SMART ENVIRONMENTS PROJECT

DOCUMENTATION REPORT

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Chapter 0: Introduction

Right now, you have team Squirtle's smart environment project in front of you. This project was worked on for the entirety of module two, Smart Environments of Creative Technology at the university of Twente. The task of this assignment was to create a smart environment ourselves with the topic: "Mind and machine". After reading this paper, you will know what this topic means to us and how we want to solve a certain issue that has to do with it.

Stress and anxiety are one of the hardest challenges that children face, especially in their early academic years. This often affects their ability to focus, learn, and interact with their surroundings. Recognizing the importance of addressing this issue, the Breathing Plushie was designed as an innovative, child-friendly solution to help children manage stress through guided breathing exercises. This interactive plushie mimics natural breathing patterns with gentle movement and incorporates sensors to monitor a child's stress levels, such as heart rate. To enhance functionality, the plushie connects to an accompanying app, allowing caregivers (parents and teachers) to monitor the child's progress remotely. The app provides real-time data on the child's stress levels to help adults better understand and support the child's emotional needs. Designed with both tactile and digital interactions, the Breathing Plushie combines immediate stress relief with long-term emotional monitoring. This project strives to create a helpful tool that adapts to children's needs while creating a sense of security and comfort.

Chapter 1: Literature Review

Find 20 meaningful publications on the general theme of the project. Make a short summary of each publication (4-5 sentences each).

You should add references properly, following the IEEE style. An example reference is shown here [1]. The list of references (bibliography) is at the end of this document.

Article 1:
Robots in Elderly Care. [1]

This article looks into the use of robots, for future healthcare purposes, especially in the use of care for the elderly. Due to an ever increasing ageing population, the costs and stress on the current healthcare system will be tremendous. This specific article looks at the ways in which robotics can aid the elderly by assisting as general assistants. However such usage of robotics, can raise ethical challenges, i.e. privacy concerns. Technological advances and the global market's readiness for robotic solutions suggest their increasing role in healthcare, yet there are risks involving data privacy, autonomy, and human contact that need careful consideration.

Article 2:
Mind Meets Machine: Towards a Cognitive Science of Human–Machine Interactions. [2]

This particular article explores the ever increasing integration of A.I. into societal contexts, such as homes. hospitals and schools. Furthermore it goes in depth on the need to understand the cognitive and brain mechanisms that govern interactions with machines. The article provides a framework in which we can study such interactions, referring to the advances in cognitive neuroscience.

It also notes the wide diversity of robots - ranging from simple devices to sophisticated humanoid machines - This makes universal homogenization incredibly unlikely. Furthermore it emphasizes the importance of the interdisciplinary nature of research like this, advocating for collaboration across cognitive science. Ultimately the point is, that by researching how we the people interact and engage with social robots, we can enhance the design and function of AI machines, to make them more effective at interacting with humans.

Article 3:
Talking to Machines About Personal Mental Health Problems. [3]

Conversational agents, powered by advancements in AI, are being integrated into mental health care to address issues like depression and chronic pain. These agents can facilitate access to treatment by conducting assessments and offering support through text or voice interactions, often helping users feel more comfortable disclosing sensitive information. However, challenges include the potential for harm from ineffective responses, privacy concerns, and the lack of regulations to ensure safety and efficacy. While these technologies show promise, further research and thoughtful regulation are essential to balance innovation with patient protection and trust.

Article 4:
The Ultimate Guide to Handheld Anxiety Devices: Finding Relief in the Palm of Your Hand. [4]

The article discusses handheld anxiety devices designed to provide on-the-go relief for anxiety symptoms. These tools include biofeedback gadgets that track metrics like heart rate and skin conductance to promote calm. Breathing regulation devices help users perform controlled exercises to reduce stress. Tactile stimulation tools, such as anxiety cubes, offer physical engagement to redirect anxious energy. Aromatherapy gadgets release calming scents, while sound therapy devices play soothing sounds or meditations. The article emphasizes the portability and immediacy of these non-pharmaceutical solutions. It also highlights how these tools cater to different preferences, from tech-based monitoring to sensory engagement. Guidance is provided on selecting the best device based on personal needs.

Article 5:
Machine learning for medical diagnosis: history, state of the art and perspective. [5]

The article explores the development of intelligent data analysis in medicine from a machine-learning perspective, highlighting its historical evolution, current advancements, and future trends. It discusses how machine learning, through methods like Bayesian classifiers, neural networks, and decision trees, has been applied to improve medical diagnosis. The state-of-the-art systems are compared, and promising new methods, such as handling classifier decision reliability and exploring complementary medicine, are examined. The aim is to showcase the growing role of machine learning in enhancing diagnostic accuracy, speed, and medical research.

Article 6:
One day, AI could mean better mental health for all. [6]

The article examines how AI could improve mental health care accessibility, particularly in low-resource settings. Dr. Vikram Patel highlights the treatment gap in countries like India, where most people with mental health disorders receive no care. He advocates using community health workers for evidence-based interventions while integrating AI technologies to personalise treatments and predict outcomes. While AI holds promise, Patel stresses it should complement, not replace, human providers. The article also calls for structural reforms and culturally sensitive approaches to reduce stigma and enhance care delivery.

Article 7:
Mind and machine in drug design. [7]

The article by Gisbert Schneider discusses the integration of artificial intelligence (AI) into medicinal chemistry. Schneider highlights the initial challenges faced by medicinal chemists in adopting AI-based methods for drug discovery. He emphasises that, despite early difficulties, the field is now prepared to embrace AI technologies to enhance the efficiency and effectiveness of drug design processes. The article underscores the potential of AI to revolutionise drug discovery by enabling the analysis of complex data and the identification of novel therapeutic compounds

Article 8:
An Intelligent and Smart Environment Monitoring System for Healthcare. [8]

The article presents an Android-based wound care solution that assesses environmental feasibility for wound healing, focusing on factors like temperature, humidity, air quality, and dust. Using an Arduino-based system (EEMS) and a neural network (NN) model trained in MATLAB, the solution predicts environmental suitability for wound recovery with high accuracy across different settings. Patient testing showed the solution is user-friendly and effective for various age groups, offering a convenient way to monitor wound environments without clinical visits. Future enhancements could include additional sensors for interior wound monitoring, integration with other machine learning methods, and expanded patient profiles to account for broader health factors.

Article 9:
Virtual machines in education. [9]

Virtualization is increasingly used in education to enhance administration, teaching, and cost-efficiency. Virtual machines, which simulate physical computers through software, enable innovative uses of computing resources. Applications in education include setting up test environments, virtual classrooms, remote access, and utilising existing hardware without upgrades. These benefits improve backup processes, simplify maintenance, and provide flexible learning solutions.

Article 10:
Emotional and Behavioural Distraction by a Social Robot for Children Anxiety Reduction
During
Vaccination. [10]

This paper explores using social robots before medical procedures to reduce children's stress, anxiety and happiness. The writers of the report did a 2 months study in the Health Vaccines centre where they came to the conclusion that in all cases the robot reduced both stress and anxiety in comparison to the same strategies but without the use of social cues and the robot. The information was received in three different ways: The parents reported the amount of fear, anxiety and happiness of the child in different stages, the child gave a self-report and there was an external behaviour evaluation. Lastly, the original level of anxiety had an impact on the ability of the robot to engage well with the patient.

