Social Robotics

Exercising with Drones

Social robotics for Autism Therapy

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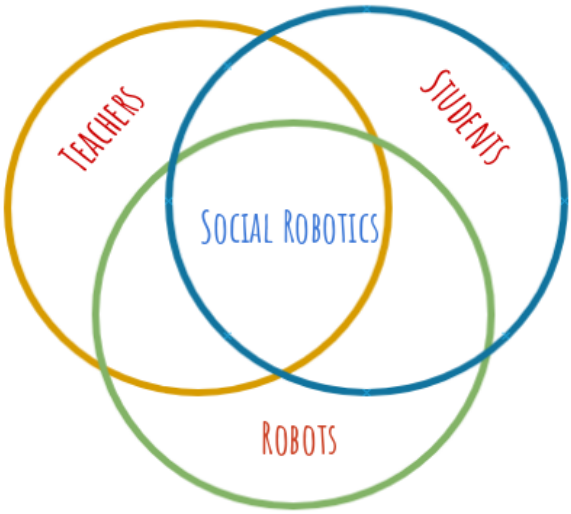
Abstract

Most autistic children have prevalent problems during gross motor development. Children with deficient gross motor skills predominantly tend to develop Developmental Coordination Disorder (DCD). Panacea for DCD is to conduct physical and occupational therapy sessions for students. Autism educators encounter numerous challenges while conducting these therapy sessions. It is physically and mentally taxing for the instructors to conduct therapy sessions. Also, most autistic students hesitate to participate in therapy due to lack of motivation. Hence these therapy sessions are not found to be sufficiently effective.

Social robotics is a field of robotics where robots are programmed to aid teachers in day to day teaching. Robots are enabled to interact with students and help them learn better. Drones, as a part of social robotics, were deployed for the first time in autism therapy sessions. The aim was to evaluate the benefits of using Drones as an interacting tool between the teachers and students for the betterment of these therapy sessions. A pre-post study was conducted to observe how Drones can help overcome the challenges faced by teachers to conduct these sessions effectively. The results of this study show that the Drone inclusive therapy sessions have proved to demonstrate significant benefits to the focused students who participated in this intervention with Drones.



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1 Gross motor skills (GMS)

1.1 What are Gross motor skills and why we need them?

Gross Motor Skills (GMS):
Skills those which require whole body movement and which involve the large (core stabilising) muscles of the body to perform everyday functions, such as standing and walking, running and jumping, and sitting upright at the table. They also includes eye-hand coordination skills such as ball skills (throwing, catching, kicking) as well as riding a bike or a scooter and swimming.

Importance of Gross motor skills:
Gross motor abilities also have an influence on other everyday functions. For example, a child's ability to maintain appropriate table top posture (upper body support) will affect their ability to participate in fine motor skills (e.g. writing, drawing and cutting) and sitting upright to attend to class instruction, which then impacts on their academic learning. Gross motor skills impact on your endurance to cope with a full day of school (sitting upright at a desk, moving between classrooms, carrying your heavy school bag). It also impacts your ability to navigate your environment (e.g. walking around classroom items such as a desk, up a sloped playground hill or to get on and off a moving escalator). Without fair gross motor skills, a child will struggle with many day to day tasks such as a eating, packing away their toys, and getting onto and off the toilet or potty.(for further read)

1.2 What is GMSD? How is it critical for autistic kids?

Gross Motor Skills Deficiency (GMSD):
It is observed when a child is not rolling, crawling, walking, or doing other gross motor activities when the child is at the right age to do those things.

GMSD observed in Autistic kids:
Studies have shown autistic children usually have varying degrees of difficulty with fine and gross motor skills.These are difficulties are believed to exist due to the neurological differences in autistic children and their challenges with sensory processing. Children with ASD would show motor delays in overall gross motor development and locomotion when compared to their age matched typically developing children.

Prevalent problems observed with autistic kids:
Autistic kids with GMSD are observed with low energy levels, poor posture control, seem tired or lethargic and take longer to respond to stimuli around them. On the longer run, they tend to develop a condition called Developmental Coordination Disorder (DCD). DCD is a disorder that's defined as an impairment in the learning of coordination and motor skills. The challenges of DCD impact many aspects of life. [1]

Therapy for GMSD:
Early intervention with Physical and Occupational therapy is the primary treatment for GMSD. These therapy sessions involve a set of exercises and physical activities on a daily basis.

