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AALBORG UNIVERSITY
STUDENT REPORT

Title: Breathe Out - A Breath-Based Game Supporting Prerequisites for Learning about Asthma

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ABSTRACT

The lack of understanding from peers to a child with asthma, often affects the child negatively. Children with asthma often feel frustrated with their medicine and excluded from their peers. In the field of human-computer interaction, many studies focus on mobile applications for monitoring and reporting asthma data for the asthma patient. Other studies focus on teaching children with asthma about their disease. Few to none studies focus on supporting the inclusion of children with asthma. In this paper, we present Breathe Out, a breath-based interactive game that supports learning about asthma through prerequisites gained from 'The Five Characteristics of Learning Through Play' model. We have evaluated Breathe Out with 47 children, where 17% of the children have asthma. We found that Breathe Out taught both children with and without asthma, about the disease. Our study highlights the potential of technology facilitating a conversation about asthma, which could potentially make the children with asthma feel more included among their peers.

Pages: 13 Pages
Appendix: 0

By signing this document, each member of the group confirms participation on equal terms in the process of writing the project. Thus, each member of the group is responsible for the all contents in the project.

Summary

This study is based on a previous study we did about children and adolescents with asthma. We found that they often feel excluded because they do not feel understood by their peers or adults without asthma. Other studies also suggested that children with asthma often struggle with being open about having asthma, in fear of not being listened to. Within HCI, there seems to be little focus on creating an inclusive community in a primary school setting, which we find important to explore to combat the feeling of being excluded. This lack of research combined with our own research led us aiming to answer the following research question:

"How can we, through digital technology, support the prerequisites for learning about asthma in primary school settings?"

We wanted to make an engaging system with educational properties for children to answer our research question. We propose to use 'guided play' by creating an educational game for children with and without asthma supporting prerequisites for learning about asthma. To create the prerequisites for learning in our prototype we found a theory on learning through play called 'The Five Characteristics of Learning through Play'.

The prototype, Breathe Out, is a breath-based game that runs on a Windows laptop and is used as the artifact to facilitate the prerequisites for learning. The game was created using the Unity Game Engine. In the game, the user controls a character with asthma up and down on the vertical axis by exhaling. The game controller consists of a watering hose with a cardboard mouthpiece. The hose is connected to a wooden box that acts as the shell for the electronics which are used to detect when a user exhales. The shell is placed inside a cardboard box, which contains the Arduino Mega, which connects all the separate electronics that detect when the user exhales into the controller. What makes this prototype unique is that depending on what ingame objects the player hits, the air flow is getting either smaller or bigger to give the player a simulated experience of what it feels trying to exhale while having an asthma attack.

We conducted a pilot test with one 2nd grade class (N=22) and evaluations with three different 2nd grade classes (N=47) where the children were divided into 13 focus groups. The evaluation involved a qualitative semi-structured interview and workshop with the purpose of learning about the children's prior knowledge about asthma. This was followed by a session where the children played the game after a short tutorial by the facilitator. The facilitator did not explain what the game was about or what the different game elements meant as it was the task of the children to figure that out. Finally the children took part in a qualitative semi-structured interview for us to understand if and how Breathe Out supported the prerequisites for learning through a conversation. The facilitator used pictures of the game objects to facilitate the conversation.

The data from the evaluations were analyzed using the technique 'Affinity Diagram' to find patterns leading to themes in the data. From the three evaluation sessions, we learned that Breathe Out does have four out of five of the prerequisites to teach children about asthma. Most of the children understood the game objects and the purpose of them through the game, and got a deeper understanding of the objects through the conversation with their classmates. In terms of the first prerequisite revolving Joy, most of the children were positive towards Breathe Out and enjoyed playing it. Active and Engaged thinking were present as some of the children made the connections about being out of breath with how it may feel like to have asthma. The children understood and found meaning in the game objects, and connected the objects to the disease. Social interactions were also present as some of the children without asthma asked the children with asthma, how it affected them. Showing that the children without asthma were curious and wanted to gain an understanding for those with asthma. The only prerequisite the Breathe Out prototype did not support was the prerequisite Iterative Thinking. Theoretically, Breathe Out supports learning, however it had to be further tested in a study spanning over a longer period of time to confirm this.

Breathe Out - A Breath-Based Game Supporting Prerequisites for Learning about Asthma

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ABSTRACT
The lack of understanding from peers to a child with asthma, often affects the child negatively. Children with asthma often feel frustrated with their medicine and excluded from their peers. In the field of human-computer interaction, many studies focus on mobile applications for monitoring and reporting asthma data for the asthma patient. Other studies focus on teaching children with asthma about their disease. Few to none studies focus on supporting the inclusion of children with asthma. In this paper, we present Breathe Out, a breath-based interactive game that supports learning about asthma through prerequisites gained from 'The Five Characteristics of Learning Through Play' model. We have evaluated Breathe Out with 47 children, where 17% of the children have asthma. We found that Breathe Out taught both children with and without asthma, about the disease. Our study highlights the potential of technology facilitating a conversation about asthma, which could potentially make the children with asthma feel more included among their peers.