Article 11:
Big Data and Machine Learning in Health Care. [11]

This article highlights the use of Machine Learning in Health care. It allows algorithms to learn tasks from data, without them needing to be specifically programmed for them. The models can be watched over and guided by humans or be mainly autonomous, making them deep learning machines. Even though deep learning machines require a lot of data, they can achieve high levels of accuracy with little human involvement. Essentially Machine Learning is used to analyse data.

Article 12:
Artificial intelligence, machine learning and health systems. [12]

This paper explores the direct impact of machine learning (ML) on health systems and acknowledges its broader effects, such as drug discovery. It highlights the value of integrating ML systems into healthcare decision-making. It provides scalability, cost-effectiveness and efficiency. However strong leadership and collaboration is needed, if these types of systems are to succeed. Szolovits warns us against the misplaced fears of AI, displacing workers, advocating instead for embracing AI to drive transformative change within the healthcare field.

Article 13:
An Effective Machine Learning Framework for Data Elements Extraction from the Literature of Anxiety Outcome Measures to Build Systematic Review. [13]

This paper proposes a method for automatically building a training corpus and using a sentence classification to extract certain data for anxiety outcome measures. While random classifiers effectively identify relevant sentences, it is nowhere near enough as of now. Future improvements are certainly warranted, but this is a major building platform for what is to come. Using deep learning techniques, like word embedding, there is a certain precedent to boost accuracy. The system will eventually feed directly into systematic reviews, providing a narrative synthesis for clinical researchers to assess data.

Article 14:
Mental health monitoring with multimodal sensing and machine learning: A survey. [14]

Tackling mental health requires a lot of monitoring physical and emotional conditions. Ecological Momentary Assessment aims to simplify this process by having wearable devices like phones and fitness bands to track physical conditions such as heart rate, location, mood and movement. These statistics will then be analysed using machine learning and gives us a clearer overview for the sake of helping people deal with mental health problems.

Article 15:
Social Robot to Mitigate Stress, Anxiety, and Pain in Hospital Pediatric Care. [15]

This paper wants to close the gap between supply and demand of social and emotional care for children and parents in hospital by creating the Huggable. The huggable is a virtual and physical character to engage patients in playful interactive activities. The paper explores the effects of the robot both virtually and physically and provides qualitative analysis of the behaviour of patients and parents when using the Huggable. Lastly, the report suggests that children are more willing to connect with a physical robot than a virtual character

Article 16:
Five trends of education and technology in a sustainable future. [16]

This Article highlights the importance of education, namely how it's crucial for solving global problems. It states that education styles should be transformed using new technologies such as information technologies and AI. We must redefine educational goals, environments and the use of technology to further educational growth and sustainable education.

Article 17:
Learners' (mis)understanding of important and difficult concepts: a challenge to smart machines in education. [17]

This article examines how students often misinterpret complex educational concepts. In other words, The article discusses how students often misunderstand complex concepts and how smart educational technologies can help address these issues. It emphasises the need for advanced educational technology to diagnose and address these misunderstandings effectively. The paper explores the role of intelligent systems in customising learning experiences, bridging cognitive gaps, and enhancing conceptual clarity. By identifying key areas of difficulty, smart machines can provide targeted interventions, fostering better comprehension and retention.

Article 18:
Robotics technology in mental health care. [18]

The article examines the role of robotics and intelligent sensors in mental health treatment. It looks into how these technologies could improve patient care, particularly for those with mental health disorders. It also addresses challenges such as privacy concerns and design complexities, while exploring future prospects for robotics in making mental health care more personalised and accessible. As the field grows, robotics could significantly enhance mental health interventions.

Article 19:
Robot Therapy: A New Approach for Mental Healthcare of the Elderly. [19]

The article explores the use of robot therapy in mental healthcare for the elderly, particularly for those with dementia. It highlights how robots like the Paro seal can serve as therapeutic tools by mimicking the effects of animal-assisted therapy. These robots provide benefits such as improved communication, emotional support, and entertainment. The review also discusses the advantages of robot therapy over animal therapy and emphasises the essential functions of these robots to support elderly patients.

Article 20:
An Empirical study and effect evaluation of installation art and computer interactive technology in public space. [20]

This article starts by stating that in this century, installation art has become one of the most mainstream artforms. The artform is now shown in three of the biggest contemporary art exhibitions in the world. Nowadays, more and more people are exposed to new digital technologies such as smart environments, so much that it is fully integrated into their daily lives. The paper also talks about the fact that VR and AR completely transformed the interaction fields and that these developments also create opportunities for both entertainment and art. The development of combining art and computer technology goes hand in hand with the constantly developing science and technology, which is why the development is rapid. Finally the article states that people believe the combination of installation art and computer technology is going to improve even more to create more influential, beautiful pieces

Chapter 2: Identification of General Problems and Challenges

Based on the read and summarized literature 10 problems have been identified. All of these problems are categorized based on their accompanying SDG, Sustainable Development Goal.

Problems:
Good Health and Well Being

- Elderly do not always take the right medication at the right times and there is not enough healthcare staff to regulate this daily.
- There is no effective way to support and monitor anxious people, like children. With the use of technology.
- Students have difficulty helping themselves calm down in a classroom when their anxiety gets too high
- Physiotherapy exercises are not always well tailored for someone's needs, besides that, there is no way to give feedback to the patient without the help from an employee.
- Patients recovering from illnesses or who are managing chronic conditions have no smart way for meal planning and nutrition tracking.

Quality Education
- People are not motivated for their job / education.
- Classes do not always have much interaction with students, because of this they learn less efficiently.
- Traditional classrooms are not equipped to accommodate students with sensory, cognitive or physical disabilities
- Teachers waste a lot of time on administrative task such as making lesson plans and taking attendance

Gender equality

- Not everyone is aware of the difference in political representation between genders.

Chapter 3: Formalization of Relevant Problems

Select three problems and explain why based on criteria and feasibility (SMART; may use the template tables below – *but feel free to be creative!*)

For each problem, fill the following table accord to the SMART criteria.

Problem 1	
Problem title **_Elderly do not always take the right medication at the right times and there is not enough healthcare staff to regulate this daily_**	
Problem description (max. 100 words) *Age, dementia or be it a general lack of discipline. There are numerous reasons as to why someone, especially a senior citizen, could miss out on their medication. The consequences of such forgetfulness can be quite grave, even life-threatening. Additionally keeping track of medication schedules, can be time consuming and resource intensive. This problem is inspired by source 1 of chapter 1, which talks about the increasing price of elderly healthcare together with the supply and demand at the moment.*	
Social impact of (solving) the problem (max. 200 words) *Our goal is to ease the burden of medical staff by breaking the constant cycle of nonstop micro-management. By developing a system that incentivizes and manages medication adherence, we can significantly reduce the need for staff to keep track of numerous patients, allowing them to take care of more critical patients.* *Not only would this allow us to take the workload of staff, but it also empowers patients and their family. Allowing them to take a more active role in their health management. Fostering confidence, and independence,*	
Relevant citations	
Specific	*Is your problem specific: can you define a solution that concretely solves this specific problem* *Yes, because it specifically targets the elderly that forget to take medication on time*
Measurable	*Can the effects of (solving) your problem/goal be quantified; if so, how?* *Yes, effects can be quantified by tracking reduced missed doses, improved health outcomes and time saved for healthcare staff.*
Attainable	*How likely is it that you can prototype a solution that contributes to*

	solving the problem/goal? *Highly likely, there are already existing technologies for reminders, tracking, and caregiver alerts so developing a prototype combining these current tools is very feasible.*
Relevant	*Is the project relevant to the theme of M2?* Yes, because it's directly linked to the SDG good health & well being and is focused on making a machine for people with cognitive problems.
Timebound	*How likely is it that you can prototype a solution that contributes to solving the problem/goal?* *It is feasible to create the prototype in time as it would just need a timer, a place to fill in which medication needs to be taken at which intervals and a system to remind the patient what to take using for example light cues.*

