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“AI-TOP - An AI Tool to Predict Engagement and Meltdown Events in Students with Autism”

Project Number: 2020-1-UK01-KA201-079167

AI-TOP

Intellectual Output 2:

IO2 - Transferred Mobile Engagement and Meltdown Measurement App

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1 Introduction

We should support all students with autism (Autistic Spectrum Condition, ASC) with opportunities to realise their potential. They should participate in education and training on the same basis as students without autism and they should not be subjected to discrimination. Due to the progress in the IT sphere, digital technologies are easily accessible and widespread, and these provide students with new opportunities.

Due to the high degree of diversity among students with autism, there is no single technological solution that can suit the needs of all. The best outcomes can be achieved using custom-made solutions designed according to the requirements of a particular group of students. This is where the AI-TOP project comes in. By tracking the student's engagement and attention, it will provide guidance on pedagogical approaches that are most suitable for each individual child, based on their observed competences and abilities. It will also identify the early signs of challenging behaviour episodes, enabling early intervention to increase the chances of a calm classroom.

AI-TOP is a 36-month (01/09/2020 – 31/08/2023) project. Its aim is to contribute to the uptake and implementation of inclusive education by providing teachers and teacher educators with a toolset to support engagement assessment of each child, as part of a holistic approach towards inclusive education. It also aims to raise awareness of the importance of learning technologies and provide direction for the adoption of technological innovations. The technology developed will also track students for early signs of potential rumble and meltdown moments and inform the teacher at an early enough stage for intervention. This offers support to teachers who face the challenge of teaching in inclusive education classrooms and enhances their professional development.

Tracking engagement and early detection of emotional dysregulation in students with Autism is crucial, as deep learning is not possible without engagement, and emotional dysregulation events can cause disruption in the classroom and distress to the student. This project allows for the tracking of student engagement, support and re-engagement of those with the greatest learning needs, and identification of early signs of rumble moments occurring. The engagement and rumble moment prediction of the app was trained on data gathered from students with autism in schools across Europe (the UK, Bulgaria, Belgium and Greece).

This document summarises all the work that has been done under the guise of Intellectual Output 2. This includes:

- Structured Interviews and Analysis
- The AI-TOP adjusted game suite
- Observational Behavioural Checklists
- Data collection and labelling
- Data processing
- Technical solution and implementation
- Ethics documentation.

2 Summary of O2 Work

2.1 DELIVERY

The core AI-driven engine for inference of engagement and prediction of 'meltdown' events - even at the 'rumble' stage, delivering an optimised algorithm trained specifically for use with students with autism is available at https://www.ai-autism.eu/outputs-results/.

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This includes adjusted 'Continuous Performance Test' games to label engagement, and observational behavioural checklists to label arousal. The games were repackaged for Windows machines which are most commonly found in schools, and adjusted to suit the needs of the ASC children. The observational behavioural checklists were developed in consultation with teachers based on the interviews carried out as part of O5, and allowed spotting of multiple engaged, bored or frustrated behaviours. These videos were labelled retrospectively using VIA software ahead of being used to train our algorithms.

The algorithms were trained with these extensive labelled data sets collected by NTU, PhoenixKM, NARHU and St Paisy Hilendarski in schools in the UK, Belgium and Bulgaria, and labelled by NTU.

Developments have also included a complex multi-modal data tracking system for Windows PCs which use the webcam stream to detect body pose, eye gaze, facial expression, heart rate and also uses interaction data and fuses all this data to create a prediction of engagement and emotional states, and sends the results to a cloud server. We prioritised the use of Decision Trees from an eXplainable AI (XAI) model for engagement & behavioural analysis. This approach allowed us to visualize the decision processes of multi-modal data, which helped us assess the accuracy of the model. The accuracy of the model is slightly lower than "Deep Learning" approaches, but provides explainable results, which are more trusted by, and therefore useful for inclusive education professionals, in assisting with the assessment of children with ASC.

There is also a separate Android app which receives the data from multiple instances of the Windows application and displays the data for a teacher to use. The app notifies the teacher of any potential loss of engagement or emotional dysregulation events with haptic feedback, and allows the teacher to identify which student is having which issues.

2.2 TARGET GROUPS

- Teachers, teaching assistants, and SEN coordinators in mainstream education, inclusive settings, and special educational settings.

- Beneficiaries: students with ASC, and their families, students in the same class.

- Stakeholders: policy makers, pedagogical experts, schools, school authorities and their umbrella structures all over Europe. Service providers supporting students with ASC; Local education authorities at all levels, Associations for teachers and teacher unions, Autism charities, National Governments.

2.3 ELEMENTS OF INNOVATION

Use of continuous performance test games to train algorithms to recognise engagement in students with Autism by comparison with experts using Observational Behavioural Checklists, and to train algorithms to recognise arousal before 'meltdown' moments occur in students with autism using multimodal data streams is absolutely novel practice in Schools throughout the EU.

The use of XAI methods to build our models to predict engagement and meltdown events is also novel in this population.

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2.4 EXPECTED IMPACT

A tool to infer engagement, and predict the likelihood of students exhibiting challenging behaviour, or experiencing 'meltdown' events has the potential to radically change practice in schools throughout the EU when supporting students with ASC.

At the multiplier event the impact can be inferred from feedback made by participating teachers and experts. 100% of respondents thought that the mobile app has the potential to change/augment practice in schools supporting students with ASC, and 86% thought it could be used by any school, parent or carer.

2.5 TRANSFERABILITY POTENTIAL

Our App to infer engagement and predict 'meltdown' events in students with ASC can be taken up and adopted by any school in the EU, as it will be a freely available and open educational resource. From Multiplier event feedback, the app may also be useful in non-school scenarios such as at home, and with students with other diagnoses such as ADHD, SEMH difficulties, and could also be used in neuro-typical mainstream classes.

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3 The AI-TOP Adjusted Games Suite

3.1 Data Collection Process

Data Collection used four transferred games (or continuous performance tests) previously developed for iPhone in the Pathway + project, which have been recoded for AI-TOP for use on a Windows platform, more suited to use in schools. The games collected data that was then used to train the algorithm which is used when predicting the students' level of engagement and rumble events. Running behind this was Captura, which is the video and screen capture software, capturing both the game screen that the player will be seeing and simultaneously capturing a video stream of the webcam. These were later labelled, and the labelled data sets were used to train the algorithm to recognise both engagement, and early signs of rumble events.

The games constitute a Continuous Performance Test (CPT). A CPT is a neuropsychological test that measures a person's sustained and selective attention. Sustained attention is the ability to maintain a consistent focus on some continuous activity or stimuli, and is associated with impulsivity. Selective attention is the ability to focus on relevant stimuli and ignore competing stimuli, and is associated with distractibility. This is the principle the games rely on. The student must respond by pressing a button after a predefined signal (pattern) is displayed to them. The signal and other similar or contrasting patterns will be displayed to the student in random order in a continuous repetitive test. The CPT outcome measures allow us to then label and segment the multimodal data (eye gaze, head posture, facial features, body pose), collected from each student playing games, into regions of high and low attention, which is key to training the algorithm.

Captura software was run in the background capturing the entire session with each student from the start where they were introduced to the games, up to the point where the games had been played and the student was moving on to their next schooling activity. It was hoped that this would give the highest opportunity of capturing any relevant rumble events which occurred before, during, and after the gameplay session.

3.2 Games

3.2.1 Gameplay principles

During gameplay a signal slide is shown and is followed by a blank slide. When the participant sees a predetermined Target image (See Figure 1), with or without an extra condition or noise added, they should respond with a predetermined action - pressing the red button. This is the aim of the game.

Casey the cat
(Target image)

Berry the dog
(Target imitation image)

Green backpack
(Contrast image)

Figure 1 Introducing the characters in the game

The blank slides between the signal slides act both as a short break before the next slide and make the learner respond by relying on their recollection. Students' responses on blank slides, no matter

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how late, are still taken into account. The time the student has to respond is the combined display time of the signal and blank slides.

- Increasing or decreasing the slides' display time, decreases or increases the level of difficulty, respectively (all games).
- Increasing or decreasing the number of images on each pattern slide, increases or decreases the game's complexity (Seek X, Seek AX).

Useful to know

Before the game starts, the teacher should introduce the characters encountered in the four mobile games to the students who will be playing them. This is done to establish a more personal relationship between the participants and the platform, which has shown to improve memory and recall abilities in subsequent sessions with the students. The participant should also have a valid recognition of the Target from the other distractor (similar or contrasting) images in order to ensure the measurement's validity. Some useful ways of familiarizing the students are:

- Providing the students with (enlarged) colorful images of the characters - on paper, laminated.
- Having a conversation in which the students themselves describe the appearance of Casey, Berry and the Green backpack.
- Colouring pictures of Casey, Berry and the Green backpack.
- Creating short stories about Casey, Berry and the Green backpack.
- Comparing Casey, Berry and the Backpack in external qualities - Similarities/Differences. Why are Casey and Berry so alike? Why are Casey and the Backpack, as well as Berry and the Backpack, so different?

3.2.2 The Four Games

When choosing a game, the teacher should always keep in mind that the level of difficulty and complexity of the game should match the student's capabilities. The progression of difficulty is given in Figure 2.

Figure 2 The progression of difficulty with the games

3.2.2.1 Type X Game

This game is the simplest of the four games. The teacher can use this game with learners with limited memory and recall ability. Participants can be instructed easily because of the simple nature of the game's signal definition, dynamics and goal.

The participant sees a sequence of images of the Target (Casey the cat) and the Target imitation (Berry the dog) in random order. When the student sees Casey, they have to press the red button. When

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Berry appears on the screen, they have to refrain from pressing the button. This is the goal of the game.

After the participant has correctly recognized Casey and pressed the button, there is a reward slide - a short congratulatory animation with a fun melody accompanying it. The respective slides are shown in Figure 3.The level of difficulty of the game can be increased or decreased by decreasing or increasing slide display time, respectively.

Figure 3 Target, reward and distractor slides in the Type X game

3.2.2.2 Seek X Game

The Seek X game is the next level up the Type X game. The signal definition is the same level of complexity as the Type X game but with noise added, which is done by displaying the Target in between many distractor images (Target imitation and Contrast – as in Figure 4). In the game Casey the cat is the Target, Berry the dog is the Target imitation and the Green backpack is the Contrast image.

The goal of the game is to spot Casey the cat among the many distractors (Berry and the Backpack) and to press the red button. The participant does not have to use memory and recall ability. The level of difficulty of the game can be changed by altering the slide display time. In addition to this, the level of difficulty can be increased or decreased by increasing or decreasing the number of images displayed on the screen.

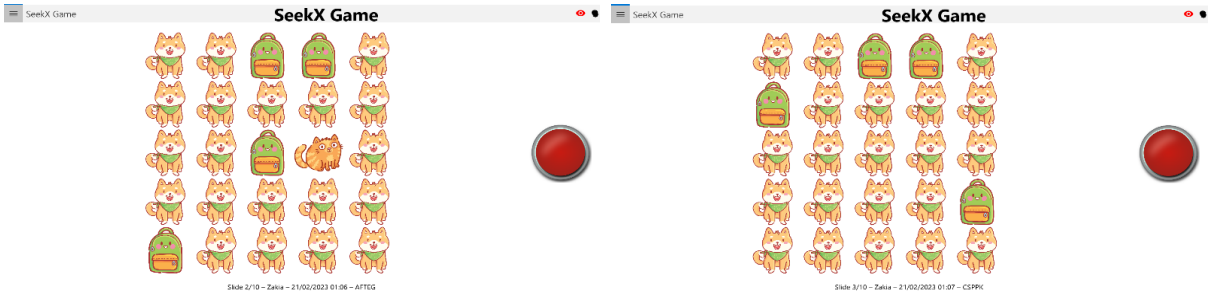

Figure 4 Target and distractor slides in the Seek X game

This is why the Seek X game (and the Type X game) are best suited for children with special educational needs – their signal definition is uncomplicated, while the game can be made more or less challenging without changing the game dynamics. An added advantage of the Seek X (and Seek AX) game is that it tests the visual motor skills of the learner. It can be used as a method of discovering partial visual blindness and motor restriction in the eyes.

3.2.2.3 Type AX Game

In the Type AX game the signal definition is more complex than in the previous games. It has the same dynamic as the Type X game but with an added precondition. The participant has to successfully

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recognize the Target (Casey the cat), while a predefined condition is met (the screen border to be of gold colour).

Figure 5 Target and distractor slides in the Type AX game

There is a sequence of images of the Target (Casey the cat) and the Target imitation (Berry the dog) in random order and with differently coloured borders. When the student sees Casey and the screen border is golden, they have to press the red button.

3.2.2.4 Seek AX Game

The Seek AX game is more challenging than the previous games, while sharing some similarities with them. It has the dynamics of the Seek X game and the same logic as the Type AX game.

The student should only press the button when they spot Casey the cat (Target) among the many distractors (Berry the dog and the Green backpack), while a predefined condition is met. Here the precondition again is for the screen border to be of gold colour.

Figure 6 Target and distractor slides in the Seek AX game

This more complex signal is better suited to the capabilities of mainstream students. This is so because the Seek AX game is designed to track the visual attention and multitasking skills of mainstream students. The level of difficulty can be changed by altering the slide display time and the number of images displayed on the screen.