KEYWORDS:
Children, asthma, learning, 'The Five Characteristics of Learning Through Play', breath-based, game, inclusion, 'The Inclusion Flower', focus group, school context

INTRODUCTION
Children with asthma often feel excluded and struggle with whether to be open about having asthma or keep it a secret in fear of not being listened to from their peers [28], which we confirmed through interviews with a physician and a nurse in our previous study [34]. We also found that children and adolescents with asthma often feel frustrated with their medicine and exclusion from their peers, resulting in a lack of understanding from adults, adolescents and children who do not have asthma [34].

How do we combat the feeling of exclusion? Frode Skår states that children with asthma should be an active part of the conversation [23], this is based on a PHD by Anne Trollvik where she, among other findings, found that if children with asthma feel they can talk about their experiences with other adults and children they have an easier everyday life [29].

Asthma is the most frequent chronical illness in children in Denmark [13, 30] and about every tenth child in elementary school has asthma [30]. Asthma is a chronic inflammatory condition in the airways affecting the bronchi. The muscles of the bronchi swells, restricting the air ways [15]. When a person with asthma experiences an asthma-attack, it is due to them encountering a trigger, such as allergies or cold weather [2]. A person with asthma can live symptom-free if they are medicated correctly [3, 14].

Many studies on asthma within HCI focus on mobile applications for monitoring and reporting asthma data for asthma patients [1, 20, 21, 24, 31] while others aim to teach asthma patients about their disease [7, 9, 11, 32]. In contrast, there seems to be less research focusing on supporting the inclusion of children with asthma, which we find important to explore as we want children with asthma to feel secure when dealing with their asthma.

Løw and Skibsted state that to feel included raises one's feeling of security. This is because when we feel insecure or anxious the brain uses mental resources that could have been used for another purpose, e.g. learning. The feeling of belonging is a social goal as well as a motivational factor. [19]

'The Inclusion Flower' is created with a focus on inclusive communities for children [4]. An inclusive community is characterized by having a high level of difference, as both a condition and a potential [19]. 'The Inclusion Flower' has four leaves, each leaf refers to a parameter within inclusiveness. A community must achieve a high level of each parameter in order to become an inclusive community. The parameters being; 'Presence', 'Acceptance and recognition', 'Participation' and lastly, 'Development' [4].

'Presence' is about the extent to which level of present the children are, if the children are engaging amongst each other. 'Acceptance and Recognition' is about to which extent the children feel accepted and recognized by other children and adults. 'Participation' is to which extent the children participate actively in activities and the community. 'Development' is about to which extent the children benefit and learn from the activities they participate in, both academically and socially. [4]

Focusing on the parameter 'Development', as the children in the community must beneficially learn to engage in an inclusive community. [4] This led us aiming towards answering the following research question:

"How can we, through digital technology, support the prerequisites for learning about asthma in primary school settings?"

Our goal for this study is to give insight into the challenges children sometimes face when having asthma and create a prototype that supports the prerequisites for learning about asthma, to support the inclusiveness of children with asthma.

LEARNING THROUGH PLAY

Playful learning spans from 'free play' to 'guided play'. 'Free play' is often devoid of adult supervision and control. It includes anything from object-play to pretend to roughhousing and often includes peers. 'Guided play' is when adults try to instill a specific knowledge in a way that seems playful, relaxing, or fun. It often involves specific objects and supervision from adults, so that they can ask questions to facilitate learning. Like with 'free play', 'guided play' respects the children's own pacing. [17] The model 'The Five Characteristics of Learning through Play', states that learning through play happens when [33]:

- an activity sparks joy,
- supporting active and engaged thinking,
- the children find meaning in what they are learning or what they are doing,
- it involves iterative thinking and
- involve social interactions with peers and adults

We chose the five characteristics for our prerequisites for learning, to support the level of 'Development' in the community.

The sparking of Joy does not have to continue the entire play session. Sometimes frustration is necessary to feel the joy of a breakthrough. In a variety of definitions of joy here are some: pleasure, enjoyment and thrill.

Supporting Active and Engaged Thinking is about being actively engaged in the game. A high level of actively engaged, is when one makes connections within the game, and questions the function of an element, or their knowledge about that element.

Finding Meaning in what they are learning or what they are doing, builds upon being actively engaged in the game. It revolves around connecting elements from the game to elements they already know from the real world.