Problem 2	
Problem title ***Students have difficulty helping themselves calm down in a classroom when their anxiety gets too high***	
Problem description (max. 100 words) *Due to a large number of responsibilities and social reasons, some people struggle with experiencing high levels of stress and anxiety. Calming down and taking a break become even harder in academic settings, as there's a big amount of pressure. Moreover, this issue also affects the students' academic performance and overall well-being.*	
Social impact of (solving) the problem (max. 200 words) *There are a multitude of benefits that come from easing the anxieties of students. Firstly it allows them to turn their full attention towards their studies, which not only makes their life more fulfilled and driven, but it also helps educate the workforce of the future. Anxiety causes many stress-related health issues, so reducing it makes people healthier. It also should go without saying that a decrease in anxiety will lead to an overall increase in the happiness and well-being of the patient.*	
Relevant citations	
Specific	*Is your problem specific: can you define a solution that concretely solves this specific problem* *Yes, because it specifically focuses on the symptoms that anxiety brings,*

	namely higher blood pressure
Measurable	*Can the effects of (solving) your problem/goal be quantified; if so, how?* *Yes, we are able to measure the total increase/reduction of the patient's heart rate*
Attainable	*How likely is it that you can prototype a solution that contributes to solving the problem/goal?* *It's very attainable, because we'll choose a simple anxiety reduction exercise (eg. breathing patterns) and then have our machine in some way communicate the exercise to the patient*
Relevant	*Is the project relevant to the theme of M2?* *Yes, as it is tackling a mental health problem which is linked to one of the Sustainable Development Goals with the help of an interactive technology*
Timebound	*How likely is it that you can prototype a solution that contributes to solving the problem/goal?* *It is possible with a right amount of research on the topic and implementing the anxiety reduction techniques to the prototype.*

Problem 3
Problem title ***Teachers in high schools waste a lot of time on administrative task such as taking attendance***
Problem description (max. 100 words) *In most high schools, the absence registration is done manually by a teacher through systems such as SomToday and Canvas. This normally takes up to five minutes, which loses time for the actual class itself, this loss of time is unfortunate during normal lessons. But gives more problems during an exam, if someone has to call out all the names separately. The workflow and concentration of the students will be disturbed.*
Social impact of (solving) the problem (max. 200 words) *The social impact of the problem is that classes do not make use of their time efficiently which means there is less material that can be covered during a single lecture. Which either means*

that students have to do more outside of the classes, or the school has to schedule extra classes to make up for the lost time. If this is not done the grades of the students could start declining, which has a negative influence on the level of education students have. Solving this problem would also have a positive influence on the teachers because then they must spend less time on administrative tasks.	
Relevant citations	
Specific	*Is your problem specific: can you define a solution that concretely solves this specific problem* *Yes, since it focuses explicitly on attendance lists and the speed at which these can be completed*
Measurable	*Can the effects of (solving) your problem/goal be quantified; if so, how?* *Yes, because we can measure the accuracy and speed at which the attendance list is completed*
Attainable	*How likely is it that you can prototype a solution that contributes to solving the problem/goal?* *A prototype that can reduce the time it takes to take attendance could be made with an RFID reader and for example people's student cards. [22] It would be difficult however to connect such a system to the online attendance system SomToday, since there is no public access to SomToday which means a teacher from a school would be needed to test this. To tackle this problem however, there could be a list of the students on a self-made application, which makes the program more complicated. However, it should be possible to create a prototype to solve the problem.*
Relevant	*Is the project relevant to the theme of M2?* Yes it is relevant, since it directly impacts the quality of education and it has to do with mind and machine in a literal sense, since the machine would give people more freedom to fill our minds with knowledge
Timebound	*How likely is it that you can prototype a solution that contributes to solving the problem/goal?* *Making the RFID part of the program should be possible within the timeframe of the assignment. The more difficult part is connecting the data of the RFID cards to names and a premade list by the teacher so the people who do not scan their card get picked out without the teacher having to find the names.*

Chapter 4: Final problem and potential solutions

Select one final (of the three) problem (motivate your choice based on the Sustainable Devlopment Goals, theme, etc...). Outline what the high- and low-level context is you would need to solve your problem. Additionally, think of 5-8 solutions to your problem and fill in the ubiquitous computing (UBC) table per solution (*or feel free to be creative, as long as you cover everything*).

For our final problem, we chose: "**Students have difficulty helping themselves calm down in a classroom when their anxiety gets too high",** we chose this topic for a multiple of reasons. Firstly, most people in the group were drawn to the topic of healthcare and specifically mental health for our smart environment. Secondly, we feel like the problem could be solved in a large number of different, creative ways. Which doesn't put finding the solutions in a small box but gives us a big spectra of areas to find solutions in. Lastly, we were discussing a specific solution on this topic before we had decided on the final problem yet, this made us really motivated and enthusiastic, which is why we chose this problem as our final one.

Our problem mostly aligns with SDG 3: Good health- and wellbeing, but also dives into quality education, SDG 4. Because if students feel less anxious in the classroom, they will be able to focus easier which indirectly improves the quality of the education. The target audience for this problem depends on the solution, since some of our solutions are more targeted towards children (Breathing Plushie). While other problems could be used for a variety of age groups (exercise reminder/guider and the fidget toy). The ultimate goal to solving this problem is finding a way to make students less anxious in the classroom to improve both their mental wellbeing, as the ability to focus in class to improve academic results.

Solution #1	
Solution title: Breathing Plushie	
Solution description (max. 250 words) *The breathing plushie is an idea born to help children with their breathing patterns when they are stressed, since a good breathing pattern is one of the biggest stress relievers there is[21]. If the user does not experience any stress at all, the plushie will just look and feel like your average stuffed animal. If the user does experience stress, the plushie will have a soft moving stomach so children will be able to match their patterns to the plushies'. After the breathing exercises the plushie will be able to evaluate how effective the exercise was to maximize effectivity. If the child is not calmed down after the exercise, an external person, for example a parent or teacher, will be notified to help the child.*	
Distributed?	*Is your solution distributed over multiple devices to get a wide range*

	of information? The plushie in itself is one object, it could however communicate with for example a phone or computer for the evaluation part of the process, a (different) device could also be used to notify someone to help the child when it's needed.
Context-aware?	*Is your solution adaptable to new situations/aware of its surroundings and relevant information/context?* The plushie will be able to choose a specific breathing exercise based on what the level of anxiety and stress is that the child is experiencing. The breathing exercises could also be chosen from evaluations of previous exercises with the same person.
Interaction?	*Is there interaction between the user and your solution, and is this interaction explicit, implicit, or both?* There is both explicit and implicit interaction between the user and the solution. The explicit part is the plushie itself, the user can hold the plushie so they can feel that the stomach of the toy is going up and down. The interaction is also implicit because sensors such as heart-rate sensors and maybe a galvanic skin response work without the user actively interacting with them.
Intelligent?	*Is there some form of smartness in your solution (problem solving, decision making, artificial intelligence)?* The plushie is in fact smart, choosing which exercise is best for the user based on the stress levels and the effectivity of different exercises on a specific user.
Autonomous?	*Can the solution run without the interference of an operator?* The solution can in fact run without the interference of an operator. If everything is nicely set up, the plushie will decide the exercise when the user is in a state of stress. After the exercise is finished the plushie will send an evaluation to an external device (phone/tablet) and if necessary contact someone to further help the child.

