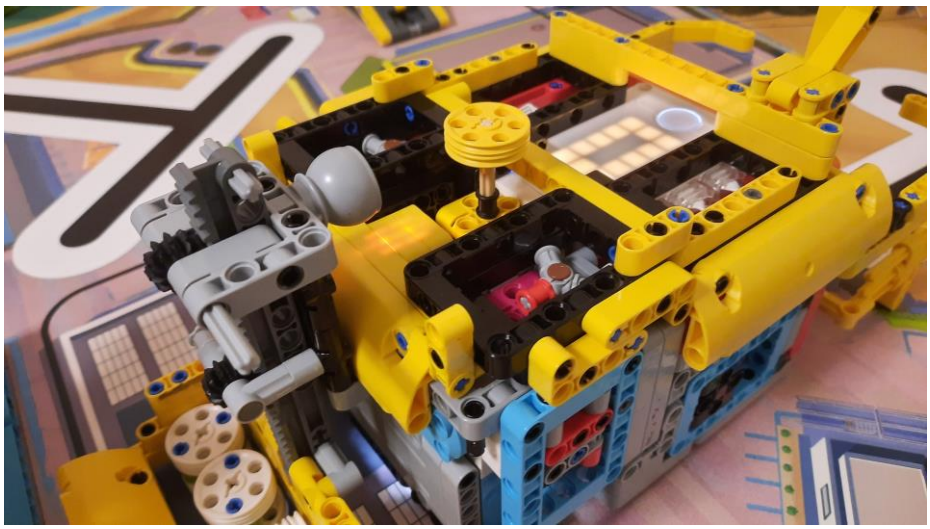
We built a simple one-way box with which to grab the battery. The battery can go inside the box, but can't get out.



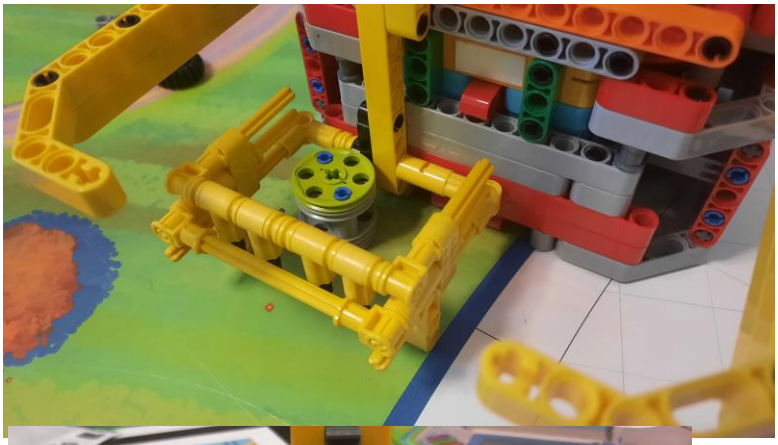


A number of solutions were more or less finished, it was necessary to complete the construction of a base on top of the robot to which these solutions would be attached.

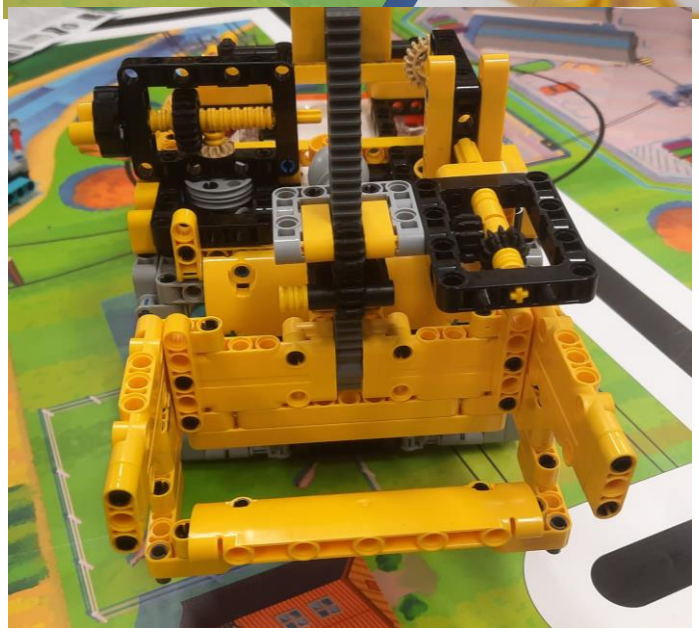
We added a mechanical solution to the ride so that two energies would fall into it when we drive into the red hopper of the toy factory.



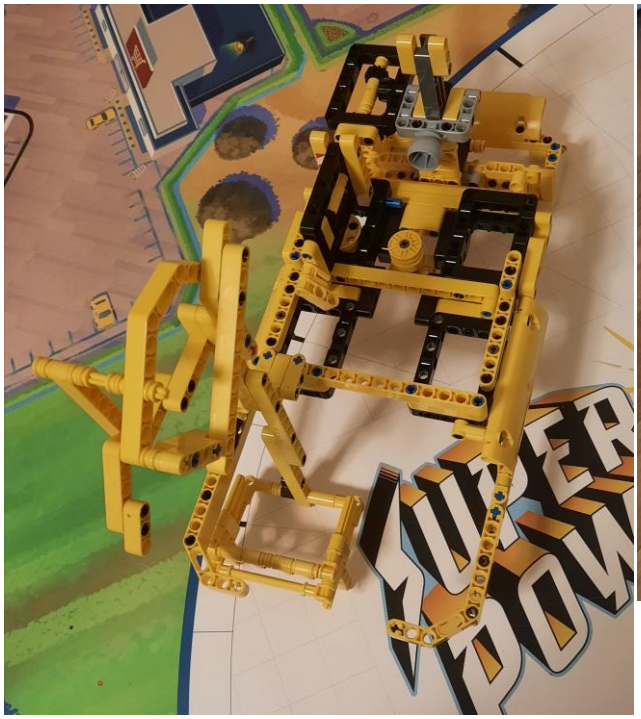
We built the box and the rack that drives it on the ride and began to look for the simplest solution for how to connect it to the motor.

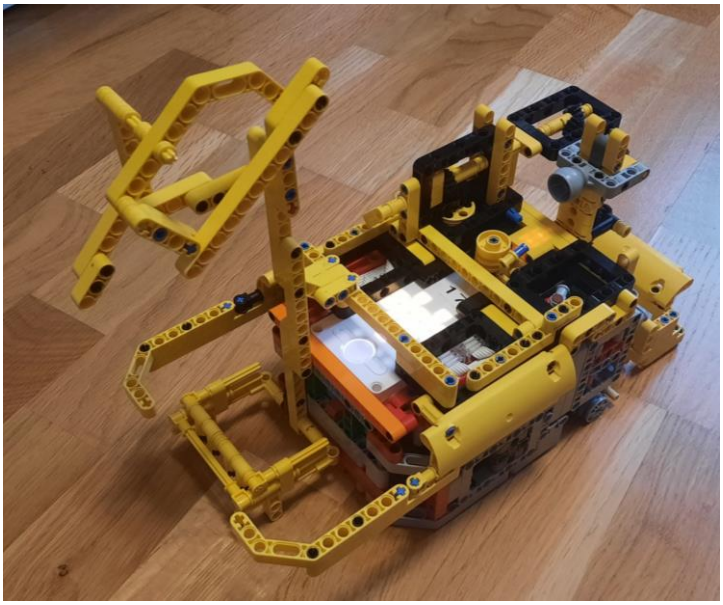


We also built a battery-picking solution on the ride and added yellow supports for launching the robot.

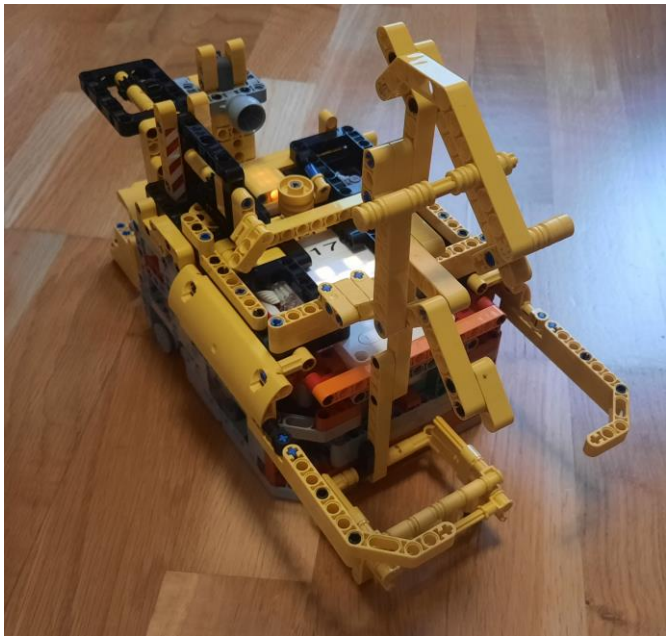


We connected the rack driving the box to the motor.

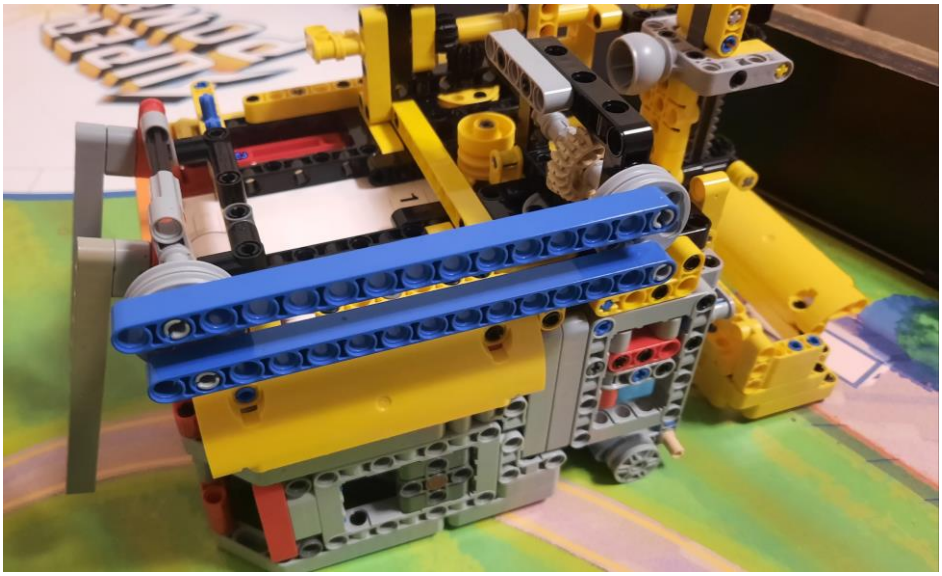


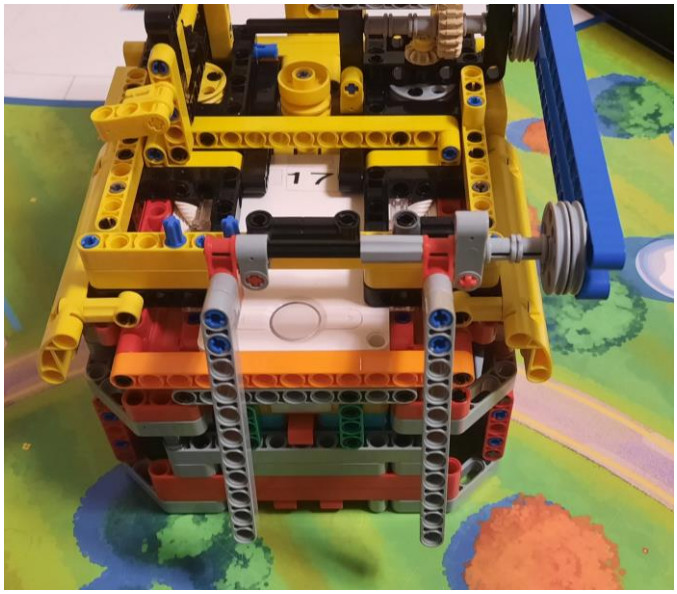


And so the first version of the third ride was finished.

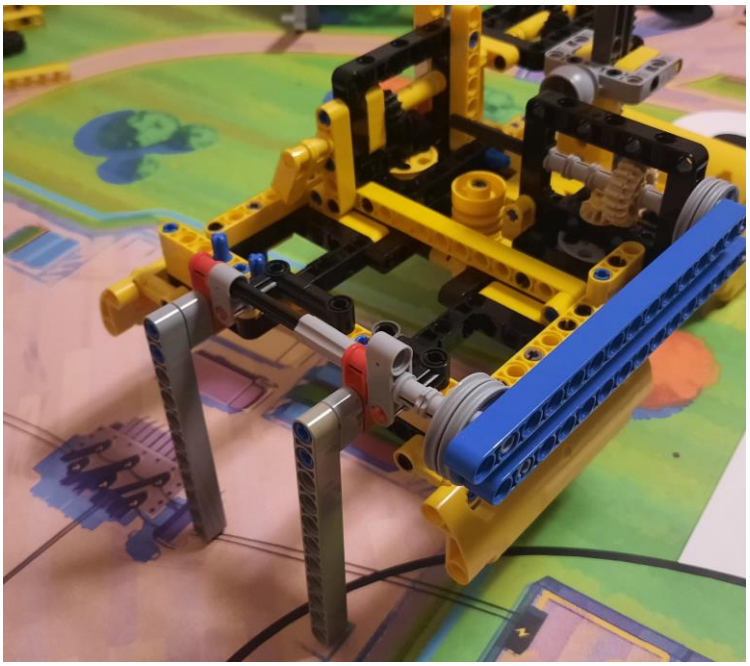


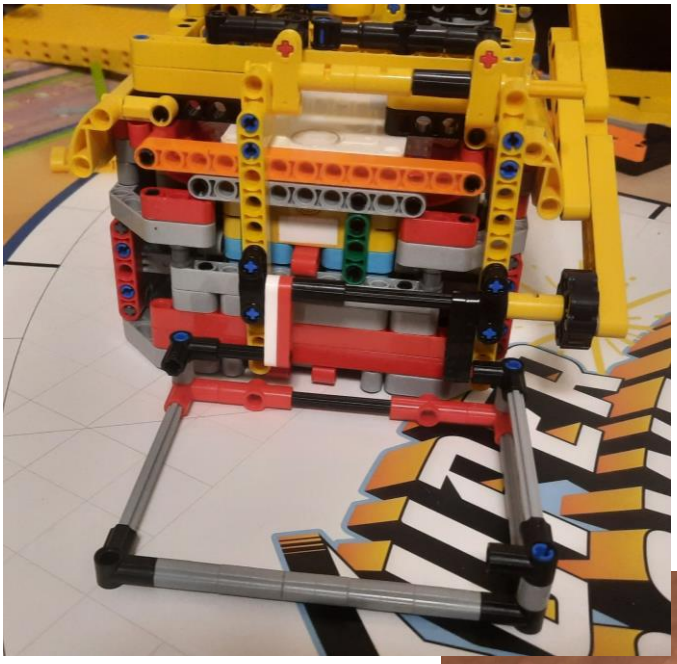
As a further development of the ride, we started thinking about how to get even more points with this ride. The plan was also to solve the hybrid car, smart grid and power plant with this ride.