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3.3 Features

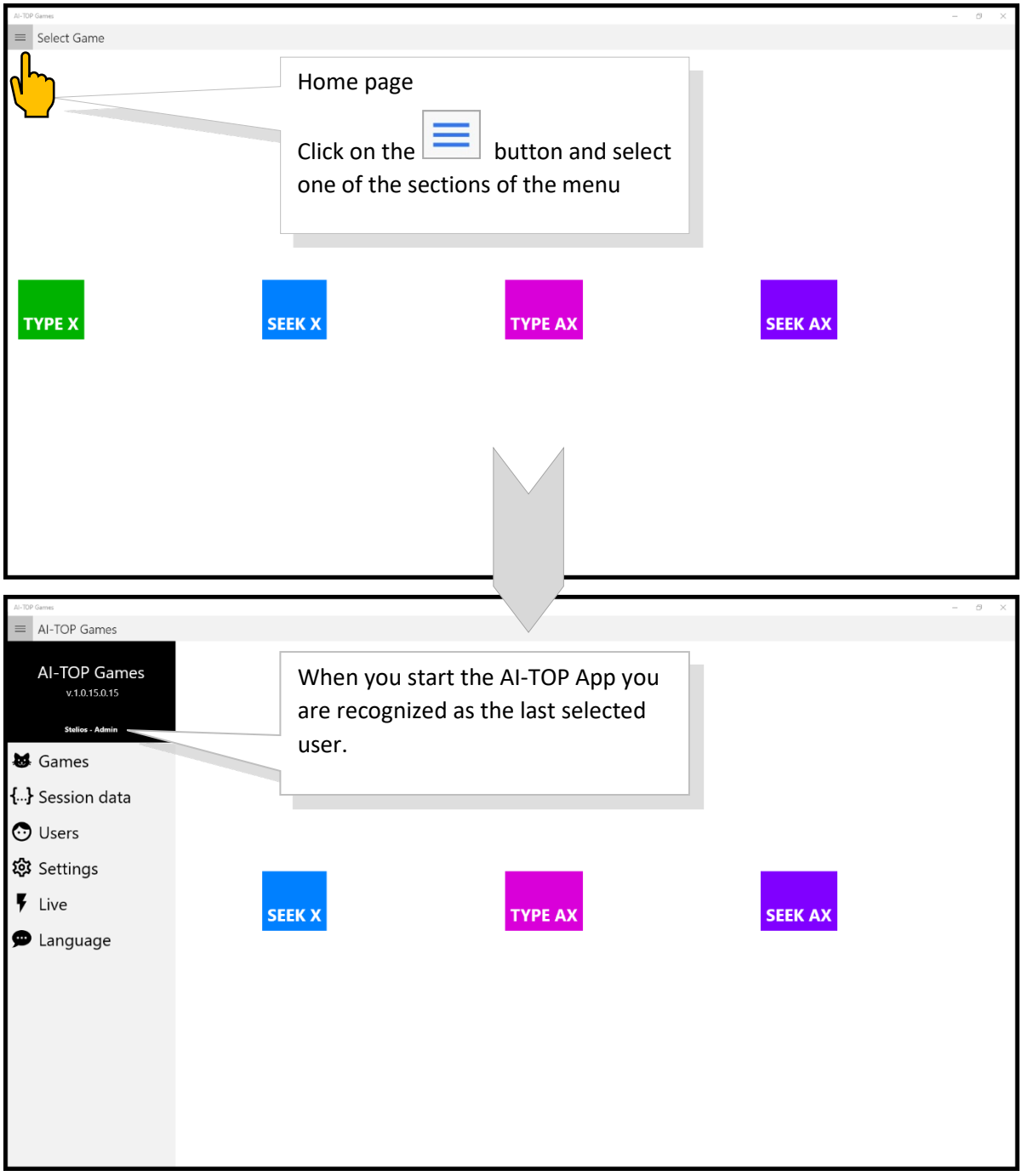

Figure 7 Game menu showing listed user

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Users

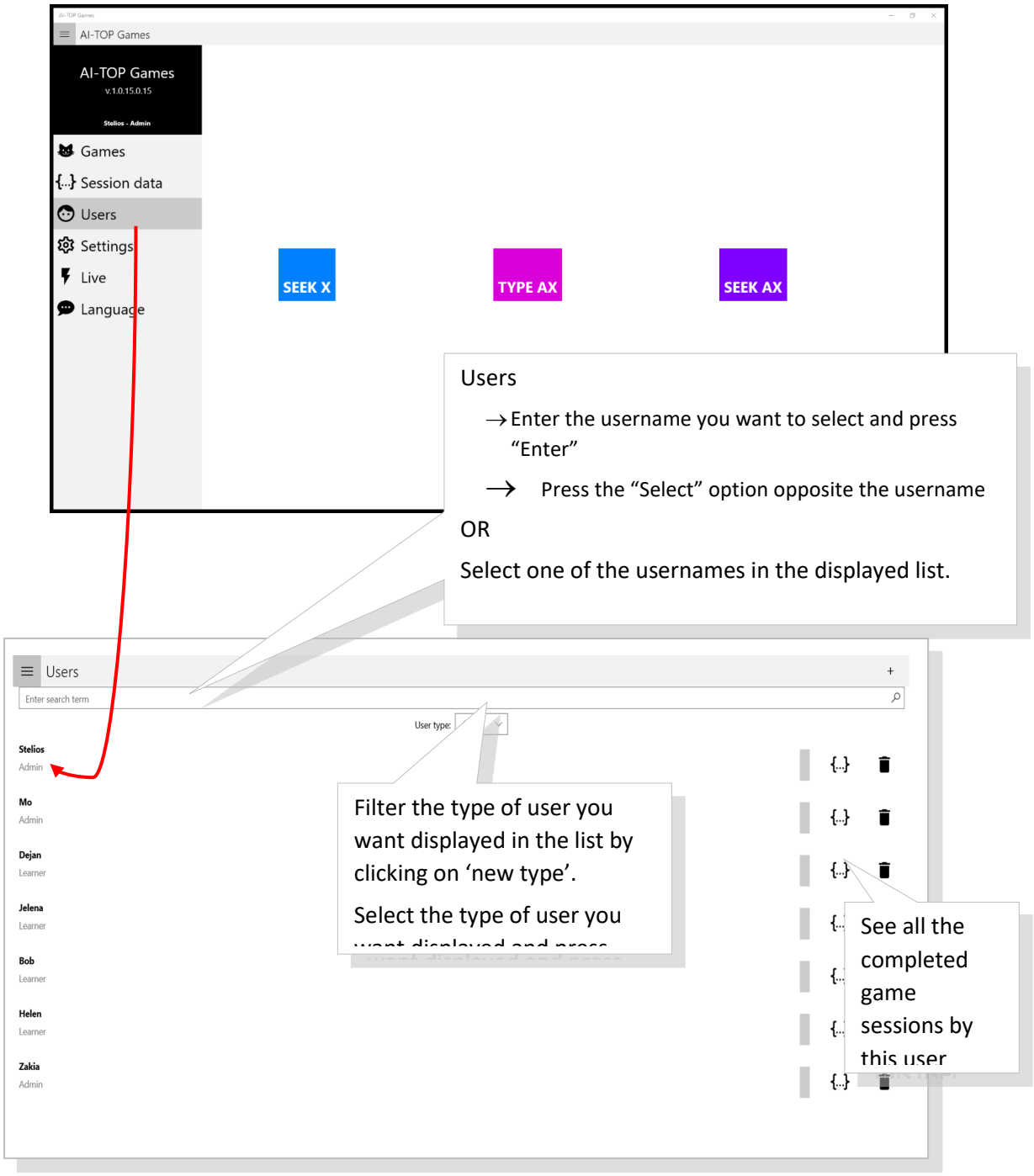

Figure 8 Editing users in the game menus

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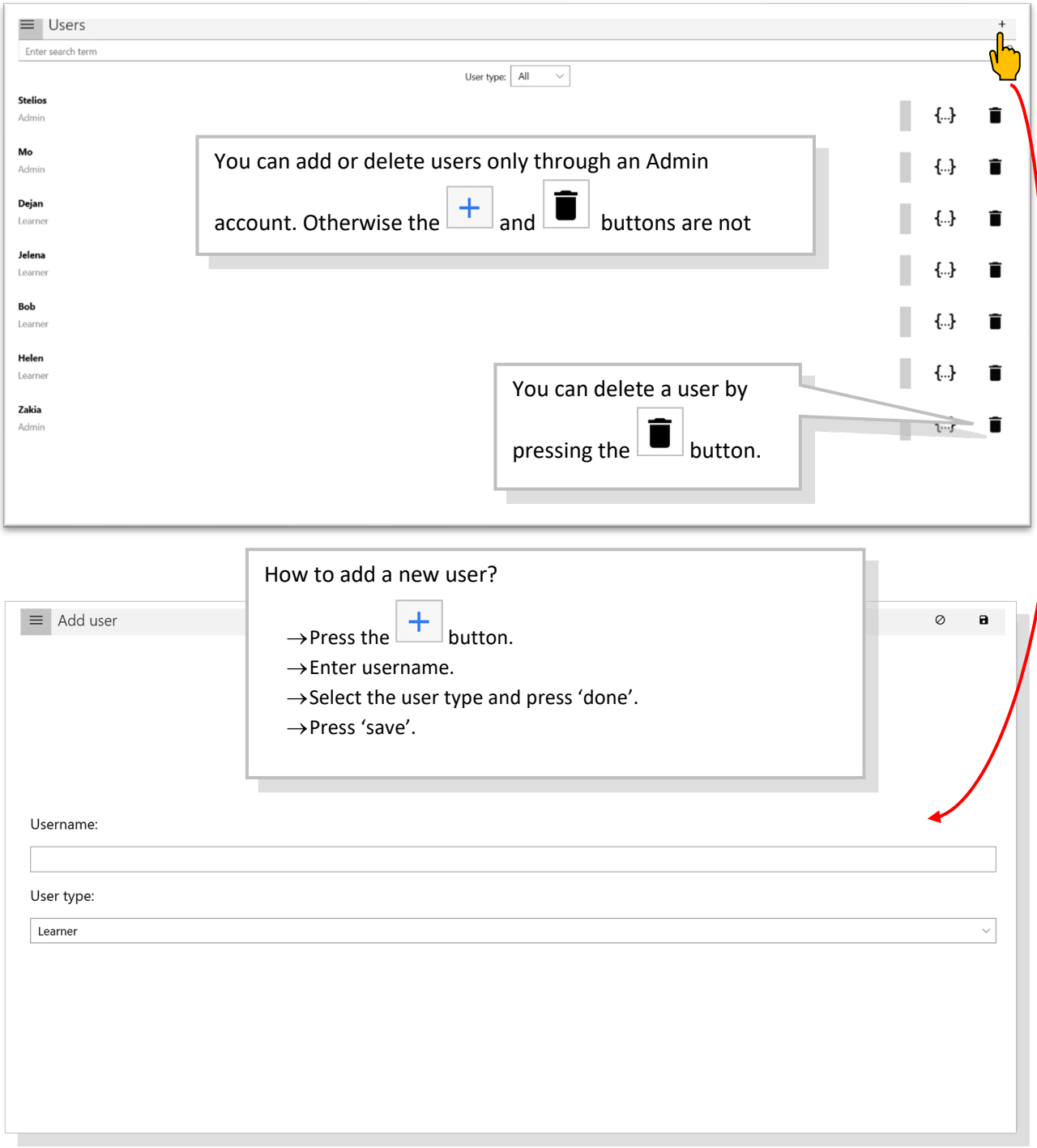

Figure 9 Adding a new user

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3.3.1 Settings

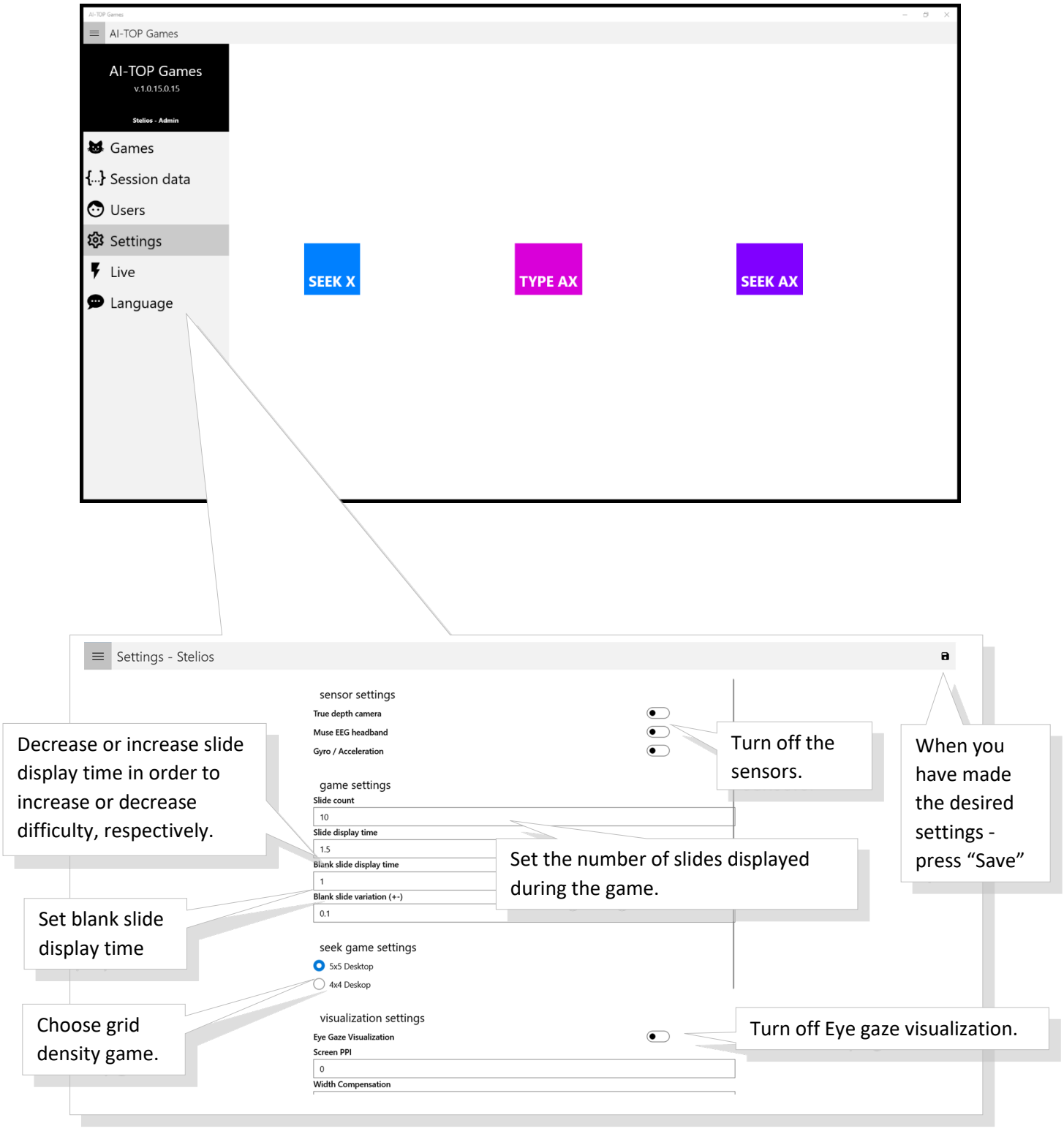

Figure 10 Settings to alter gameplay

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3.3.2 Session data

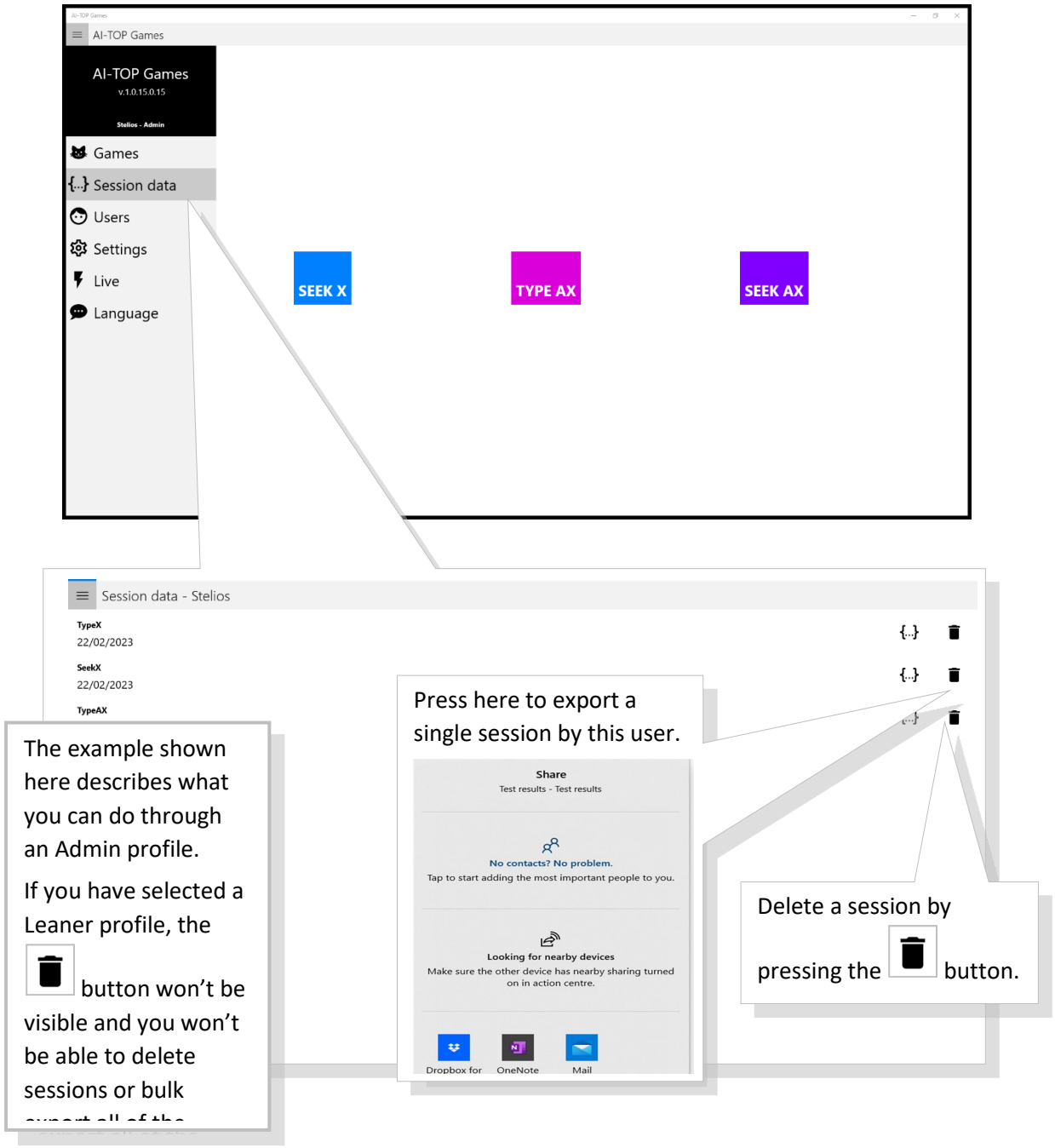

Figure 11 Exporting Data

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3.3.2.1 How to export a game session

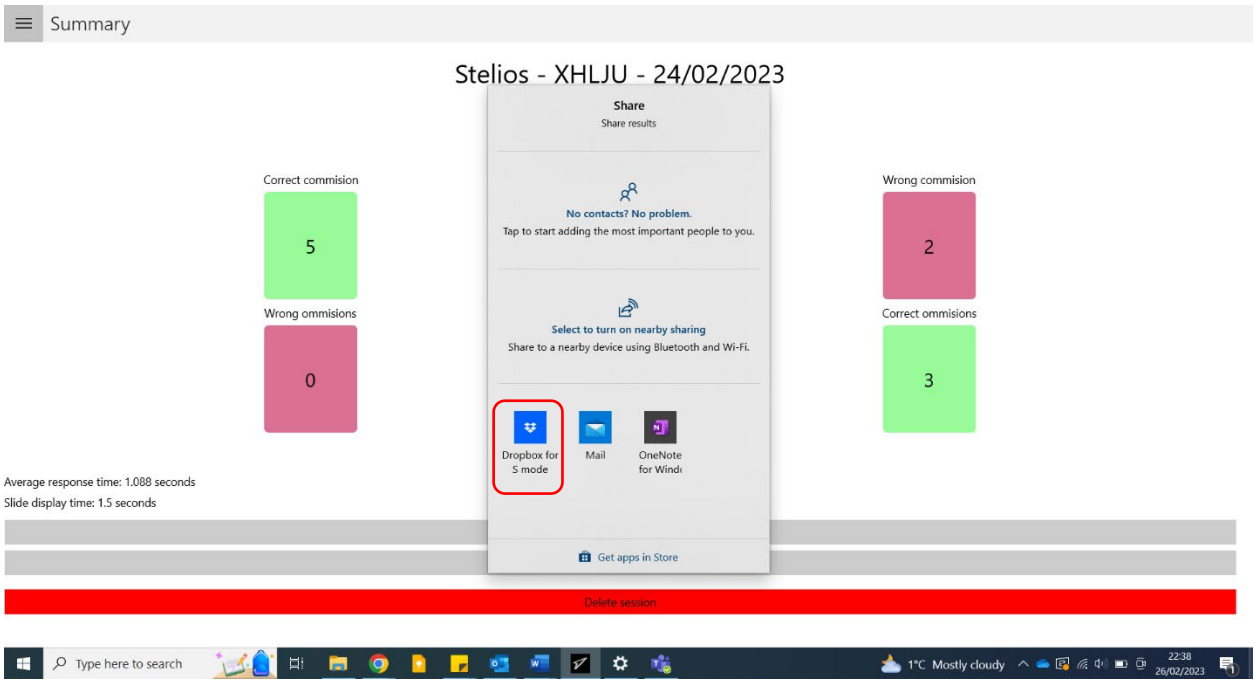

Figure 12 Export of a single session

1. Click on ‘export results’ and then ‘Dropbox for S mode’ as in Figure 12.
2. Login to Dropbox app.
3. Select respective save folder.
4. Rename the file according to the naming convention and save it.