Solution #2
Solution title: Drawing Corner
Solution description (max. 250 words)

Drawing Corner is an interactive stress-reduction tool designed for classrooms. It uses the therapeutic benefits of drawing to help students calm down and express themselves creatively. The solution features a digital screen or tablet connected to a circuit that monitors physiological stress indicators, such as skin conductivity or heart rate, to adapt to the user's emotional state. *When stress levels are high, Drawing Corner provides simple, calming templates (simple shapes and colors) or free-draw options to reduce tension. For lower stress levels, it offers more challenging drawing tasks to keep users engaged without causing frustration. This adaptability ensures a personalized and supportive experience for every student.* *The device is autonomous, using real-time stress data to select appropriate activities, but also allows users to choose their preferences. To enhance its functionality, Drawing Corner is distributed via a connected app, enabling teachers to monitor multiple devices and track student progress. The app also allows students to use Drawing Corner remotely, extending its benefits beyond the classroom.*	
Distributed?	*Is your solution distributed over multiple devices to get a wide range of information?* Yes, there'll be a companion app that connects to the Drawing Corner via Bluetooth or Wi-Fi to select drawing preferences remotely. Also, teachers can access it to monitor the students' well-being.
Context-aware?	*Is your solution adaptable to new situations/aware of its surroundings and relevant information/context?* Yes, it adapts to the user's stress levels and adjusts drawing tasks based on real-time inputs, making it context-aware.
Interaction?	*Is there interaction between the user and your solution, and is this interaction explicit, implicit, or both?* The solution supports both explicit interaction (user selecting templates) and implicit interaction (stress sensors detecting emotional state).
Intelligent?	*Is there some form of smartness in your solution (problem solving, decision making, artificial intelligence)?* Besides choosing the topic preferences of the user, the Drawing Corner could also choose one of the drawings based on difficulty and how stressed the user is in that moment, so that the user gets an easier drawing when their stress levels are higher and a more difficult drawing when the stress levels are a little lower.

Autonomous?	*Can the solution run without the interference of an operator?* The solution can run without the interference of an operator since the user can choose what type of drawing they want themselves and then start drawing without needing extra help. The machine can also decide the difficulty without any external help.

Solution #3	
Solution title: Talking toy	
Solution description (max. 250 words) *Help with anxiety and promote mental well-being. Equipping a cute face with a calming voice and soothing interactions, is bound to help any kid out. We aim to have toy leverage, evidence-based techniques for such as; breathing exercises, mindfulness and affirmations. The toy can also help talk a person out of a panic attack with vocal exercises. This solution was inspired by article 3 of chapter 1, this article states that talking about personal problems with a machine is easier than with a person. The talking toy wants to be that for its user, a friend who listens.*	
Distributed?	*Is your solution distributed over multiple devices to get a wide range of information?* We definitely see that this device could be distributed over multiple devices. The talking toy just functions as it's primary interface, but there is room for accompanying integrated apps.
Context-aware?	*Is your solution adaptable to new situations/aware of its surroundings and relevant information/context?* The solution is made to be aware of its surroundings and should be capable of responding to its surrounding contexts Maybe using sensors, to detect heart-pulse.
Interaction?	*Is there interaction between the user and your solution, and is this interaction explicit, implicit, or both?* There is both explicit and implicit interaction between the user and the device. For example, the interaction will lie in verbal communication. The user could say "I am feeling stressed" and the toy could formulate a response.
Intelligent?	*Is there some form of smartness in your solution (problem solving, decision making, artificial intelligence)?* There is a potential of incorporating Machine learning based technology, to make it "Smarter"

Autonomous?	*Can the solution run without the interference of an operator?* No, the idea of this device relies solely on the input of the operator.

Solution #4	
Solution title: Interactive Fidget Toy	
Solution description (max. 250 words) The device features multiple fidget mechanisms—rotating dials, clickable buttons, sliding panels, and squishy surfaces—integrated with sensors to track usage patterns. It’s customizable, allowing students to personalize their experience with adjustable resistance levels or sensory feedback (e.g., lights or gentle vibrations). This solution was inspired by article 4 of chapter one, which discusses using fidget toys as a stress reliever. Additionally, the device promotes social interaction through its "Fidget Chain" mode, where multiple devices can connect via Bluetooth for collaborative games or challenges.	
Distributed?	*Is your solution distributed over multiple devices to get a wide range of information?* Yes, the Cool Fidget Buddy is distributed. Multiple devices can connect via Bluetooth to share usage data and participate in collaborative activities or challenges. Additionally, a companion app can aggregate data from all devices to provide insights into stress trends across students
Context-aware?	*Is your solution adaptable to new situations/aware of its surroundings and relevant information/context?* Yes, it is context-aware. The device monitors fidgeting patterns using sensors and adapts its sensory feedback (e.g., vibrations or lights) based on the intensity or frequency of usage. For instance, if the user fidgets excessively, it can activate a calming mode.
Interaction?	*Is there interaction between the user and your solution, and is this interaction explicit, implicit, or both?* Both users directly engage with the fidget mechanisms (buttons, dials, sliders, etc) making it explicit. And the device tracks fidgeting patterns and adjusts feedback automatically which is an implicit property.
Intelligent?	*Is there some form of smartness in your solution (problem solving,*

	decision making, artificial intelligence)? Yes, the solution incorporates intelligence. It analyzes usage data to detect stress levels and adapts its responses. The connected app can also use this data to suggest tailored stress-management techniques, such as breathing exercises or mindfulness tips.
Autonomous?	*Can the solution run without the interference of an operator?* Yes, It operates independently, monitoring user behavior and adjusting its feedback without requiring operator input. It only needs manual input when the user wants to customize settings.

Solution #5	
Solution title Exercise reminder/ guider	
Solution description (max. 250 words) *The Exercise Reminder/Guider is a smart device designed to encourage regular physical activity in any setting, such as home, office, or during leisure time. It consists of a wearable device or a compact desktop gadget paired with a mobile app for enhanced functionality.* *The device monitors the user's activity levels through built-in sensors that detect movement and posture. If extended inactivity is detected, it delivers personalized reminders to perform simple exercises, such as stretching, walking, or posture adjustments. These prompts are provided through gentle vibrations, visual notifications, or audio cues.*	
Distributed?	*Is your solution distributed over multiple devices to get a wide range of information?* Yes, the solution is distributed. Multiple devices can sync to the app, allowing users to track activity across different environments, such as home and office, and consolidate the data into a single platform.
Context-aware?	*Is your solution adaptable to new situations/aware of its surroundings and relevant information/context?* Yes, it is context aware. The device adapts to the user's activity patterns, time of day, and preferences to provide relevant and timely exercise recommendations.
Interaction?	*Is there interaction between the user and your solution, and is this interaction explicit, implicit, or both?*

	Both, explicit: Users customize settings or follow exercise guides via the app. implicit: The device tracks inactivity and provides reminders without user input.
Intelligent?	*Is there some form of smartness in your solution (problem solving, decision making, artificial intelligence)?* Yes, the solution uses intelligent algorithms to analyze inactivity, tailor exercise recommendations, and adjust prompts based on user behavior and goals.
Autonomous?	*Can the solution run without the interference of an operator?* Yes, the device operates autonomously, detecting inactivity and prompting exercises without requiring manual intervention.

Chapter 5: Final solution

Select the final solution and motivate/explain (based on the UBC table) why this is the best fit (include sketches of different implementation ideas). Include the feedback loop from the *implicit Human-Computer Interaction* lecture (outline the implicit/explicit input/output of the potential implementations).