(For further read [1], [2])

2 Interaction with ASHA

ASHA

2.1 ASHA - Academy for Severe Handicaps and Autism

Established in 1995, Academy for Severe Handicaps and Autism is an institution that provides education along with a comprehensive set of therapies to individuals with autism spectrum disorders. ASHA is one of the leading Autism schools in India with over two decades of experience,they have evolved and developed capabilities and expertise to address the different needs of over 500 individuals and their families. ASHA is known for assigning a teacher for every two students at the organization.

2.2 Therapy available at ASHA

ASHA has a certified occupational therapist as well as a physiotherapist who assess, design programs, work with the child and guide the parents on improving the functioning ability of the child. The school conducts regular Gross Motor sessions for the children as a part of occupational and physical therapy. The students are made to perform a certain set of exercises thrice a week and physical training sessions (games period) thrice a week.

2.3 Challenges while conducting therapy sessions

Students with low compliance are unable to follow a given instruction by the teacher. Teachers tend to physically help the students perform these exercises. Despite assigning one teacher for every two students, it is still arduous for the teacher to complete a single therapy session. The physical and mental efforts put in by the teachers during therapy sessions are exhausting.

Students are often seen to be disinterested to perform any physical task. They lack imitation skills to even follow the teacher performing the exercises. Hence, teachers find it highly challenging to motivate students to perform any given physical task.

Students lack focus and often lose eye contact with the teacher during therapy sessions. They often get diverted during sessions, due to which they fail to complete a cycle of an exercise. Because of this diverted attention, the efforts of the students to perform exercises turn out to be futile and ineffective.

Students find it challenging to even sit or stand on command. Teachers have to verbally prompt commands several times to spawn a reaction from the student. Often, teachers themselves end up physically aiding the students in order to motivate them to perform better.

Students are often found to be lethargic and disinterested during therapy sessions. While performing therapy, they often get easily fatigued. Due to lack of stamina, they fail to complete a cycle of exercises.

3 Social robotics for Autism therapy

3.1 What is "Social Robotics"?

Social robotics is a field of artificial intelligence where Human-Robot interactions are designed to achieve positive outcomes in diverse applications such as education and health.

How is "Social Robotics" interesting for Autism?

An autism educator has to find innovative ways to motivate the students to perform day to day tasks. Social Robotics can succeed in mitigating the challenges and constraints faced by the teacher (as discussed in section 2.3) In this regard, a pilot study was conducted to understand how Drones can be deployed as a stimuli for autistic students to engage in physical activities. (Refer B for details)

Engaging Drones for therapy

Mini Drones:
Mini Drones are relatively safer they weigh about 100g and have a dimension of about 100mm x 100mm x 50mm (Average figures). These Drones are less likely to cause any untoward incidents or accidents. Propellers are made of soft plastic which are not corrosive and just causes a mild prick if our skin makes contact while propelling. Also they are manufactured and tested to be sturdy enough to take minor head on collisions with obstacles.(Refer A)

Such an experiment of deploying Drones for autism intervention or use Drones as a tool to aid in therapy is first of its nature.

Mini and Nano Drones are essentially toys which often spawn interest and curiosity among kids. As a part of **Social Robotics**, these mini Drones could be programmed to aid teachers in conducting therapy sessions for the students. Having said this, the following questions are posited.

1. **Can Drones spawn some interest among autistic students with GMSD?**
2. **Can Drones reduce the physical and mental efforts of the teacher conducting therapy?**
3. **Could Drones be effective and efficient in helping teachers to conduct therapy?**

3.2 Result of Engaging Drones for therapy

There were a few exercises which were a part of regular therapy sessions and were fairly challenging for the teachers to conduct them. With this as the objective, we chose four elementary exercises (refer C) and included it as a part of the Drone therapy sessions.

There were a total of seven students who participated for the Drone therapy sessions (Refer C.3.2). The following are the success stories of three students namely Student1, Student2 and Student3. Amongst other participants, these three students showed significant progress during this small scale study. Each of the success stories indicates that Drone therapy sessions show better positive results compared to regular gross motor classes, which weren't as efficient, for these students.