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3.3.3 The Games

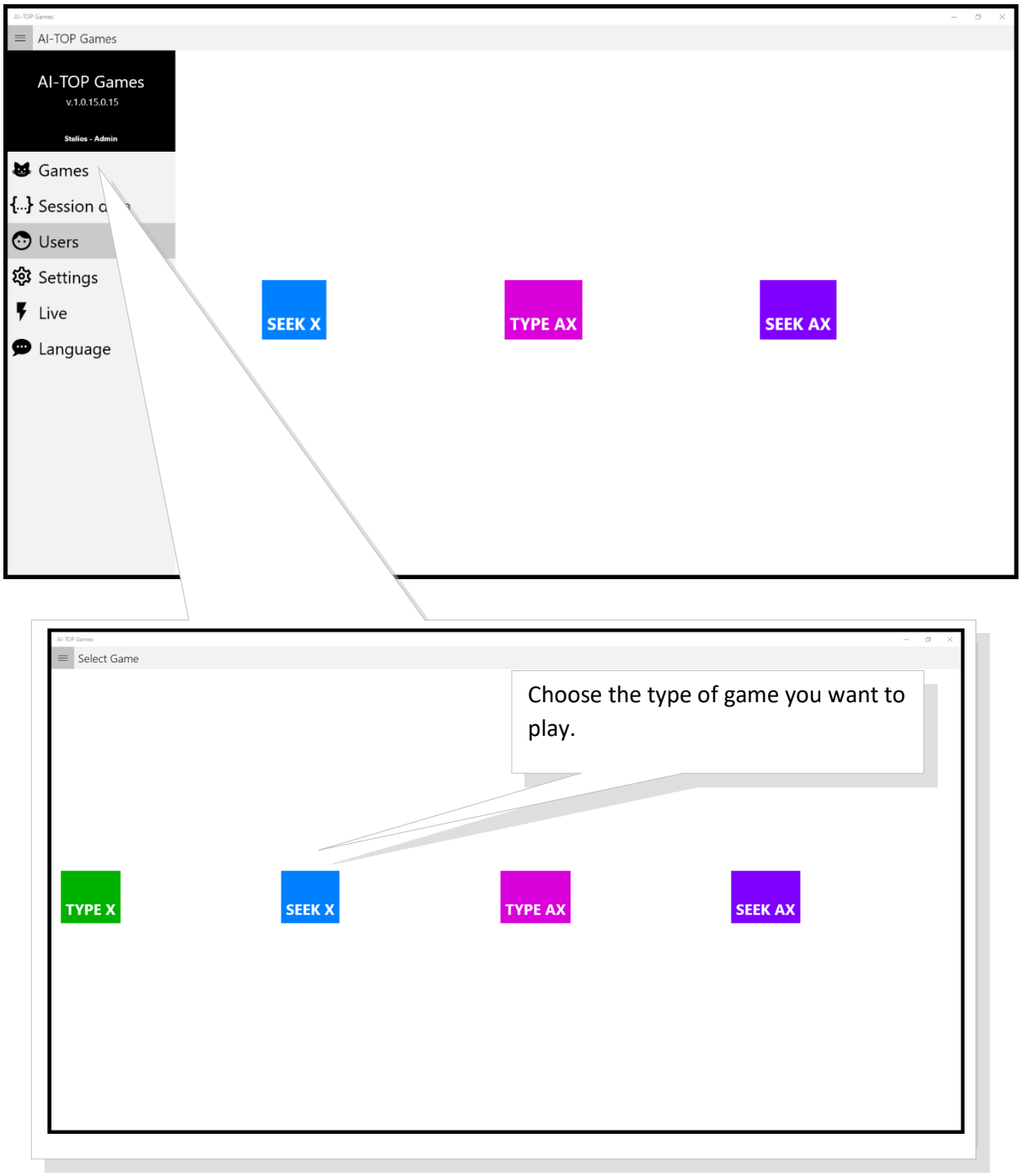

Figure 13 Selecting a game

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3.3.3.1 Type X Game

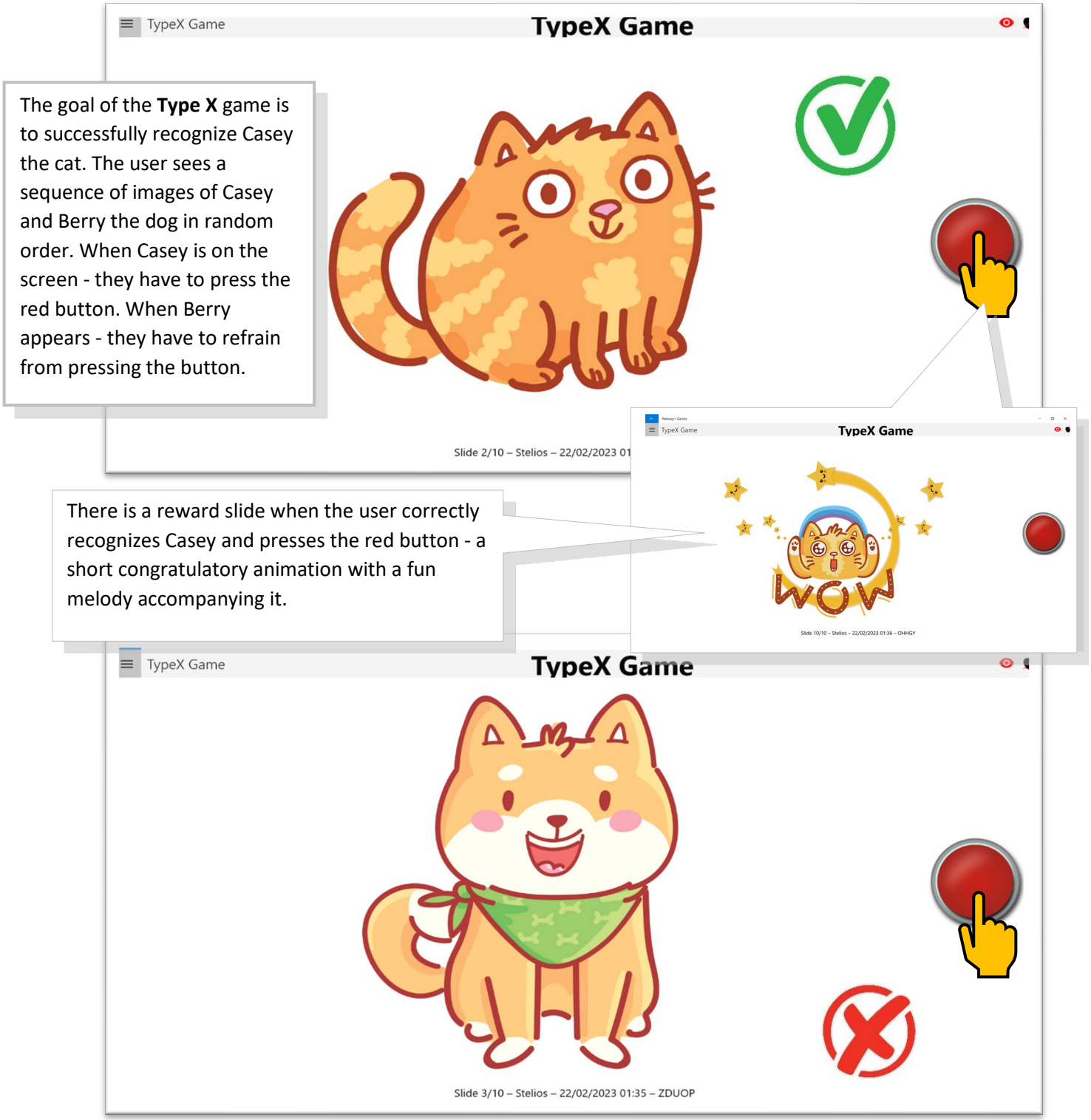

Figure 14 Type X game play

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3.3.3.2 Game scoring summary

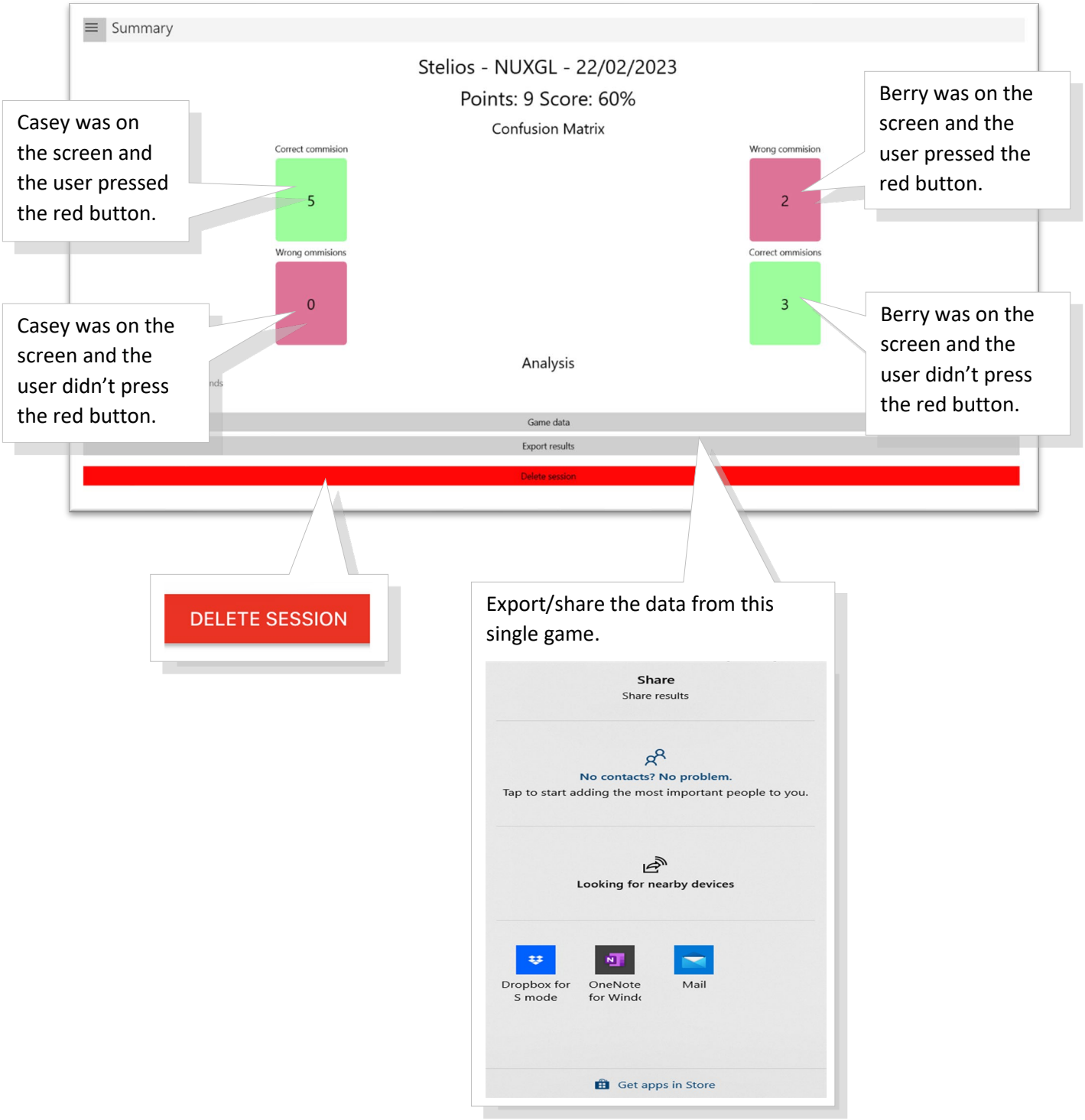

Figure 15 Scoring Summary of Type X game

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3.3.3.3 Seek X Game

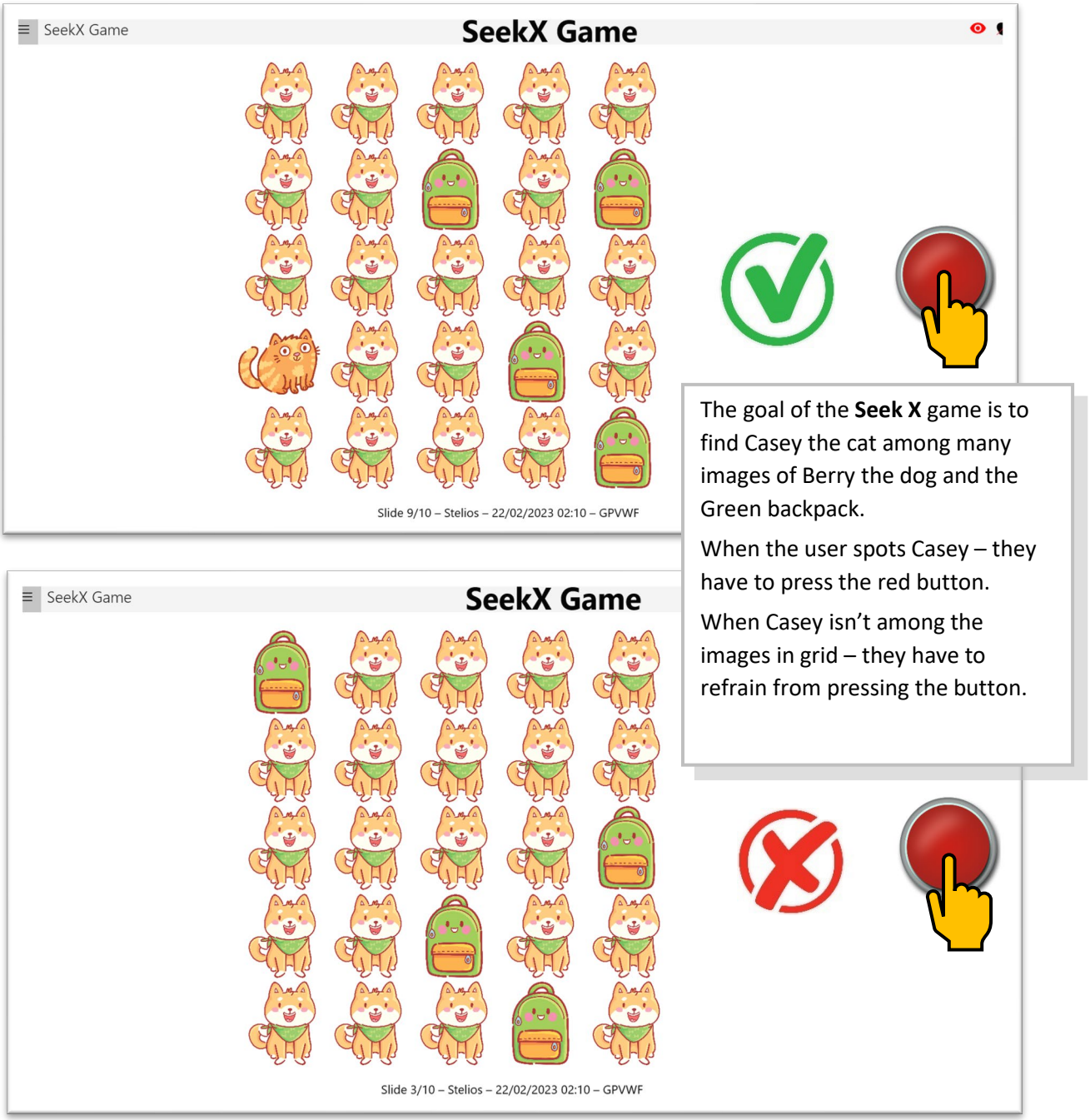

Figure 16 Seek X gameplay

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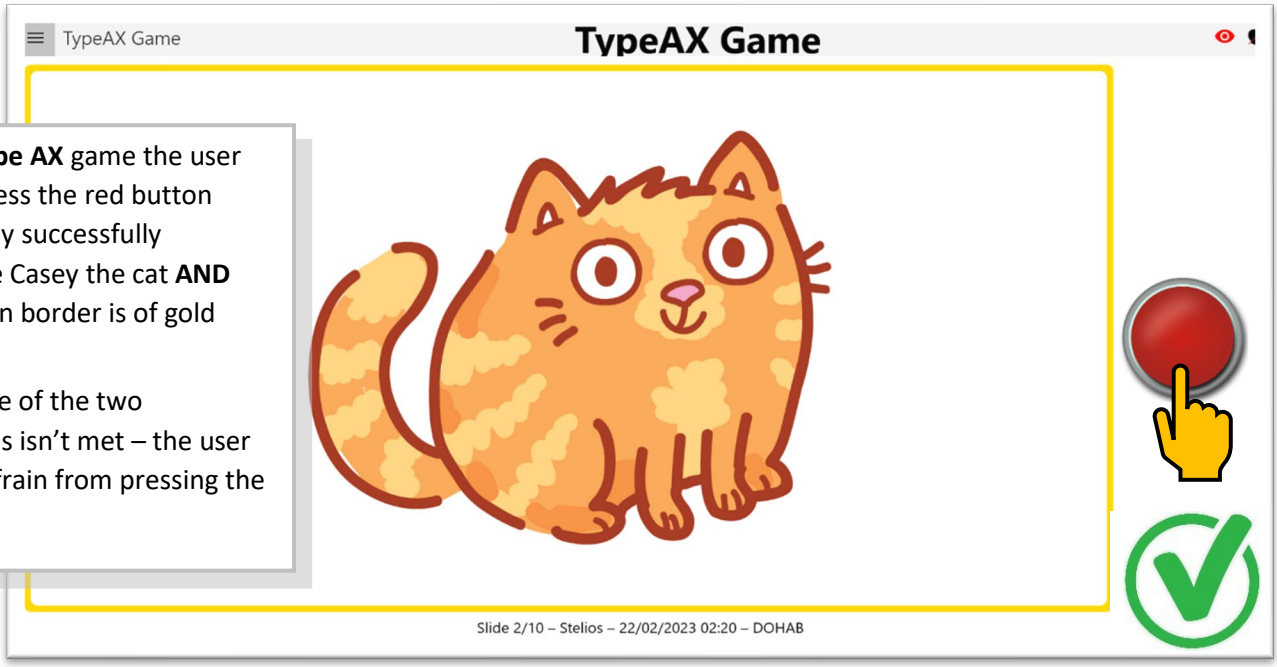
3.3.3.4 Type AX Game

In the **Type AX** game the user has to press the red button when they successfully recognize Casey the cat **AND** the screen border is of gold colour.

When one of the two conditions isn't met – the user has to refrain from pressing the button.



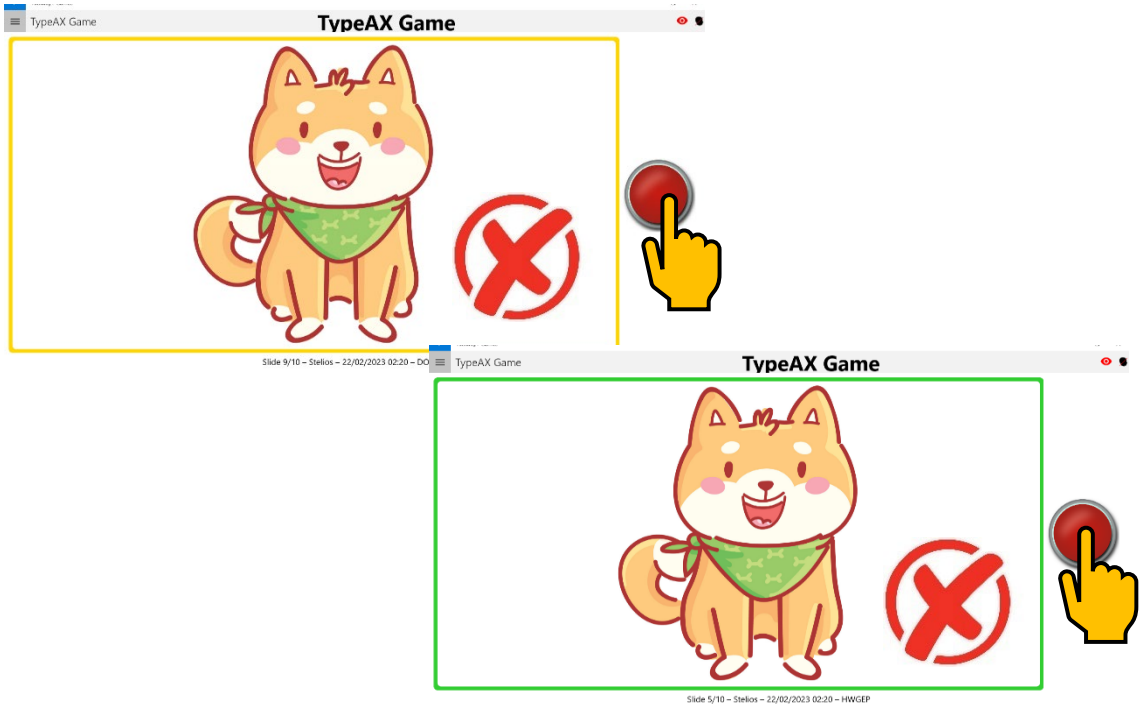


Figure 17 Type AX Gameplay

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3.3.3.5 Seek AX Game

In the **Seek AX** game the user has to press the red button when they spot Casey the cat among many images of Berry the dog and the Green backpack **AND** the screen border is of gold colour.

When one of the two conditions isn't met – the user has to refrain from pressing the button.

