**Slide 1 : Hi, I’m Jennifer, I have just finished third year in Confey College. I am very passionate about Maths and I was asked to take part in this ROBOTICs competition because of my involvement in Maths both inside and outside school. For the last two years, I have taken part in Irish Maths Olympiad training , I was also part of the Confey team who won the 2017 Applied Maths National Junior Problem Solving Quiz. Because of my .....skills, my role on the team is ....**

**Slide 2: Before we start here’s an overview of the FIRST Global Challenge 2017 - Play Video**

**Slide 3:**

**The video you just saw has hopefully given you some idea of WHAT’s involved and our presentation today will now explain the Background Information - HOW we got involved, the DESIGN of Robot, OUTREACH and WHAT we have LEARNT from the whole EXPERIENCE. We will then demo our ROBOT and finish with a Q&A session.**

**Slide 4:**

**FIRST global made contact with Professor Peter Redmond and asked him to put together an Irish team to take part in their World Robotics Competition 2017 which was to include 164 teams from across the globe. Peter selected our school Confey Community College.**

**Slide 5:**

**Confey was selected because of our 2017 and 2016 successes in the European Space Agency’s CANSAT competitions – coming third in Europe in 2017 and very close runners up in the Leinster final 2016.**

**To give you an idea of the Cansat competition, here is an infomercial made by our team last year which describes the ESA competition and here is our CAN that won the National Final last year. You can see flexible solar panels to detect the sun’s power, a light for detection, and a beeper which could be turned ON/OFF for location. We could maintain two way communication with our can on descent and landing, we had GPS tracking and it contained Pressure, Temperature and Humidity Sensors as well as an accelerometer to identify the forces it received at various stages of flight.**

**The FIRST in FIRST Global stands for For Inspiration and Recognition of Science and Technology. FIRST Global is a non profit organization set up to promote the study of Robotics and STEM in secondary schools across the globe so that we may use our knowledge in these areas to solve major world problems (such as lack of clean water)**

**It’s founder Dean Kamen is both an inventor and an entrepreneur who is passionate about the promotion of STEM. His notable inventions include the Segway, the Drug Infusion Pump and the iBot wheelchair.**

**Here is a picture of us after opening our Robot KIT. There were 1852 pieces in total. It is important to note that each team was given EXACTLY the same kit. Some modifications to parts were allowed but NO other materials or parts WHATSOEVER could be used/added in the making of the robot.**

**After familiarizing ourselves with the challenge and examining the kit, we realized that there were several aspects that we would need to consider when designing the robot. Three team alliances that changed every round meant that we would need to have a robot and software that was very flexible and adaptable in design and purpose.**

**It also meant that communication with the 163 teams across the world would be vital for our success since, before each round we would have to agree strategies with different world teams based on each team’s robot capabilities**

**We initially brainstormed several ideas – some of which were a little on the aggressive side (slide) – however, on revisiting the rules we realized that Cooperative Competition was essential and points would be lost if our actions went against this philosophy.**

**Now, To recap on the important features of the game:**

**Each game lasts 150 secs**

**Initially 40 blue and 10 orange balls are released and then 1 ball every sec for 150 secs – 1 Orange to 4 Blue until the flow of Orange is stopped – this means that, throughout the game 200 balls are released**

**The flow of Orange stops once 10 Orange balls have been deposited into the chemical store. From then on all balls released into the river are blue.**

**There is a neutral ‘no go’ area and two exclusion zones – one per team. Robots cannot be extended beyond 50x50x50 within these areas.**

**An orange ball into the Chemical store (up ramp) gets 4 points, whereas a blue ball into the Pure water area on ground gets 1 point.**