Iterative Thinking is about trying out possibilities and revisiting hypotheses. This leads to a deeper understanding of the game.

Social Interactions with peers and adults supports learning as sharing one's mind, understanding others gives clarity to the subject. [33]

RELATED WORK

For our project, we found two categories of research that are interesting and relate to our work: 'Learning through digital games' and 'Breath-based Games'.

Learning Through Digital Games

A field within HCI is learning through digital games. It has been explored in depth and shown promising results in educating children [10, 16] or facilitating conversations in the classroom [12]. Vallerand et al. designed an educational game on an Android device that works as an educational activity in addition to school. The game was effective at engaging the children in the educational activity. In addition, the results of the test showed that the children had improved their knowledge while playing the game.

Breath-Based Games

A Danish health organization called Danske Patienter has made a school exercise that teaches school children what it is like for their peers with asthma to have an asthma attack and what types of physical boundaries it sets for the children with asthma. For the exercise, participants have to inhale and exhale through a straw while doing different types of physical activities like standing, walking around, and jumping up and down. After the exercise the class is encouraged to discuss what it was like to exercise with more restricted airways. [6]

Breath-based controlled games have also seen interest within the HCI community. Examples like the respiration game ChillFish has been used to calm and relax children with ADHD in order to better self regulate their emotions [25, 26]. In addition, ChillFish has also been used to calm and distract children during blood samplings [27]. ChillFish is a breath-based biofeedback 2D game, played on a tablet, where the user controls a pufferfish character to collect starfish. The pufferfish is controlled by inhaling and exhaling into a physical controller. [27]

Another use of breath-based gameplay is SpiroPlay, where children with asthma are triggered to use a spirometer correctly through metaphors for regulation of their asthma severity. The metaphors are designed to teach the children when to exhale and inhale in order to get the best results from a spirometer. [31]

Findings from our previous study supports that it is important for children with asthma to understand what is happening with their bodies. When interviewing the Asthma School in Aalborg we found that they guided the children to feel their bodies, both when breathing normally and when having an asthma attack, to give the children a sense of control. [34]