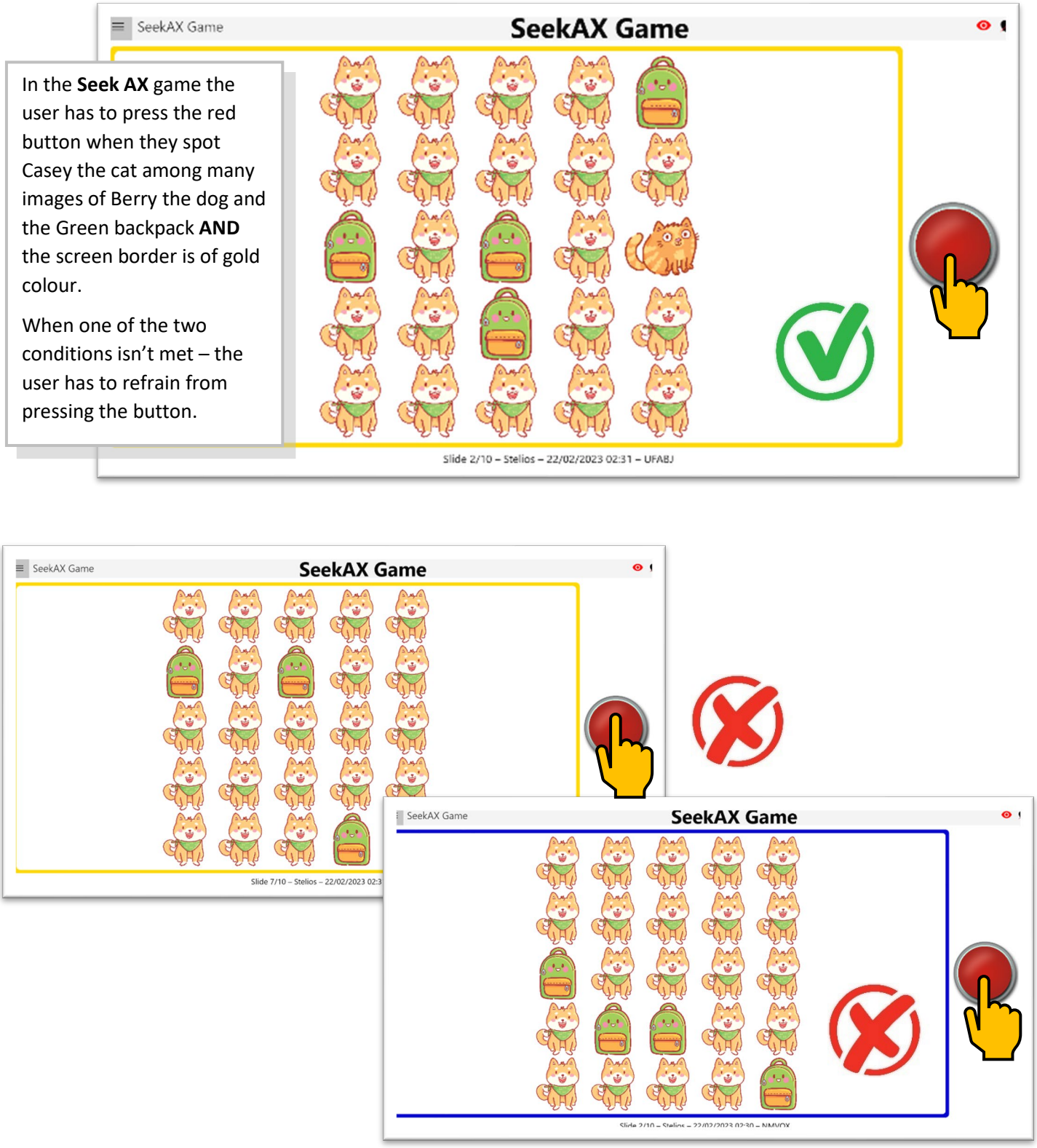

Figure 18 Seek AX Gamplay

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3.4 Data collection sessions

3.4.1 Data collection algorithm

- Create an 'Admin' account.
- Select the Admin user.
- Create 'Learner' user accounts for the number of participants you have.
- To anonymise your users, print out the paper-based register (Annex 1), which records which Learner ID corresponds to which student in the App. You should destroy this paper after the project has ended as it has the real names of the participants in it.
- Using a paper-based version of the games (Annex 4), explain to participant what the game dynamic is. For example, when they should press the red button and when they should not press the red button. Show them what the cat looks like and what the other characters in the game are, the dog and the backpack. Make sure they understand that they should only press the button when the cat is on the screen. If the participant presses the red button during a blank slide - it still counts.
- Ask them to demonstrate to you using the paper-based game. They have to understand the game dynamic for the Type X game.
- If they have shown that they can perform in the paper-based Type X game - Follow the 'Deciding which game type' (Annex 2) flow chart to designate the appropriate game difficulty.
- You only need to do this once for each participant. Record which game type is most suitable for each participant in the participant register.
- You do not have to make a record of any game settings as the App saves them for each learner, and reloads the last used settings when that learner profile is selected.
- Follow the "Data collection" (Annex 3) flow chart to carry out your data collection sessions.
- Export completed sessions through one of the available channels.

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3.4.2 Optimal positioning and lighting

3.4.2.1 Positioning

- The webcam should be facing the user – easily done on a laptop which is designed to have the camera facing the user, but if using a USB webcam you should ensure that it is facing the user and able to pick up the face and gestures of the upper body. It is preferred if the camera can capture arm movements as well as the face if possible in your set-up.
- The mouse should be positioned comfortable for the user to be able to select the button.

3.4.2.2 Lighting

- Neutral indoor lighting is best for sensory data collection.
- Extreme back light or extreme hard light on face are not advisable.

3.4.3 Session frequency

- It's better to have no more than two sessions per participant per day to achieve maximum variability in the participants' mood in the samples collected. Having one session in the morning and one in the afternoon, allows us to have a session when the participant is high energy and one when they are more fatigued.
- Make sure to delete all test sessions or all sessions that are not from learners from the computer immediately. Do not leave any test sessions on the computer as you may forget to delete them later.

4 Observational Behavioural Checklists

The AI-TOP team reviewed data from the structured interview phase, along with literature reviews and also consulted with the expert teams from Bulgaria, Greece and Nottingham City Council in order to establish a set of checklists defining the states of students whilst performing the continuous performance test games.

The following checklist was established:

- Engaged:
  - Calm
  - Smiling
  - Eyes on game or tutor
  - Responding to game
  - Visibly excited
  - Touching head or face
- Bored
  - Yawning
  - Eyes not on game or tutor
  - Not responding to instruction
  - Not interacting with game or tutor
- Frustrated
  - Red face
  - Sweating
  - Twitching
  - Fidgeting

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- Scratching
- Flapping
- Rocking
- Touching face
- Touching head
- Touching ears
- Getting out of seat
- Walking off
- Visibly sad

This checklist was recreated within the VIA video annotation software with an additional checkbox to note if there was anyone other than the student in view, and an option to add notes to further explain the video actions in case any further observed behaviours should be added to the lists (See Figure 19).

Tutor in view	Engaged	Bored	Frustrated	Notes	←
No	☑ Calm ☐ Smiling ☑ Eyes on game or tutor ☑ Responding to game ☐ Visibly excited ☐ Touching head or face	☐ Yawning ☐ Eyes not on game or tutor ☐ Not responding to instruction ☐ Not interacting with game or tutor	☐ Red face ☐ Sweating ☐ Twitching ☐ Fidgeting ☐ Scratching ☐ Flapping ☐ Rocking ☐ Touching face ☐ Touching head ☐ Touching ears ☐ Getting out of seat ☐ Walking off ☐ Visibly sad		
🗑					

Figure 19 The checklists as they appear in the VIA software on adding an element to the observational timeline.

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5 Data Collection

Data was collected across multiple partners to create a comprehensive set of data to label and train the machine learning algorithms. The previously described methodology was used, where the students played the continuous performance test games whilst being recorded via webcam and also capturing the on-screen gameplay on the machine. These videos were brought together to produce a single video for each session that could be annotated in the labelling process by the assigned expert.

5.1 UK (NTU and NCC)

Nottingham Trent University worked with the Nottingham City Council Autism team to get access to 5 different schools where data collection was undertaken. The team worked with 39 different students across the schools and collected 74 separate sessions, averaging around 12 minutes in length, with some up to 28 minutes.

The students who played the games had a range of diagnoses. Some were diagnosed with ASC and had Educational Health and Care Plans (EHCP) in place, and were in receipt of Higher Level Need (HLN) funding. Some were also diagnosed with ADHD. Several students were as yet undiagnosed, with diagnoses in progress, or suspected of having ASC by the teaching staff working with them. Several neurotypical students were also involved to provide extra control data.

5.2 Phoenix KM

Phoenix KM collected 67 videos of up to 3 minutes 17 seconds working with 20 students from their connected schools.

5.3 SU Paisii Hilendarski

Between 1st may and 10th June 2023, SU Paisii Hilendarski worked with 20 students and collected 72 videos of up to 3 minutes 19 seconds working with students from the school. All students involved were form mainstream public schools. The students included students with ASC, students with ADHD, students with learning difficulties and SEN, as well as students with typical development.

5.4 NARHU

Between 1st may and 10th June 2023, NARHU worked with 20 students, and collected 66 videos of up to 4 minutes working with students from their connected schools. All students involved were form mainstream public schools. The students included students with ASC, students with ADHD, students with learning difficulties and SEN, as well as students with typical development.

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6 Data Treatment

6.1 Data Labelling

Following Data Collection (See section 3.4 above), Data labelling was allocated across the team at NTU for fast delivery of a time-consuming task. Eight NTU Team members worked on labelling the videos collected. The steps used for data labelling can be found in Annex 7. The individual annotations produced by the team were verified by the Autism team of Nottingham City Council to provide a check for accuracy and consistency.

The team used the software VIA (VGG Image Annotator). This is a simple and standalone manual annotation software for image, audio and video. VIA runs in a web browser and does not require any installation or setup. VIA is delivered through an HTML page (< 400 kB) and runs as an offline application in a web browser.

VIA is an open source project using HTML, JavaScript and CSS, and has no dependency on external libraries. VIA was developed at the Visual Geometry Group (VGG) of Oxford University and released under the BSD-2 clause license which allows it to be useful for both academic projects and commercial applications.

The labelled data was saved on the NTU Secure Server ready for the processing phase.

6.2 Data Processing

The video was used to train the action recognition model, which forms a part of the whole multimodal system. The other elements of the system relied on pretrained model data.

The video data was segmented into labelled slices in order to be useful for subsequent ML processing. Each label can have a variable duration, so an upper duration of 10 seconds was used. If any label covered a duration longer than this, then that section was sliced into multiple sections with a maximum duration of 10 seconds.

Multiple labelled actions may occur at any point and could well overlap, the same part of video may well be segmented multiple times to include overlapping or parallel labels.

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7 Technical Solution and Implementation

7.1 Introduction

When it comes to detection of engagement in a classroom, we can look at two means, report driven and technology driven. Report driven engagement detection looks at observations taken by teachers, therapists and carers, it can use behavioural assessments with standard guidelines, or where appropriate, can rely on self-reporting or self-assessment. However, with the use of technology driven engagement detection we can take some of the responsibility away from the staff present. Using such technologies as eye-tracking, physiological measurements, and video behavioural state detection we can determine the state of engagement in real time.

When the student is actively using a computer or similar device we can track interactions with that device, such as mouse clicks/screen taps, keypresses, and mouse pointer location. We can also track emotions (facial feature recognition), eye gaze, heart rate and pose/action from the video feed alone. This is important as the research phase showed that many people with ASC were resistant to wearable technology such as smart watches and skin patches. The non-invasive use of the camera feed alone, along with some ingenious algorithms, allows estimation of some of the features that these wearable technologies could have provided.

Below we describe the system created for AI-TOP utilising the technologies described above in a real classroom.

7.2 AI-TOP System Architecture

AI-TOP's engagement and meltdown tracking system mainly consists of two key components:

- Engagement and Meltdown Detection System (ASCMate)
  - Runs on the students' computers (Background service)
  - Powered by Artificial Intelligence (Advanced Machine Learning)
- Monitoring Mobile Application (AI-TOP App)
  - Runs on teachers' mobile devices (e.g., smartphones)
  - Notifies about students' behavioural and learning states

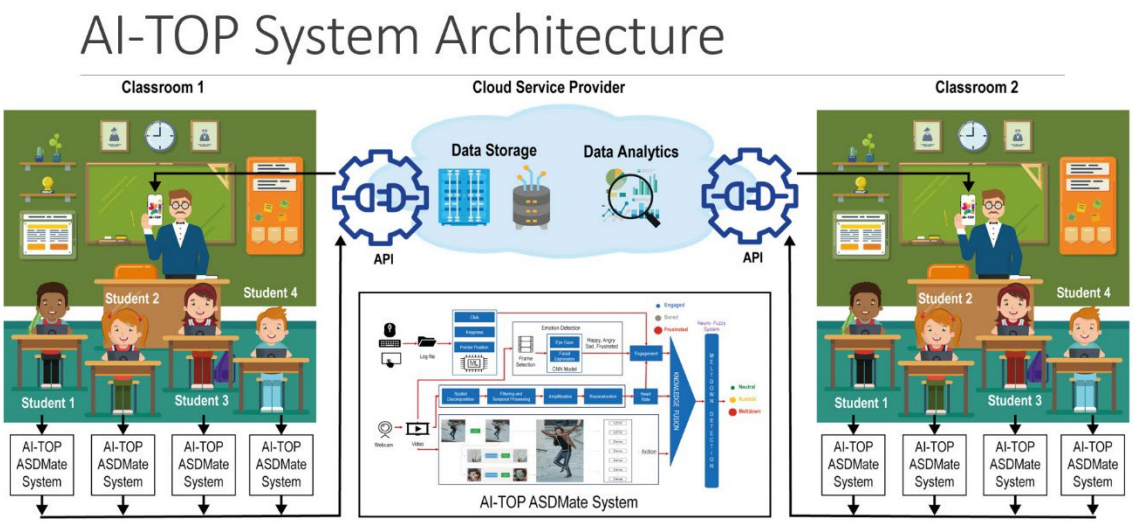

Figure 20 Full AI-TOP System Architecture

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Figure 20 shows a schematic of the full AI-TOP architecture, where the ASCMate system is running on the computers of students in multiple classrooms. The relevant data for each classroom is processed and pushed to the cloud data storage and analytics systems. The apps of the relevant teachers are then updated in real time to notify on the states of students in their classroom.

7.2.1 Detecting Eye Gaze

Gaze tracking seeks to estimate the x and y coordinates of the user's focus on the screen. This can be achieved in a variety of ways, falling into 3 categories, namely: 2D mapping-based methods, 3D model-based methods, and Appearance-based methods. With developments in machine learning, we can largely avoid the requirements of calibration, limited pose detection, and specialist equipment necessary for the first two methods and rely on the more robust approach that the Appearance-based methods offer.

The student's gaze is estimated firstly, by detecting the primary face in the field of view, then extracting the features from this face, and then approximating the direction of gaze, based on the model's understanding of eye and face structural features.

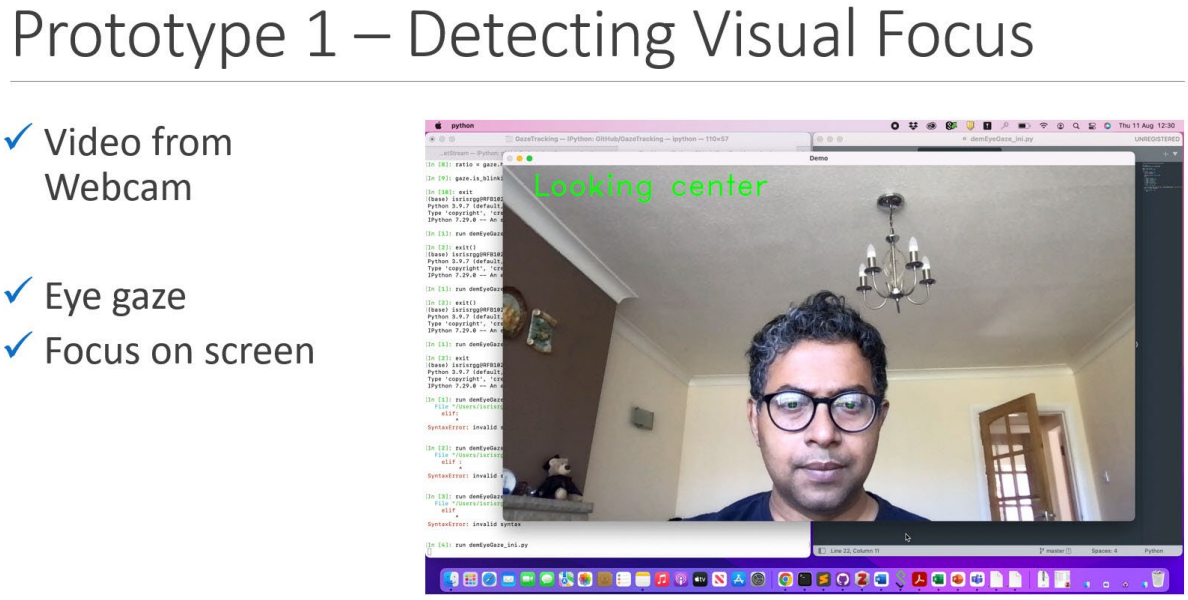

Figure 21 Detection of visual focus

A key element in using any machine learning based tool is that the model data on which it works is adequate for the task at hand. In this case, face detection is based on the publicly available prebuilt model: *shape_predictor_68_face_landmarks.dat* trained on the ibug 300-W dataset (Sagonas *et al.* 2016)[1], using OpenCV and Dlib Python libraries to achieve real-time prediction.

[1] Sagonas, Christos, Epameinondas Antonakos, Georgios Tzimiropoulos, Stefanos Zafeiriou, and Maja Pantic. 2016. '300 Faces In-The-Wild Challenge: Database and Results'. *Image and Vision Computing* 47 (March): 3–18. https://doi.org/10.1016/j.imavis.2016.01.002.

Wu, Hao-Yu, Michael Rubinstein, Eugene Shih, John Guttag, Frédo Durand, and William T Freeman. n.d. 'Eulerian Video Magnification for Revealing Subtle Changes in the World'.

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7.2.2 Detecting Heart Rate

Heart rate variability (the variation in time between heartbeats) can be indicative of cognitive processing, mental load, and stress. Literature suggests that heart rate can be measured purely from a video stream and train machine learning algorithms for accurate estimation. Heart rate can be detected using the temporal variations in a video that are not visible to the naked eye [2]. Region of interest (ROI) I.e., face is detected from a video stream and spatial decomposition followed by temporal filtering is applied to the frames. This sequence of video is then amplified to reveal the hidden information. As the blood flows through our face, this technique can be used amplify and reveal the small motions. The resulting signal is then Fast Fourier Transformed (FFT). Frequency peaks of this FFT signal are then isolated to calculate the heart rate and heart rate variability.

Figure 22 Image processing sequence for heart rate detection

7.2.3 Detecting Emotions from facial expression

Emotion detection is achieved using this module. It uses OpenCV, MediaPipe and TensorFlow to estimate the face mesh and it recognises facial emotion using the detected key points in a simple multilayer perceptron.

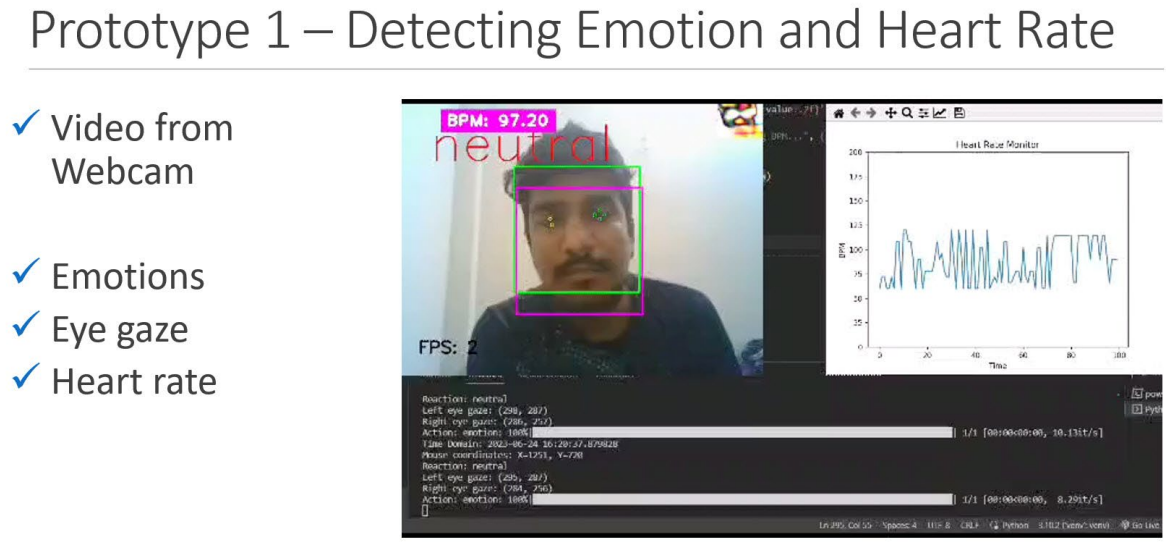

Figure 23 Detection of emotion and heartrate

7.2.4 Detecting Pose and Action

Pose and action enable us to identify some characteristics of stereotypical autistic behaviour. An increasing amount of research has been taking place to identify the signals that a child with ASc might

[2] Wu et al. 'Eulerian Video Magnification for Revealing Subtle Changes in the World'. ACM Transactions on Graphics (Proc. SIGGRAPH 2012) 31, no. 4 (2012).