Success Stories

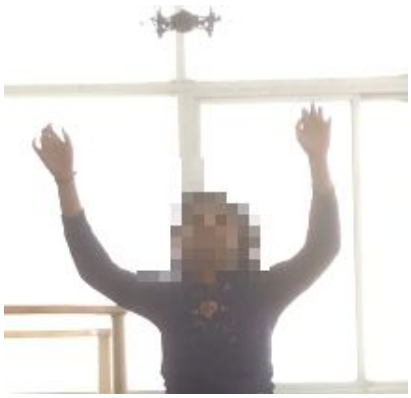
I) Student1 - Exercise became fun with Drones

Diagnosis: Student1 is diagnosed with ADHD and MR (for further read). He is a cognitively bright student but has behavioral issues.
Regular GMS sessions: Student1 displays reluctance and disinterest to participate, and he prefers to be in isolation during these sessions.
Drone sessions - Student1 is a tech savvy student who is naturally drawn towards any electronic gadgets and hence was easily motivated to engage himself in gross motor session with Drones.

II) Student2 - Started to sprint because of the Drone

Diagnosis: Student2 is diagnosed with Autism with ADHD (for further read).
Regular GMS sessions: He is found to under-perform regularly because of his lack of focus and his physical developmental delay,due to this he maintains a clumsy posture and has difficulties sprinting.
Drone sessions - Student2 found the Drone to be a great stimuli and he often enjoyed performing exercises during Drone sessions. He used to attempt to chase the Drone, thus helping him to sprint on his own.

III) Student3 - The girl who lifts her neck to see the Drone



Diagnosis: Student3 is diagnosed with Autism Spectrum Disorder. (for further read).
Regular GMS sessions:
She has poor posture control and is often found slouching. Due to her low stimuli and compliance levels, it requires great effort and time for the teachers to make her perform gross motor exercises.
Drone sessions - Student3 finds the Drone to be a stimuli and performs these exercises with great joy as she is fond of the down wash of the propellers below the Drone (similar to standing under a fan). Hence she automatically moves her neck around (Physio therapy) gazing at the Drone.

3.3 Conclusion and Future work

Drone Tech:

Usage of Drones for autism intervention has been attempted for the first time in this study. Drones were never used as a tool to aid therapy sessions. Moreover since these Drones are programmed to function autonomously, there is no dependency of a pilot to be present during these therapy sessions.

Small scale study

Since there was no relevant literature available, a 'pre and post study' was conducted to design the overall structure for Drone therapy sessions. (refer B)
The overall engagement of all the students responding to the Drones were pretty insightful. But for a focused study, we narrowed down to seven students.
The elementary exercises which were included as a part of the Drone therapy sessions were to answer three key questions. The success stories addresses these questions constructively as follows.

1. Can Drones spawn some interest among autistic students with GMSD?
Yes, in fact all the seven students selected for this small scale study were motivated to perform exercises; the reason being that the Drone was a great reinforcer and a successful stimuli.

2. Can Drones reduce the physical and mental efforts of the teacher conducting therapy?
If we observe the case of Student3, the teachers used to spend exhaustive efforts to make the child perform exercises for the therapy. But during the therapy session with Drones it was observed that Student3 was able to mimic the Drone's actuation or movements. The teacher had to only monitor and issue verbal prompts for her to perform these exercises.

3. Could Drones be effective and efficient in helping teachers to conduct therapy?
Each of the three students, part of the success stories, was benefited individually. Student1 found the therapy session with Drones to be fun and hence used to look forward to attend them. Student2 is student diagnosed with developmental delay and hence used to find difficulties in sprinting. He was found to attempt sprinting while he attended therapy session with Drones. Also the Drone was a successful positive reinforcer for him to look forward to therapy sessions. Student3 has a significantly bad neck posture where she is often found slouching or gazing towards the ground at most times. She is instructed to perform physiotherapy regularly which is critical for her overall posture. The teacher's efforts to conduct her physiotherapy is futile. But during Drone sessions Student3 was found to gaze up to the Drone and effortlessly perform the physiotherapy exercises.

Future Work

This small scale study provides assurance to conduct a larger scale study with more focused students and increased number of Drone therapy sessions to present better results. The current design and structure of Drone therapy session are easily replicable. If the design of Drone therapy sessions could be personalised by trying to address each individual student's disability, it can definitely be proven to be more effective. We could also improve and explore additional autonomous capabilities of mini and nano Drones.