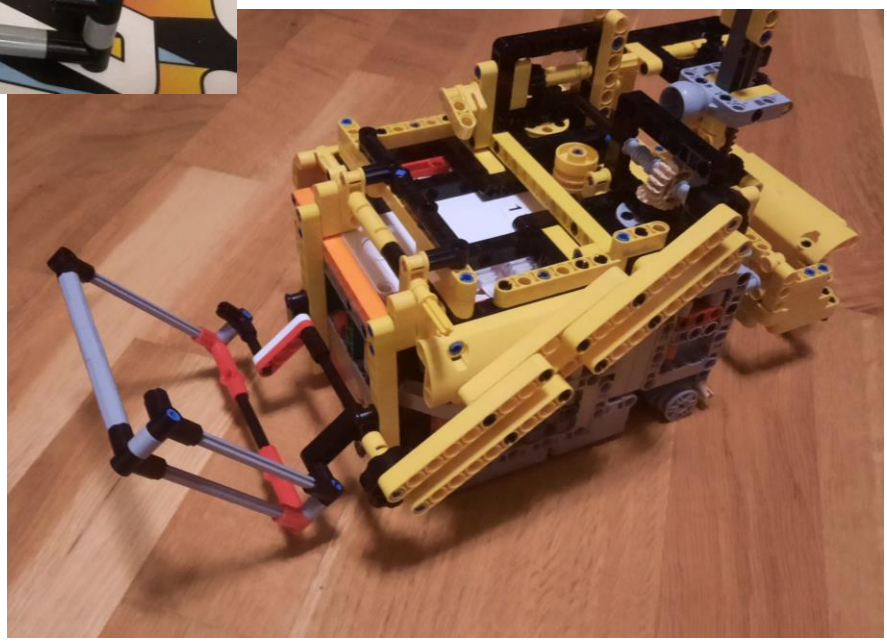


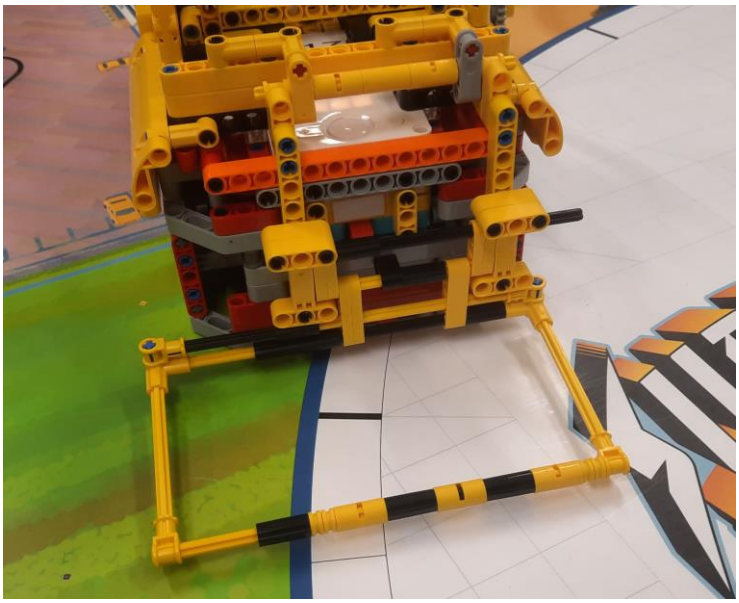
We tested a familiar liftarm transmission from last season to get a rotating shaft at the rear end of the robot.





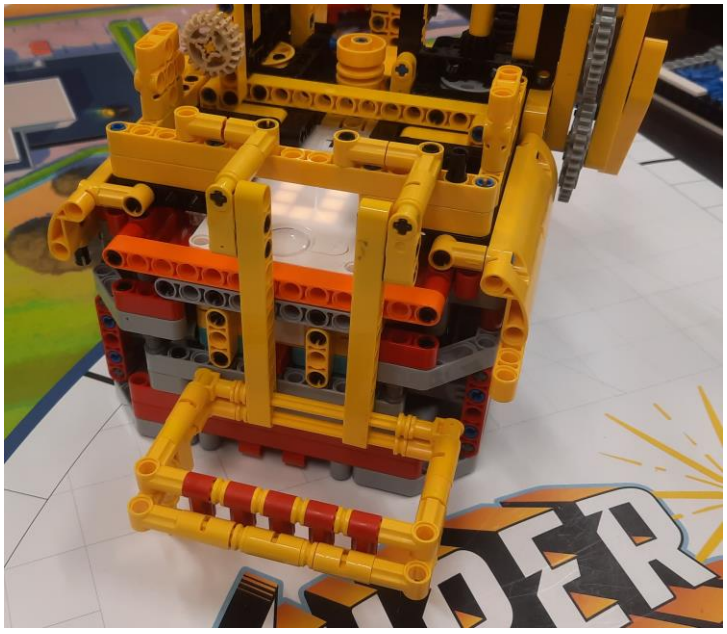
We added a box with which we tried to solve the hybrid car, the smart grid, and power plant. In addition, we planned to bring the battery with it.



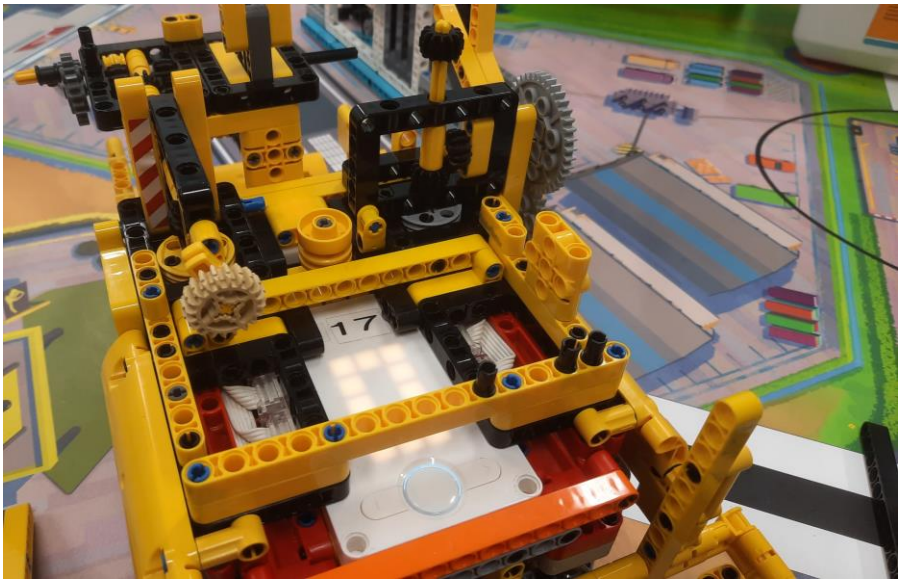


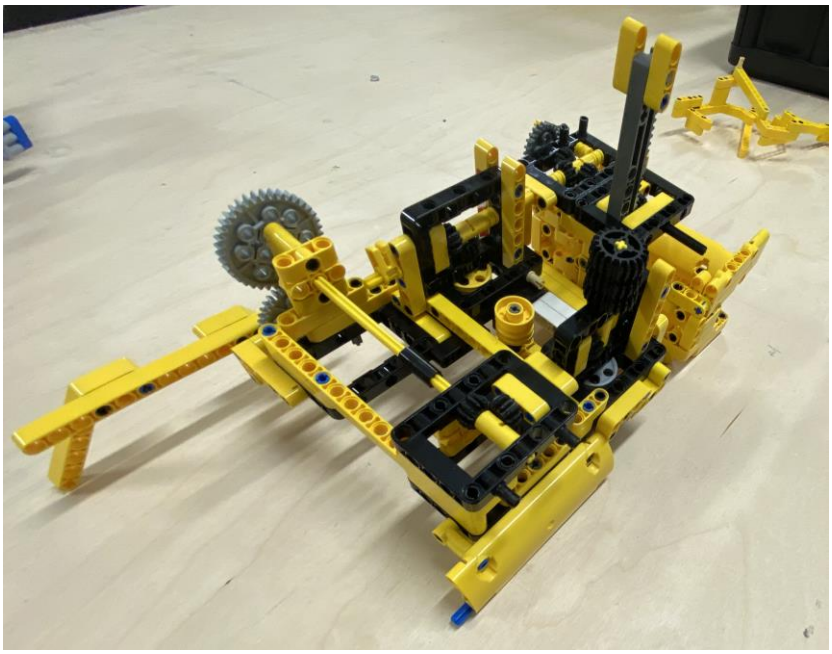
As an experiment, we built the box bigger.

We added a simple gate to the side of the robot to bring the battery instead of this box.



We changed the location of the gate that grabbed the battery.

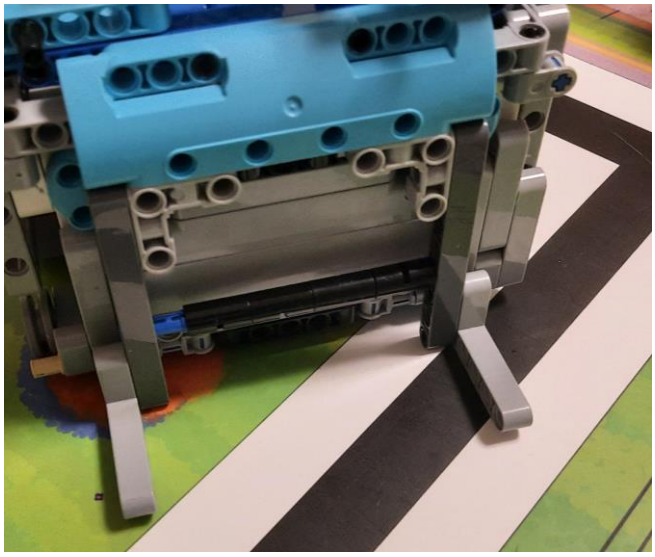




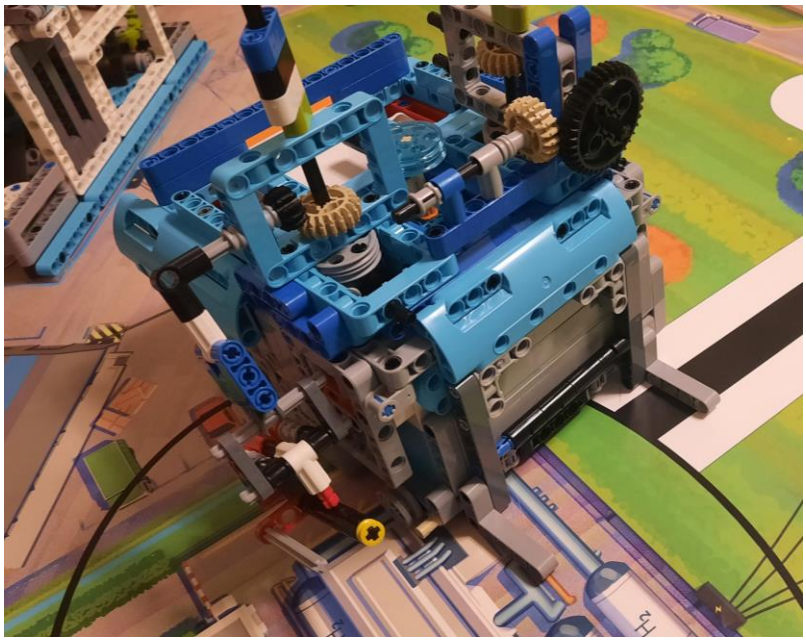
We built a simple paw on the robot with which to solve the hybrid car.

So, the third ride was ready for the preliminary round.

2.3.8 Development of the fourth ride

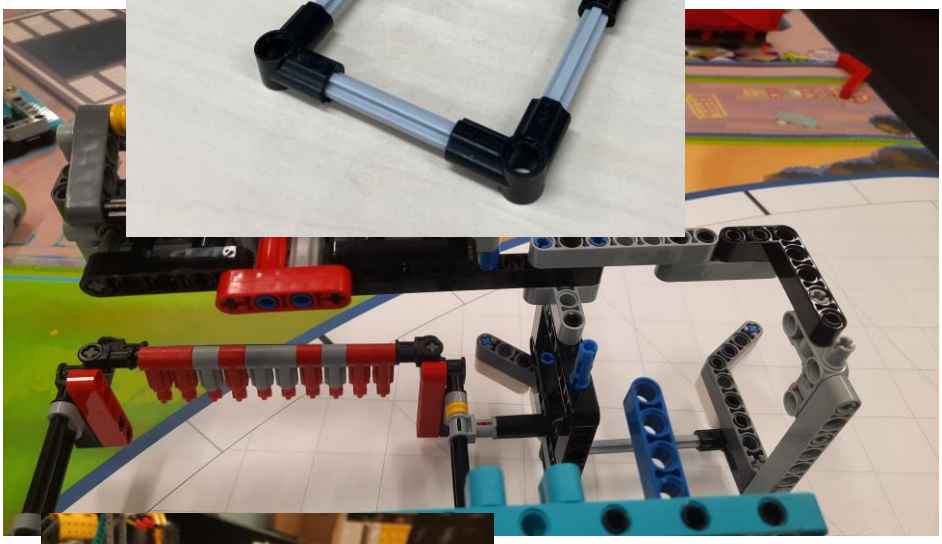


The beginning of the fourth race with the addition of pieces between which to drive a dinosaur from one base to another.

