Mixed Reality and Robotic Engineering Design Processes

NOVA #20785X

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Word count: 1000. (Excluding title page, citations, credits and all picture captions)

STEM Career: Mixed Reality Engineer

Mixed Reality engineers combine the physical and digital world to create an environment where we can interact with both virtual and real objects seamlessly. Upon learning about what Mixed Reality Engineers do, our team were enamoured by the augmented reality that emulated the likes of Tony Stark's technological wizardry that we only thought existed in movies. Hence, we decided to investigate this cutting edge segment of the engineering industry further.

To understand what a MR Engineer does, our school visited an engineering showcase called “Advanced Engineering” where we visited a stalls to see first hand the devices and software produced by these engineers.

Whilst speaking to the engineers regarding the MR headsets they were demonstrating, we described what we did whilst developing and building our robot, and we all drew the same conclusion: the process followed by both is the same.

The design process used by us both will be discussed further in our report.

Use of The Engineering Design Process

A MR Engineer creates devices and software that enables us to move beyond screens and creates a new reality mixing both real world and computer-generated elements. Holographic Processing Unit -> computer vision, machine learning, human computer interaction, and more is used to allow the user to immerse themselves into another reality to complete a task.

Both the engineers and our team use the same universal Engineering Design Process as detailed in Figure 1.

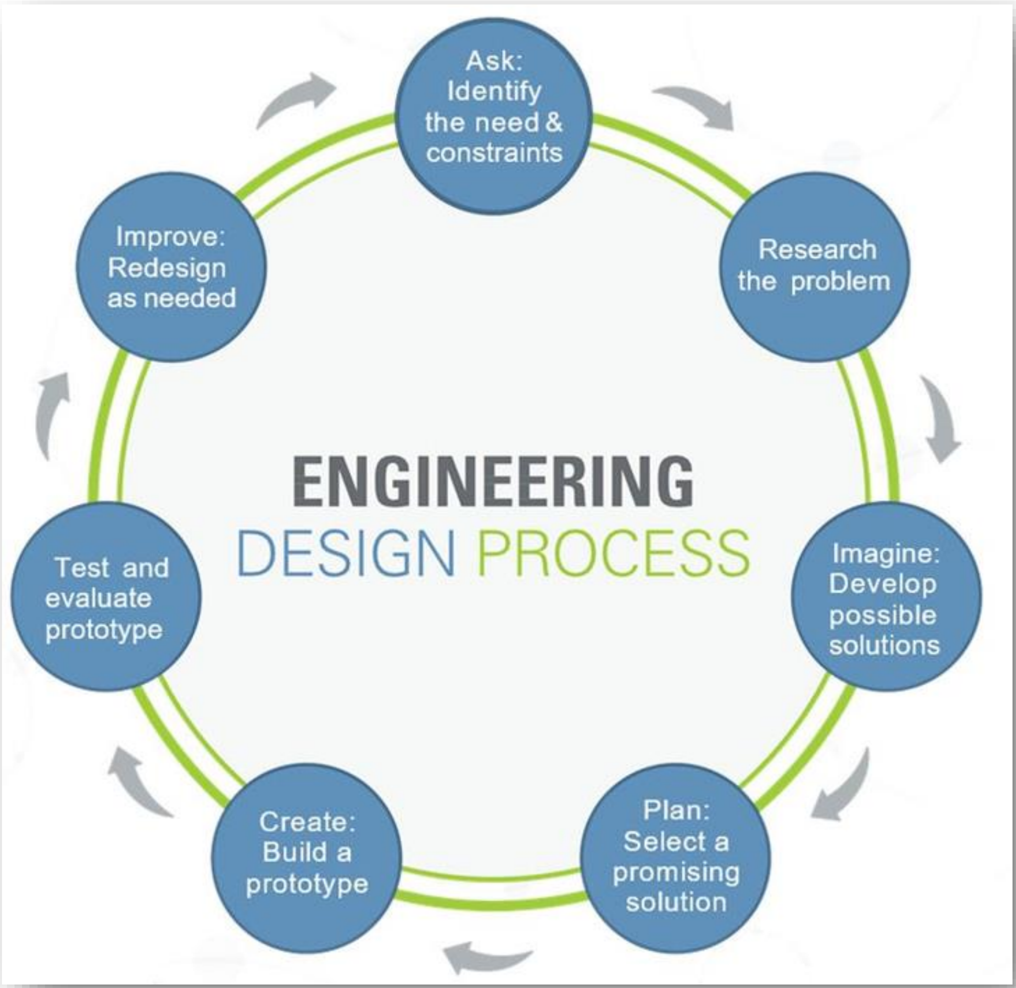


Figure 1. Universal Engineering Design Process

Implementation of the Engineering Design Process

Identify the Problem and its Constraints

For us both, the objectives will need to be identified and defined clearly so the resultant product fulfils the needs it is created for. The headset should be durable and comfortable to wear for long periods of time, should be able to display the virtual and real realities with no glitches and be responsive to the user. Our robot will need to be able to successfully score triballs, manoeuvre around the field with ease and be sturdy enough to withstand collisions.

Both the headset and robot would need to adhere to the correct specifications and rules and regulations so the products produced are safe.

Researching the Problem and Developing Potential Solutions

For this stage, the MR Engineer would need to gather anthropometric data regarding head sizes to ensure the design is inclusive for the vast majority of the population. The dimensions for the internal components would be needed ensure they are easily encased within the headset, taking care to ensure the comfort of the wearer is not compromised.