A Drone Technology

DJI tello

A.1 Mini and Nano category Drones

Mini Drone used for the therapy session:

- DJI Tello (1) and Parrot Mambo (2) were used for the pilot study and therapy sessions
- The actuation of the Drones were coded using the developer APIs available as a part of the SDK.
- These predefined actuations are sent via a WiFi base-station (Laptop)

They are safe:

- They weigh about 100g and have a dimension of about 100mm x 100mm x 50mm (Average figures)
- Mini and nano category Drones are relatively safer for indoor setting applications. It is less likely to be prone to any untoward incidents or accidents.
- Propellers are made of soft plastic which are not corrosive and just cause a mild prick if our skin makes any contact while propelling.

Scalable and reliable:

- Mini and nano developer Drones are commercially available in the market priced around ₹ 10,000 a piece.
- With developer APIs available on commercial Drones it is easily portable on various platforms.
- Precision is available in autonomous maneuvering capabilities.
- Drones are manufactured and tested to be sturdy enough to take minor head on collisions with obstacles.

Application:

- Mini or nano Drones have been used for various indoor applications like warehouse monitoring and surveillance.
- Mini or nano Drones were never used as a tool to aid in therapy sessions. (Autonomously)

B Pilot study

B.1 Testing waters

Spelling bee with Drones: A pilot experiment was setup where pictures of alphabets were scattered on the ground. Given a word to spell, the Drone would fly over the alphabets and hover over each alphabet in that word. The children were instructed to move over to the alphabets by simply following the drone. This was assumed to benefit the children to learn spellings and do some physical activity while they are at it.
This experiment was found to be a little too complex for the children to follow and perform . Hence the structure and design of the Drone therapy sessions had to be modified.

B.2 Understanding reactions and behavior of autistic kids around drone

Given that students may not be aware Drone technology, it was vital to understand on how the autistic students interpreted this technology. So another pilot study was conducted to observe the children's reactions to the Drone flying. 55 students participated in this study. The reactions and observations of all these students were recorded.

Follow the drone task: The students were simply instructed to follow the drone as it flies around. This helped in understanding the varied reactions and responses of each student.

Student Reactions	Excited and happy	Mixed or diverted	Afraid of the drone	Unresponsive
Number of students	23	18	6	8

With this study it was understood that Drones were helpful in stimulating a response and could be a motivational tool for students to engage in physical activities. Students were observed to constantly gaze at the drone while it flies which would aid in improving their focus and concentration levels.

B.3 Design of GMSD therapy with Drones

After several iterations and pilot experiments with the Drones, it was understood that while engaging Drones for therapy sessions it must be implemented with the following facets

- Utmost safety : The experimental setup should be designed to eliminate occurrences of any untoward incidents involving students or teachers.
- Structured teaching : The Drone therapy sessions must be part of a daily routine and must be conducted in a disciplined manner.
- Complexity: The experiment should be setup with minimal complexity to help teachers and students participate easily in these therapy sessions.

C Therapy session with Drones

C.1 Final structure: List of exercises and instructions

There were four exercises chosen as a part of Drone therapy sessions. These chosen exercises were already a part of regular occupational therapy.

The following are the list of exercises with description of each exercise and instructions for how it should be conducted.
Exercise 1:(Hands up/Hands down)

- In this exercise the drone changes its altitude (Height) from roughly 1.5 meter to 3 meters off the ground. The children are instructed to raise the hands up and down accordingly. This exercise is done in two rounds, eight counts each round. (Eight times hands up and Eight times hands down in total)
- The students are instructed to perform these exercises by standing in one particular spot. (There are visual markings on the ground to indicate this position). This is to ensure the students do not walk towards the drone in order to hinder or cause damage to the drone while flying.
- The teacher instructs the students to raise their hands up when the Drone increases its height and hands down when the Drone decreases its height.