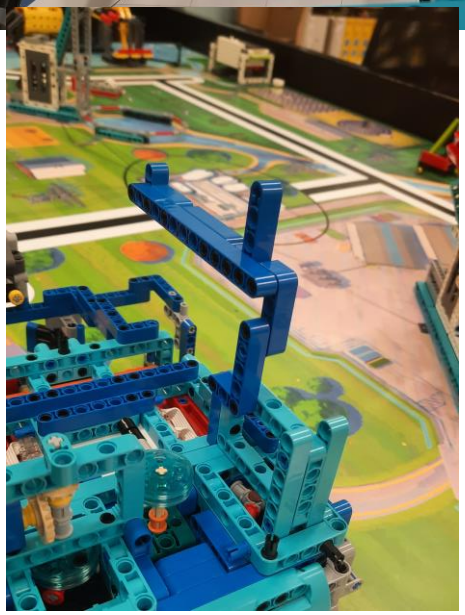


We added a motorized carbine to take water from the hydro dam. The carbine is the same as what we used to collect unhealthy packages during the RePLAY season.

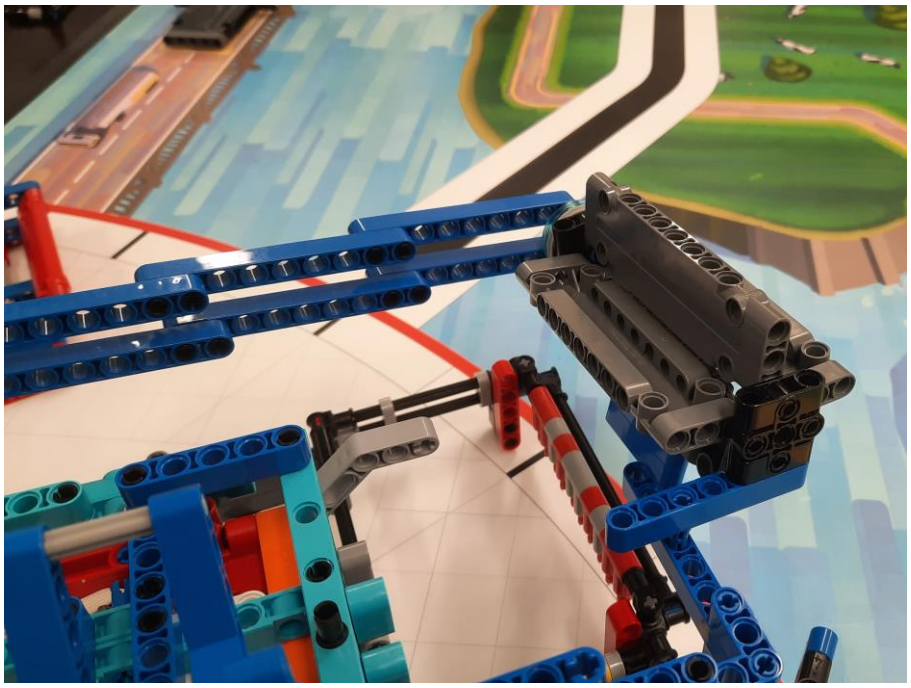
Initial prototype for a non-motorized solution for getting the energy from the hydraulic dam.



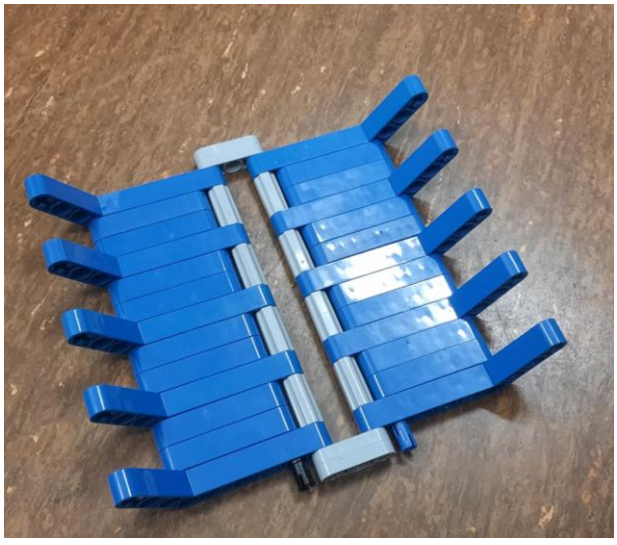
We added solutions with which to get energy from the hydrodam and with which to take the drawer with us. We also added a solution with which to transfer energies to the energy storage.



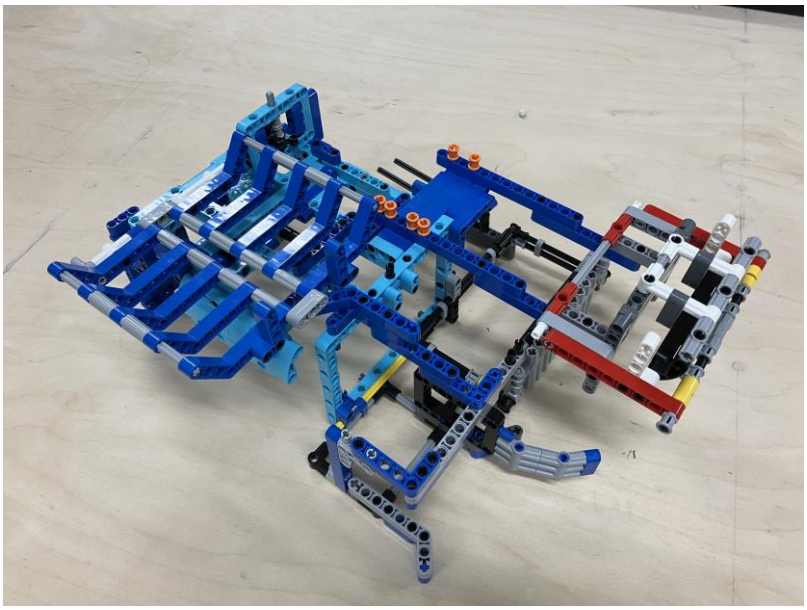
We added a arm with which to take the waters collected by the first ride to the second launch area.



We also tested a motorized solution to bring energy to the energy storage.

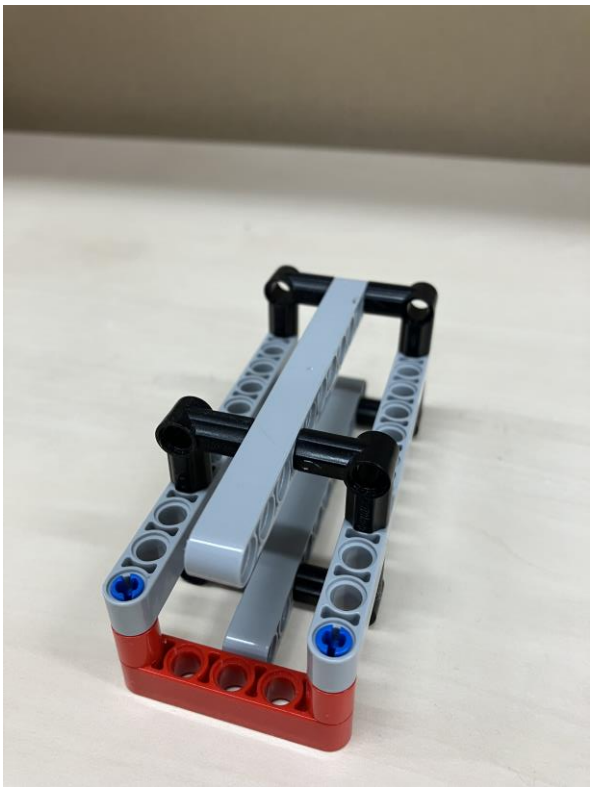


We decided to build a tilting platform with which to dump the dinosaur and three energies into the other base before the ride resumes other operations.

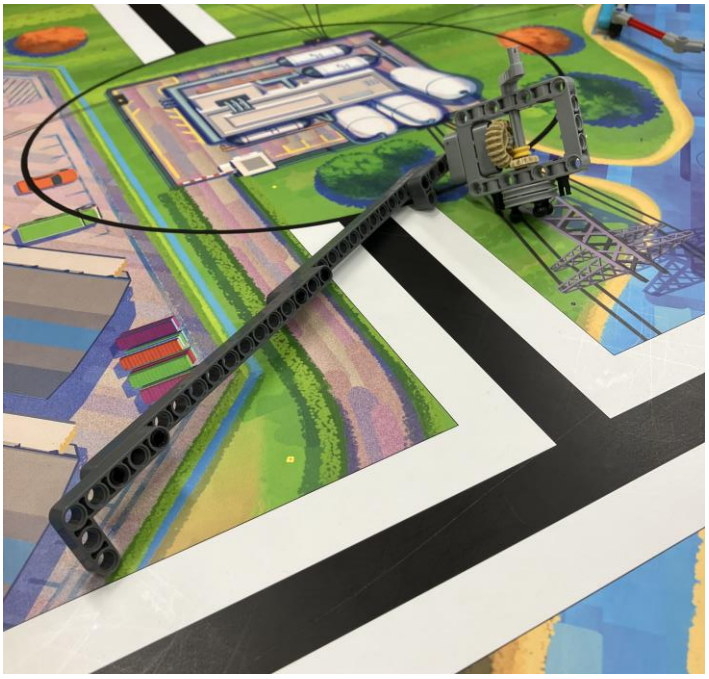


We added a tilting platform to the robot, replaced the energy storage solution with an even simpler one and added aligners to the danger points. So, the fourth race was ready for the preliminary round.

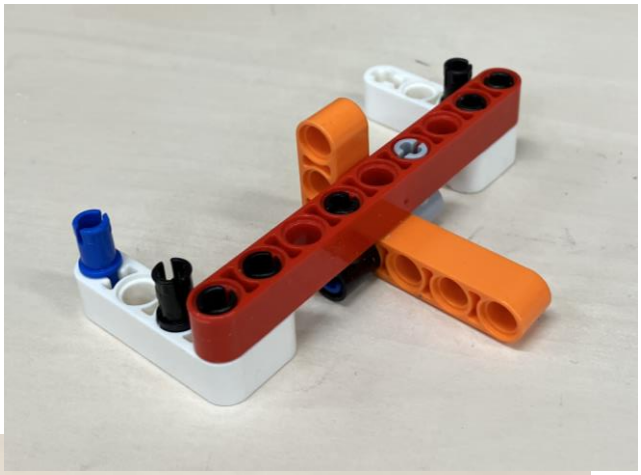
2.3.9 Development of fifth and sixth ride



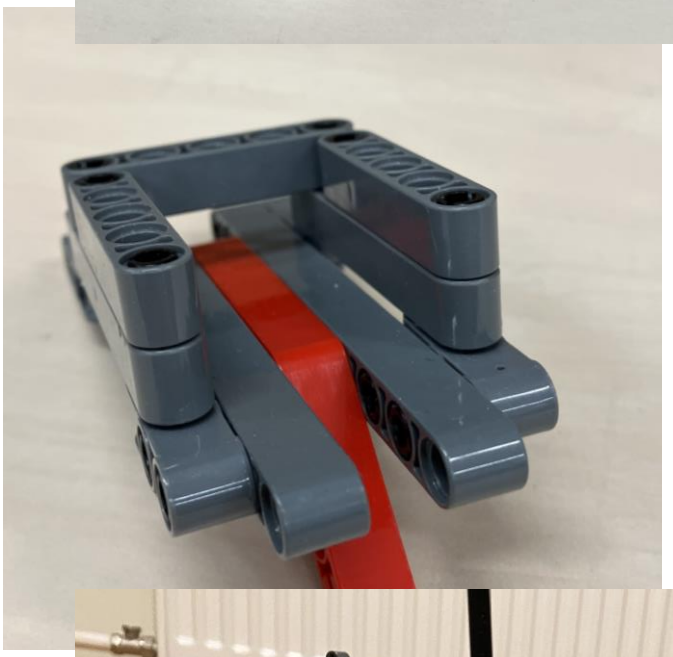
The construction of the fifth and sixth races (these are two separate launches on the same basis) began with the invention of individual solutions.



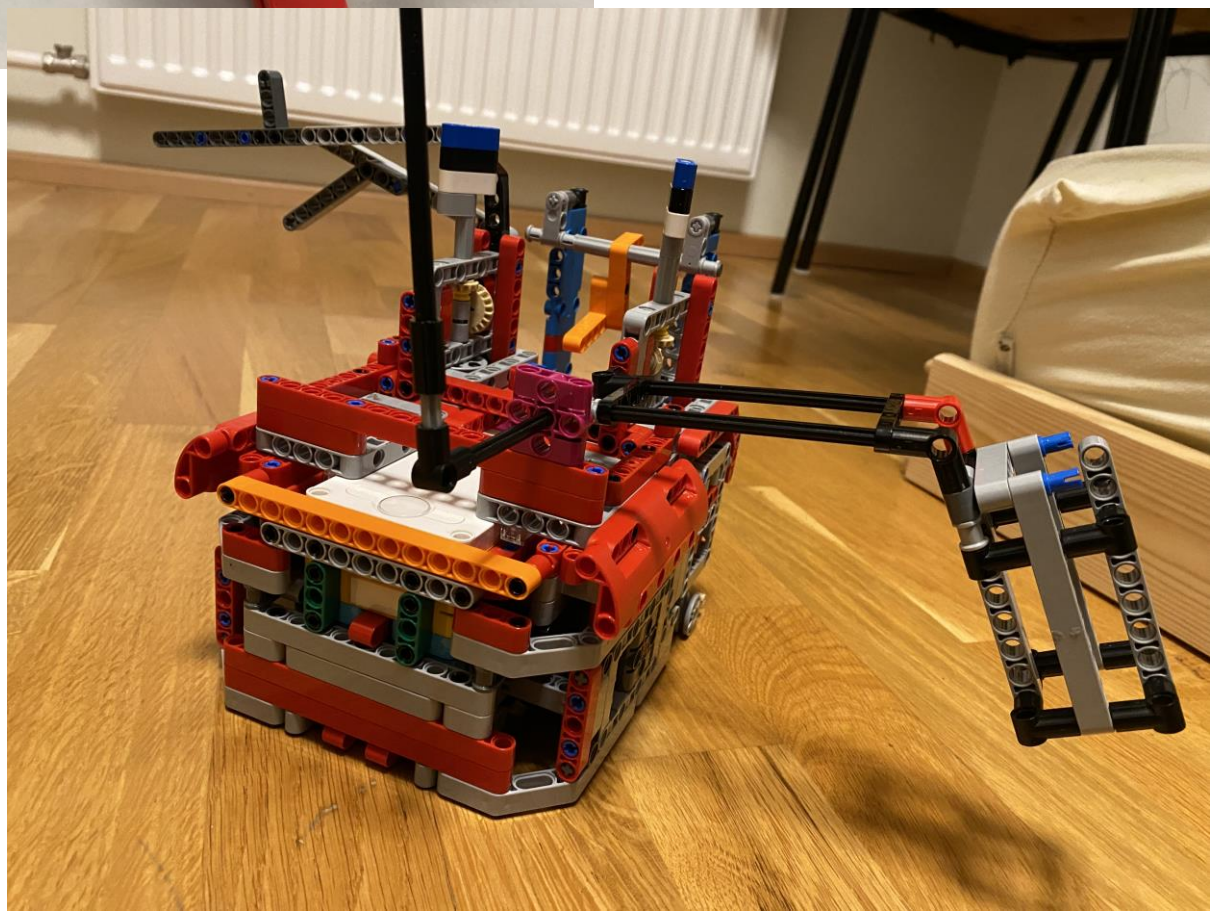
The original plan was to bring the fuel truck away with a motorized arm.