Likewise, our team gathered data on common structures used for the foundations and supports of large buildings which inspired the utilisation of triangular bracing via standoffs for our robot. Once details have been collected, brainstorming will commence in the form of sketches so ideas can be visualised and portrayed to all.

Figure 2 illustrates some designs of mixed reality headsets and Figure 3 displays those for our robot and our notebook where we developed our ideas into a competition ready robot.

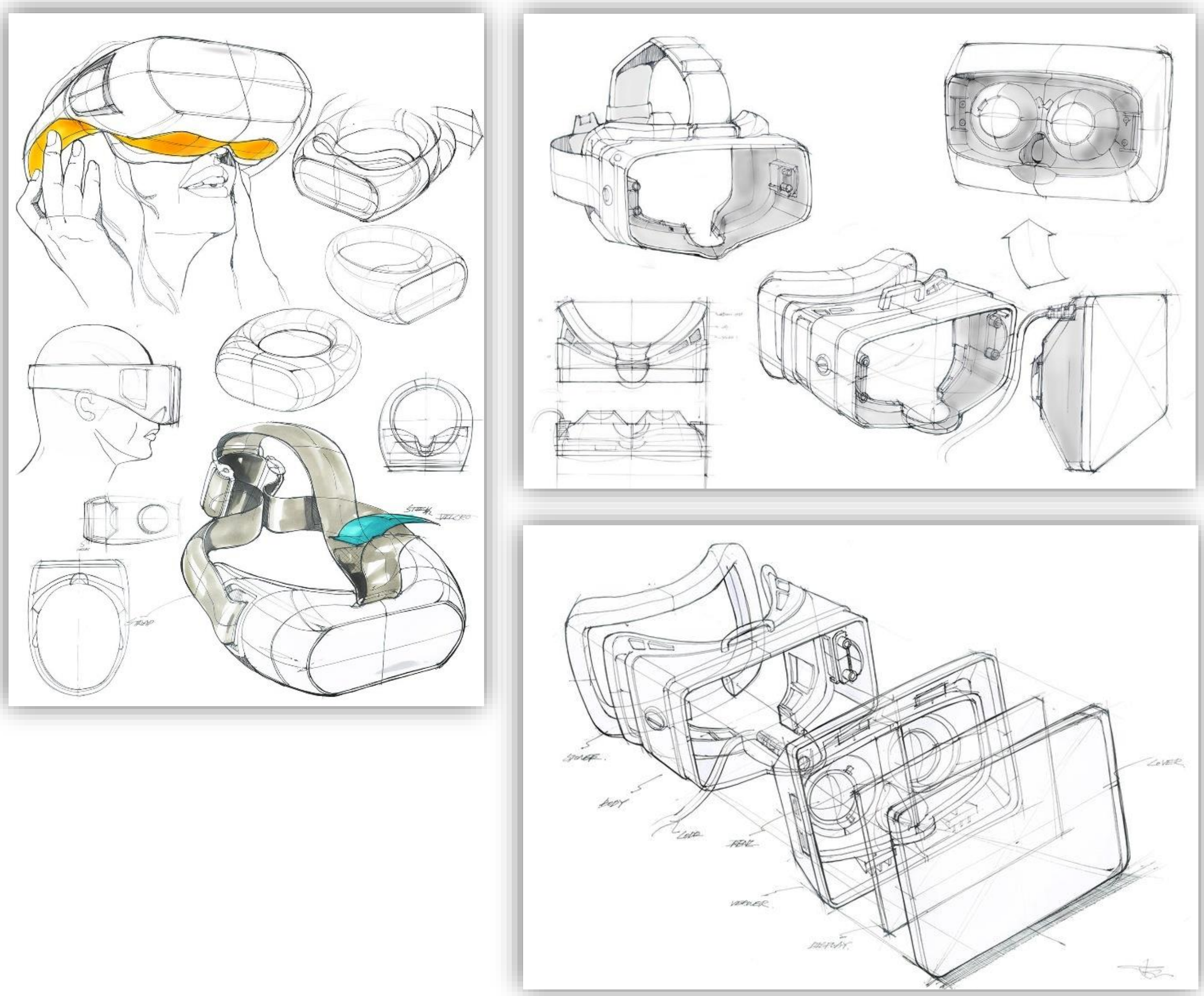
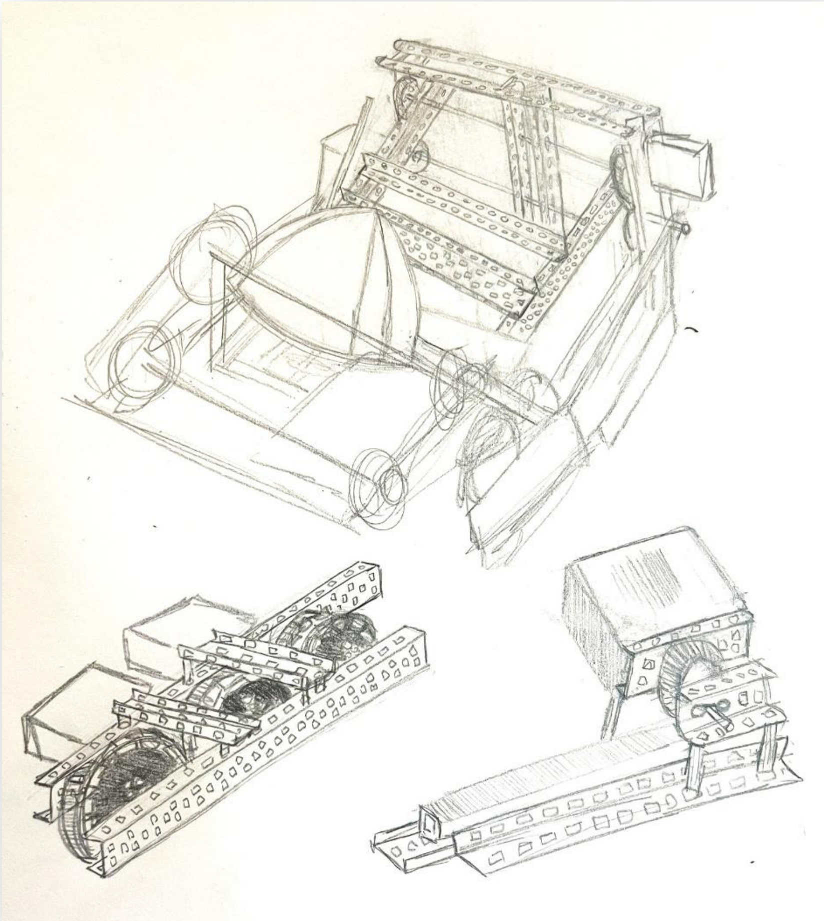
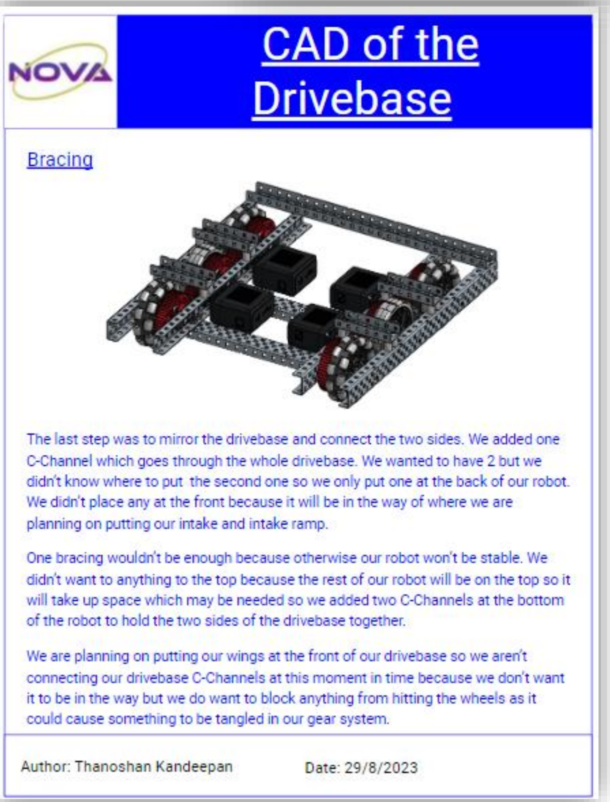