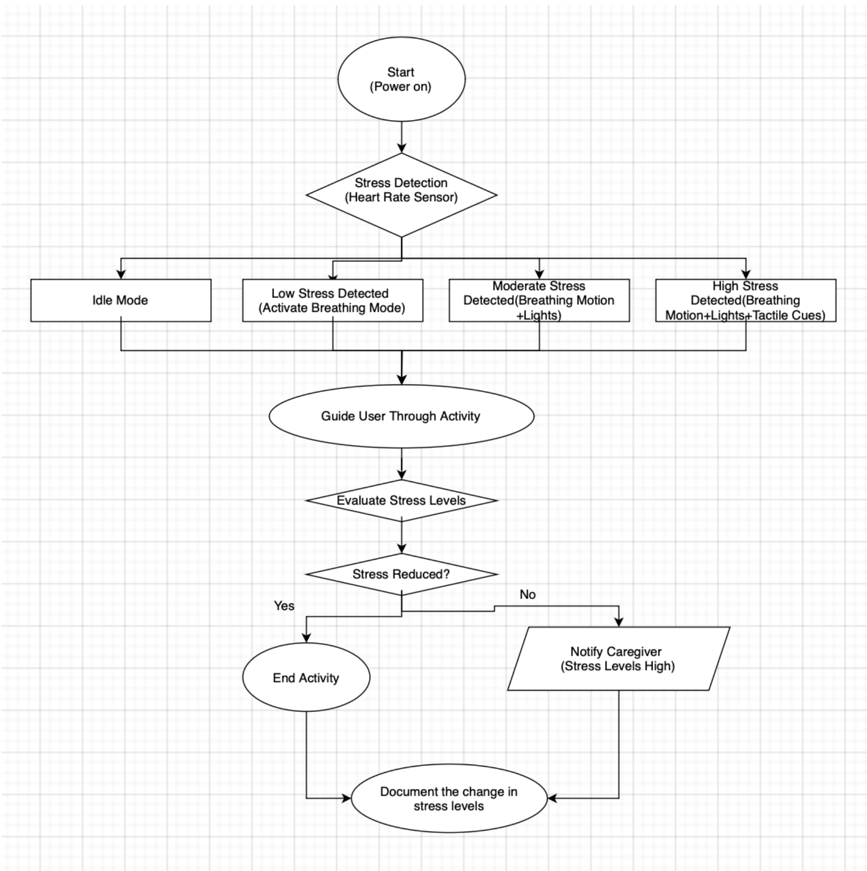
Solution selected:	1
Solution title: **Breathing Plushie**	
Solution description (max. 250 words) *The Breathing Plushie is an interactive and intelligent tool designed to help children manage stress and anxiety by guiding them through breathing exercises. Shaped as a comforting stuffed animal, the plushie has a soft, rhythmic moving stomach that mimics natural breathing patterns. Children can match their breathing to the plushie's movement, helping them regulate stress levels effectively. The plushie is equipped with sensors such as heart rate monitors and galvanic skin response sensors to detect and evaluate stress levels. Based on this data, the plushie can adapt by selecting specific breathing exercises tailored to the user's anxiety type and intensity.* *The plushie also gathers and evaluates data to measure the effectiveness of previous exercises. If the exercise does not sufficiently reduce stress, the plushie can notify an external person, such as a parent or teacher, via a connected device (phone or tablet). Additionally, the plushie offers long-term insights by sharing patterns of stress and coping mechanisms with caregivers, allowing them to provide more targeted support.* *The target audience for this project are children from the ages of 8 to 13. We find this plushie to be suited to them, because of its friendly appearance and its much more motivating to follow the breathing patterns of a visual and physical guide. Plushie's are generally lovable to all, so it's something that most age groups can appreciate as well.*	
Distributed?	*Is your solution distributed over multiple devices to get a wide range of information?* *Yes, the plushie communicates with external devices like smartphones or computers for real-time evaluations, notifications, and data storage.* *Yes, the entire system transmits and receives signals with wireless transmission hence does not require wiring for data carriage.*

Context-aware?	*Is your solution adaptable to new situations/aware of its surroundings and relevant information/context?* *The plushie adapts its response based on the child's stress level and past exercise effectiveness, ensuring it suits the current situation.*
Interaction?	*Is there interaction between the user and your solution, and is this interaction explicit, implicit, or both?* *The plushie offers both explicit (physical interaction by hugging and holding) and implicit (sensor-based stress detection) interaction.*
Intelligent?	*Is there some form of smartness in your solution (problem solving, decision making, artificial intelligence)?* The plushie is in fact smart, choosing which exercise is best for the user based on the stress levels and the effectiveness of different exercises on a specific user.
Autonomous?	*Can the solution run without the interference of an operator?* Yes, it operates independently to guide activities, track stress levels, and notify caregivers if necessary.

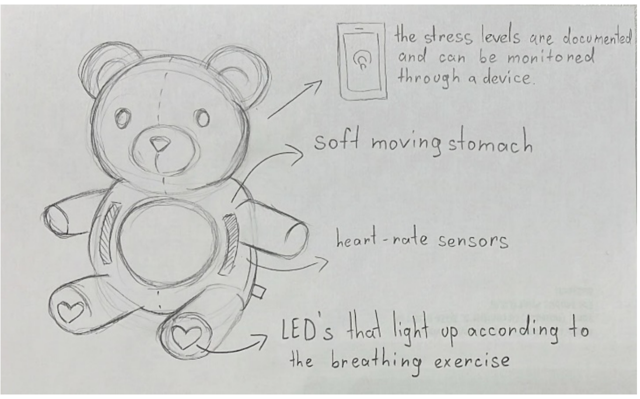
The Breathing and Activity Plushie has been selected as the final solution for reducing stress in children. This choice was made because it combines simplicity, child-friendly design, and proven stress-relief techniques such as guided breathing and sensory engagement. Additionally, it aligns with the available components and adheres to the feedback provided, such as expanding its functionality beyond breathing exercises and adapting to various stress scenarios.

Utility	Behavior	Creativity
The plushie addresses the target users' needs (children experiencing stress) by offering effective stress-relief methods. Breathing exercises are well-known for regulating anxiety, while additional sensory features provide extra calming options.	The plushie promotes a habit of self-soothing and creates a tendency for children to deal with stress independently.	The design is engaging and creative, featuring a comforting, interactive toy that children will naturally gravitate toward.

Implicit Input	Explicit Input	Implicit Output	Explicit Output
Heart rate sensor measures stress without requiring user input and sent by wireless transmission. The light sensor adjusts LED brightness based on the environment.	Physical interaction with the plushie (hugging, squeezing).	Plushie adjusts breathing patterns or light intensity to suit the child’s needs.	Breathing motion, LED light effects, or calming tactile feedback is provided directly to the user.



A basic flowchart for how the smart environment could/will work.



Rough sketch of plushie and a quick overview of it's abilities.