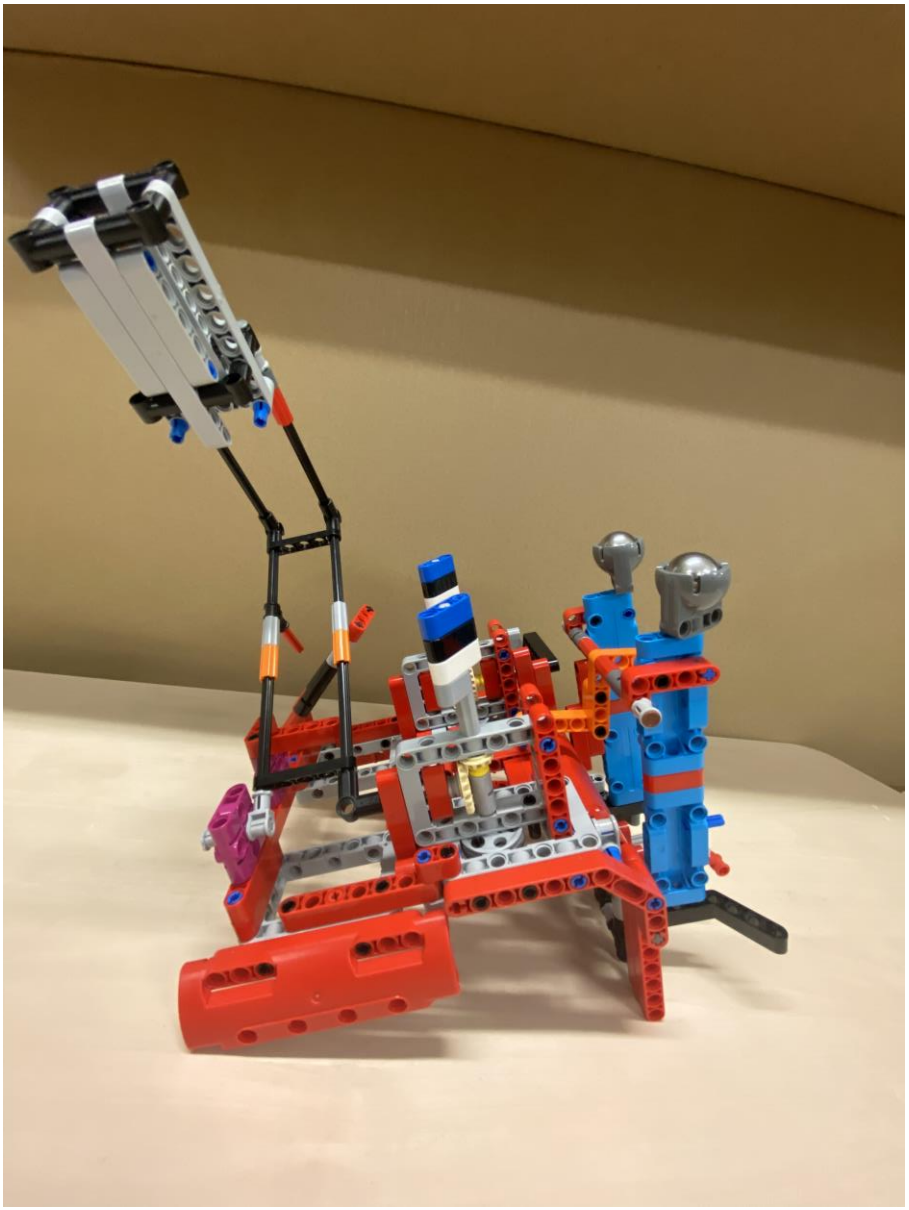
We decided on a more reliable and significantly simpler gate solution.



We also built a ramp to overthrow the innovation project and energies in the target circle in the middle of the table.



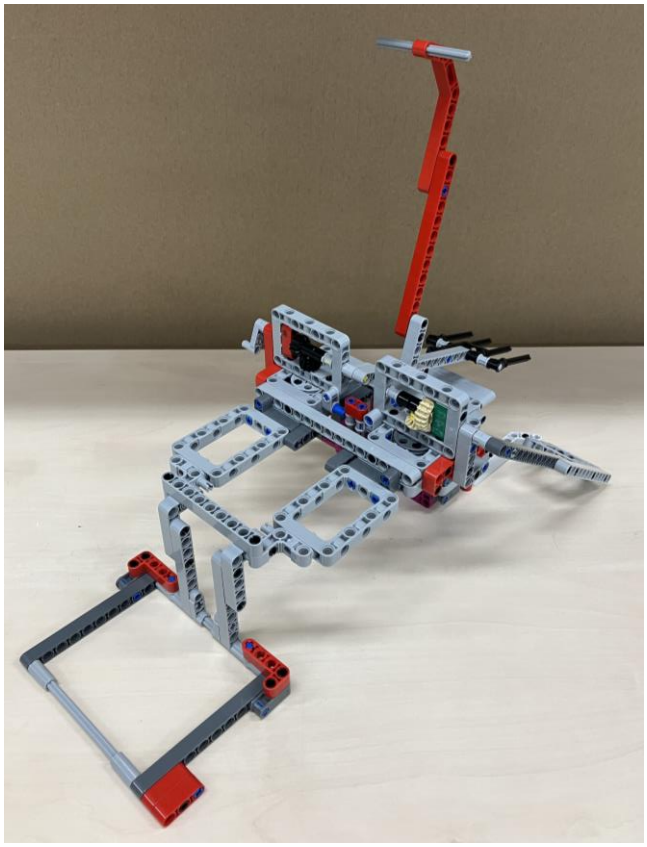
We integrated these solutions into one ride and finished our initial ride.



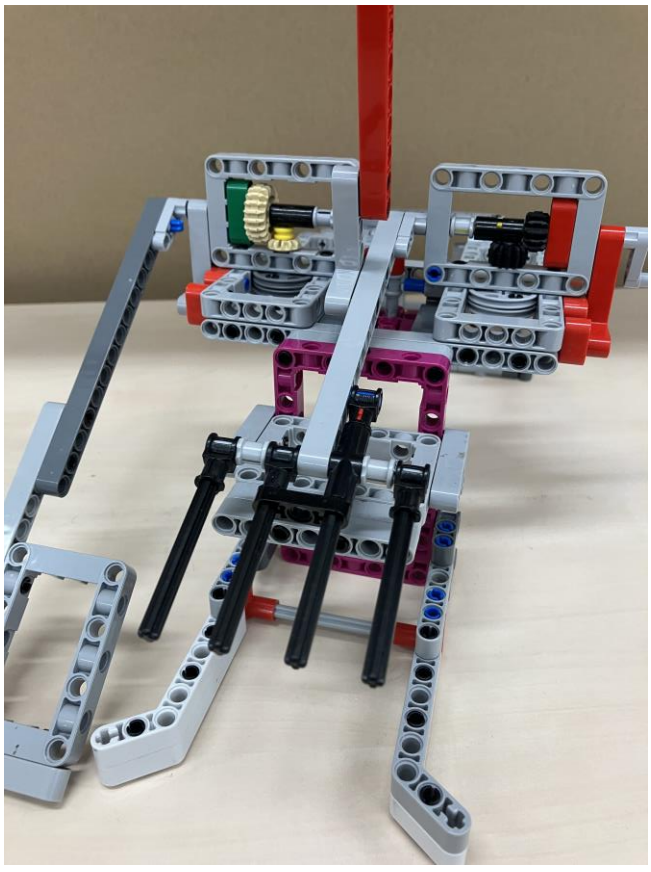
We made a couple of simplifications to the ride and the fifth and sixth rides were ready for the preliminary round.

2.4 Improvements to the robot for the national final

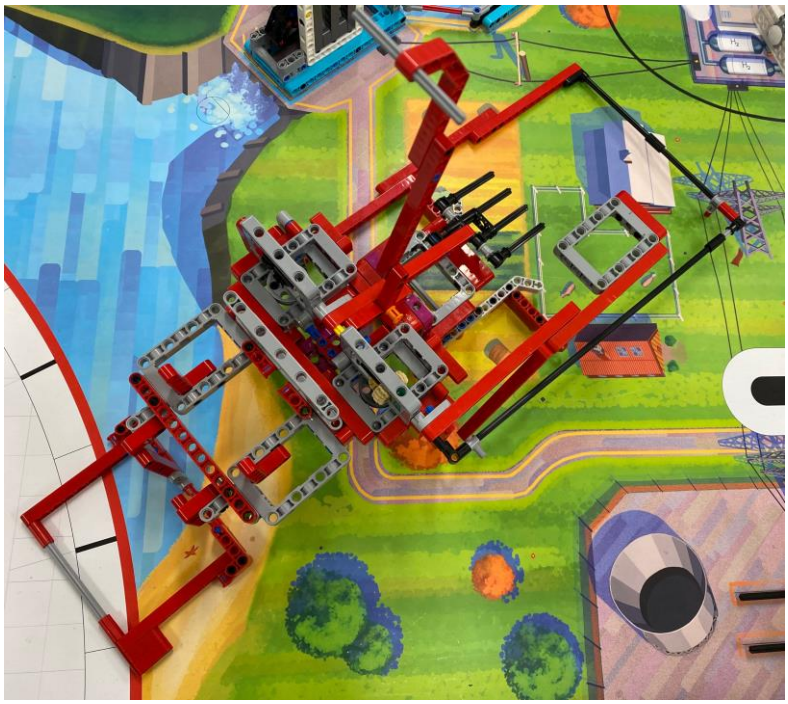
2.4.1 Improvements to the first ride



Our first ride in the final is basically our second ride from the preliminary round.



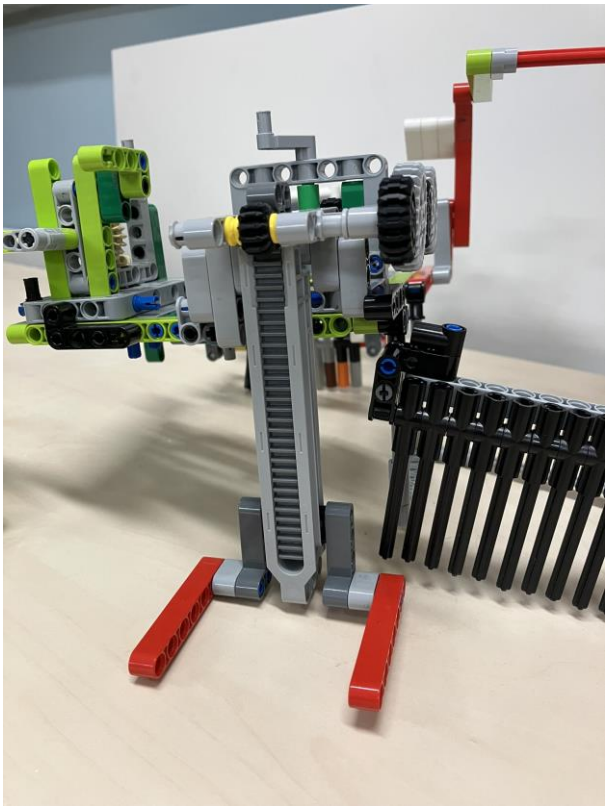
At the front of the robot, we added a solution with which we lift the looped water in front of the dam away. The same motor with which the loop moves the water-raising solution also releases powerplants energy. In addition, we added a solution with the same working principle behind it that we used in the fourth race of our preliminary round.



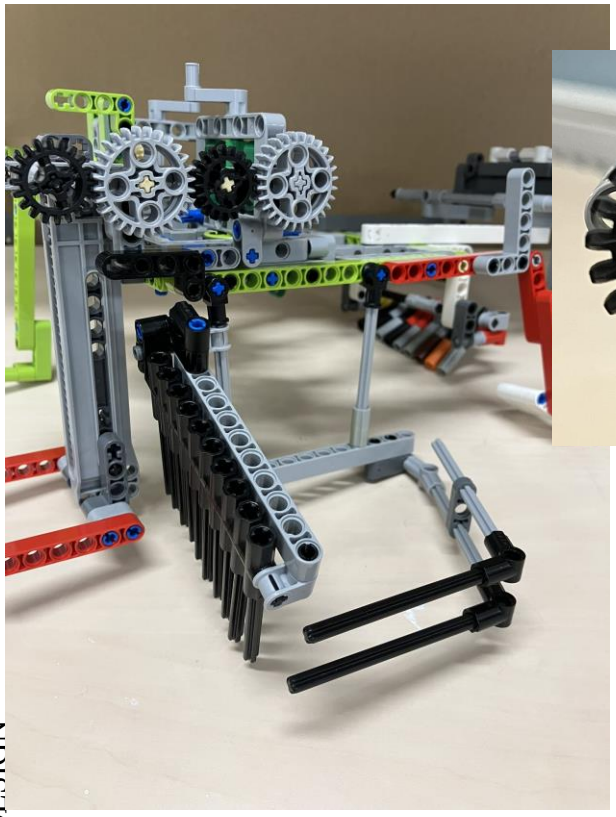
We added a arm to the robot with which we can collect two waters. This paw is moved by the same engine that knocks away the obstruction gate of the power plant. And with that, the first race was ready for the final.