Figure 2. Sketches of headsets





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CAD of the Drivebase

Bracing

The last step was to mirror the drivebase and connect the two sides. We added one C-Channel which goes through the whole drivebase. We wanted to have 2 but we didn't know where to put the second one so we only put one at the back of our robot. We didn't place any at the front because it will be in the way of where we are planning on putting our intake and intake ramp.

One bracing wouldn't be enough because otherwise our robot won't be stable. We didn't want to anything to the top because the rest of our robot will be on the top so it will take up space which may be needed so we added two C-Channels at the bottom of the robot to hold the two sides of the drivebase together.

We are planning on putting our wings at the front of our drivebase so we aren't connecting our drivebase C-Channels at this moment in time because we don't want it to be in the way but we do want to block anything from hitting the wheels as it could cause something to be tangled in our gear system.

Author: Thanoshan Kandeepan   Date: 29/8/2023

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Step 2 Brainstorm

To lift our locking mechanism we are planning on using a 4 bar lift like so:

When the 36 tooth gear is spun clockwise the 72 tooth gear spin anti-clockwise. This means that the horizontal c channels also spin anti-clockwise as they are connected to the 72 tooth gears. This means that the vertical c channel goes higher.

We are using a torque ratio as using mechanical advantage puts less strain on the motor and means it has to do less work but it will be slower so during a match we would have to distribute our time properly so that we have enough time to hang but we don't waste time in which we can score triballs hanging.

We will have to use a 100 rpm cartridge for our endgame because if we use a 200 rpm or 600 rpm cartridge then there is a risk of the motor burning out which could lose us points in a match but is also expensive to replace.

Author: Hasnain Jiwa   Date: 24/7/2023

Figure 3. Sketches and development of robot

Select a Promising Solution and Create a Prototype

After a viable design is chosen, the engineer uses CAD to accurate model the headset which can then be tested virtually. For our robot, we use OnShape to use the VEX parts for our robot to ensure our design will be feasible when build physically. Figure 4 and Figure 5 show the CADs.