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exhibit before becoming emotionally distressed. This phase of emotional transition is sometimes known as the 'rumbling stage' or 'rumble moments', which can include covering their eyes and ears with hands, flapping, and pacing. Identification of rumble moments can assist parents, teachers, and caregivers in reducing or removing the offending stimuli where possible and to deescalate the situation before the child becomes emotionally dysregulated which is also commonly termed as a meltdown event.

In this project, an action recognition model has been implemented to detect four most common actions that that pre-empt the onset of a meltdown. These include hand biting, covering the face, head scratching and covering the ears (Figure 24 Detection of pose and actions). These actions were selected to build a proof of concept, and both the list and the model are expandable for future upgrades.

Figure 24 Detection of pose and actions

For the purpose of developing an action recognition model, MediaPipe library has been used. It is an open-source framework created by Google that allows for building ML solutions for live and streaming media. In particular, the MediaPipe Holistic pipeline has been used, which detects up to 543 points on face and body for a real time motion tracking model. Because the features and actions of the subject are stored in this manner, the collected data can be shared without compromising the identity of the subject, making the data readily shareable (Figure 25).

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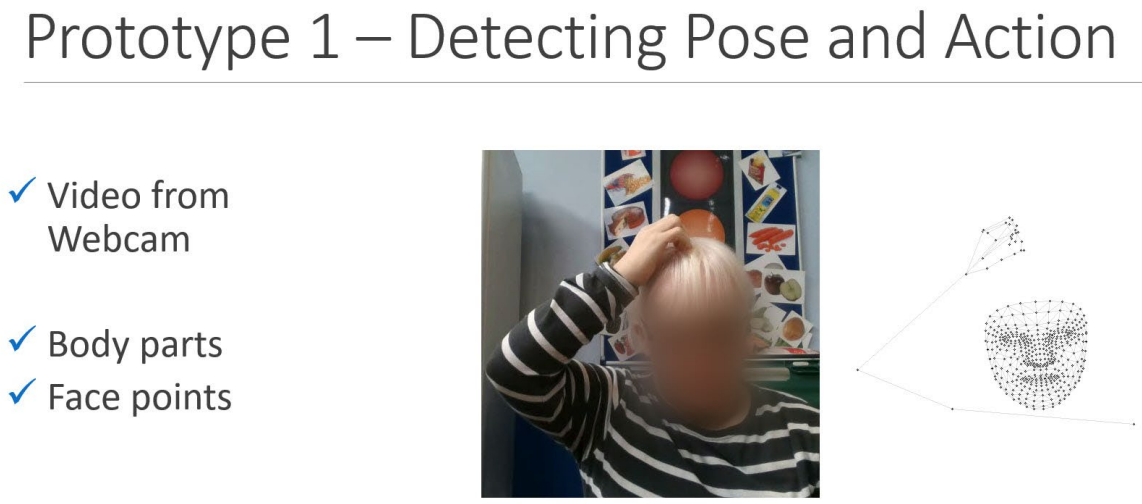

Figure 25 Point cloud creation using MediaPipe

The process of further training the model takes the labelled up segments of video, described in 6.2 Data Processing and updating the model with this additional data. In this way we can start to describe and detect a much broader range of features, as listed in 4 Observational Behavioural Checklists.

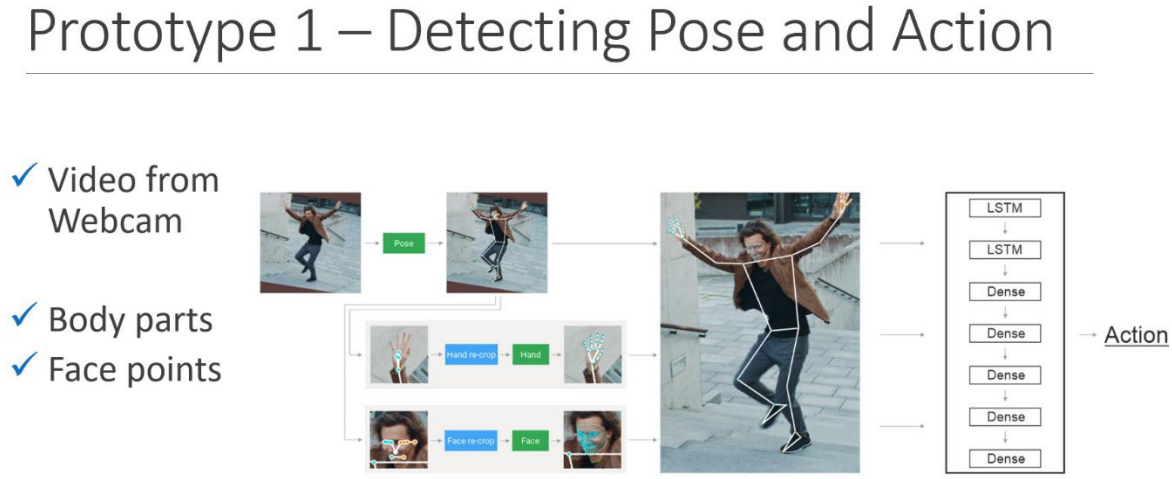

Figure 26 Detecting pose and action (body)

7.2.5 Fusion of the Data

The different inputs derived from the video, keyboard, mouse and/or touch screen are processed to provide two simple 3 state “traffic light” outputs, one looking at the student’s disposition towards their learning, and the other seeking to provide early indication of emotional dysregulation.

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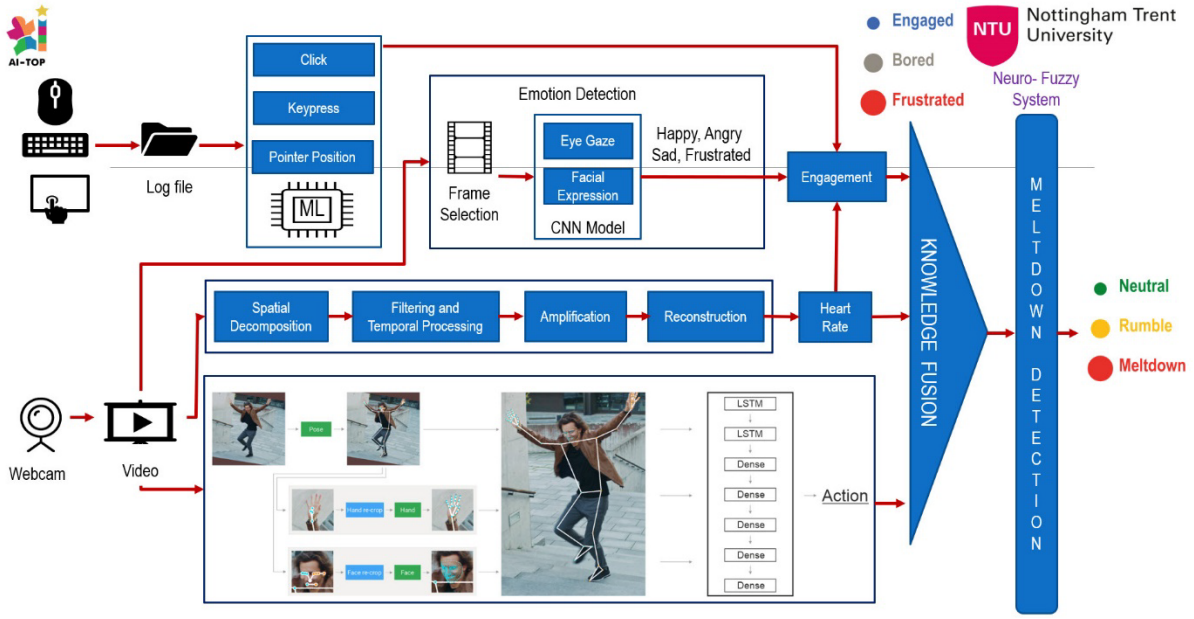

Figure 27 Data Fusion to predict engagement and meltdown from input streams

Figure 27 is a schematic describing how the different inputs are processed, to achieve the traffic light results which are subsequently sent to the teacher or carer's mobile device. User input is combined with the eye gaze, heart rate and expression data to provide an output of how engaged the student is with their learning activity. This, along with the pose and action detection, is fused and processed by a neuro-fuzzy system to present an estimate of the student's likelihood of emotional dysregulation.

7.3 The ASC Mate final prototype

Following installation buy unzipping the install folder to the local drive of your Windows laptop, and Running "main.exe", the desktop application will start. You will at first see a splash screen as shown in Figure 28. Here select I agree, and execute the program.

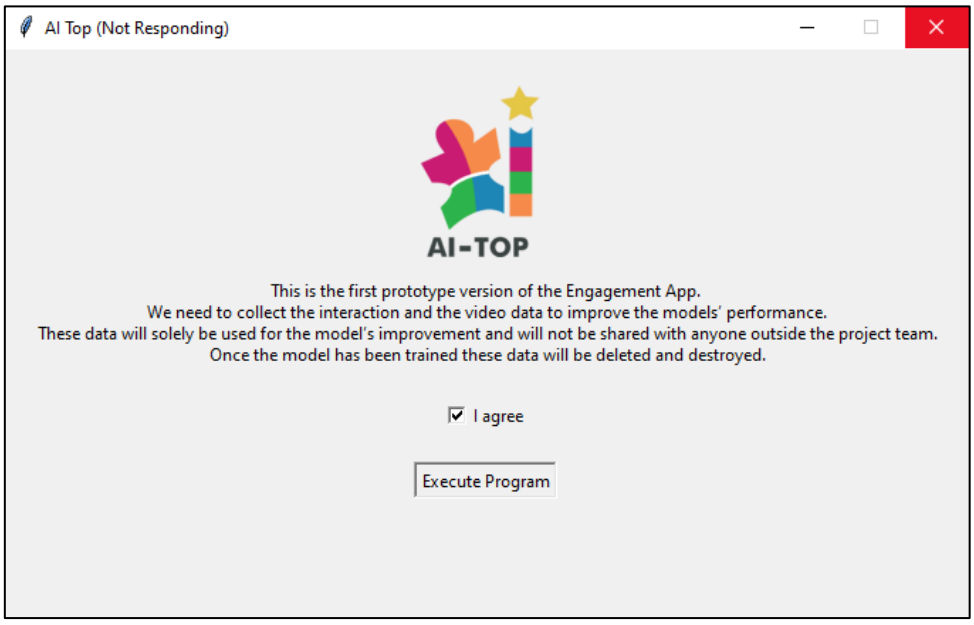

Figure 28 The ASCMate Windows application splash screen

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The app will now run the merge.exe script and begin a timer monitoring the calibration of the environment. Soon a camera feed screen will load as in Figure 30, stating that the system is initiating.

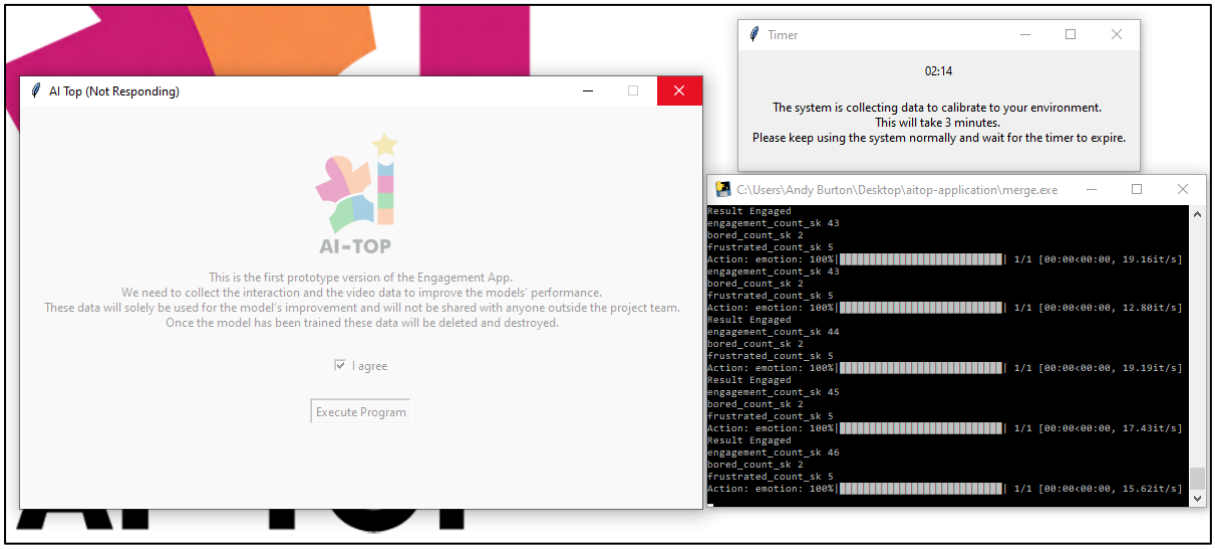

Figure 29 Capture showing the timer, merge window and whilst awaiting the camera initiation window.

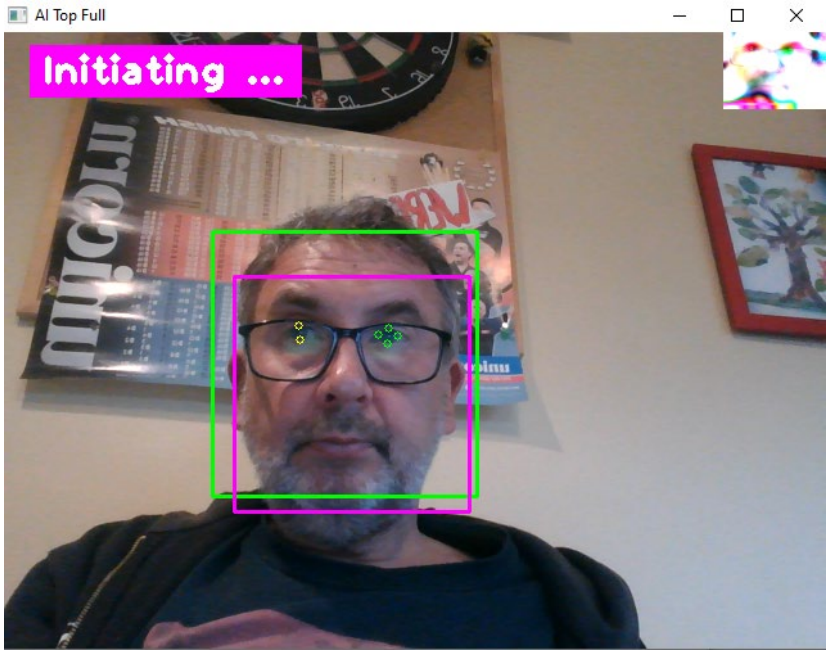

Figure 30 The Initiating window – awaiting the initial state detection of the user

Once the system calibrates successfully the camera screen will begin to show feedback as shown in Figure 31. In this case the system shows an engaged state, and also the mouse and eye tracking total movements on screen.

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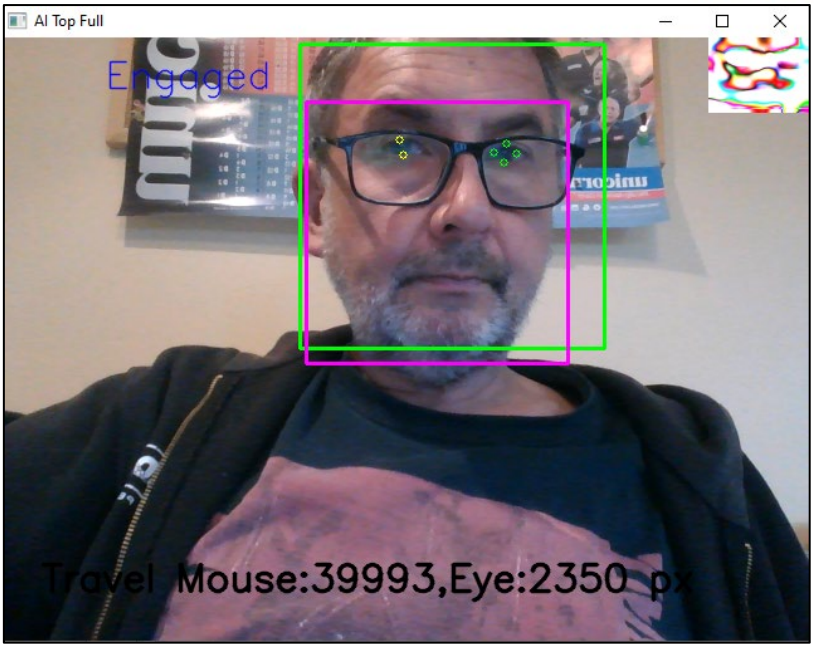

Figure 31 User states now recognised and tracking

At this point data is sent out via the Azure system and can be accessed by the Android AI-TOP Application associated with the relevant classroom.

7.4 The AI-TOP Application

The Application is the teacher facing interface, available on their mobile device which will alert them to any detected situations in the class with monitored students. The remit of the design was a simple clear interface highlighting quickly to the teacher which student an alert was for, and what type of alert it was.

This led to the development of an interface that used coloured dots to show the state of each pupil on the main screen relating to each of their behaviour and learning states, as represented in Figure 32. The states related to learning are Engaged, Bored and Frustrated. The states related to behaviour are Neutral, Rumble and Meltdown.

On receipt of a state change that the teacher should be aware of, a haptic (phone rumble) alert is generated which prompts the teacher to check the app to discover the detected issue and student. This allows the teacher a chance to intervene with pre-planned student focussed interventions to increase engagement or calm the student.

It is installed as an app currently on an Android device, but the development methodology allows porting to Apple devices also.

Annex 8 describes the initial technical proposal and implementation for AI-TOP mobile application, which will be reviewed following the piloting phase in Output 3. An improved version based on piloting feedback will be developed towards the end of the project.

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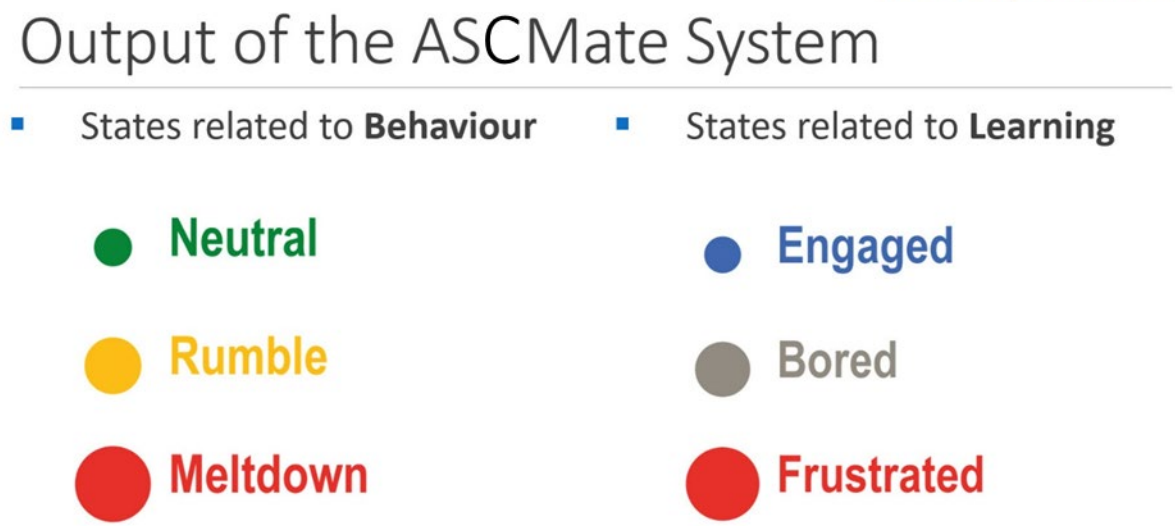

Figure 32 Output states delivered by the mobile app from ASCMate

Following installation of the app, starting reveals a splash screen for the project followed by a login page. The teacher must enter a pre-determined classroom ID which their students are already linked to in the ASCMate desktop application. On selection of the correct classroom, the app will display current states for learning and behaviour for each registered child. The app uses haptic rumble to alert the teacher to any ongoing suggested interventions and the teacher can then view the summary page of class states as shown in Figure 33. Selecting an individual student from the list gives a further breakdown of the stats that have caused the alert to be sent.