2.4.1 Improvement to the second ride

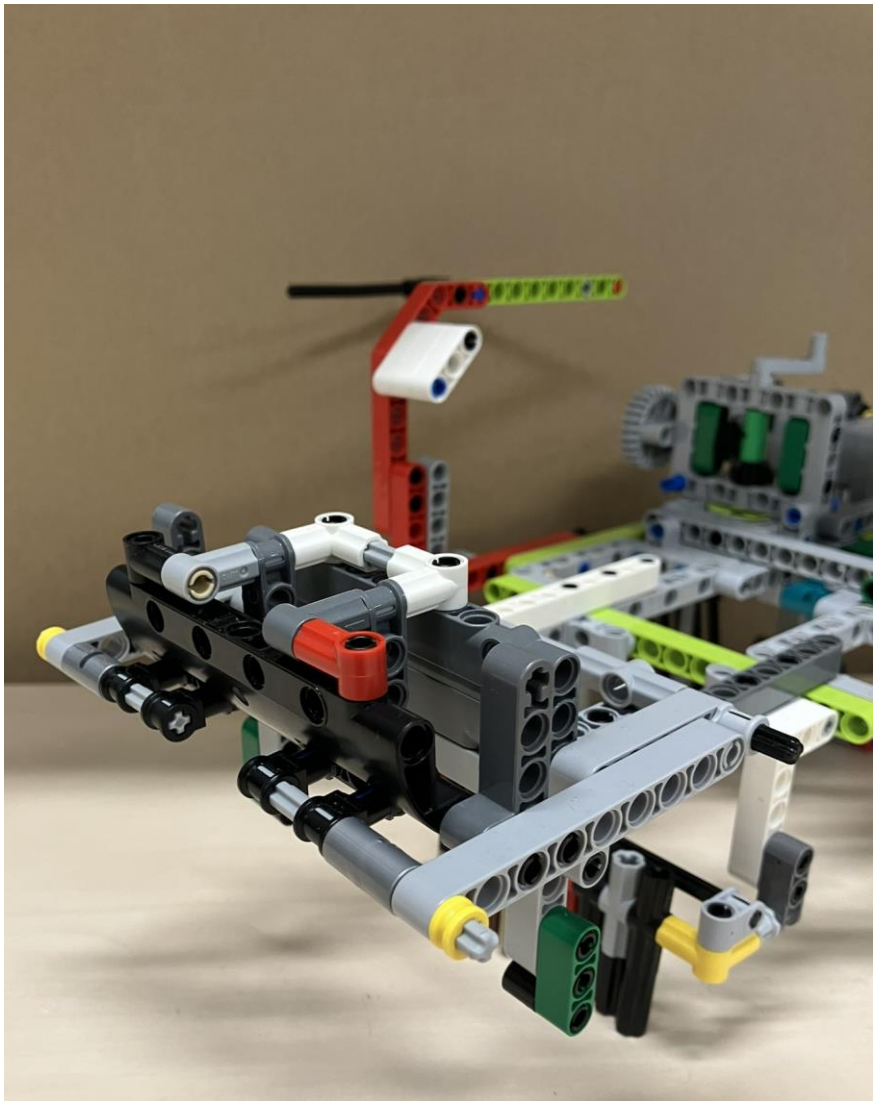
After the preliminary round, we decided rebuild your second race from scratch.



Rebuilding the second ride began with the thought of a more reliable solution to oil charging. Instead of a simple ramp, we decided to use the rack and motor for greater reliability.

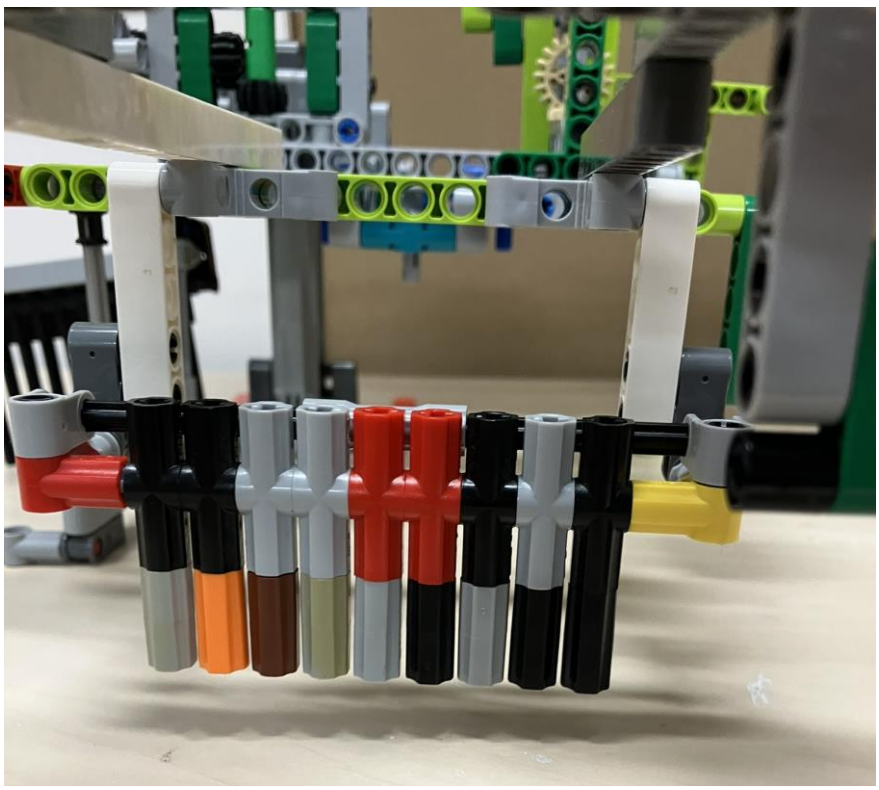


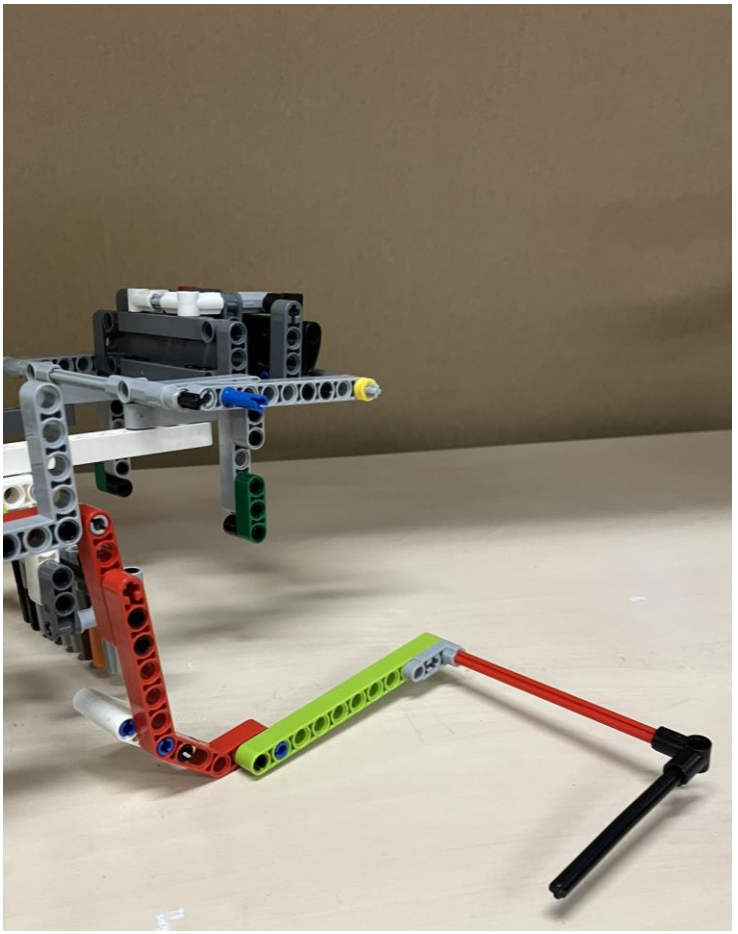
We connected the rack to the motor using a gear transmission. The transmission was built in such a way that we can pick up a little extra speed from there. We added a collection basket next to the robot, with which we picked up one energy and two water.



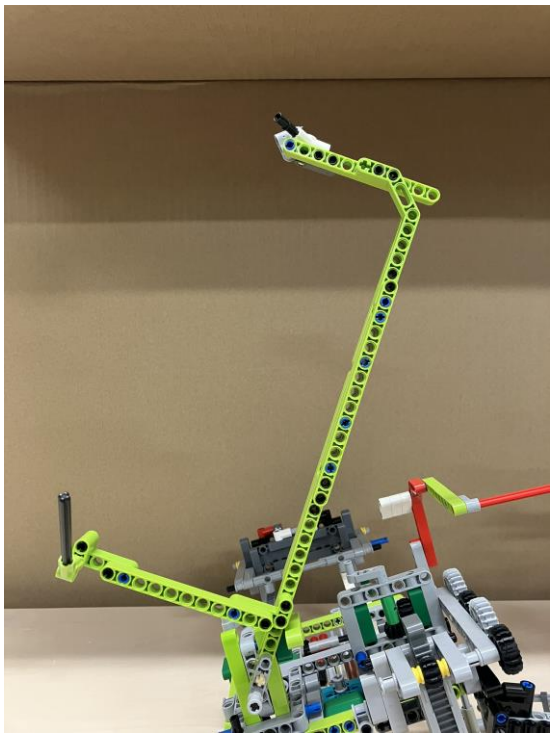
The solution of delivering energy to the energy storage remained the same from the preliminary round. Still working on the principle of the key. When driving into the mission model, the wall that obstructs the energies disappears and they fall in freely into it.

Under the energy storage solution there is a one-way gate, with the help of which we bring out the drawer.

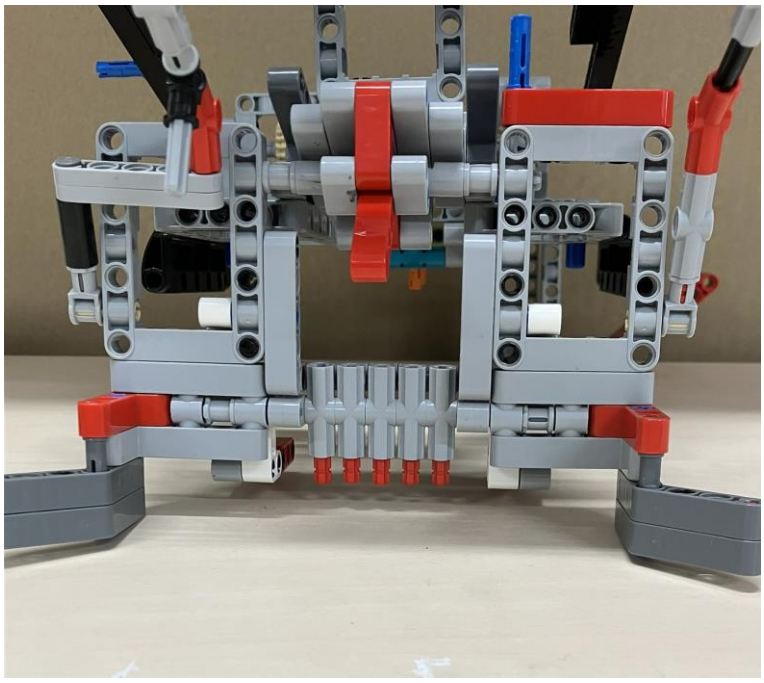


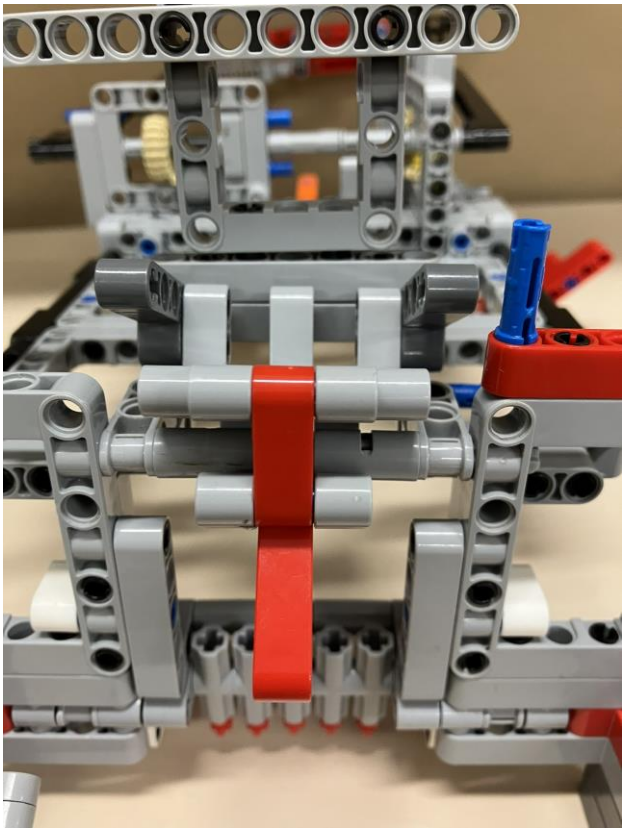


We added a solution to our robot that falls down when it enters the energy storage and thus brings two solar park energy to the base.

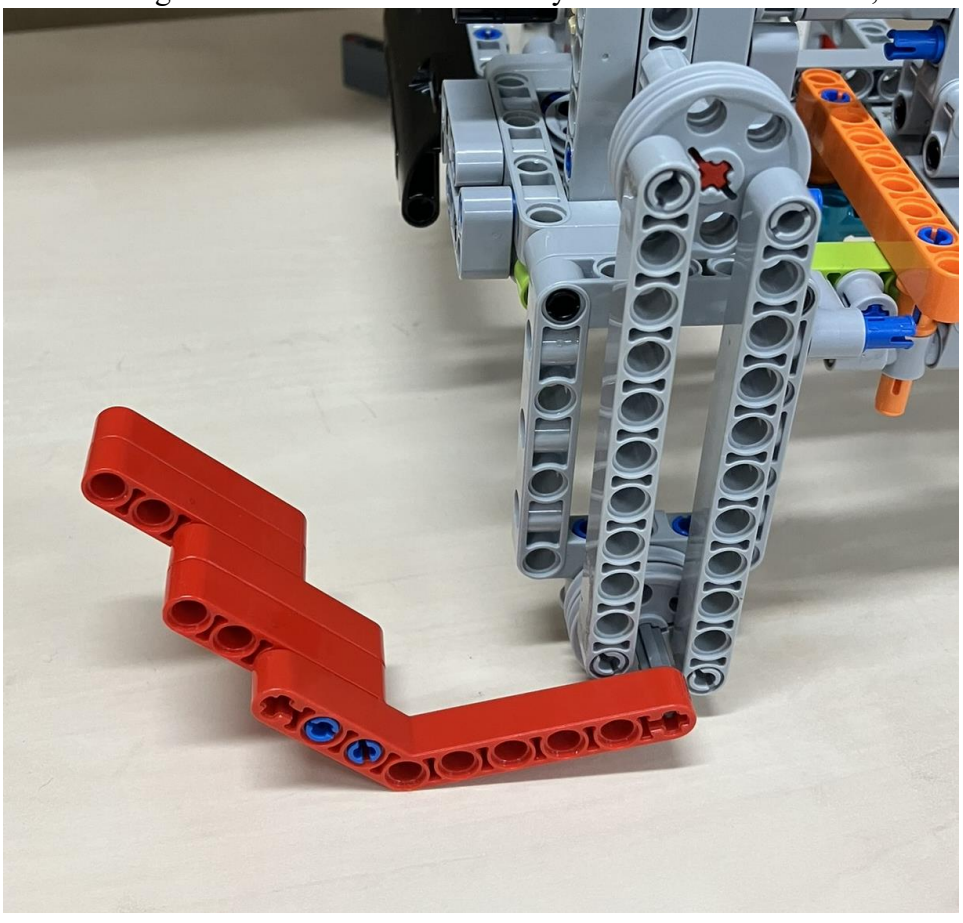


As a final addition, we added a paw to our new ride to bring a previously loaded fuel truck to base.