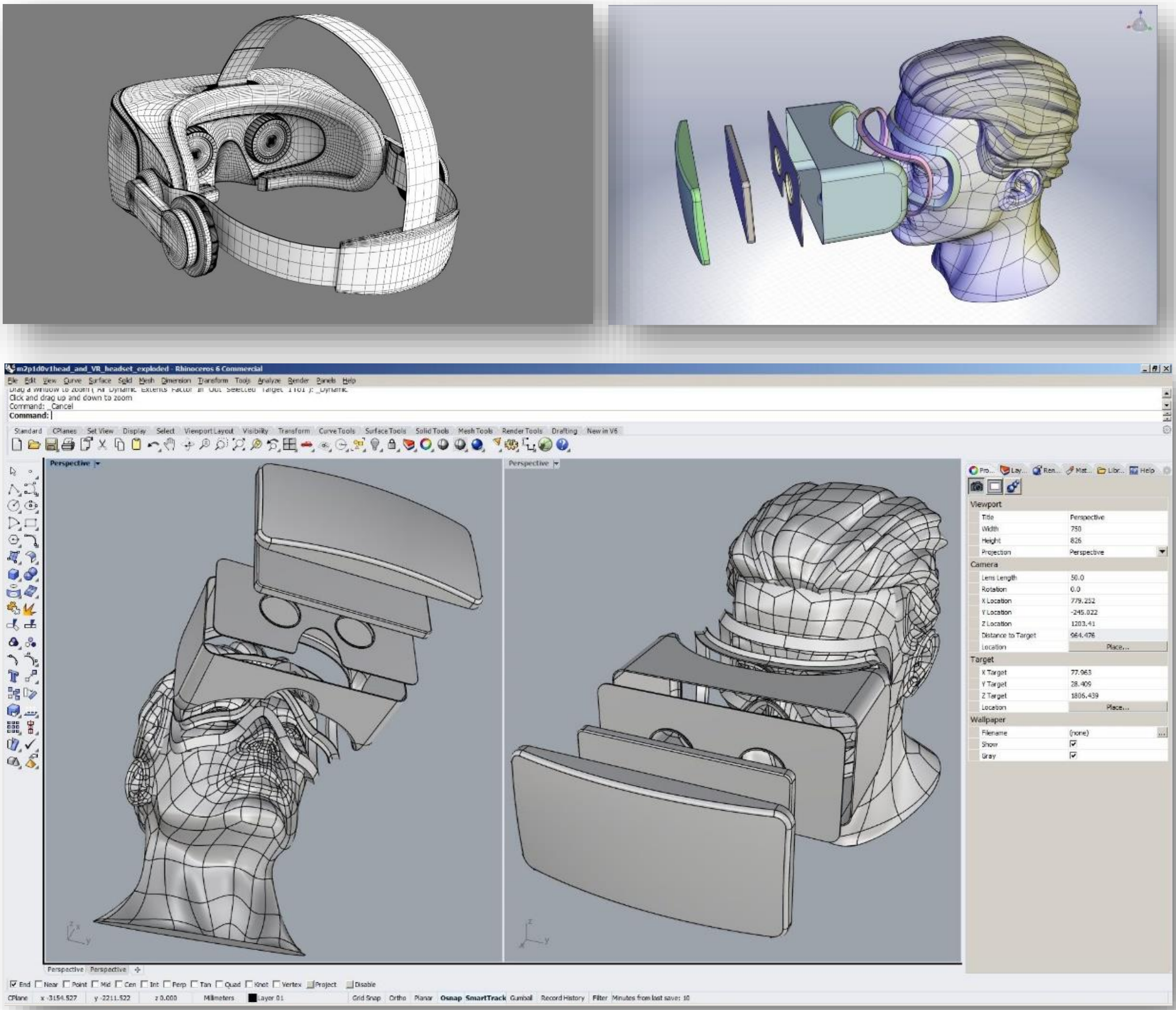
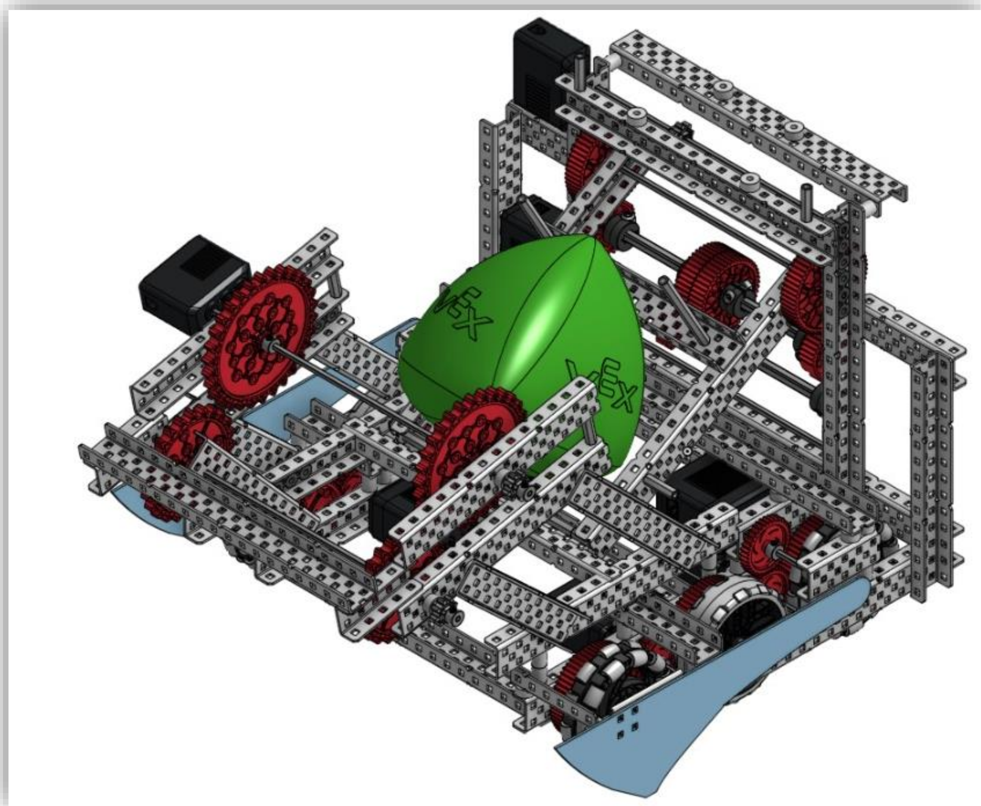