Exercise 2:(Left/Right arm raise)

- In this exercise the drone moves sideways and the students are instructed to stretch their left and right hands accordingly.
- The students are instructed to perform these exercises by standing in one particular spot. (There are visual markings on the ground to indicate this position). This is to ensure the students do not walk towards the drone in order to hinder or cause damage to the drone while flying.
- The exercise is mapped to each of the drone's actuations for a count of eight for each side.
  1. The drone initially flies in the center or at neutral position (students keep their hands at rest)
  2. The drone moves 1.5 Meters to the right (The students stretch only their right hands)
  3. Back to neutral position (Hands are brought back to rest)
  4. The drone moves 1.5 Meters to the left (The students stretch only their left hands)
  5. Back to neutral position (Hands are brought back to rest)

Exercise 3:(Sit/Stand task)

- In this exercise the drone takes off and lands from a particular spot and the students sit and stand accordingly.
- The student are instructed to perform these exercises by standing in one particular spot. (There are visual markings on the ground to indicate this position). This is to ensure the students do not walk towards the drone in order to hinder or cause damage to the drone while flying.
- In this exercise the students are instructed to stand up when the drone takes off or is off the ground, and they sit when the drone lands on the ground.
- This exercise is performed for a single round with a count of eight. Thus they sit and stand four times each.

Exercise 4:(Follow the drone)

- In this exercise, the Drone follows a rectangular shaped path.
- The Drone traverses along the perimeter of the rectangle twice. (7m x 3m)
- The students are instructed to follow the Drone along its path. There are additional markings on the ground to guide the students to follow the drone.

C.2 Observation and Data collection

The teachers at ASHA were recording some basic parameters and reactions while the students performed these exercises as a part of Drone therapy sessions.

1. Teacher's cue or prompt for each exercise
   - **High:** The teacher prompts instructions at all times to spawn a response from the student
   - **Moderate:** The teacher's prompts are sparsely present and not at all times.
   - **Low:**The teacher's prompts are minimum or not present. (Implying the student is self motivated as to follow the drone without prompt)
2. Response of the student for each exercise
   - **Unresponsive:** The student is found to be indifferent to the drone flying around.
   - **Low:** The student seems to be distracted often, loses focus on the drone and fails to complete the given task or exercise.
   - **Moderate:** The student seems to be distracted a little and at times loses focus on the drone and partially manages to complete the task.
   - **High:** The student correctly follows the instructions at all times and responds as expected.

C.3 Small Scale study

C.3.1 Selecting students for GMSD therapy

With all the data and previous results from the pilot study and student observations recorded, a set of seven students were selected as a part of this small scale study. These students were primarily selected given that they showed great response to pilot experiment with Drones. (Refer B.2) Moreover these students were found to have a few prevalent problems when considering gross motor development.

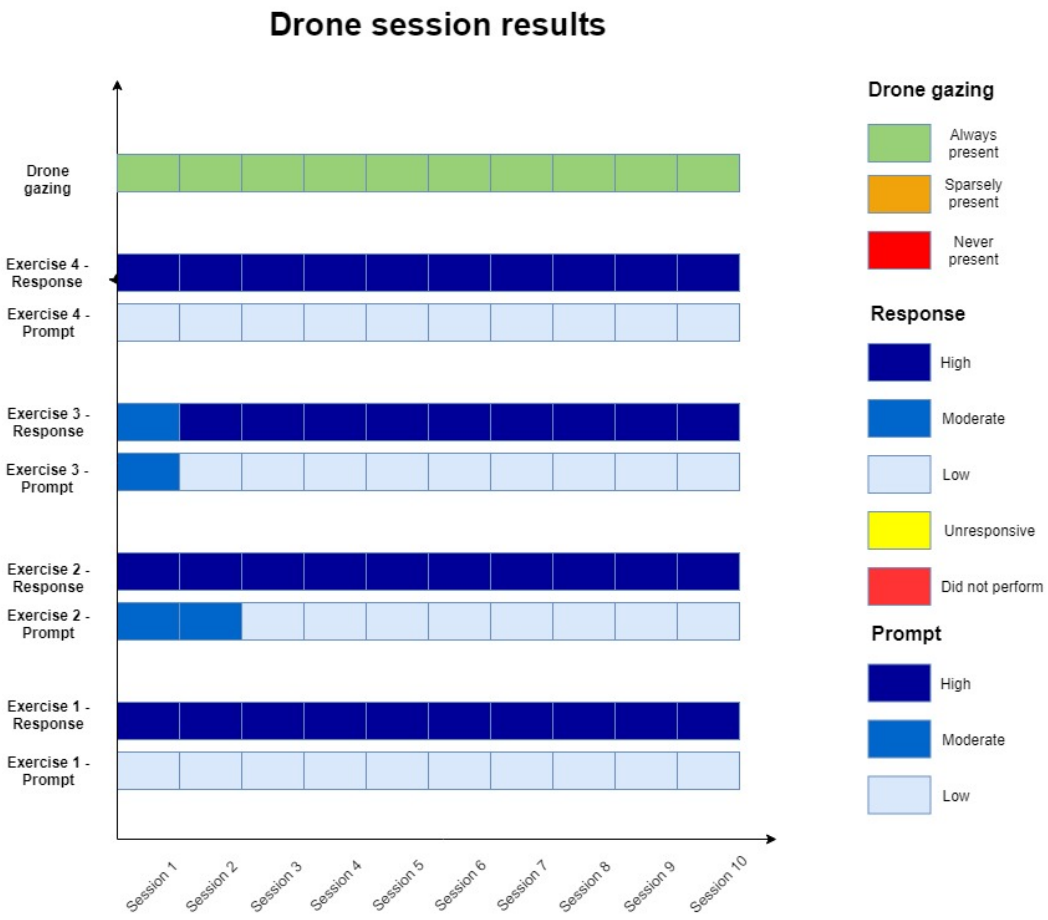
- Students who have physical developmental delays
- Students showing total disinterest during regular gross motor classes
- Students who need regular physiotherapy and occupational therapy