Teachers should refer to the AI-TOP handbook to identify and plan interventions that they may use for each student based in individual requirements they may have. There is a need to have this planned in advance as the app offers no guidance on specific interventions – just an early warning system.

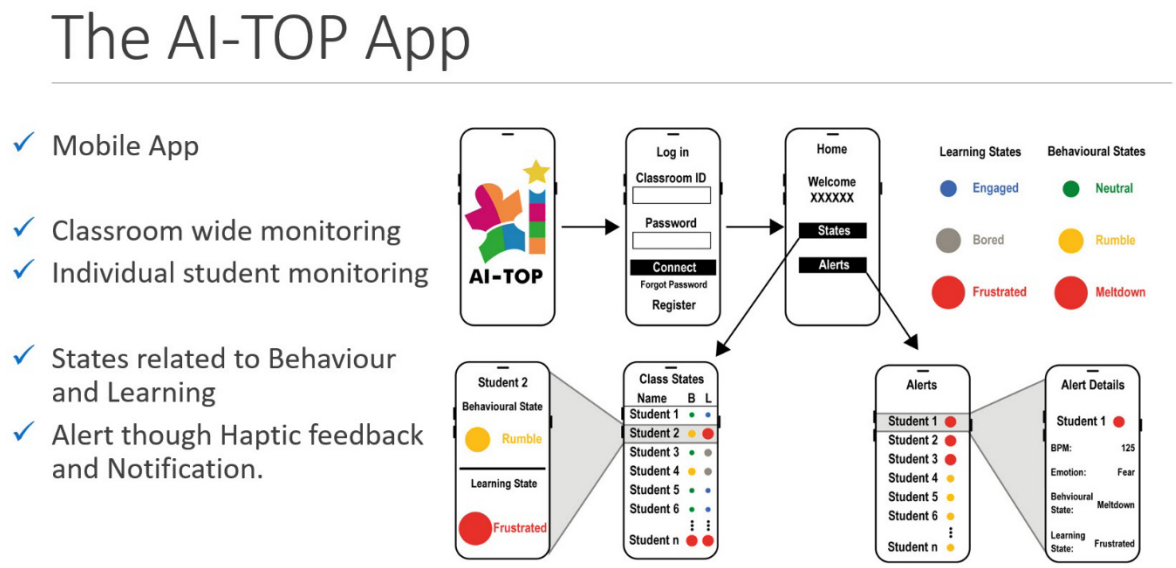

Figure 33 Summary of the app

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8 Further Reading and Contact information

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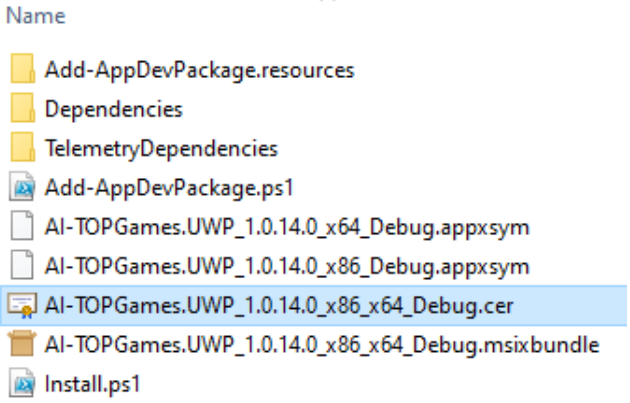
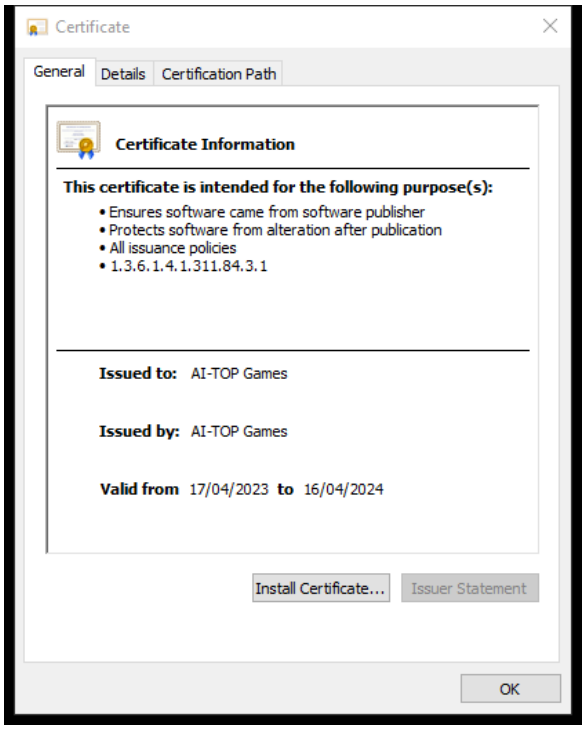
Annex 1 Software Installation (Data Collection Phase)

a) Installation of the AI-TOP Transferred Games (CPTs)

1. Double click on the certificate file to install it (the one that end .cer)



2. Click **Install Certificate**



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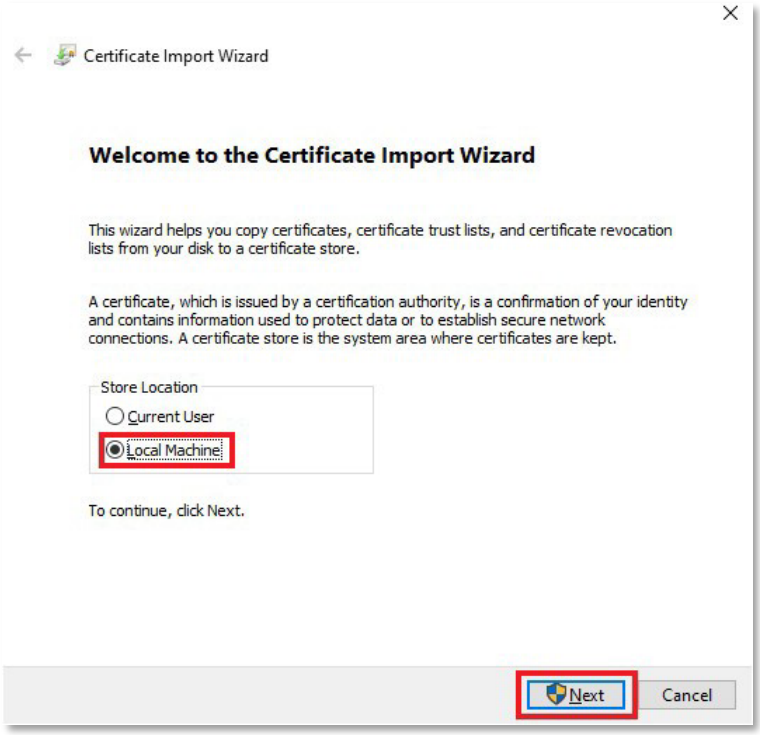
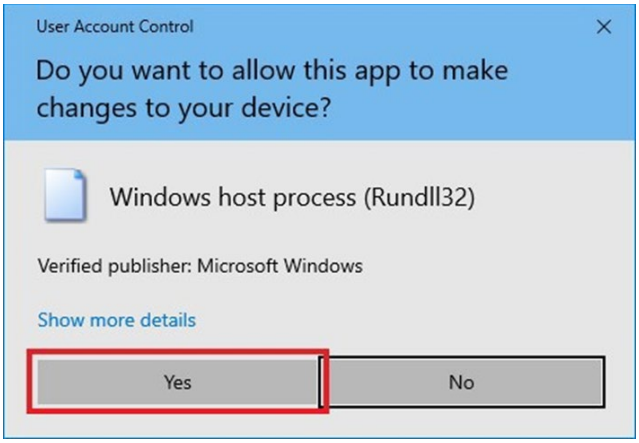
3. Select **Local Machine**, and click **Next**



4. Click **Yes**



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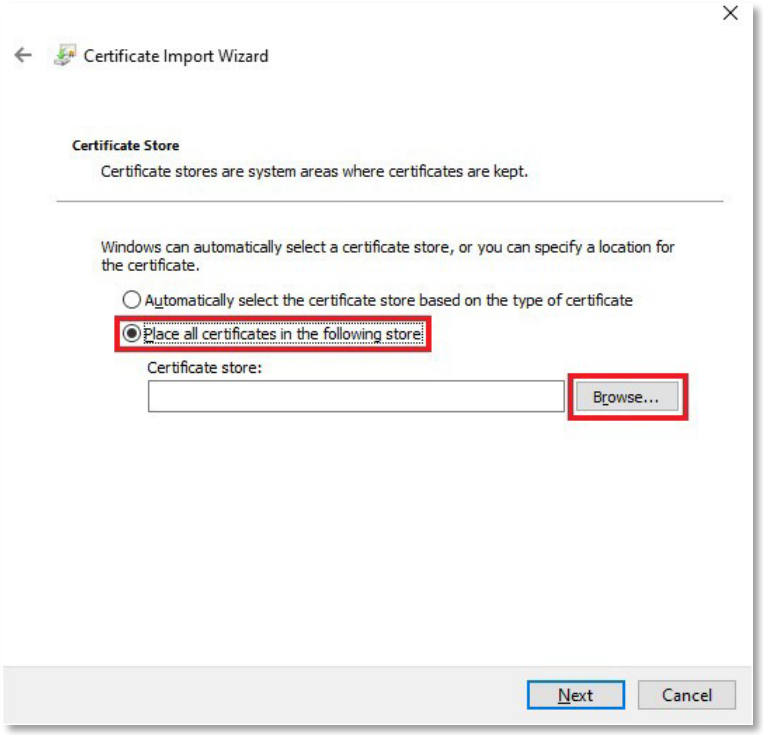
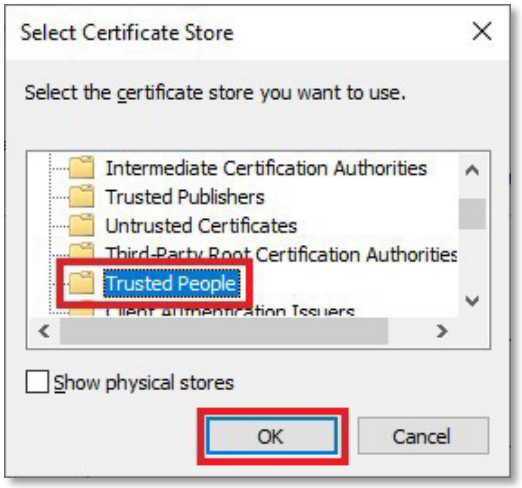
5. Select **Place all certificates in the following store** and click **Browse...**



6. Select **Trusted People** folder, and click **OK**



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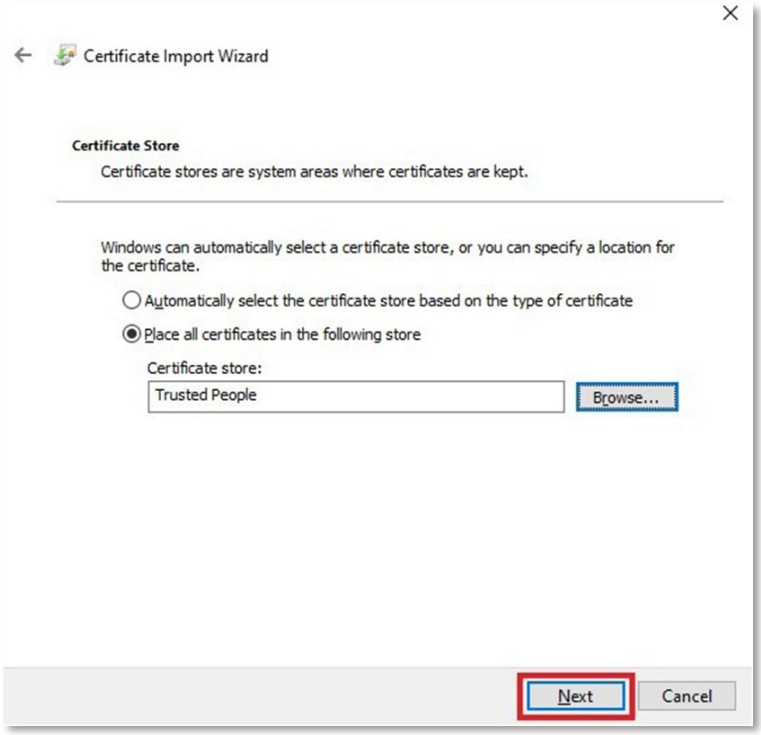
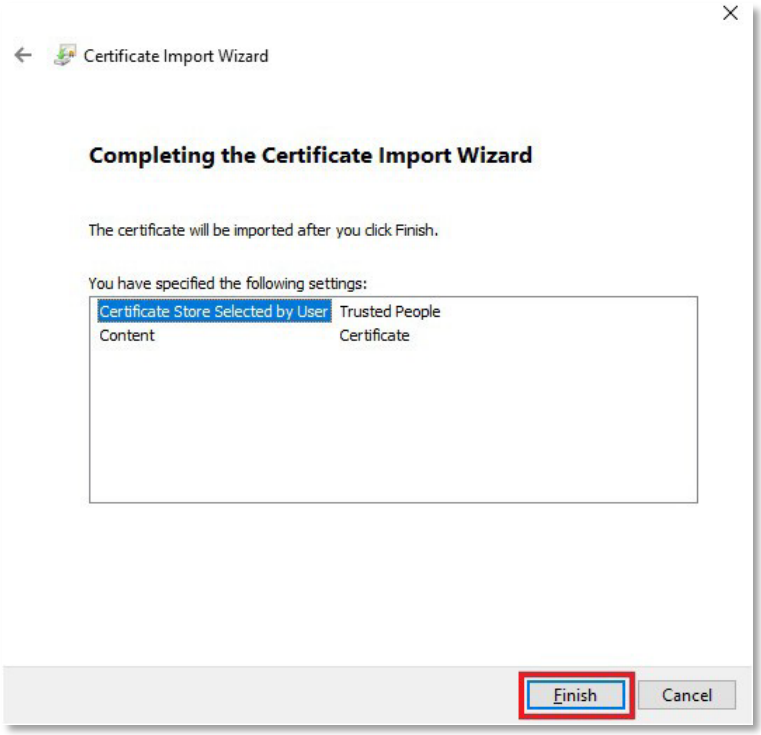
8. Click **Next**



9. Click **Finish**



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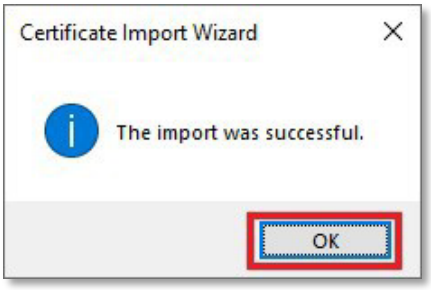
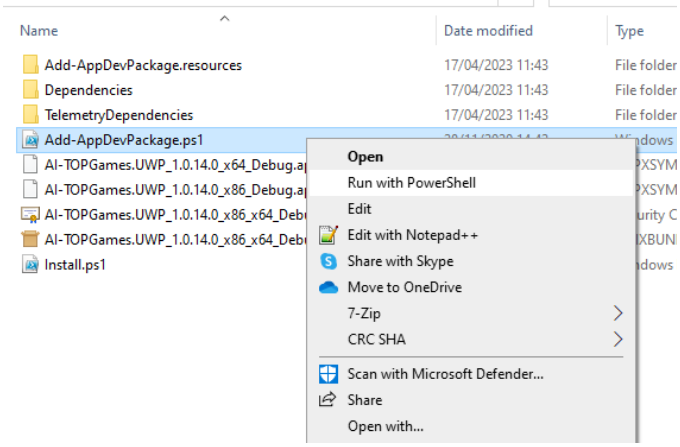
10. A popup will display with a message that the import was successful. Click **OK**



Certificate is installed. Now we can install the application.

11. Right mouse click on **Add-AppDevPackage.ps1** and select **Run with PowerShell** in the context menu



12. When the PowerShell window opens, it may ask, “Do you want to run software from this untrusted publisher”, If so, type R and press **Enter.**

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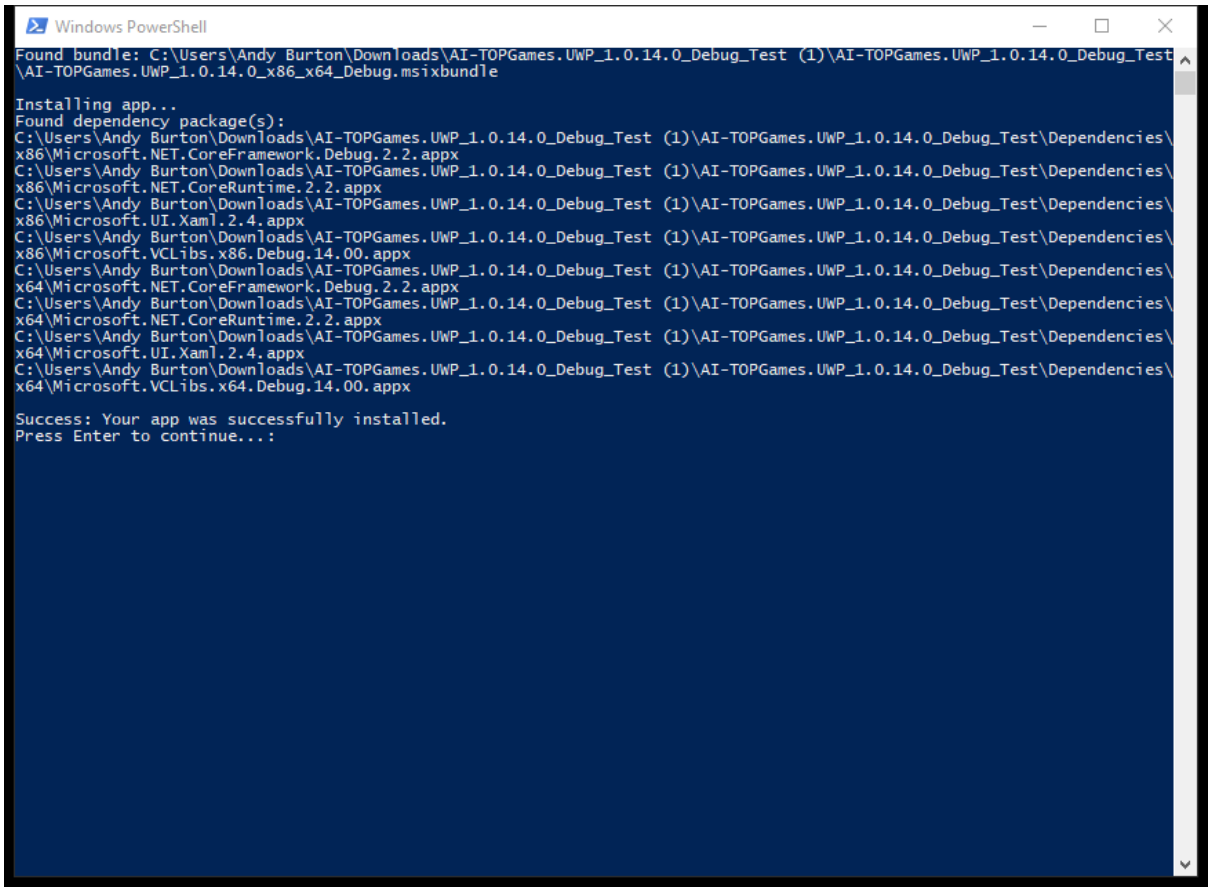
13. **It may ask the same question again, if so T**ype **R** again and press **Enter**



Finally press enter to quit PowerShell. You have now installed the AI-TOP application and all of its dependencies.