Figure 4. CAD prototypes for headset



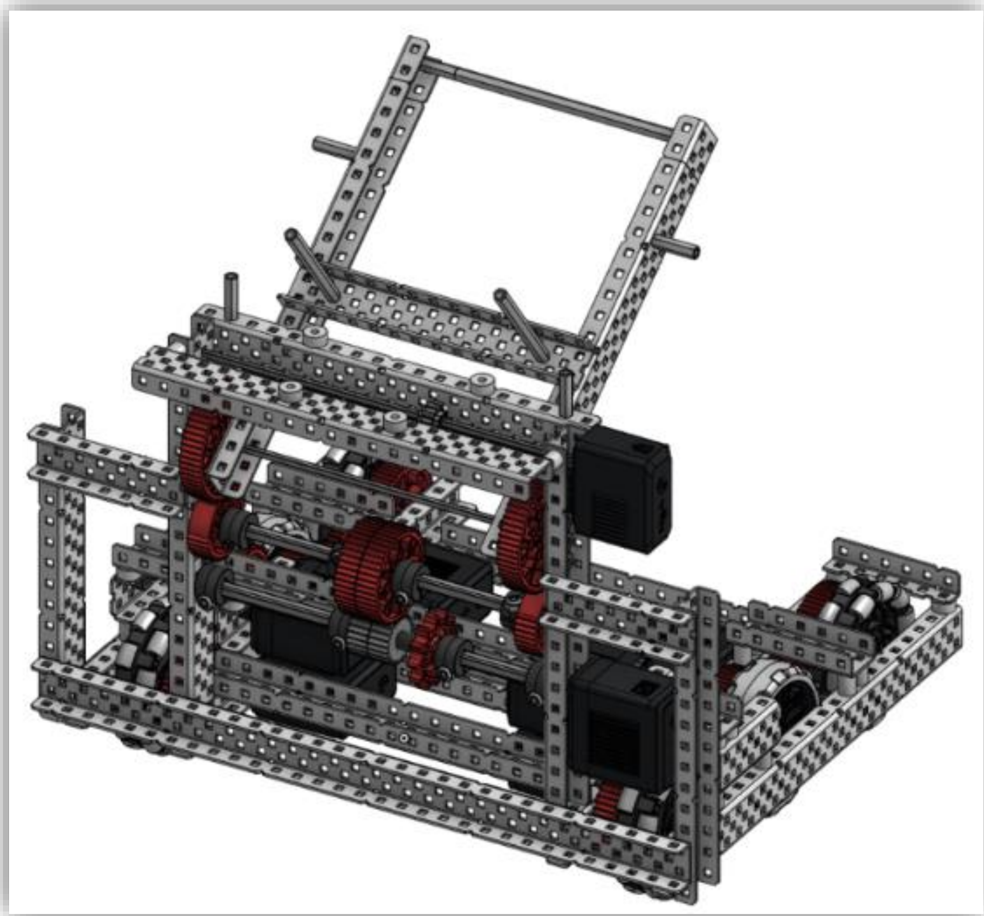


Figure 5. CAD prototypes for our bot

Test and Evaluate

Figures 6 and 7 show the real prototypes created by the engineers and ourselves. The headset is tested for comfort, durability and its ability to allow the wearer to experience the mix reality environment successfully in a fully immersed manner. Our robot is stress tested to ensure it functions as required.