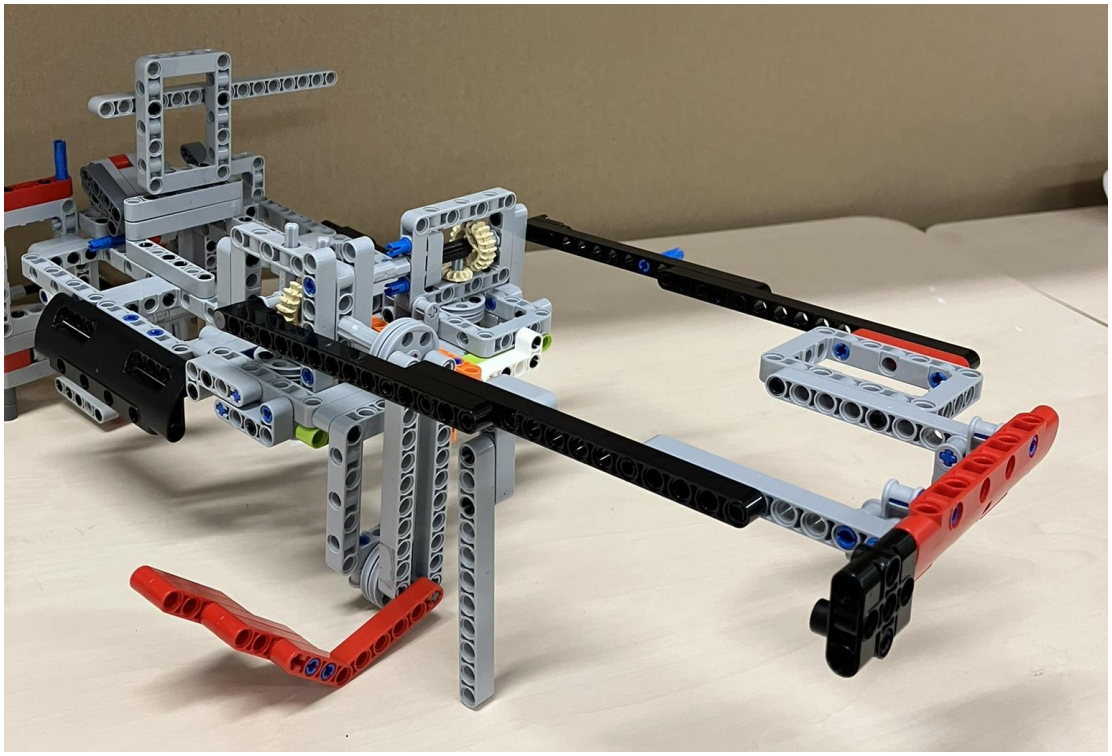


We decided to rebuild our second race one more time from scratch because we found ways to solve things even easier and more reliably. At the head of the ride, we added a värа va with guides and a mechanical tilt which, when entering the energy storage device, pours three energies into it and takes the drawer with it.

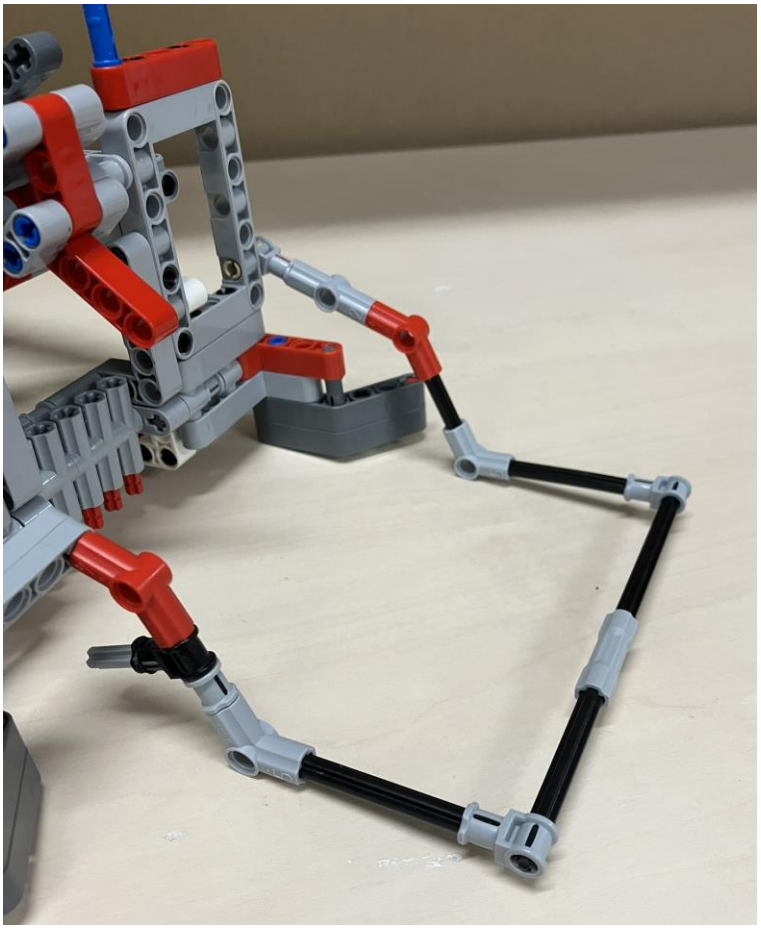


With the help of a paw built next to the robot, we charge three oils into

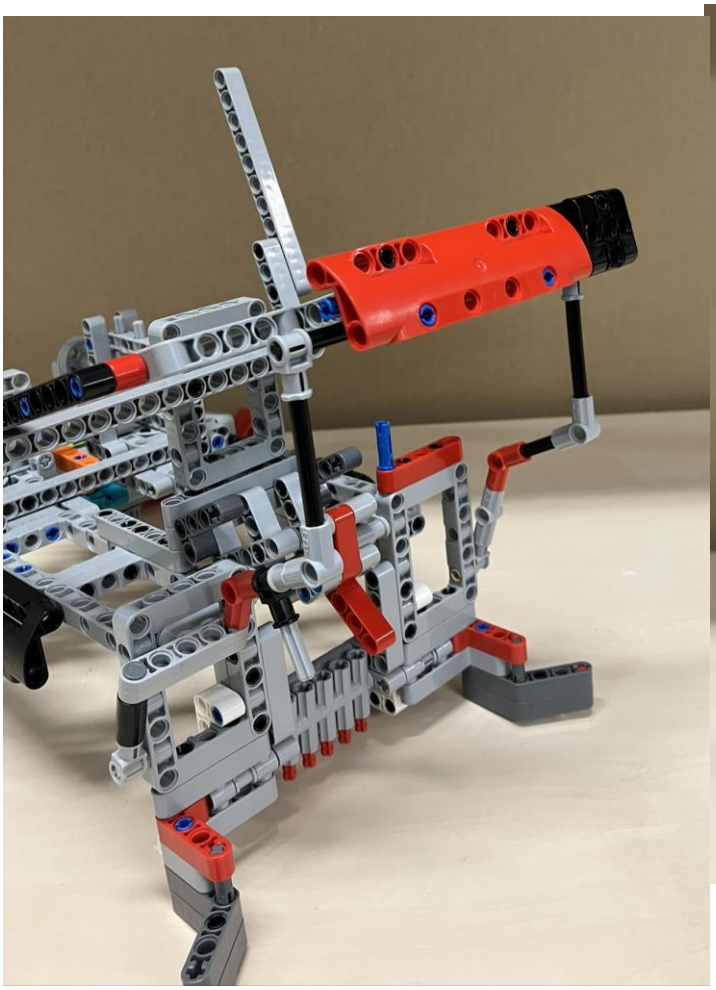
the fuel truck. For this solution, we decided to use liftarms for transferring motor rotation because of its simplicity.

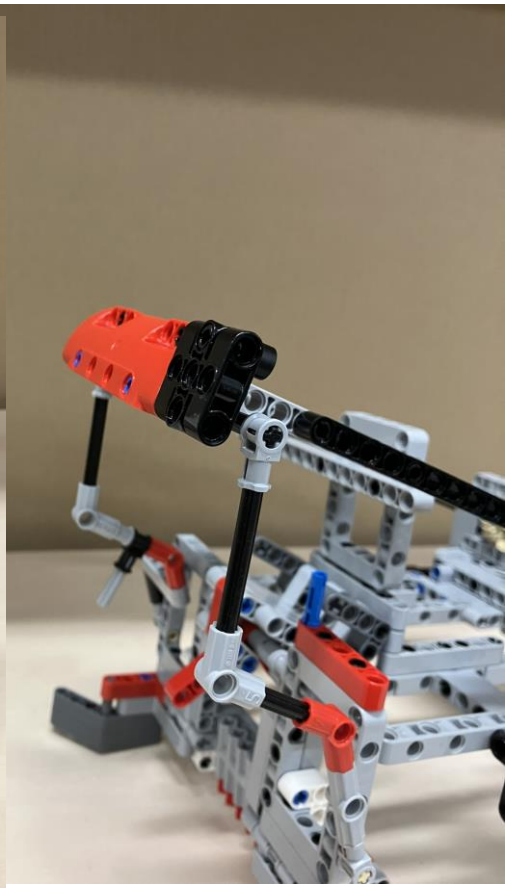


We added a large paw to the robot with which to ram the fuel truck into the home area.

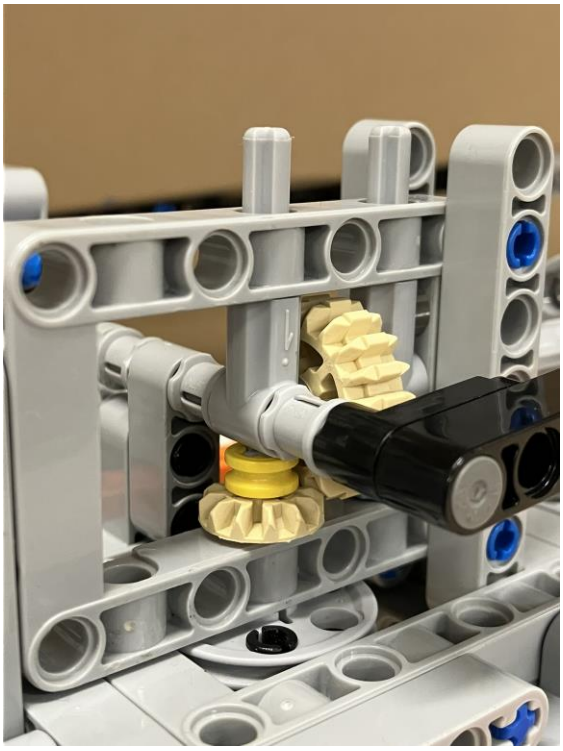


We added a box of shafts with which we grab two energies from the solar park.



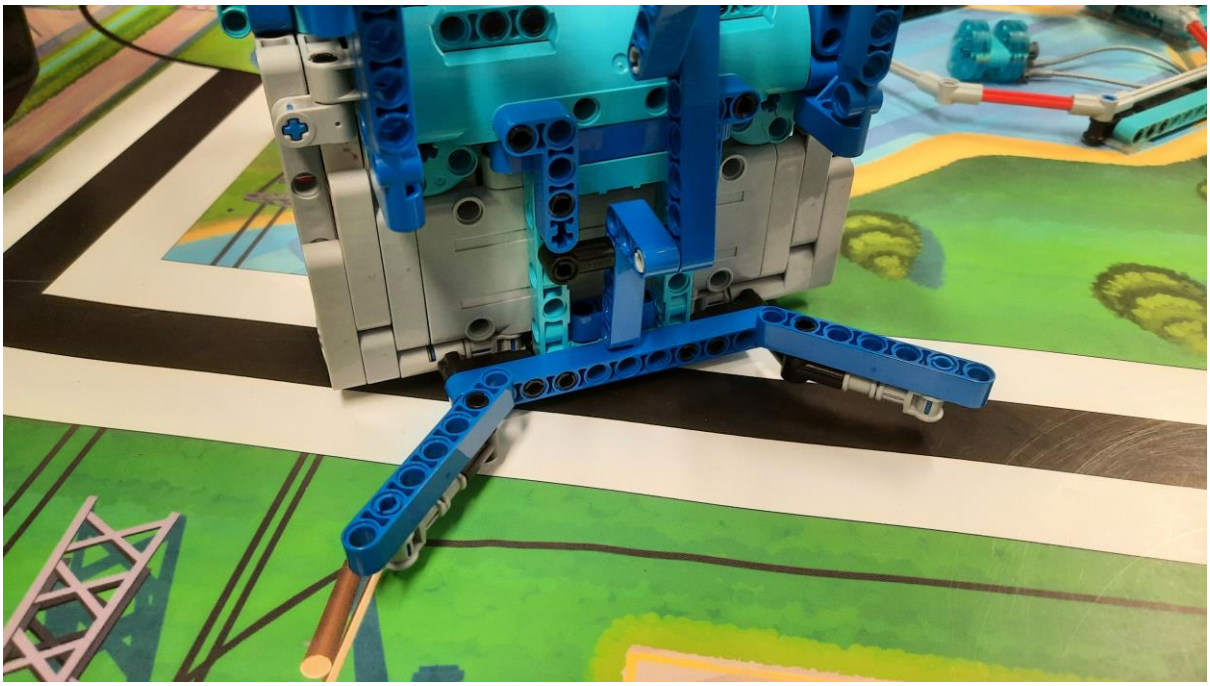


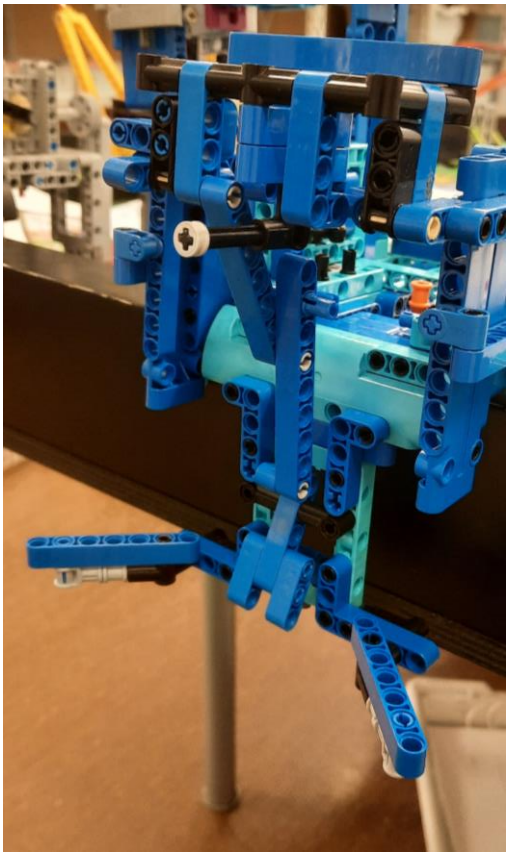
We extended the paw ramming the car in such a way that it would hold the solution that solved the solar park at first.