Chapter 6: Methodology

For the methodology, we split up our tasks into the duo's that we have made for the programming and physical computing course. Tjerk and Bilge will focus on the first part of the environment which checks if there is stress. As shown above in the flowchart, if the user is not experiencing stress in the moment. The plushie will not start an activity, Tjerk and Bilge will figure out when a person is experiencing stress with sensors such as a heart-rate sensor, a GSR sensor and transmitting the processed data through RF circuits and antennas by wireless transmission and frequency modulation to the plushie itself. The second pair consists of Laman and Nick who focus on the second part of the environment, the activity itself. They will have the goal to find (breathing) activities that could work to reduce stress and to implement these into a plushie in two ways. One part of the code will control a motor that moves the stomach of the plushie so the user can feel the movement which makes it easy to replicate. The second part also shows the movement of the activity but in the form of LED lights in the paws of the plushie. This means that the activity is not reliant on one of the five senses but on two which makes the plushie more accessible. The last duo consists of Annika and Romy who will focus mostly on communication and evaluation. Their implementations happen after the activity has taken place, the data of the effectivity of the activity will be sent to an application. Based on this data the activities for this user will be changed based on the effectivity of certain patterns. This duo will also focus on the safety of the environment, the plushie has to be durable and should not have issues to do with heat or water for example. We will also contact a senior student, who already developed a device with similar attributes to our current design, and see if we can learn something from his previous discoveries.

Before we start implementing our ideas into our final prototype. We all have to research our tasks further. This means that the first duo will look into what type of sensors they can use for our goals and how we can implement these into the environment without them intervening with the child normal doing. Besides that, they will research how you can measure stress. The second duo will also need to research certain topics, such as finding breathing patterns that will be useful for our type of environment. The last duo will have to look into how you can communicate properly between an arduino, an application and external people. They will also have to research how to make such an application with the things that we want it to do. Lastly, they will have to research how to make this environment fool proof and how you can make it usable for the users. The fur of the plushie has to have the possibility to be cleaned for example.

After the research part, everyone will dive into their own tasks shown in the tables below. During this process, the team members will check with each other if the nodes can interact with one another properly to prevent a large amount of issues towards the end of the project. The design team will also work on the plushie part of the project, they will design a housing for the arduino and cables and work on the plushie. So everything can be combined and tested.

Some of the sensors that we use will need calibration, we need to know when the child is experiencing stress and does not just have a raised heartbeat because they walked up a flight of stairs. This means that calibration needs to be done for the part where we check if the person has stress. These sensors will collect data before the activity starts, during the activity and after the activity so we will be able to look at the differences to draw conclusions if the activities are effective or not.

During this process we will set deadlines for ourselves to make sure that we do not run into time issues or other problems towards the end of the module. We will work on the project every single week obviously during the lectures and will hold occasional meetings when we deem necessary.

The plan that we have right now is not final but more of an indication how we are planning to work on the project in the upcoming weeks and so that it is clear to everyone what they have to do. We are sure that things are going to change along the way because of revelations, things being more difficult/easy than expected and other things as well.

We believe that this methodology will lead to a solution that solves the problem for a certain group of people, the methodology that we propose is an ambitious but realistic one where we still have a lot of room to add things if we have time for them. We believe that our solution will be able to reduce stress with children inside the classroom, and if the solution works well, we could also start looking into using this project in other environments.

Tjerk and Bilge - Check if there is stress

Who?	Module 1 - Week 4/5/6	Module 2 - Week (6)/7/8/9
Tjerk	Develop algorithms to process raw sensor data and detect stress.	Develop algorithm to send alert to other nodes
Bilge	Developing wireless transmission to send the processed raw data to the receivers(s).	1. Develop wireless transmission RF circuits operated with modulation to send/receive signals. 2. Creating our antennas responsible for carrying the transmitted signals coming through the RF circuits.

Equipment needed:
- Heart rate sensor
- Frequency/Amplitude Modulation Circuit Components
- RF circuits (Radio frequency circuits)

- Antennas
- GSR sensor (Stress the detection based on deviation and electrical conductance in the skin.)

11.2 Transmitting and receiving

Figure 11.1 shows a basic transmitting/receiving system. At the transmitting side, the signal is amplified with a power amplifier (PA) and fed into an antenna. According to the voltage law, the current law and Ohm's law this should yield a zero current in the antenna as there is no closed loop at the output of the PA including the antenna. As a result the power going into the antenna should be — from a low frequency point-of-view — zero and hence no power would be transmitted. After reading this chapter, you'll know better: the antenna generates an (AC) electromagnetic wave from its (AC) input voltage and thereby converts electrical energy into electromagnetic energy. In the electrical domain the antenna then is an impedance: an electrical element that may store electrical energy but also converts electrical energy into energy in another domain.

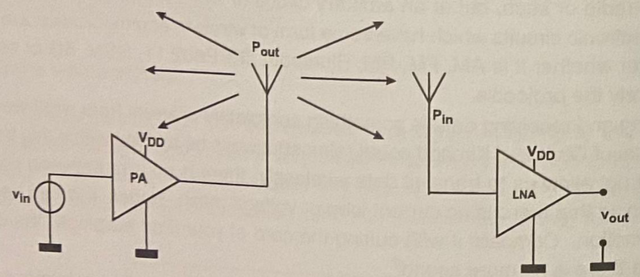
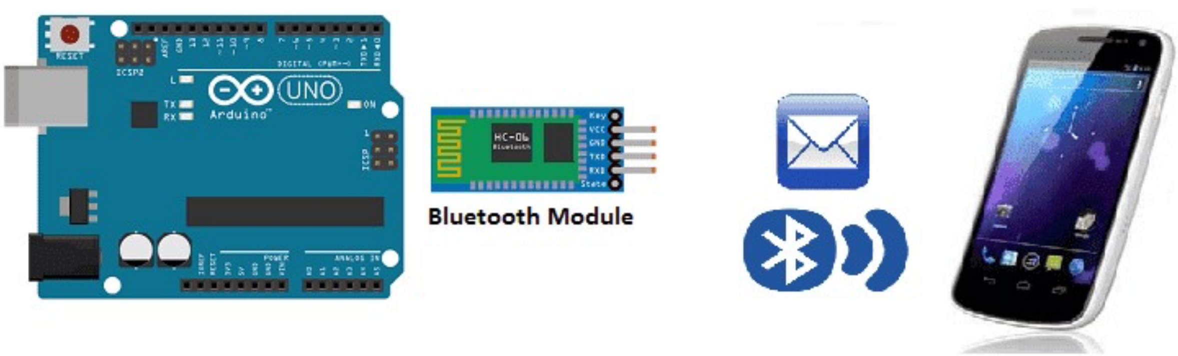


Figure 11.1: A transmit-receive system: a signal is transmitted wirelessly

Pout is going to be the antenna that transmits the processed raw data at the sensor.
Pin is going to be the antenna that receives the processed raw data and sends it to the plushie.

<u>Parts of the Project we are still trying to figure out:</u>

One of our major concern for this project is managing to do real-time communication with devices like communication of the plushie with an iPhone and the reason is the basic model Arduino uno's they provided us in the proto kit do not have Bluetooth and Wi-fi modules like other microcontrollers such as ESP32.
Maybe purchasing a Bluetooth module will solve that issue as follows:



(Robotique Tech. (n.d.). *Send a message from Arduino to smartphone*. Retrieved December 5, 2024)

Laman and Nick - Regulate the stress

Who?	Module 1 - Week 4/5/6	Module 2 - Week (6)/7/8/9
Laman	Research evidence-based calming methods.	Delve into what kind of movements fit the ideal breathing pattern and discover whether other functionalities for the bear might be a useful addition
Nick	Develop a prototype code that performs all those methods and motions	See if we can find any way to apply such codes to a circuit, making the bear move in a way that is comforting, consistent and not too mechanical

Equipment needed:

- Servos
- LEDs
- Motors for vibration (DC or Stepper)
- Heart rate sensor
- Speaker

For this node, we believe that every piece of equipment would be tested first in a controlled environment and would therefore not require any special casing of any kind. The focus for our team will be making sure that once the bear is activated, he performs the ideal breathing patterns and potentially also plays soothing music, if that addition would seem to help the bear's functionality. We will place emphasis on the bear's calming routine and motions, since that is its whole purpose. The goal is for the bear's motions to be calming, consistent, in line with recent data regarding healthy breathing patterns and that as many kids as possible can approve of his functions. Ideally, if certain kids don't like the music that he plays, then they can change it or turn it off fully, while still being able to use the breathing mechanics. We will explore all these details in depth and aim to make sure that the bear is customizable to the user's desires.