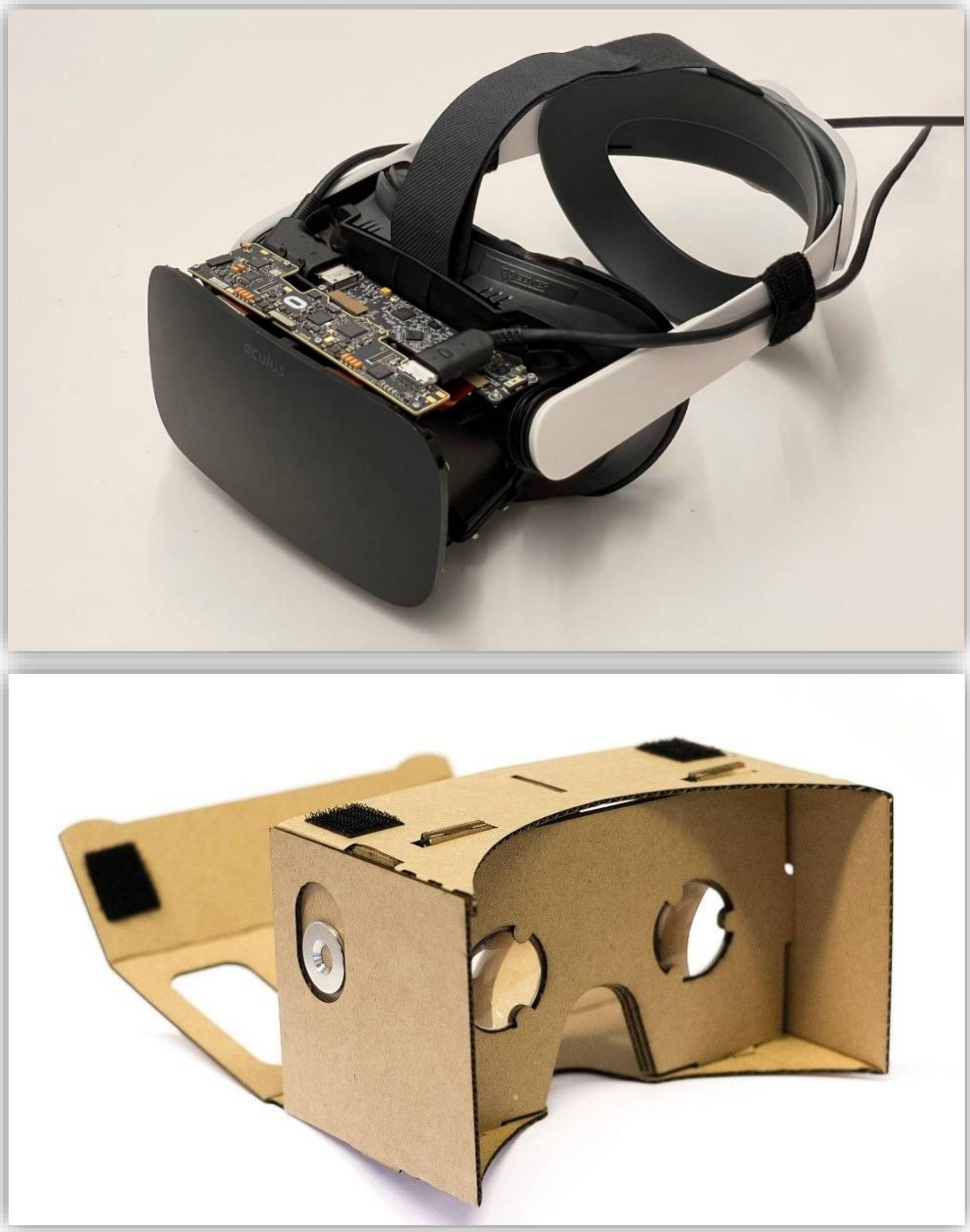


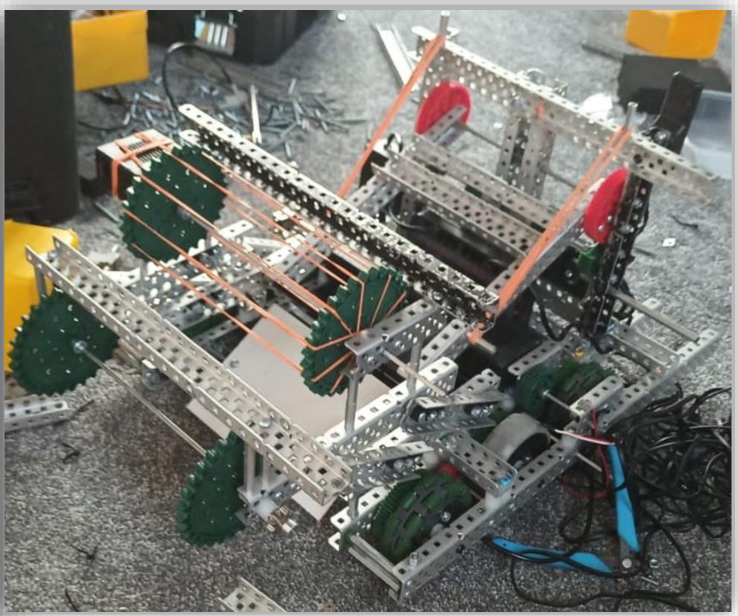
Figure 6. Testing model headsets

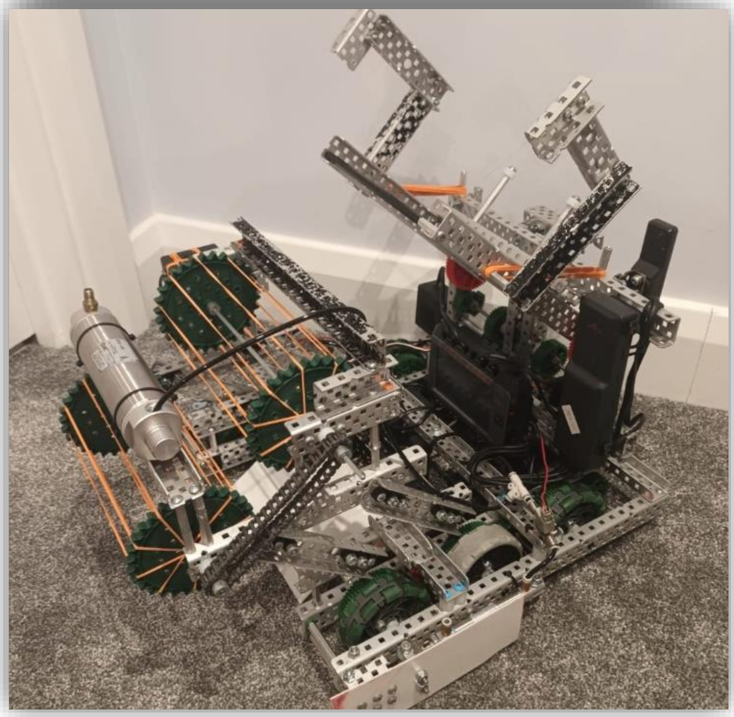
Testing the Drivebase

We ran the motor and it took 2.3W to power the motor for it to spin the 36 tooth gear and the wheels. This told us that there was a force acting against the motor. Because the drivebase isn't on the ground, we realised that there is a lot of friction in the drivebase.