List of students selected

C.3.2 Data collection results of focused students

The data collected over the ten sessions shows progressive response in three out of the seven students selected.(refer C.2)

Student1

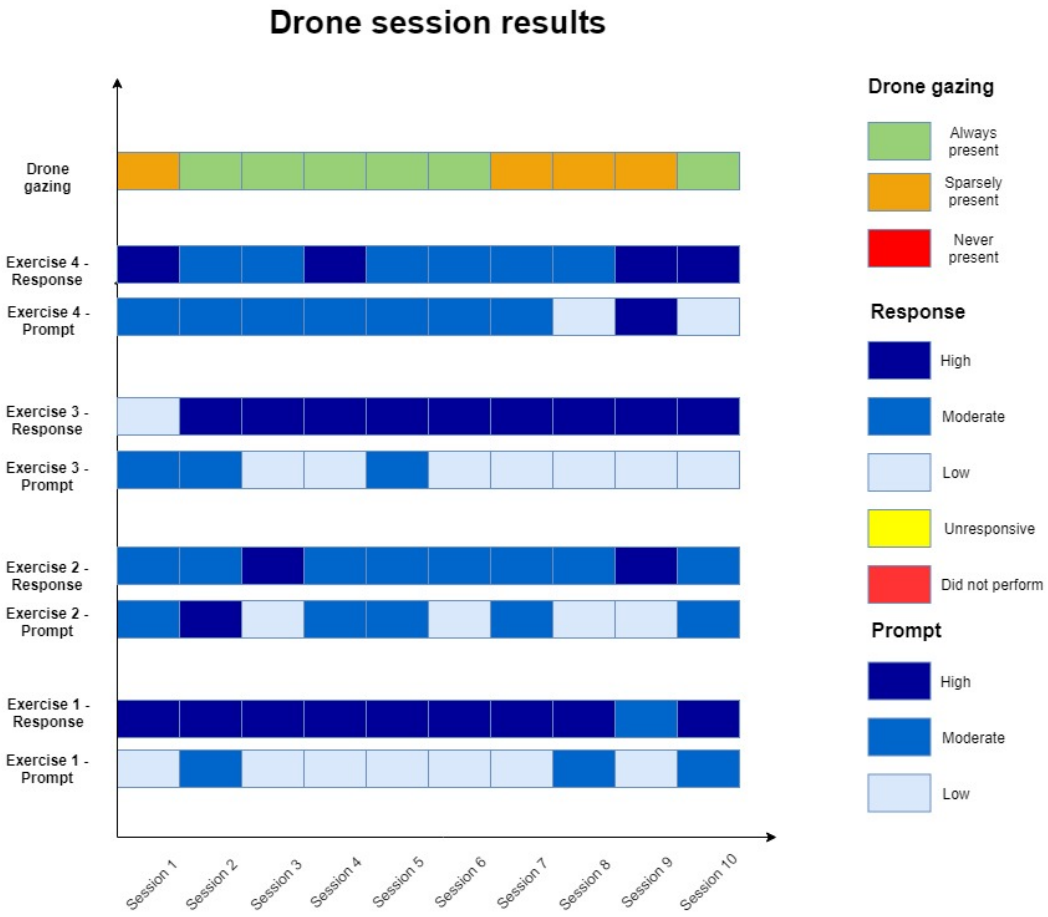


Student1's observations over ten session with Drones

Key observations and developments post drone sessions:

- Student is motivated to perform exercises given his interests and inclination towards technology, therefore he would perform exercises without the teacher's prompt.