You can find the AI-TOP application in Start menu, click on the Windows Start button and type or select “AI-TOP Games”.

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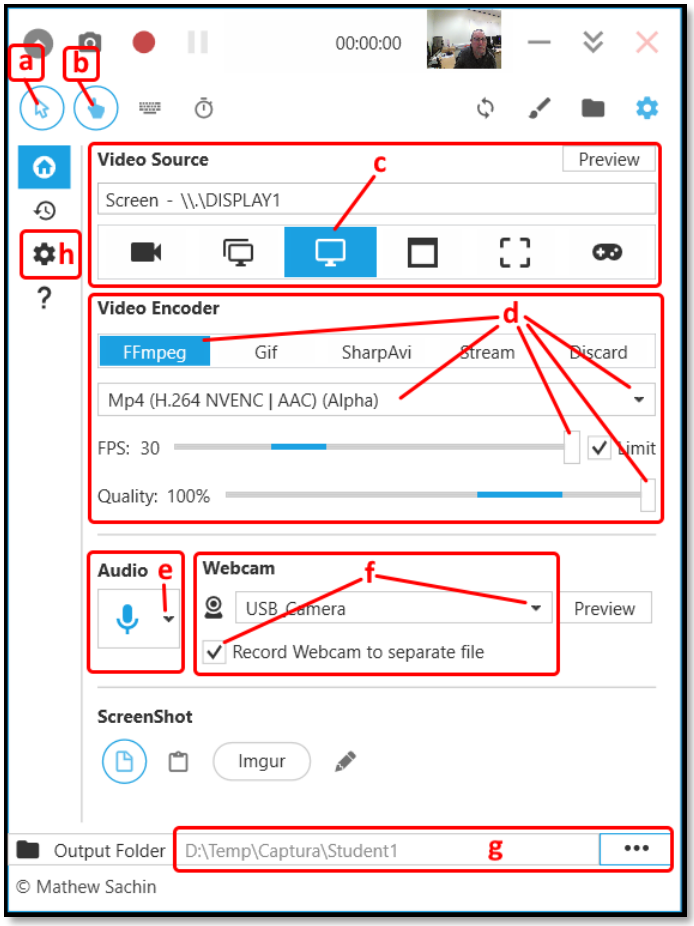
b) Installation of the Software for Data Collection

1. Download *Captura-Portable.zip* from MS Teams IO2 folder.
2. Extract Captura-Portable.zip into a local folder.
3. The app can be started by clicking on ***'captura'*** in the folder where you unzipped it. You may wish to add a desktop shortcut for convenient quick start-up. (Right click on the ***captura*** icon, select create a shortcut, then drag the shortcut to your desktop)
4. Set up Captura from the main screen as follows:
   a. Select *"Include Cursor"*.
   b. Select *"Include Mouse Clicks"*.
   c. Video Source
      → Select the screen you want captured.
   d. Video Encoder
      → Select the *FFmpeg* tab.
      → Select *"Mp4 (H.264 NVENC | AAC) (Alpha)"* from the dropdown list. *
      → Set *FPS* slider to 30.
      → Set *Quality* slider to 100%.
   e. Audio - Select all from the first section.
      (Don't select the last 2 items: *Playback recorded audio in real-time / Separate files for every audio source*).
   f. Webcam
      → Select your webcam from the dropdown.
      → Check *"Record Webcam to separate file"* (you should see a tiny webcam image at the top of the controls).



   g. Output Folder
      → Browse to select an appropriate folder to store the video (could be a removable USB stick, for example).
   h. Configure:
      → Set up timings if you want (e.g. a delay before start). Don't set a capture duration.
      → Select *"Minimize on Capture Start"*.
5. To Record **
   a. Click the red dot to start recording (it will turn into a square).
   b. Click the red square to stop recording.
   c. Or use [Alt]+[F9] to start and stop recording.

Minimise the Captura screen, you are ready to start recording – do a test before using with students.

* If the recording crashes, select "*Mp4 (x264 | AAC)*"

** If you want to play the videos back you can use something like VLC (https://www.videolan.org/vlc/)

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Annex 2: Paper-based register

Real Name	Learner ID in App	Hardest game they can play (Type-X, Seek-X, …)	Number of sessions

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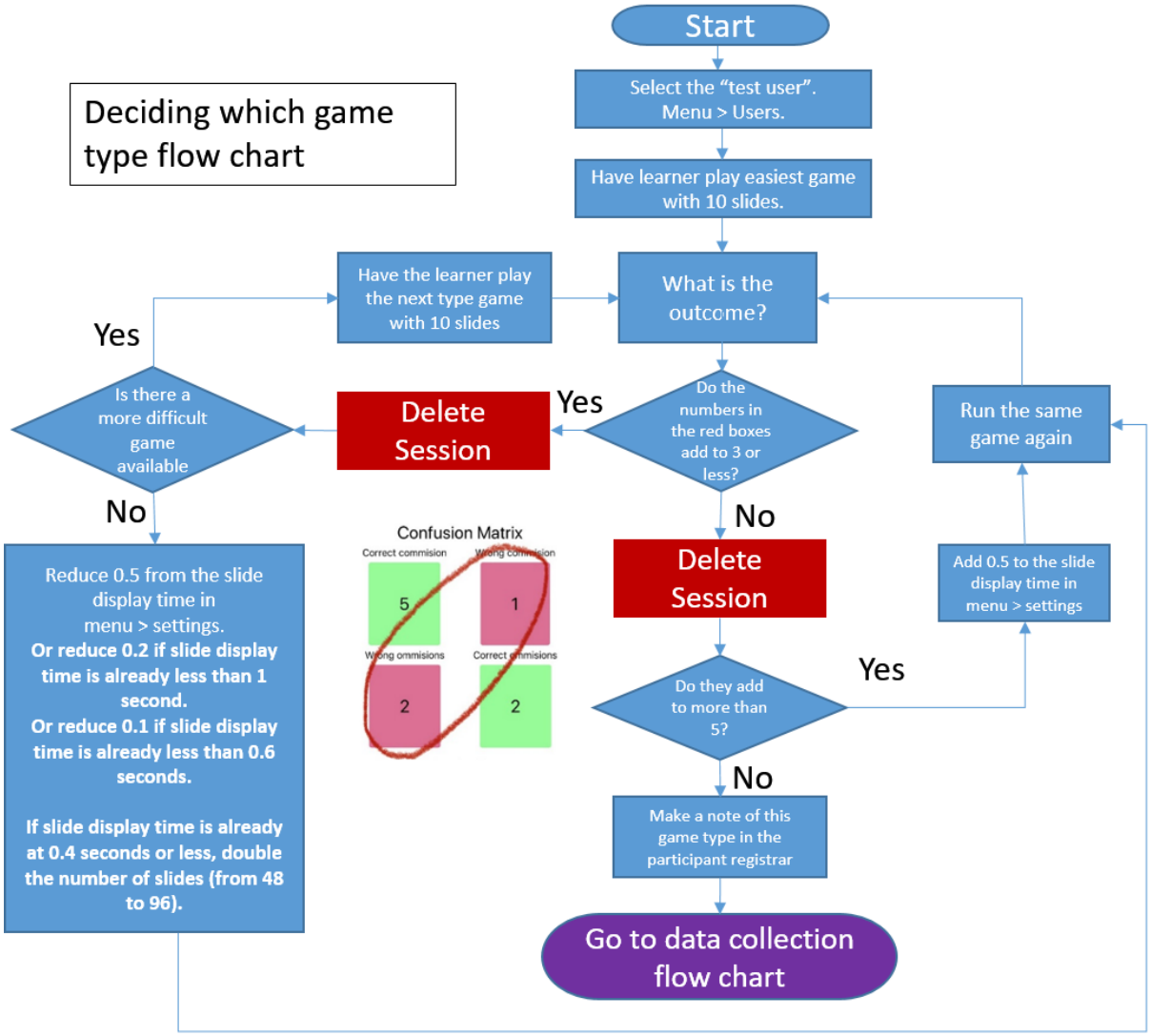
Annex 3: Deciding which game type.



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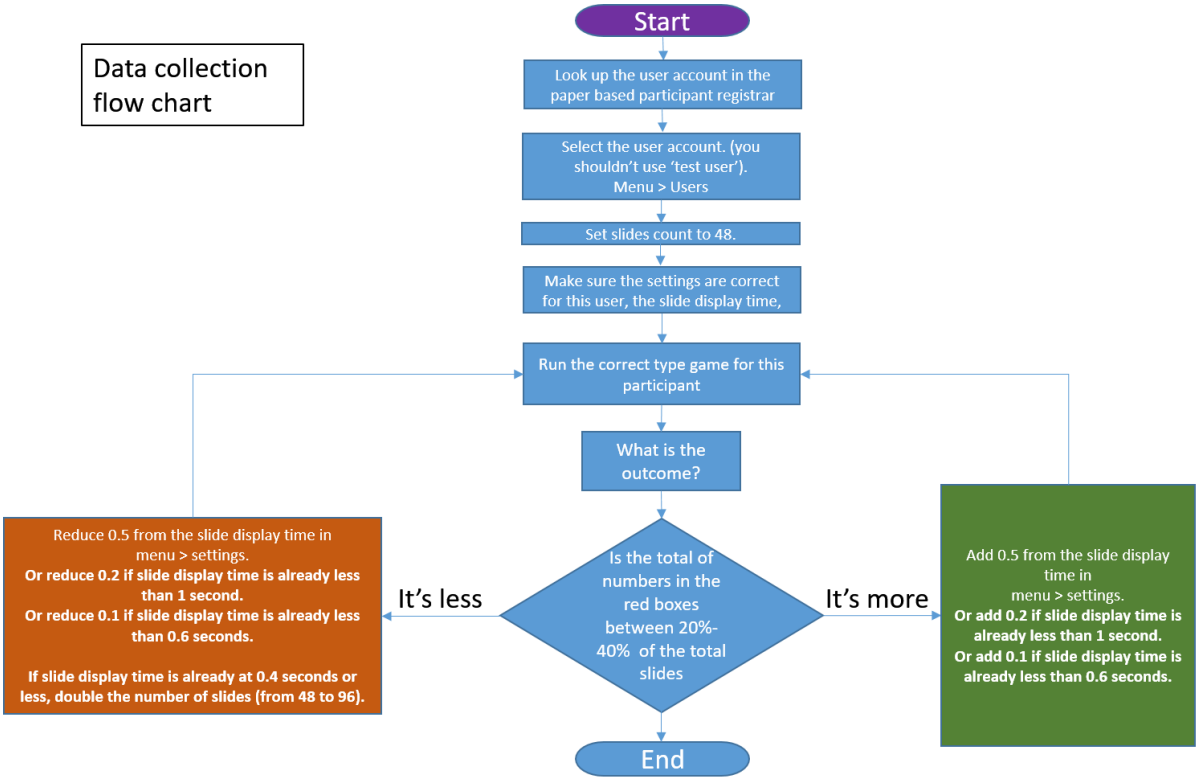
Annex 4: Data Collection Flow Chart



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Annex 5: Paper based games.

To be printed out in colour – to help to explain the game rules to each child.

This is Casey the cat

This is Berry the dog

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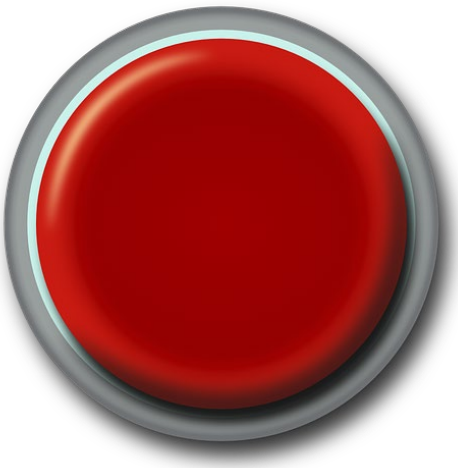
This is the Green backpack 1

Red button



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Type X game, target slide

Reward slide. Well done!

Type X game, distractor slide

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Seek X game, target slide

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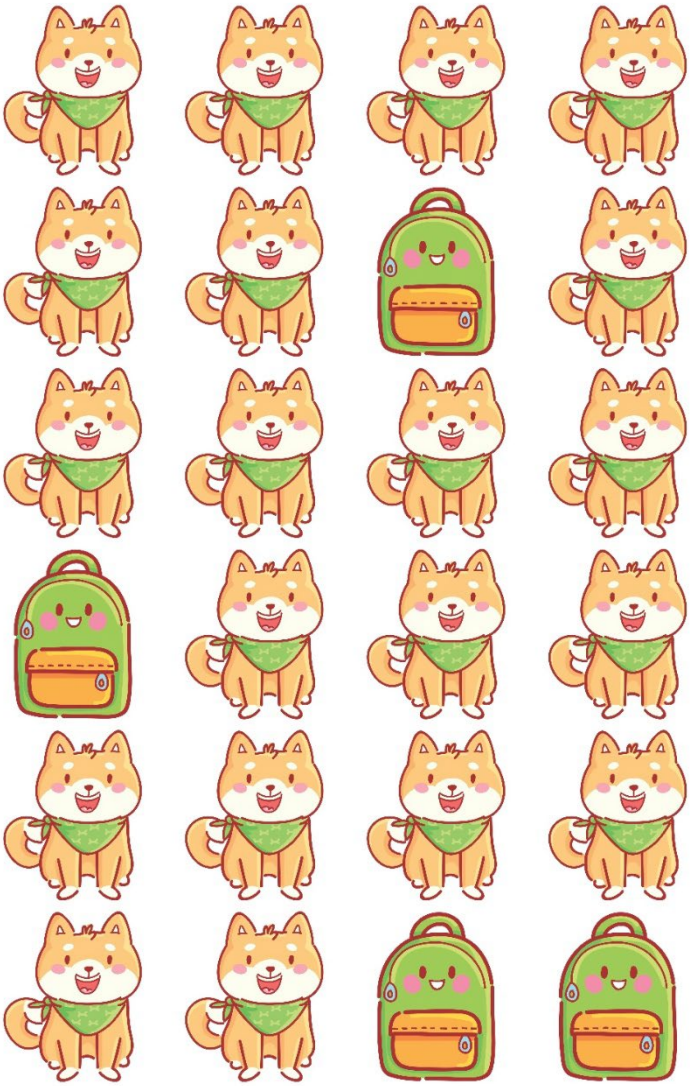
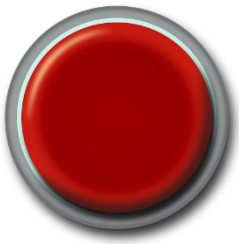
Seek X game, distractor slide





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Annex 6: Data Collection and Piloting Ethics Documents

Study Description for Children with ASC

AI-TOP – A study to create an engagement tracking and rumble moment prediction technology for students with Autism Spectrum Condition (ASC)

We will be watching how much you are enjoying your work with a camera, and listening to how fast your heart is going with a smart watch. By doing this, we can learn what the signs are that you are happy or sad in the classroom.

Then we will make a phone app which can guess when you are starting to get sad, or need a rest, or want to change what you are doing before you get too cross.

What is the purpose of this study?

We want to make something that can spot when you are starting to feel sad or uncomfortable before you get cross or upset, so that you can be given something else to do that will calm you down, like going to a quiet place, reading or listening to music.

What will I be expected to do if I take part?

All you have to do is do what you normally do at school, or sometimes we might ask you to play a computer game. There will be a camera watching you, and a watch if you can wear one comfortably. We will do it in your classroom or in a nearby room or space with people you know from school.

Will my taking part in the study be kept confidential?

We won't give any of the videos we take to anybody else – they will just be used by us to make the app to help you in school. We will never use your name in anything we write.

What will happen if I don't want to carry on with the study?

If you decide you want to stop doing any of the things we have asked, or need to take off the watch – you just need to tell us - or tell your teacher and you can stop straight away. We won't make you do anything you don't want to do, and your teachers will still be around to help you.

What will happen to the results of the research?

We might write about what we found out by working with you, but we will never tell anyone your name.

Thank you.

Andy

Contact Information
Dr. Andy Burton
E-mail: removed

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Nottingham Trent University
Research Fellow

Study Description for Over 18s with ASC

AI-TOP – A study to create an engagement tracking and rumble moment prediction technology for students with Autism Spectrum Condition (ASC)

Tracking a student's engagement with their learning and prevention of meltdown events has the potential to increase effective learning. A technology which could alert the you or a carer to signs of low engagement or early signs of a meltdown event could allow you to implement strategies to mitigate events. AI-TOP aims to develop this technology. To help you decide whether to take part, this sheet explains why the research is being done and what it would involve for you. Please kindly take the time to read the following information.

What is the purpose of this study?

People with ASC and the people surrounding them often face challenges in dealing with the wide variety of learning needs. The challenge of this project is to use sensor data which may include eye-gaze, facial expressions, heart rate, skin temperature and body posture as indicators, for gauging the engagement of participants, and for the prediction of rumble moments and meltdown events. This could in turn assist in the creation of personalised learning pathways, to ensure all students with ASC reach their full potential.

It is intended that an array of sensors will be used, selected from many possible available devices including smart watches, phones, iPads, wristbands, chest straps, cameras and eye trackers. These devices can measure a wide range of physiological, movement and visual data including heart rate variation, movement data, eye gaze, electrodermal activity and body pose. A machine learning algorithm will be developed to find the correlations between the fused sensory data, attention levels and rumble moments.

If successful, the technology will alert you or a nominated person to intervene using various approaches including calming measures - to maintain attention and engagement or to prevent rumble/meltdown events before they happen.

Testing and review will follow the principles of an iterative quality circle, in that the initial versions of the database, the developed app, the user manual/handbook, and the pedagogical framework will be thoroughly tested by a selected group of users (alpha testing), while beta testing will involve all identified pilot users. This will allow the revision of these outputs in response to the collected feedback, and the final outcome will be an optimised set of project outcomes and O3: Optimisation of Autism Engagement and Meltdown Framework.

We are testing in schools and envisage 30 teachers/country, from special/inclusive educational settings for students with autism. The UK. Bulgaria, Belgium, and Greece sites will be involved in running studies. We are also testing with parent/child dyads.

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Key performance indicators will be as follows:

• Active Participation of Target Groups

• Effectiveness of results

• Usability

What will I be expected to do if I take part?

Researchers at NTU and our partner organisations in the project will be gathering data from students on the autism spectrum by having them wear and be tracked by sensor devices including cameras and physiological data. The data will be correlated with expert analysis (to be given by the teachers/parents/carers involved in the study) of when rumble/meltdown/engagement events happened to train an explainable artificial intelligence machine learning model. This model will then be used in the second phase of the project to predict rumble and meltdown events in order to allow for quick interventions to prevent them from occurring.

We are working to establish which technologies and sensors are most appropriate, useful and acceptable for you to use, to identify practical limitations and barriers in the implementation of these sensors and technologies in a real-life environment, and to identify the potential benefits which can be gained by the implementation of such technologies.

Where/how will the experiment take place?

We are flexible about your participation, and will endeavour to equip participants with sensors that they can tolerate without issue, but that will provide the most complete set of data for our algorithm to use. We are aware that not all participants will tolerate all types of sensors, and so have developed a flexible system which is able to take sensor inputs from a number of different sources. The experiment will be carried out within the child's normal classroom in school, or at home if working with a parent/carer.