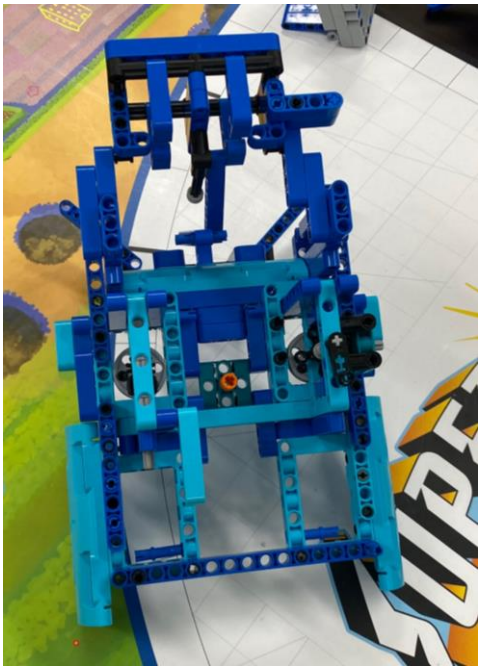
There is also one interesting and very precise transmission on this ride. In a very small volume, there are three shafts rotating in different axles. Beige gears are for charging oil into the fuel truck, and the shaft in the foreground is that of the solution for ramming fuel truck into home area.

2.4.1 Improvements to the third ride

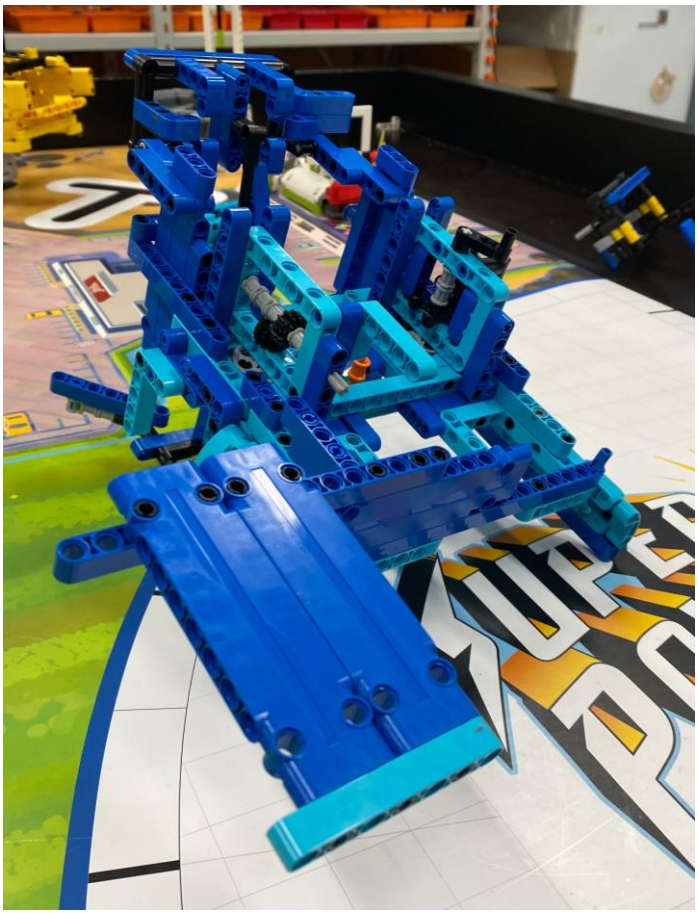




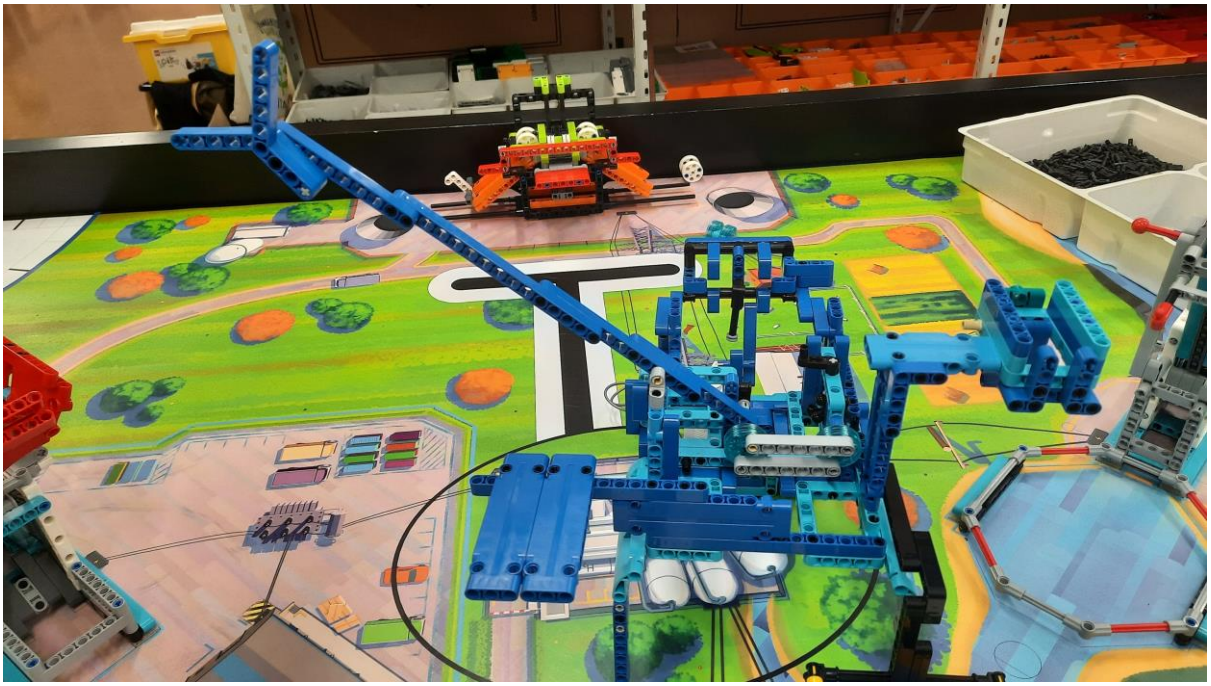
The development of the third race for the finale began with the idea of a good and simple solution for how to bring the waters hanging on hooks and one water into the target circle. We decided to use a key and liftarms that carry the key's movement forward. In other words, when driving to the boundary of the target, the box holding the waters is rearranged so that the loops of the two waters are on the hooks, and when reversing, they remain hanging. The third water falls around as you move into the box.



When we finished it, we continued to build our ride.

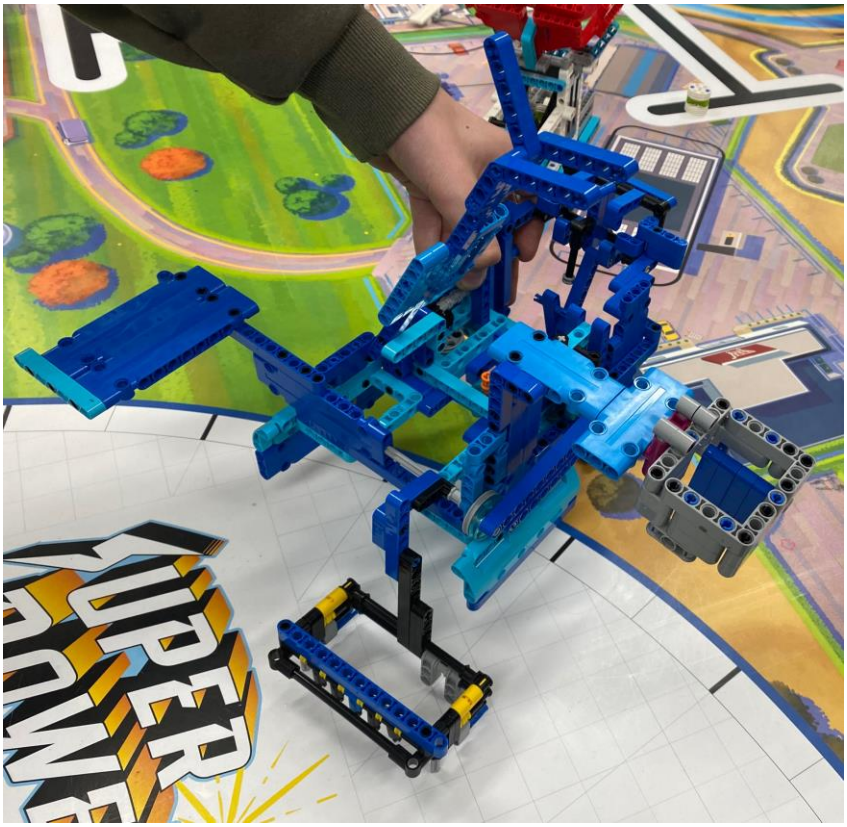


We added two blue plates that, when reversed, do the smart grid mission.



We added an arm to the robot with which it could take the Innovation Project model and two energies to the target circle in the center of the table.

We built the arm a little shorter and simpler.

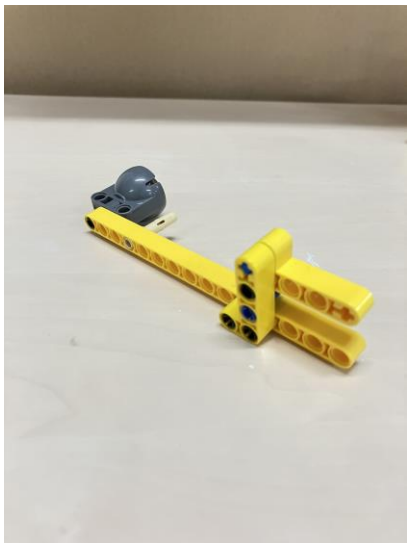


We added a one-way gate system to capture the last energy in the solar park and added a key system with which we solve the toy factory. So, the third race was ready for the final.

2.4.2 Improvements to the fourth ride

We added a couple of changes to the fourth race. We made the arm bigger to make it more reliable.

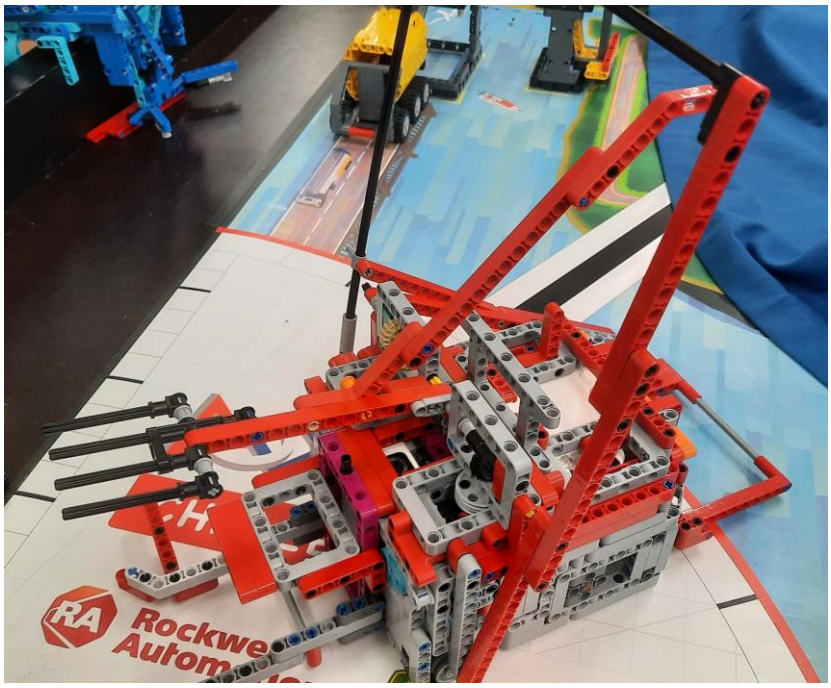
While in the preliminary round, the sixth race, or the last race, brought the fuel truck to the target circle, it is now the fourth race. In addition, we built another arm on the fourth ride. This arm drops energies into the toy factory.



That's how the current fourth and final ride was completed.