Romy and Annika – evaluate and external messages

Who?	Module 1	Module 2 - Week (6)/7/8/9
Romy	Evaluate the performance of the plushie	Research potential ways for the device to reach out to potential guardians.
Annika	Research if the plushie meets safety regulations put in place, there are	As an anxiety based product, it's essential to determine whether the design effectively

	no hazards	fulfils its intended purpose

Equipment needed:

- Arduino

This node is not as hardware based as the other two nodes, the hardware that we do need will be used to communicate between the other nodes and the application. The main focus of this node will be to develop software so that the other nodes will be able to function in the most effective way possible and to communicate this back to the environment itself. Besides, we also want to focus on the ability to pass a message to a contact person that needs to be added to the profile of the user. So that if the environment is not as effective as it should be, the child will still get the care that they need.

Since the use of a sensor is crucial for making a node, a heart rate sensor will be used to see how effective the exercises are. Later on when assembling everything, this will be the same heart-rate sensor as the first duo since it would be impractical to have to heartrate sensor in with the plushie.

Ambitious vs basic plan:
As we have demonstrated, this is a very ambitious group, and that seeps into our goals and vision for the project. However, we also want to keep our vision realistic and contained. We realize we are merely a group of first-year students. We simply do not have the means, capacity or the time. So we want to design this research with accessibility, simplicity and feasibility in mind.
The data for this study will be collected through the practical involvement of participating examinees. Participants will parrot the prototype plushie throughout their daily routine and interact with it across various scenarios. This approach allows us to observe and measure their responses, providing insights into whether the plushie elicits any meaningful or tangible effects.
To ensure the rigor and credibility of the study, we aim to divide the participants into two groups to address potential biases, including but not limited to the placebo effect.

- Experimental group: This group will carry the interactive plushie throughout the day, allowing you to assess direct impact.
- Control group: This group will carry around a non-interactive plushie to establish a baseline for comparison.

With the more ambitious vision in mind, we would focus on recruiting a bigger pool, and ensure more diversity among that pool. User engagement would be more at the forefront, and we would have more time to explore and observe the effects.
Challenges:
However, recruiting two different groups that we need to control and observe would require significant resources that we may simply not have nor have the time for to gather. Hence, it’s important to produce a basic plan that would, hopefully, lessen that burden.

Basic plan;

This plan focuses more on the realistic bounds for us, as first-year students, to reasonably work within. While still providing meaningful insight into the plushie's potential as an anxiety-calming product.

- Ensure the plushie's interactive features are functional, available and reliable
- Evaluate whether the plushie provides emotional comfort in day-to-day scenarios.
- Collect initial feedback on usability design and emotional engagement

Data collection:

- Focus on recruiting a smaller pool, so we can allocate more attention to our observations.
- Use simple survey or interview, and conduct further short-term investigations

The huge advantage of this plan is that it is a lot more manageable within our current constraints. Ensuring we can work on delivering a reliable and meaningful product with meaningful results.

"Aim for the moon, and you'll reach for the stars" is the vision of this plan. We will aim as high as we can, but we recognize that the basic plan is more suited to our current capacity as first-year students. By starting with a practical and achievable approach, we can lay a strong foundation for any future iterations. When we have the basics down, it will become a lot more manageable to scale up the production.

Chapter 7: Validation

To validate the plushie's effectiveness, we first need to find participants to check their stress levels. Even though our target audience is young children, we intend to test the plushie on young adults. To increase the stress levels of participants, they will first play a set of timed puzzle games or math exercises.

Once the stress levels are heightened, participants will interact with the plushie by following its breathing patterns. Data will be collected using the plushie's built-in heart rate sensor, measuring the stress before and after the exercise. Moreover, participants will complete a brief questionnaire to share their perceived stress levels and overall feedback on the experience. Any limitations or areas for improvement identified during testing will be addressed and updated.

The website https://mathsstarters.net/quickquiz was used to test the smart environment, the website provides quick math questions to increase the person's heartbeat. While testing however, we found that it was quite difficult to get a heartrate higher than 110 BPM, which was the heartbeat threshold used to notify that a user is stressed. This meant that for testing the threshold was changed from 110 BPM to 90 BPM which was easier to achieve.

The table below shows the results with a few of our participants who tried the validation process:

Person	BPM in rest	BPM after math	BPM after Jeremy
Laman	80	85	78

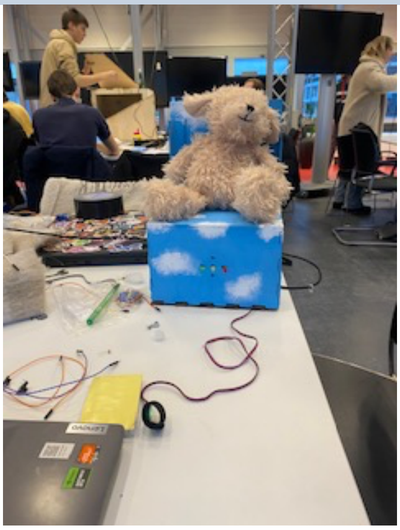
Romy	78	97	73
Annika	70	88	80
Nick	75	95	69

Chapter 9: Results and Conclusion

In the end, a wooden chair was built so that the plushie has an upright position, if the plushie is just laying down, the servo would not move in a correct way meaning that there was no breathing pattern noticeable in the stomach of the plushie. To improve this even further, small wooden beams were added inside of the plushie to keep its' posture upright. Besides that, the box also functioned as a way to store the ESP-32, resistors and other parts of the circuit that were not needed in the plushie itself to minimize the number of components inside of the plushie. It follows the 4-second inhale, 7-second hold, and 8-second exhale pattern, as it is widely known for its calming effect and ability to regulate breathing. To improve the experience a few LED lights were added to the wooden box, the different colors signalize the inhale, hold and exhale process. So that the breathing pattern is not fully reliable on the servo in the plushie. Besides that, the LED's have the exact same functionality as the servo, meaning that the LED pattern also repeats if the heartrate has not dropped below 110 bpm, restarting the exercise.

Another design choice that was made is that it is easy to remove Jeremy from his stool so that the plush part of the environment can go in the washing machine, this means that the plushie won't get extremely dirty over a period. Unfortunately, it is necessary to get the hardware out of the plushie before this is done, but getting the parts back in is quite easy. The most important thing is that the servo is positioned in such a way that the stomach moves without ruining Jeremy's posture.

This system was fully tested as shown in the chapter above, for all 4 participants, the heartrate was lower after doing the breathing exercises. This would normally mean that there is a significant chance that the breathing exercises indeed work as intended. However, there might be a chance that the heartrate dropped since the participants stopped making the math questions.



The picture above shows the full prototype on the demo day (24-01-2025). The results on the demo day were very positive overall, everything was working properly, the heartrate sensor, the breathing mechanism with the lights and the part of the system that's sends a message to someone's phone when the heartrate is high. If there had been more time, the heart-rate sensor could have been replaced with a bracelet available at the Interaction lab at the university. The bracelets have more accurate sensors and make it easier to use. Since you don't need to have a Velcro ring with wires attached to it to use the system.