We knew that there was friction in the drivebase so we knew that there was friction either in the wheel, the 36 tooth gear or both. To test this theory we removed the wheels. When we ran the motor, it took 1.2W to spin just an axle and gear. This didn't make sense to us as we didn't know how there could be this much friction by spinning just a gear. We brainstormed on possible reasons why there was so much friction. The reason that we came up with that made most sense was that the axle wasn't perpendicular to the c-channels rather it was bending because the C-Channels weren't parallel.

Author: Ahsan Rahman Date: 4/9/2023



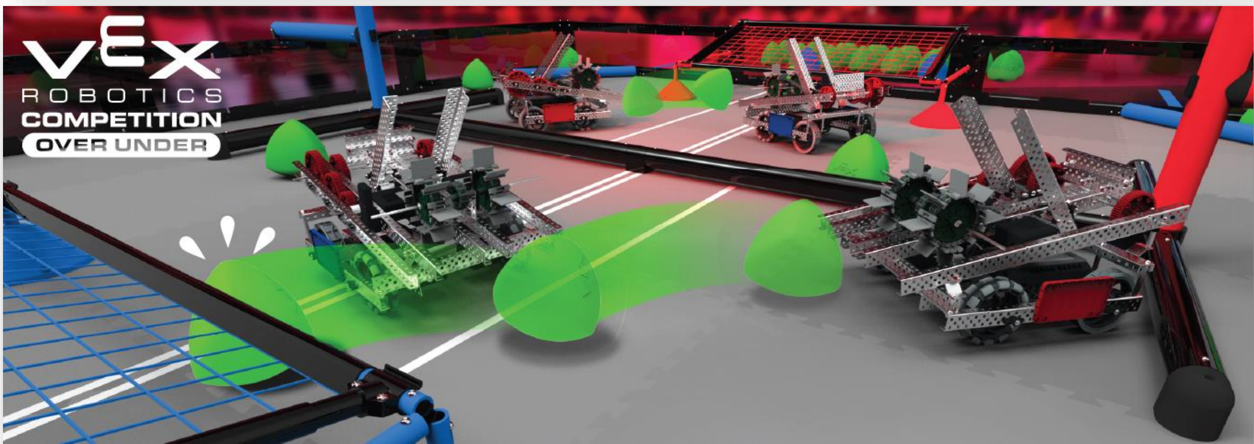


```
# Cata + Intake using L1, R1, R2
if controller_1.buttonL1.pressing():
    Cata11W.spin_for(FORWARD, 540, DEGREES)
    Cata55W.spin_for(FORWARD, 1080, DEGREES)

if controller_1.buttonR1.pressing():
    Intake.spin(FORWARD)

if controller_1.buttonR2.pressing():
    Intake.stop()

#Using buttons A, B, Y, X
if controller_1.buttonA.pressing():
    Cata11W.spin(FORWARD)
    Cata55W.spin(FORWARD)

if controller_1.buttonB.pressing():
    Intake.spin_for(REVERSE, 100, DEGREES)

if controller_1.buttonY.pressing():
    Cata11W.spin(FORWARD)
    Cata55W.spin(FORWARD)

if controller_1.buttonX.pressing():
    Cata11W.stop()
    Cata55W.stop()
```

Figure 7. Testing our bot

Improve if needed

After vigorous testing and gathering feedback from all involved, changes can be made if needed, or the design can go to the final stage. The final stage for the engineer would be to take the product to market and sell it. For our team, the final stage would be to take our robot to competitions and win. As the engineering design process is iterative, if improvements are needed, the cycle can be restarted to as many times as needed to ensure the best product is produced. For the robot, we've had to rebuild where our design hasn't preformed well in competitions and weaknesses have arisen. With the headset, usability issues could be discovered that would need the design amended.