Will it cost me anything to take part?

It will not cost you anything to take part. All costs are covered from the research budget. Equipment will be supplied but will need to be returned following completion of your participation.

Will my taking part in the study be kept confidential?

Yes. We will follow established ethical and legal practices and all information about you and your school/organisation will be handled confidentially. All information which is collected about you during the study will be kept strictly confidential and any information about you will have your name and identity removed prior to any analysis or publication of results so that you cannot be identified.

What data will be collected?

During the study data will be collected including video streams and physiological data (which may include galvanic skin response, heart rate variability, heart rate, etc depending on the devices used in each case). The data will be timestamped to allow correlation with events regarding, rumble, meltdown and engagement. Following labelling of the data, the labelled data will be used to create an explainable algorithm which will later be used to try and predict events and states of the students in the classroom.

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Your informed consent will be requested for all the data collected in the study. For publication, all data will be anonymized and no records of name, or data leading to the identification of the participants will ever be made public.

What will happen if I don't want to carry on with the study?

Your participation is voluntary and you are free to withdraw up to 2 weeks after the experiment takes place, without giving any reason and without your legal rights being affected. If you withdraw the information collected from you will be destroyed.

What will happen to the results of the research?

It is intended that the results of the research will be published formally in scientific journals and published in end user community communications. You will not be identified in any report or publication.

Our genuine thanks for your time in reading this information pack.

Contact Information
Dr. Andy Burton
E-mail: removed
Nottingham Trent University
Research Fellow

Study Description for Teachers, Parents and Carers

AI-TOP – A study to create an engagement tracking and rumble moment prediction technology for students with Autism Spectrum Condition (ASC)

Tracking a student's engagement with their learning and prevention of meltdown events has the potential to increase effective learning in schools. A technology which could alert the teacher to signs of low engagement or early signs of a meltdown event could allow the teacher to implement strategies to mitigate events in the classroom. AI-TOP aims to develop this technology. To help you decide whether to take part, this sheet explains why the research is being done and what it would involve for you. Please kindly take the time to read the following information.

What is the purpose of this study?

Teachers often face challenges in dealing with the wide variety of learning needs in inclusive classrooms that include students with autism spectrum disorder. The challenge of this project is to use sensor data which may include eye-gaze, facial expressions, heart rate, skin temperature and body posture as indicators, for gauging the engagement of students, and for the prediction of rumble moments and meltdown events. This could in turn assist in the creation of personalised learning pathways, to ensure all students with ASC reach their full potential.

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It is intended that an array of sensors will be used, selected from many possible available devices including smart watches, phones, iPads, wristbands, chest straps, cameras and eye trackers. These devices can measure a wide range of physiological, movement and visual data including heart rate variation, movement data, eye gaze, electrodermal activity and body pose. A machine learning algorithm will be developed to find the correlations between the fused sensory data, attention levels and rumble moments.

If successful, the technology will alert the teacher who will then be able to intervene using various approaches including modified teaching techniques, learning material, classroom setups and environmental factors - to maintain attention and engagement or to prevent rumble/meltdown events in the classroom before they happen.

Testing and review will follow the principles of an iterative quality circle, in that the initial versions of the database, the developed app, the user manual/handbook, and the pedagogical framework will be thoroughly tested by a selected group of users (alpha

testing), while beta testing will involve all identified pilot users. This will allow the revision of these outputs in response to the collected feedback, and the final outcome will be an optimised set of project outcomes and O3: Optimisation of Autism Engagement and Meltdown Framework.

We envisage 30 teachers/country, from special/inclusive educational settings for students with autism. The UK. Bulgaria, Belgium and Greece sites will be involved in running studies.

Key performance indicators will be as follows:

• Active Participation of Target Groups

• Effectiveness of results

• Usability

What will I be expected to do if I take part?

Researchers at NTU and our partner organisations in the project will be gathering data from students on the autism spectrum in the classroom by having them wear and be tracked by sensor devices including cameras and physiological data. The data will be correlated with expert analysis (to be given by the teachers and parents/carers involved in the study) of when rumble/meltdown/engagement events happened to train an explainable artificial intelligence machine learning model. This model will then be used in the second phase of the project to predict rumble and meltdown events in order to allow for quick intervention by staff to prevent them from occurring.

We are working to establish which technologies and sensors are most appropriate, useful and acceptable for you and your students to use in the classroom, to identify practical limitations and barriers in the implementation of these sensors and technologies in a real-life school classroom environment, and to identify the potential benefits which can be gained by the implementation of such technologies.

Where/how will the experiment take place?

We are flexible about your participation, and will endeavour to equip participants with sensors that they can tolerate without issue, but that will provide the most complete set of data for our algorithm to use. We are aware that not all students will tolerate all types of sensors, and so have developed a flexible system which is able to take sensor inputs from a number of different sources. The

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experiment will be carried out within the child's normal classroom in school, or at home if working with a parent.

Will it cost me anything to take part?

It will not cost you anything to take part. All costs are covered from the research budget. Equipment will be supplied but will need to be returned following completion of your participation.

Will my taking part in the study be kept confidential?

Yes. We will follow established ethical and legal practices and all information about you and your school/organisation will be handled confidentially. All information which is collected about you during the study will be kept strictly confidential and any information about you will have your name and identity removed prior to any analysis or publication of results so that you cannot be identified.

What data will be collected?

During the study data will be collected including video streams and physiological data (which may include galvanic skin response, heart rate variability, heart rate, etc depending on the devices used in each case). The data will be timestamped to allow correlation with events regarding, rumble, meltdown and engagement. Following labelling of the data, the labelled data will be used to create an explainable algorithm which will later be used to try and predict events and states of the students in the classroom.

Your informed consent will be requested for all the data collected in the study. For publication, all data will be anonymized and no records of name, or data leading to the identification of the participants will ever be made public.

What will happen if I don't want to carry on with the study?

Your participation is voluntary and you are free to withdraw up to 2 weeks after the experiment takes place, without giving any reason and without your legal rights being affected. If you withdraw the information collected from you will be destroyed.

What will happen to the results of the research?

It is intended that the results of the research will be published formally in scientific journals and published in end user community communications. You will not be identified in any report or publication.

Our genuine thanks for your time in reading this information pack.

Contact Information
Dr. Andy Burton
E-mail: removed
Nottingham Trent University
Research Fellow

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Consent Form (Data Collection and Piloting Stage) Adult

I, the undersigned, confirm that (please tick box as appropriate):

1.	I have read and understood the information about the project, as provided in the Information Sheet dated _____.	☐
2.	I have been given the opportunity to ask questions about the project and my participation.	☐
3.	I voluntarily agree to participate in the project.	☐
4.	I understand I can withdraw at any time without giving reasons and that I will not be penalised for withdrawing nor will I be questioned on why I have withdrawn.	☐
5.	I agree to video, audio and physiological data being collected during the research experiment.	☐
6.	The procedures regarding confidentiality have been clearly explained to me. (e.g. use of the recordings and data, names, pseudonyms, anonymization of data, etc.)	☐
7.	The use of the data in research, publications, sharing and archiving has been explained to me.	☐
8.	I understand that other researchers will have access to this data only if they agree to preserve the confidentiality of the data and if they agree to the terms I have specified in this form.	☐
9.	I, agree to sign and date this informed consent form.	☐

Participant:

_____	_____	_____
Name of Participant	Signature	Date

Researcher:

_____	_____	_____
Name of Researcher	Signature	Date

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Consent Form (Data Collection and Piloting Stage) Under 18

I, the undersigned, confirm that (please indicate Y (Yes), or N (No):

1.	I have read and understood the information about the project, as provided in the Information sheet.	
2.	I have been given the opportunity to ask questions about the project and my participation.	
3.	I voluntarily agree to participate in the project.	
4.	I understand I can withdraw at any time up to two weeks following my participation without giving reasons and that I will not be penalised for withdrawing nor will I be questioned on why I have withdrawn.	
5.	The procedures regarding confidentiality have been clearly explained to me. (e.g. use of names, pseudonyms, anonymisation of data, etc.)	
6.	Terms of consent for audio, video, physiological or other forms of data collection have been explained and provided to me.	
7.	The use of the data in research, publications, sharing and archiving has been explained to me.	
8.	I understand that other researchers will have access to this data only if they agree to preserve the confidentiality of the data and if they agree to the terms I have specified in this form.	
9.	I, along with the Witness/Parent or Guardian, agree to sign and date this informed consent form.	

Participant:

_____	_____	_____
Name of Participant	Signature	Date

Parent/Guardian (if under 18) or Witness:

_____	_____	_____
Name	Signature	Date

Researcher:

_____	_____	_____
Name of Researcher	Signature	Date

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Annex 7: Steps for Data Labelling

Andy Burton & Nick Shopland (NTU)

Setup of secure drive

To gain access contact jane.bonnell@ntu.ac.uk who will get you added to the list of people with access to the secure AI-TOP drive. (cc david.brown@ntu.ac.uk who is the ultimate owner of the project)

Ideally use a windows platform and map your drive (\\10.55.2.3\Research_Cty\AI-Top or \\ads.ntu.ac.uk\research$\AI-Top) as Z.

We will use Z:/ as this mapped location and the convention {NAME} to stand for **your name**.

Setup of VIA page

Open VIA

From the Z drive root open “via_video_annotator.html”. NB: Use of a **Chrome based** browser is recommended as some videos do not show correctly in Firefox.

Adding label set

Select the folder icon ( )“Open a VIA Project” is the tooltip.

Navigate to “Z:/via config files/AI-Top VIA Project-D.json”

Hit open. This loads the correct label set into VIA.

Adding video sets

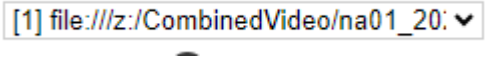
Select bulk add file icon. ( )

Make sure File Type is “Video”

Click the “Choose File” button below “Import URI from a File”

Navigate to “Z:/allocation for labelling/{NAME}/ and select {NAME}.txt.

You should now have all the videos which have been allocated to you available from the dropdown panel, e.g. :



If you use a different OS, or cannot map to the Z drive, then you will need to edit the {NAME}.txt” file to reflect the mapping or smb share that gives you access to the files.

Labelling the videos

Select a video to label from the dropdown.

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Play the video until you see a feature you wish to label, and hit pause (Hint: space bar can be used to play and pause video)

Select the track line (1,2 or 3) on which you want to record the event.

If necessary, drag the timeline slider back to the start of the event.

Hit “A” key to add an event on the timeline.

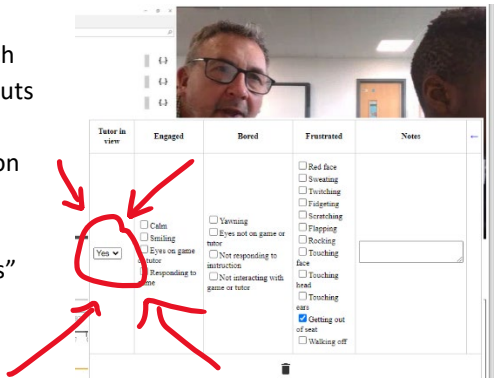
Select the event with the mouse.

Drag the right-hand end of the bar to the end of the event.

Label the event by:

a) Select the appropriate checkbox (or checkboxes) that label the event.
b) IMPORTANT: FOR EVERY EVENT that you log - use the left-hand dropdown to select whether the tutor is in view.

This important step will allow us to filter out events which have the tutor in view which could skew certain ML outputs depending on the approach used.
Click off your current event (clicking outside your event on the label line), and it will save your entry.
Continue labelling more events as above.
For any further info/other possible labels, use the “Notes” text field



Don’t modify the configuration of the data labels.

To save your current work, use the disk icon ( ), select “Save as” (if necessary) and save your progress in the “Z:/allocation for labelling/{NAME}/” folder. The file naming contains the date and time, so you don’t need to give it a particular name each time. You can use the latest save from this location to resume labelling.

A full list of shortcuts is available by clicking ( ); these are also in a document at Z:/VIA Keyboard Shortcuts.docx

Exporting labels of labelled video

Once you have finished labelling, click the import/export button ( ).

Select Export Format: [Only Temporal Segments as CSV]

Click Export button.

Save the file in the folder “Z:/Label Exports” adding {NAME}_ to the start of the file name.

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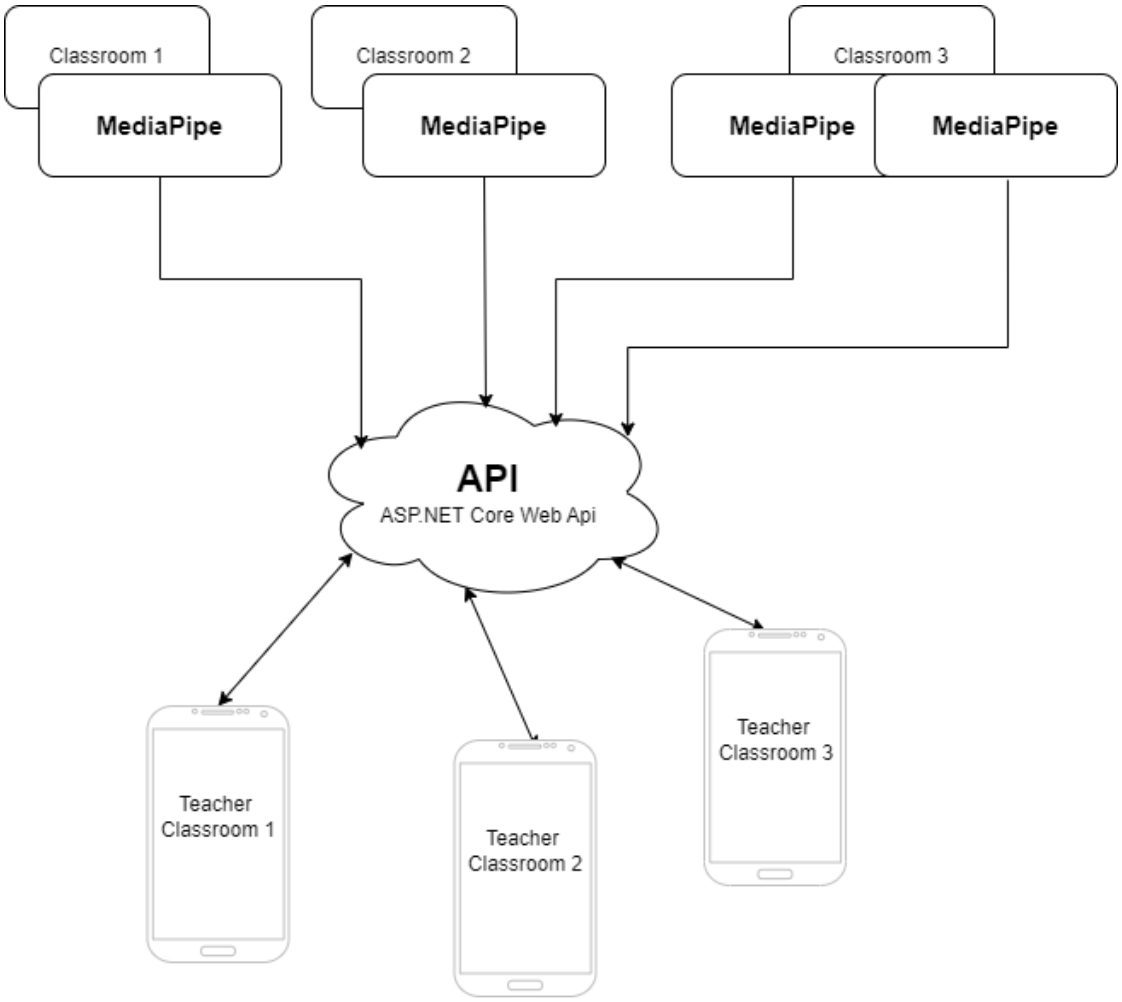
Annex 8 - Technical proposal for AI-TOP mobile application

The following represents the initial technical proposal from SoftQNR on the delivery of the mobile application.

Please find below the proposed high-level architecture:



Following the above figure, the following flow will be implemented.

1. There will be API (*ASP.NET Core Web API*) hosted on Azure.
2. MediaPipe will consume this API remotly, sending data for each student (separate instances of MediaPipe) whenever some a change occurs.
3. Data sent to the remote API will be in JSON format, as follows:

```
{
  "studentId": 0,
  "studentName": "string",
  "classId": "string",
  "behaviouralState": 0,
  "learningState": 0,
  "heartRate": 0,
  "emotionalState": "string"
}
```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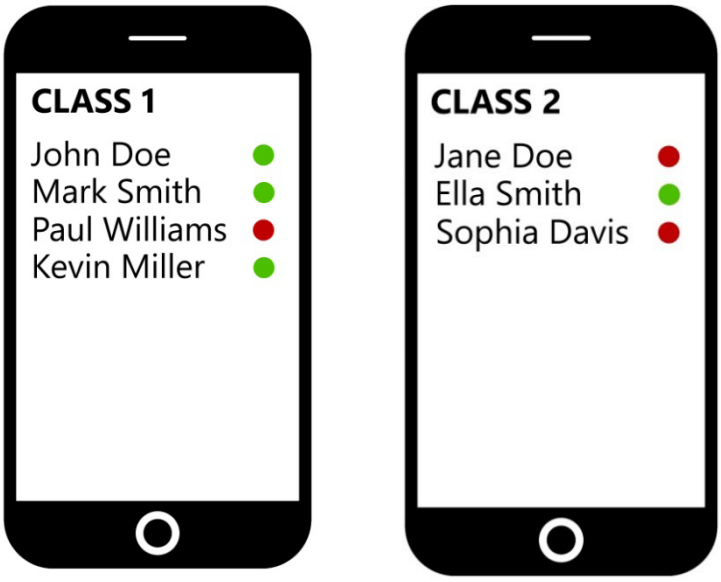
4. When a message received from MediaPipe, the remote API will forward this information to each subscribed mobile application that has matching class Id.
5. Subscriber can be any mobile device with active internet connection.
6. Mobile application will be developed in .NET MAUI (*.NET Multi-platform App UI*), as the latest framework available for ensuring the cross-platform application building.
7. On launching the app on mobile device, the user will be prompted to enter the classroom ID, that then will be used for subscribing.
8. The API will send info related to one student everything status changes.
9. Each time the subscriber receives the information from API about a student, it will forward it to all subscribed mobile applications.
   In case of a new student gets connected, it will be added to the dashboard.
   In case of an existing student, the status of that student will be updated with latest status.
10. In the dashboard will have Student name and status next to it.
11. For removing students from the list, MediaPipe should send certain value in the "results value" parameter.

In the figure below, you can see an example of the mobile application dashboard for teachers. The dashboard will present the information received from the MediaPipe for all students coming from one classroom. Techers will be able to see in the dashboard student name (or another indicator if anonymity gets applied) and an indicator of their feelings.



Mobile application AI-TOP dashboard

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Students status API Usage

API URL: https://softqnrapi20230628122139.azurewebsites.net/api/Students

SWAGGER URL: https://softqnrapi20230628122139.azurewebsites.net/swagger/index.html

Usage in C#:

```
private const string API_URL =
"https://softqnrapi20230628122139.azurewebsites.net/api/Students";

using (var client = new HttpClient())
{
	var studentJson = new JObject
	{
		{ "studentId", 1 },
		{ "studentName", "John Doe" },
		{ "classId", “Class 123” },
		{ "behaviouralState", 1 }
		{ "learningState", 2 }
		{ "heartRate", 72 }
		{ "emotionalState", “Bored” }
	};

	var response = await client.PostAsync(API_URL,
				new StringContent(studentJson.ToString(),
				Encoding.UTF8,
				new MediaTypeHeaderValue("application/json")));
}
```


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