While creating the smart environment, it turned out that creating Radio Frequency circuit was a lot more difficult than originally thought. Meaning that it was not working until the last day before the demo. This meant that implementing it into our project would have been nearly impossible with the time crunch and the difficulty of putting these wireless circuits together. If there was more time for this project this would have been the next step taken to improve the environment.

Besides just having the environment work, the decision was also made to create a little more branding around it. It is easier to sell something during the demo day if there is a name and branding around it. That's how the brand Breathing Buddies was created, before settling a name someone made sure that the handle Breathing Buddies was not used for any other product. Which was not the case. Another idea during the research phase was to create different versions of the plushie, the demo would include Jeremy, the dog/bear. But one of the set goals was to make sure there is something for everyone in our target audience. That's how Amelia the pig and Oliver the Otter were created, the fact that children have the option to choose their own favorite animal makes it easier for them to connect with their plushie, thus enhancing the anxiety relieving experience.

The problem that was chosen at the start of the project was: *“Students have difficulty helping themselves calm down in a classroom when their anxiety gets too high.”* In the end, we have a system that helps children calm down but not just in the classroom. The Breathing Buddies can be used in hospitals, at schools, at home, wherever the child needs them. We as team Squirtle can look back on this project with a feeling of pride, this project taught us a lot and made us learn a lot of new things. Most of us had never worked on a project together, but in the end, we managed to create something that we can all say we are happy with. Thank you for going on this journey with us, and we are enthusiastic about what the future has in store for us.

Bibliography

[1]

- J. Klei [1] Alessandro Vercelli, Innocenzo Rainero, Ludovico Ciferri, M. Boido, and Fabrizio Pirri, “Robots in Elderly Care,” *DigitCult - Scientific Journal on Digital Cultures*, vol. 2, no. 2, pp. 37–50, 2018, doi: https://doi.org/10.4399/97888255088954.
- [2] E. S. Cross and R. Ramsey, “Mind Meets Machine: Towards a Cognitive Science of Human–Machine Interactions,” *Trends in Cognitive Sciences*, Dec. 2020, doi: https://doi.org/10.1016/j.tics.2020.11.009.
- [3] “JAMA – The Latest Medical Research, Reviews, and Guidelines,” *jamanetwork.com*. https://jama.com
- [4] N. editorial team, “The Ultimate Guide to Handheld Anxiety Devices: Finding Relief in the Palm of Your Hand,” *NeuroLaunch.com*, Jul. 29, 2024. https://neurolaunch.com/handheld-anxiety-device/
- [5]I. Kononenko, “Machine learning for medical diagnosis: history, state of the art and perspective,” *Artificial Intelligence in Medicine*, vol. 23, no. 1, pp. 89–109,

Aug. 2001, doi: https://doi.org/10.1016/s0933-3657(01)00077-x.

- [6]J. Abbasi and Y. Hswen, “One Day, AI Could Mean Better Mental Health for All,” *JAMA*, vol. 331, no. 20, p. 1691, May 2024, doi: https://doi.org/10.1001/jama.2023.27727.
- [7]G. Schneider, “Mind and machine in drug design,” *Nature Machine Intelligence*, vol. 1, no. 3, pp. 128–130, Feb. 2019, doi: https://doi.org/10.1038/s42256-019-0030-7.
- [8]H. Sattar *et al.*, “An Intelligent and Smart Environment Monitoring System for Healthcare,” *Applied Sciences*, vol. 9, no. 19, p. 4172, Oct. 2019, doi: https://doi.org/10.3390/app9194172.
- [9]V. Mateljan, V. Juricic, and M. Moguljak, “Virtual machines in education,” *2014 37th International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO)*, May 2014, doi: https://doi.org/10.1109/mipro.2014.6859639.
- [10]S. Rossi, M. Larafa, and M. Ruocco, “Emotional and Behavioural Distraction by a Social Robot for Children Anxiety Reduction During Vaccination,” *International Journal of Social Robotics*, vol. 12, no. 3, pp. 765–777, Jan. 2020, doi: https://doi.org/10.1007/s12369-019-00616-w.
- [11]A. L. Beam and I. S. Kohane, “Big Data and Machine Learning in Health Care,” *JAMA*, vol. 319, no. 13, p. 1317, Apr. 2018, doi: https://doi.org/10.1001/jama.2017.18391.
- [12]T. Panch, P. Szolovits, and R. Atun, “Artificial intelligence, machine learning and health systems,” *Journal of Global Health*, vol. 8, no. 2, Oct. 2018, doi: https://doi.org/10.7189/jogh.08.020303.
- [13]S. Goswami, S. Pal, S. Goldsworthy, and T. Basu, “An Effective Machine Learning Framework for Data Elements Extraction from the Literature of Anxiety Outcome Measures to Build Systematic Review,” *Lecture notes in business information processing*, pp. 247–258, Jan. 2019, doi: https://doi.org/10.1007/978-3-030-20485-3_19.
- [14]E. Garcia-Ceja, M. Riegler, T. Nordgreen, P. Jakobsen, K. J. Oedegaard, and J. Tørresen, “Mental health monitoring with multimodal sensing and machine learning: A survey,” *Pervasive and Mobile Computing*, vol. 51, pp. 1–26, Dec. 2018, doi: https://doi.org/10.1016/j.pmcj.2018.09.003.
- [15]S. Jeong *et al.*, “A Social Robot to Mitigate Stress, Anxiety, and Pain in Hospital Pediatric Care,” *Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction Extended Abstracts*, Mar. 2015, doi: https://doi.org/10.1145/2701973.2702028.
- [16]N. C. Burbules, G. Fan, and P. Repp, “Five Trends of Education and Technology in a Sustainable Future,” *Geography and Sustainability*, vol. 1, no. 2, pp. 93–97, May 2020, doi: https://doi.org/10.1016/j.geosus.2020.05.001.
- [17]Mary Beth Rosson, *Advances in Learning Processes*. BoD – Books on Demand, 2010. https://www.researchgate.net/publication/234818797
- [18]L. D. Riek, “Chapter 8 - Robotics Technology in Mental Health Care,” *ScienceDirect*, Jan. 01, 2016. https://www.sciencedirect.com/science/article/pii/B9780124202481000088
- [19]T. Shibata and K. Wada, “Robot Therapy: A New Approach for Mental Healthcare of the Elderly – A Mini-Review,” *Gerontology*, vol. 57, no. 4, pp. 378–

386, 2011, doi: https://doi.org/10.1159/000319015.

- [20]J. Shen and D. Wu, "An Empirical Study and Effect Evaluation of Installation Art and Computer Interactive Technology in Public Space," *Proceedings of the 3rd International Conference on Art Design and Digital Technology, ADDT 2024, May 24–26, 2024, Luoyang, China*, 2024, doi: https://doi.org/10.4108/eai.24-5-2024.2350124.
- [21]Robinson, L., Segal, J., & Smith, M. (2018). Relaxation techniques for stress relief. *HelpGuide.org*. https://www.aboldstoryneverends.org/uploads/b/af416020-9e50-11ed-8943-ad8be5e50f68/02afa590-ed7b-11ee-a3eb-1129489af42b.pdf
- [22]T. S. Lim, S. C. Sim, and M. M. Mansor, "RFID based attendance system," *IEEE Xplore*, Oct. 01, 2009. https://ieeexplore.ieee.org/abstract/document/5356360 (accessed Nov. 29, 2020).