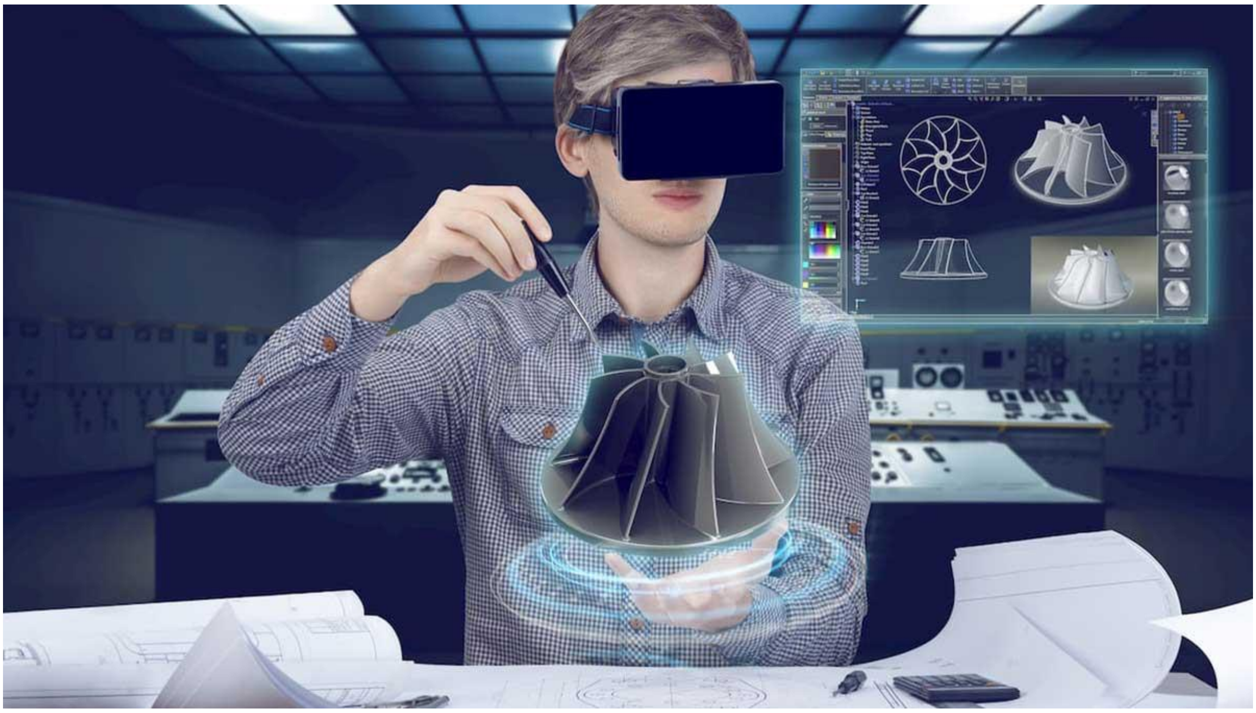
Future Careers

How our VEX experience will aid our future careers

By combining our technical knowledge with softer skills like leadership and communication under pressure as found in a professional environment, we feel that we are very strongly equipped to excel in any engineering firm in the future. With our knowledge about the engineering design process, it would be a natural step for us to aim for a career in this industry. After seeing engineers at work, this is a career that appeals to us. We have proven we can excel as engineers and these skills are portable to a whole range of other careers within STEM.

To expand on this career, we could use the headset to aid in other areas. This technology could be medical applications for example, where we could train on virtual operating tables and perform operations remotely, anywhere in the world. Another use could be within education, these headsets could be used by teachers and pupils to create virtual classrooms and a 3D learning environment that provides minimal disruption to learning in case of further lockdowns occurring.

VEX enabled us to develop teamwork and time management while also improving our individual understanding of various engineering concepts like load distribution, mass topology and the relationship between torque, power and angular velocities. We have learnt to use our time efficiently and effectively to achieve phenomenal results in short periods of time, both individually and as a team. These skills all help to ensure that we will achieve great things in our professional lives and make a difference to the world.



Citations

A list of resources we used when compiling this report

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https://beyondmath.com/

https://www.red-scientific.co.uk/

https://www.luminousgroup.co.uk/

https://www.unrealengine.com/en-US/blog/mindesk-brings-real-time-rendering-to-vr-cad-modeling-with-unreal-engine

https://www.uploadvr.com/project-cambria-cad-schematics-leak/

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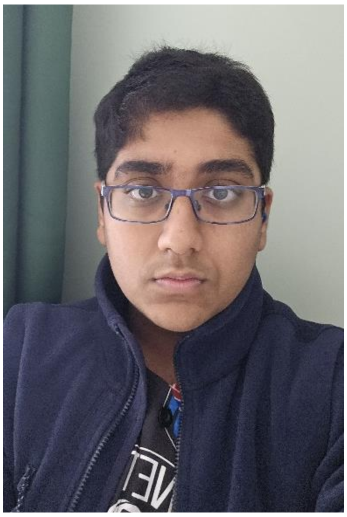
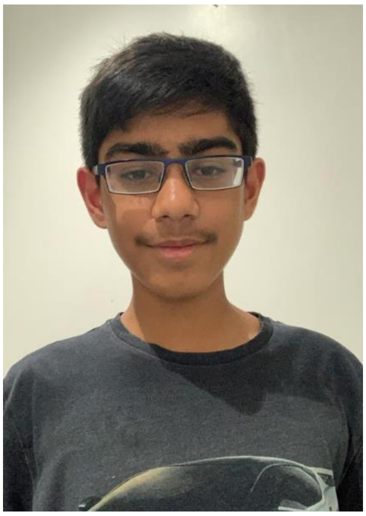
Credits



Ahsan is a builder and also fulfils the role of team admin. This includes the design board, uniform for the team and scheduling such as Gantt charts to ensure the team are sticking to their time boundaries to excel at each and every competition.

Hasnain is the team leader and a designer. As team leader I am responsible for ordering parts, managing our funds, going to meetings with teachers and other admin based work. I create the robot CAD for the robot that is used by the build team.



Jaydon's main role in the team is to drive the robot and lead the team to success in the competition. As part of his role as driver, he is able to rectify issues with the robot based on its performance and feedback to the rest of the team

Paarth is a programmer and plays a crucial role in programming the robot. He is responsible for writing and debugging code to control the robot's movements, actions, and responses to various sensors and inputs.

Thanoshan focuses on doing notebook. He see's it as a diary of how our team is doing and believes it is an amazing way to make sure the are on track with what they are doing as well as learning how to develop our bot and team.

Tuhin works on the online challenges. As an online challenger, he develops key skills that are transferable for future activities within the team that help us achieve well in competitions.

Wilson is the strategist of the team and he works closely with many other members of the team, to develop optimized game plans, produce ideas for mechanisms discussing with alliance partners on how to perfect our strategy.