**At end of game, if robot is hanging on bar it gets 15 points, if its on bridge or ramp it gets 5 points**

**There is an additional 15 points awarded to BOTH teams if the river is free from orange balls.**

**The Overall winner is one who wins the most matches – but if it’s a draw then it comes down to cumulative points**

**After much consideration we decided that our Robot should be able to :**

**Collect balls of BOTH colours simultaneously and store separately**

**Collect ALL Blue or ALL Orange (max 16)**

**Deposit balls in the Water Reserve and Chemical Storage areas**

**Release from one cage only – i.e. ONLY Blue or ONLY Orange**

**Release from both cages simultaneously**

**Lift itself up on the required bar**

**The ROBOT design can be broken into three main sections:**

**Mechanics (Chassis,Drive and Claw/Harvester )**

**Filtration: (Ball intake, Color Separation, Storage and Release)**

**Coding (Gamepad, Mechanics, Multi-Functionality)**

MECHANICS:

Hi, I’m Stephen, my interests are in the areas of Maths, Engineering, Physics, Kayaking. I have also been taking part in Maths Olympiad training over the last year and I was part of the CANSAT 2017 team and also part of the Applied Maths Problem Solving team. My role inn the team is ...

The Chassis/Drive

We started by building a simple base with the **control and expansion hubs horizontal** as shown, These hubs were heavy so we placed them at the bottom to lower the centre of gravity of the robot for stability. We put **4 motors on each corner** .

Here is a video of our first base:

Eventually, as we added to the robot we found that it’s movement slowed considerably. Timing is critical in this game as we need to collect and deposit as many balls as possible both up the ramp in the chemical area and also into the pure water area below.

So **we added gears** which sped things up.

As the robot got heavier we realized that **the wheels had too much friction** **when turning** and this caused the robot to jump rather than turn smoothly. The nature of the game meant that turning was going to be very important as the robot needed to be able to turn through very small angles especially as it had some tight corners to negotiate and there was little room to manoever when going up the ramp. The width of the bridge also meant that the robot had to be able to spin on it’s own axis in order to deposit the balls into the Chemical storage area as there was not enough room for it to turn on a circle. The robot also needed to be able to turn smoothly and sharply in order to trap balls rather than knock them out of it’s path.

We received a **late shipment of Omniwheels** and **initially changed to a four wheel design** **with JUST the Omniwheels**. This made turning corners much smoother.

We then built a ramp to spec. The ramp immediately identified several problems:

One of the gears was too low and snagged on the ramp so we had to redesign the gear system raising the problematic gear. Due to the weight of the robot and the nature of the omni wheels we found that the robot tended to **SLIDE** on the ramp, we **changed to a six wheel design adding higher friction wheels**. These wheels were placed **in the centre to allow the robot to spin on its own axis.**

Also, as the robot got heavier, we discovered that it could not get over the top of the ramp due to it’s front wheels (and hence two of it’s motors) being in the air at the top of the ramp. We moved the motors to the two middle wheels instead.

We also discovered that when the robot was driving in reverse the two gears on each motorized wheel became misaligned and did not mesh correctly. We solved this problem by connecting a **bracket between each pair of gears** to hold them firmly together preventing them from misaligning. In order to get the desired distance between the holes in the bracket we had to use a drill to widen two of it’s pre drilled holes.

Claw:

Remember **20 extra points** are given to any robot that can lift itself off the ground at the end of the game. We first constructed the bar (to scale) that the robot would have to lift itself up on. We then worked on several designs for the claw – starting with the basic design suggested in one manual. This design involve using wheels to form the gripping mechanism but we found this design to give poor grip. We then made the claw from angle brackets which gave a much better grip. However, having only one point of contact with the bar did not give the robot great stability and therefore we added a second point of contact with the bar making it much more stable and robust. We still felt that it swung when lifting itself and that could only be lifted barely off the ground. While demonstrating our robot at a Codordojo Projects showcase a student approached us. He was part of a team who had represented Ireland in a different world robotics competition. He suggested that we turn the claws the opposite way round as we would have better stability. We did as he suggested and found our robot to lift with far more stability and could hold itself a good deal higher.