Student2

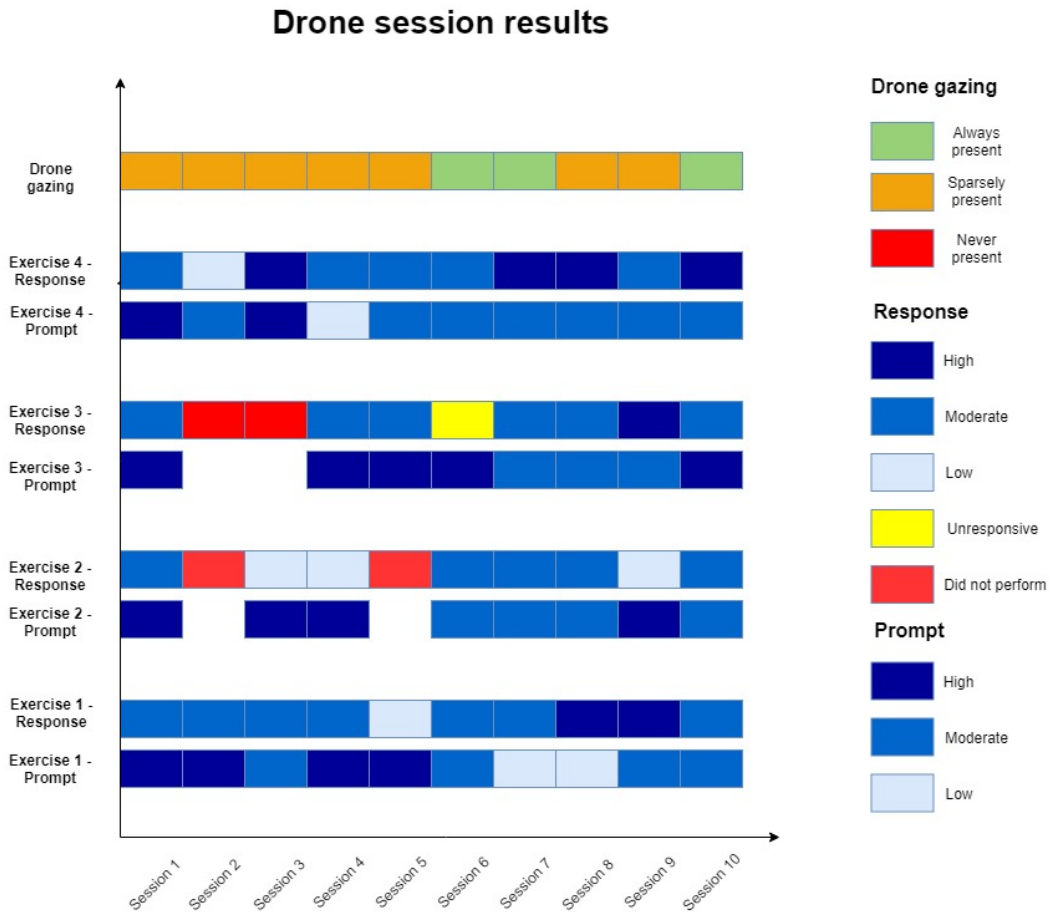


Student2's observations over ten session with Drones

Key observations and developments post drone sessions:

- Student was observed to perform exercises better with minimal prompts as the drone sessions progressed.
- Student attempts to sprint behind the drone.
- Student has been observed to have improved his focus and eye contact.
- Student has been observed to perform exercises better during his regular GMS, after these sessions.

Student3



Student3's observations over ten session with Drones

Key observations and developments post drone sessions:

- Student's ability to imitate the drone's movements greatly improved.
- Student's ability to perform exercises without teachers physical help and verbal prompt has improved significantly over time.
- Student is attracted and inclined to play with the drone because she enjoys the down wash of the propellers while she stands below the drone.
- As a result of performing exercises with Drones, she is found to have effortlessly improved performing her physiotherapy exercises for her neck posture.