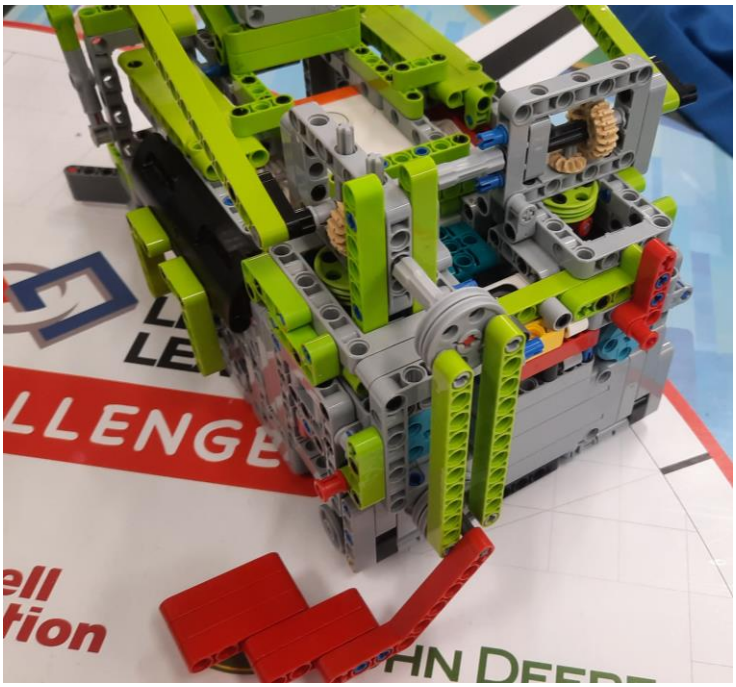
2.5 Improvements to the robot for international competition

2.5.1 Further improvement to the first ride

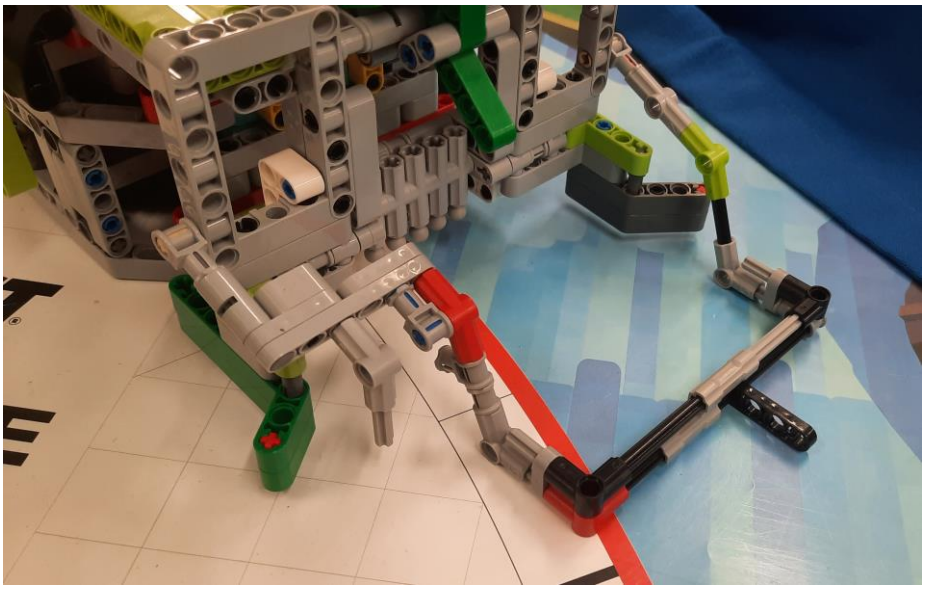


We improved our first ride by changing the angel of the arm that releases the power plant's energies. In numbers, the angle changed from 90 degrees to 45 degrees.

2.5.2 Further improvement to the second ride

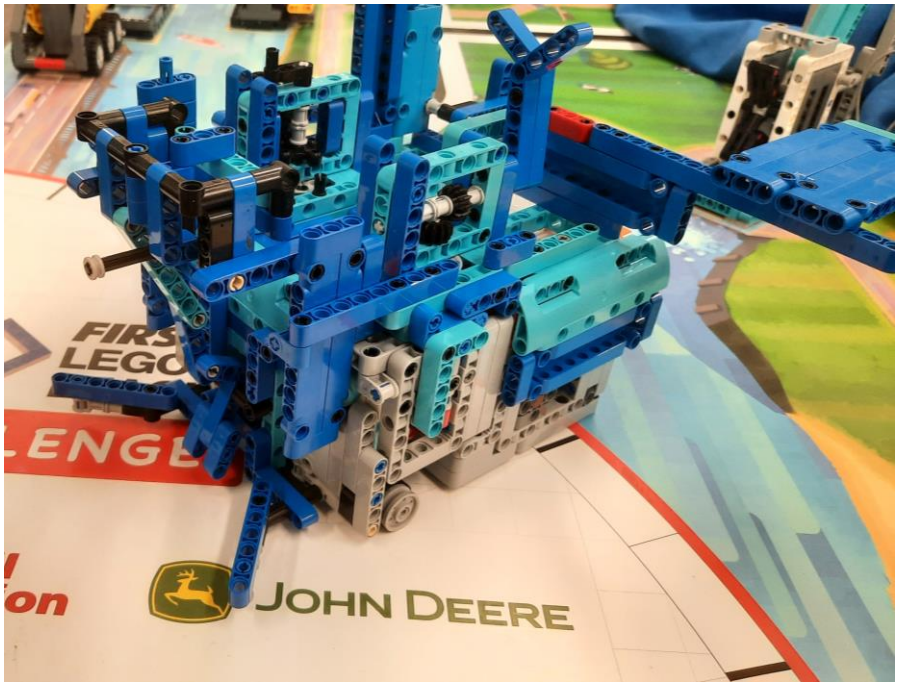


We added one and changed the location of the other locking connector. This is the only ride where ride is locked onto the robot.

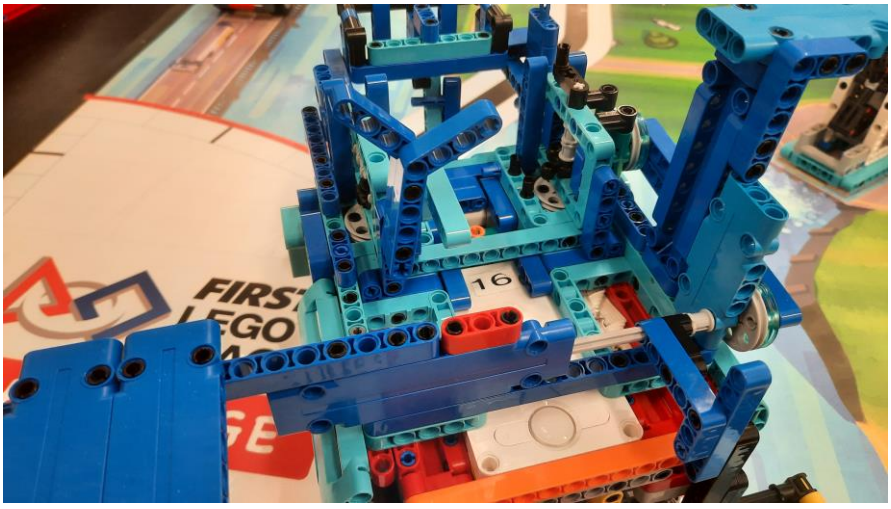


We also improved the solution for solving the solar farm. We increased the height of the walls and made the box smaller.

2.5.3 Further improvement to the third ride



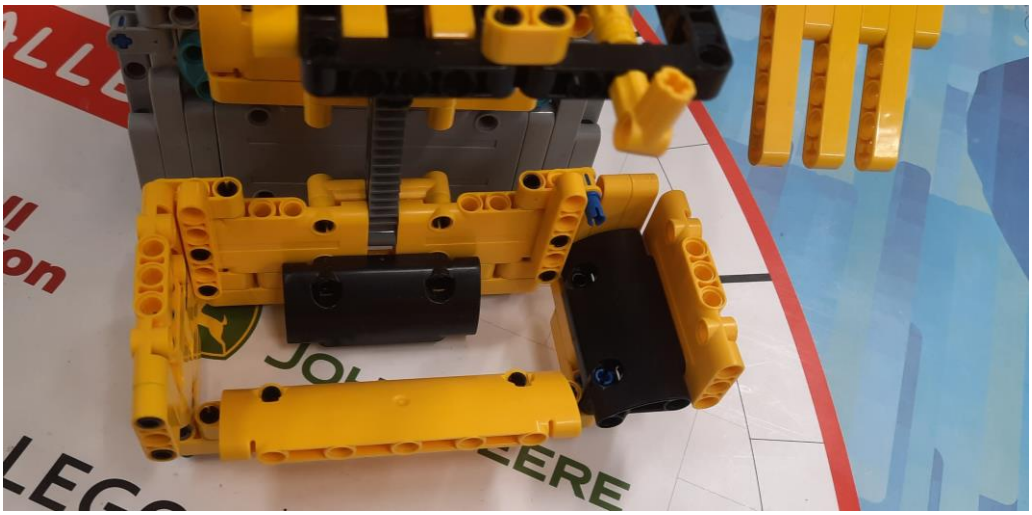
We built the entire solution for delivering waters to the red hooks and to the circle lower.



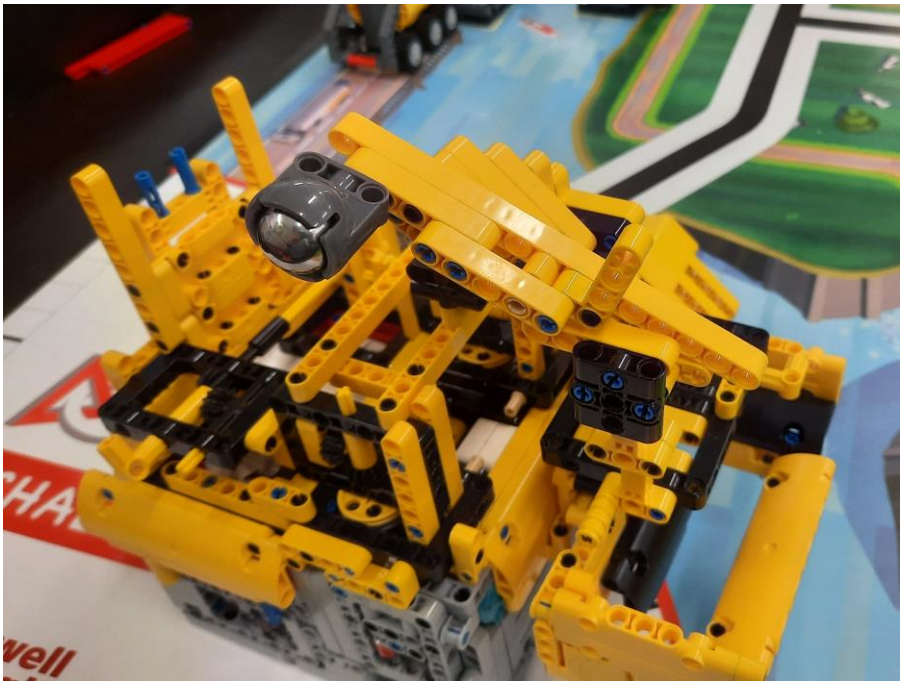
We also made the arm that drops our innovation project and two energy units into the target circle in the middle of the field smaller and lighter.

2.5.4 Further improvement to the fourth and fifth ride

We rebuilt the arm that solves the hybrid car. We made it larger and also lighter at the same time.



We made the box that solves the TV, windmill, rechargeable battery, and toy factory wider. We also added a curved plate on the inside of the box to help reduce inertia of the windmill energies as we are moving them to the rechargeable battery target circle.



We also rebuilt the arm that drops two energies into the red hopper of the toy factory. That arm is moved by lifting the box below it.

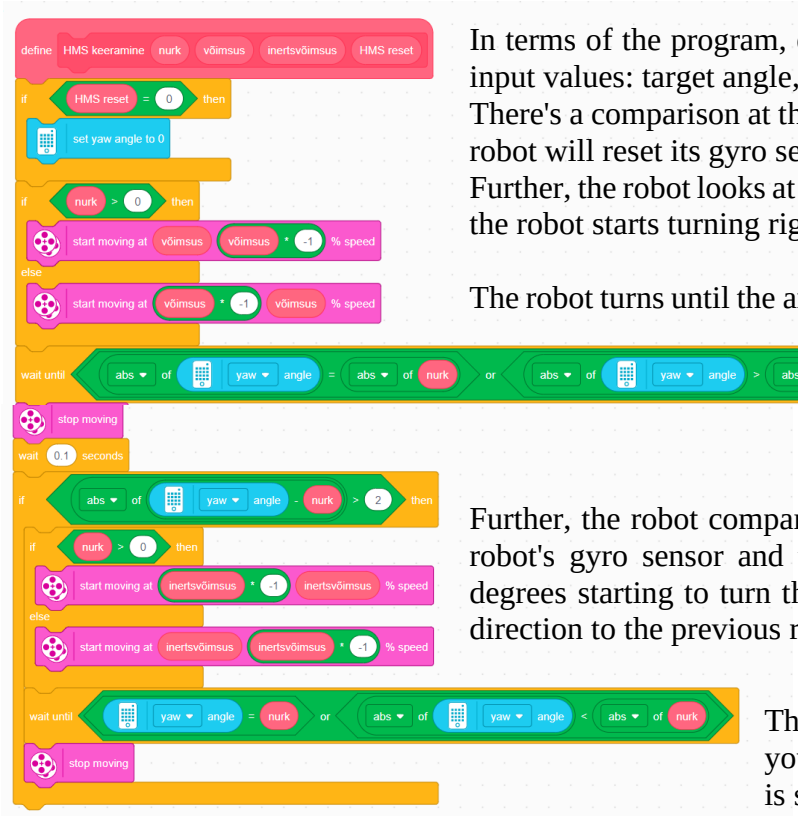
3 CODE FUNCTIONS AND EXPLANATION

3.1 Transition from EV3 to SPIKE

While in previous years we have used the EV3 robot and thus also used the LEGO MINDSTORMS Education EV3 software to program Beast, then for the last three seasons we went the other way and used SPIKE Prime. Below we have also included an image of our program using a motion sensor for turning. We will add in-depth explanations here to make the program even more understandable.

3.2 Explanation of code – turning to a certain value using Hub Motion Sensor

Below you will find our HMS turning program, i.e., turning to a certain value using the motion sensor.



In terms of the program, our gyro turning MyBlock is interesting. It has four input values: target angle, turning power, rewind power, and reset.
There's a comparison at the beginning of the program. If the last value is 0, the robot will reset its gyro sensor reading and turn relative to the new zero angle. Further, the robot looks at the direction of its target angle, with a positive angle, the robot starts turning right. At a negative angle, the robot starts to turn left.

The robot turns until the angle of the robot is equal to or greater than the target, then stops turning. We use absolute value in because you don't need separate programs to turn left and right.

Jr are equal, or the angle of

Further, the robot compares its angle when the gap between the angle of the robot's gyro sensor and the angle you are looking for is greater than two degrees starting to turn the robot back. The robot turns back in the opposite direction to the previous rotation direction.

The robot turns back until the robot and the angle you're looking for are equal, or the angle of the robot is smaller than what you're looking for.