This diagram explains why. (PULL – UPS). As you can see the centre of gravity in the earlier version created a moment (turning effect) about the bar. As the robot was lifted the robot’s centre of gravity was constantly being pulled backwards maintaining the moment all the way up. The moment required to prevent it’s back end from swinging downwards was too great and hence it was barely lifting off the ground. By changing the position of the hooks you can see that the Robot’s centre of gravity was now below the bar meaning there was NO moment about the bar. As the robot is lifted it’s centre of gravity remains below the bar and therefore there is practically no swinging about and there was no moment causing it’s back end from swinging down. This also meant there was less work needed from the motor when lifting.

The rules initially stated that a judge must see the robot hanging visibly at the end of the game. Since the power must be switched off as soon as the game ends, we realized that this meant that the robot had to be able to remain up on the bar even with it’s power off. To enable it to do this we created a latching mechanism which meant the claw remained latched in place on power off.

FILTRATION:

Ball Intake:

The game required a robot that could take in balls of both colours, sort them by color, store them and then deposit blue balls into the pure water area and orange balls into the chemical storage area. Initially we had two sets of wheels on the front of the robot that pulled the balls into the robot. We made an elevator using two plastic rotating strips that guided the balls upwards. This worked well. However, ball collection was slow as our robot could only collect one ball at a time. We added an extra row of wheels that meant that more balls could be pulled in at once. The balls could wait in line in the area between the two sets of wheels. However, we felt that we were not trapping enough balls and, because it was taking some time to get the balls up and into their cages, we decided to make a larger trapping mechanism which we call the harvester. The harvester has two functions:

(i) To LOWER and TRAP as many balls as possible into a ‘waiting area’ where they could then be elevated, separated and stored as the ROBOT moved about.

(ii) To GATHER/FLICK more balls into the entrapment area as the Robot moved about. We used our claw mechanism to lift the harvester up and down. We tried cord as a means to attach the harvester to the claw but we found ......so we changed to elastic instead. At the harvesting end, we used two elastic bands and a motor to gather and flick balls into the waiting area.

We can raise/lower the harvester as required and we also have the capability of processing balls WITHOUT the harvester. Both of these functions are useful when the density of balls is lower because the long harvester arms can become more of a hindrance than an advantage as they can knock balls out of the robot’s path when turning.

Colour separation:

We started by experimenting with the colour sensors and software. The sensor measures the amounts of red, green and blue light reflected by an object. We gathered valuable data relating the actual colour of the ball and the amount of RG and B sensed as the distance from the sensor was varied. We used this data to write a program to identify which colour was which. We found that letting the ball drop onto the sensor gave us the distance and time needed to accurately identify the colour. So we placed the sensor just below the top of the ball elevator so that the balls would tip out and fall onto the sensor. We designed a tipping mechanism and wrote the software to send the balls left or right depending on their colour. We found that a ball could get stuck at the top of the elevator if there was no ball to push it out over the edge – so we used a rotating cable tie at the top to ‘kick’ each ball out. We also added cable ties at the bottom section for the similar reasons.

Ball storage and release:

We wanted balls to be released from the back of the robot straight into the chemical storage area.

The colour separation tipping mechanism was placed so that it sent balls into one of two cages left or right depending on the colour. Each cage can store 8 balls. The floor of the cages is made from wheels and is sloped so that balls will fall easily out of the cage when open. We designed ball release latches as the ‘doors’ of each cage – initially they swung left and right but we found that, at times, balls got stuck inside and wouldn’t come out – so we increased the size of the latches and changed the position of the servo motors so that the latches sat slightly inwards and swung outwards to open. We could then use this swinging action to encourage stubborn balls to come out.

We tried using netting to expand the number of balls we could store but we found that the balls got stuck in the netting and wouldn’t flow out. Ideally we would like to be able to store more balls.

**CODING:**

**Hi, I’m Eoghan. I’m just finished TY – for years I have been passionate about engineering and programming. I was accepted into the CTI program for DCU and over the last 8 years, I have attended many courses in DCU in my spare time and I was also a member of the Cansat 2017 team. This year I was part of the team that won the Irish Rail National App Competition. My main role on the team is SOFTWARE development.**

**Here is a diagram that explains how all the software and hardware components communicate with each other.**

**The code written by the user is sent to the control hub, the Amazon Fire takes the inputs from the game pad and relays it to the control hub, the control hub communicates with the expansion hub if needed and both control hub and expansion hub send and receive information to/from the colour sensors, Motors, Servo Motors.**

**When it came to programming we had two options – Java and Blockly**

**Blockly is more suited to beginners:**

**-Simplified Java.**

**-Drag and Drop like Scratch.**

**Java has more of a learning curve but has advantages.**

**-FASTER communication with tablet**

**-Better FLEXIBILITY for coding**

**-EASIER to use ultimately**

**-More MATHEMATICAL functions**

**Software Development date:**

**•Enabled WIRELESS programming (added external tools to Android studio)**

**•BASIC MOTION (FWD, REVERSE, TURN)**

**•Ability to turn Wheel intake ON/OFF to save energy**

**•Raise and Lower the CLAW/Harvester**

**•Ability to turn Harvestor intake ON/OFF –can’t have Harvester spinning when it is raised as it gets tangled in the claw elastics.**

**•Record no. of balls in each cage – so we know when a cage is full and can redirect balls**

**•COLOUR separation –**

* **Different colours, different cages**
* **All one colour in both cages**

**•Control Ball RELEASE levers**

* **Open only one cage**
* **Open both cages**

**We wrote software to map each operation carried out to a button or buttons on the gamepad. We wrote a couple of programs to allow for customized gamepads to suit individual players.**

**The FINAL days:**

**PRACTICE: We have built a basic replica of the game field to scale and our main focus now is on PRACTICE and TIMING – we want to make sure that each team member is capable of driving the robot proficiently and we want to perfect our driving and manipulation in order to be able to gather and deposit as many balls as possible in the 150 seconds. We also need to look at the timing for various functions – how long it takes to deposit blue balls/orange balls etc. This practice should highlight any other small changes we may need to make to improve timing and flexibility.**

**STRATEGIES:**

**From the start we have been keeping a close eye on what other countries are doing through communications from FIRST Global and also through Facebook. Initially the communication was mostly about design but now the teams are starting to talk about strategies. Some teams have limited the functionality of their robots and we feel that we will have an advantage over such teams because our robot is flexible enough to take on a variety of different roles depending upon the capabilities of it’s Allies. We will have one day to practice on our own in US**

**Outreach:**

**Since the main reason for this competition is the promotion of STEM, we decided that we would visit our local Primary schools and tell them about the competition and the underlying purpose behind it (using STEM for the greater good – in this case to provide clean water), demonstrate our robot and then let students take turns controlling the robot. We feel that it generated great interest amongst the students and, overall it was a great success. We demonstrated our robot to 100’s of attendees at the Coderdojo Projects event in the RDS. We have already featured in our local newspaper and will be doing an interview/demo on National TV in the coming weeks. We will also be presenting our project to the KWETB and to our local tech giant INTEL. In addition we plan to present to the junior classes in our school in September and may also travel around to other secondary schools to spread the word.**

**Learning so far:**

**•Team work**

**•Planning**

**•Agreeing roles by identifying strengths**

**•Teamwork with the other participating teams via facebook, FIRST**

**• Other**

**•Learning through doing – trial and error**

**•Learn from others experiences**

**•Learn through discussion as a team**

**•Be flexible – willing to adapt/improve on weaknesses**

**•Refuse to give up – there is ALWAYS a way!**

**We travel to the US on Friday where we will have a day before the competition starts to practice with our Robot and Communicate with other teams.**

**We would like to thank Peter for selecting us, our school for providing help and support throughout the last two months and, especially, on behalf of ourselves and our school, we would like to express our huge gratitude to YVolution for providing us with sponsorship and therefore the fantastic opportunity to represent our country in this extremely important event.**

**We REALLY hope we will do everyone, including our country, proud.**