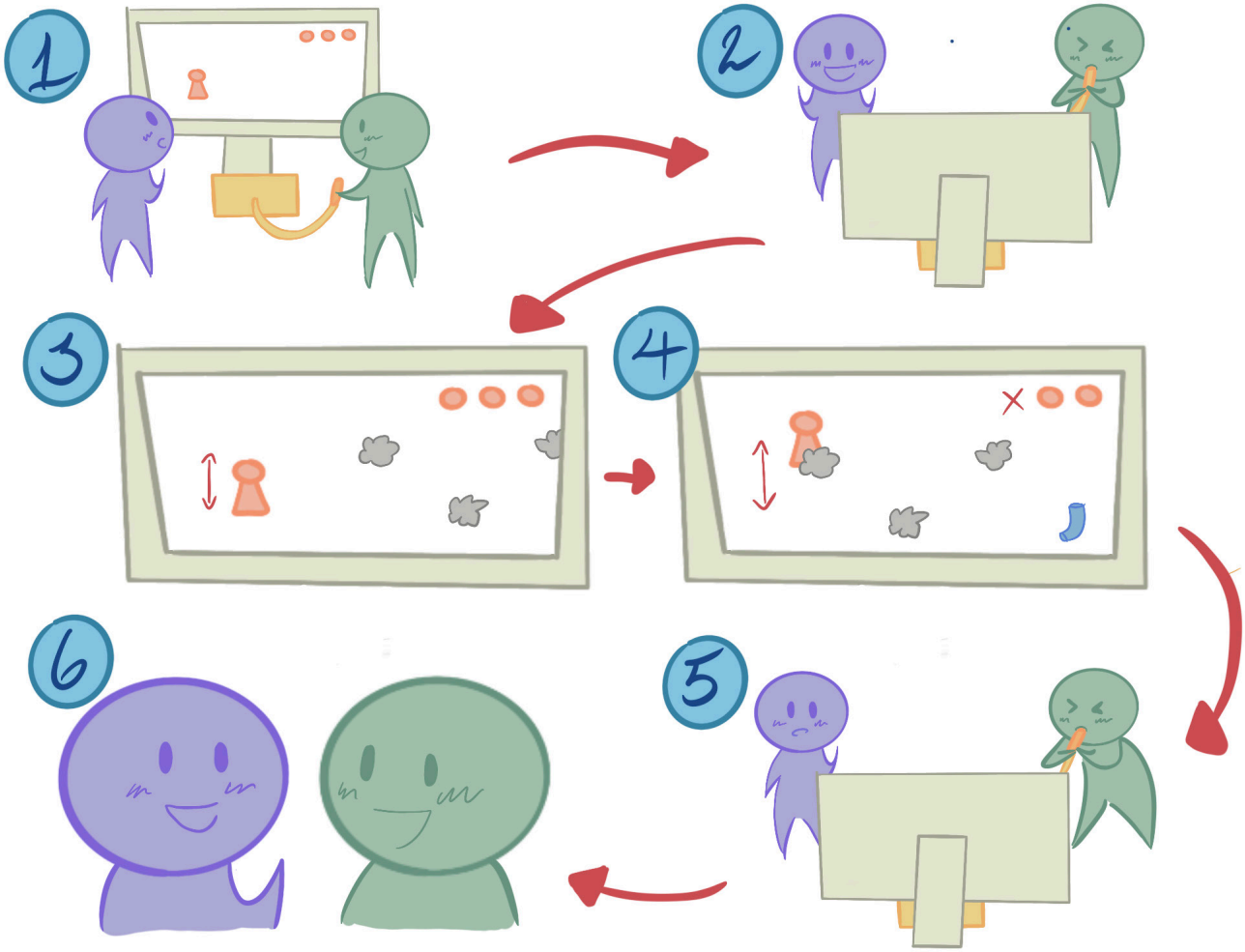

Figure 01: Shows a scenario of Breathe Out. 1) Children standing around starting the game. 2) One of the children exhales into the controller, while the other encourages the playing child. 3) The character moves up and down. 4) The character hits a dust cloud and the bronchus restricts. 5) The child exhales harder into the controller. 6) After the game the children start a conversation about the game and what it means.

THE BREATHE OUT SYSTEM

To answer the research question we propose to use 'guided play' to create an educational game for children using prerequisites for learning about asthma, as we wish to support social inclusion of children with asthma by creating understanding for what they go through.

The Breathe Out Prototype

The prototype is a breath-based biofeedback game that runs on a Windows laptop and is used as the artifact to facilitate learning. The game was created using the Unity Game Engine. In the game, the user controls a character, with asthma, up and down on the vertical axis through a breath-based interaction, see a scenario for Breathe Out on Figure 01.

When playing, the user has three health icons which show different stages of a bronchus, these are displayed in the top right. Each time the character hits a dust cloud, one bronchus is lost indicating that the character's bronchi are swollen resulting in an asthma attack caused by the dust cloud. By hitting the blue inhaler containing medicine the character can counteract the effects of the asthma attack. The game is designed so the inhalers only appear if the character does not have a bronchus with a clear passage for the air. If a character hits a dust cloud three times in a row, the game ends. The different in-game objects can be seen in Figure 02.

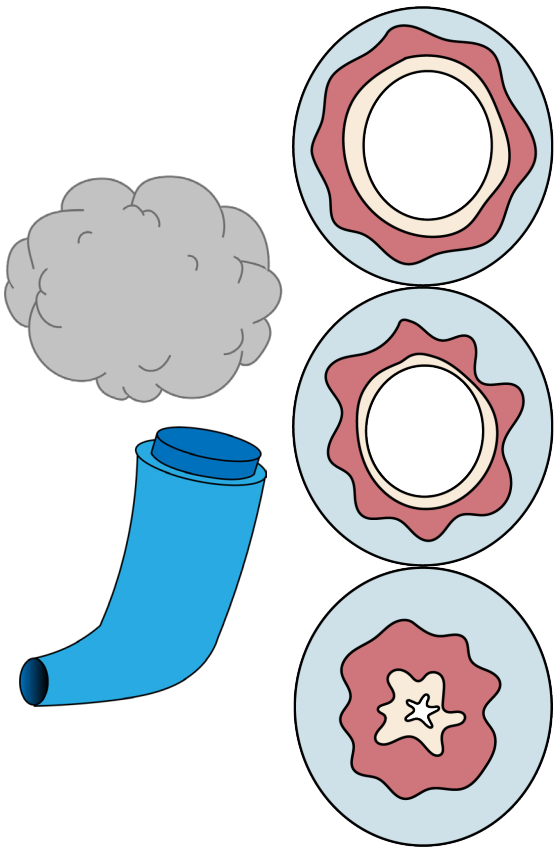

Figure 02: Illustrations of the dust cloud, inhaler and three stages of the bronchus that are used in the game.

Description of the Prototype

The game controller consists of a watering hose with an interchangeable cardboard mouthpiece for the sake of hygiene during testing with multiple participants. The hose is connected to a wooden box that acts as the shell for the electronics which are used to detect when a user exhales.

The shell is placed inside a cardboard box, which contains the Arduino Mega, which connects all the separate electronics such as a LDR photoresistor, a white LED, and a Step Motor 28BV J-48. The setup can be seen in Figure 03. Using the LDR photoresistor and the white LED, we can detect when the user exhales into the hose and send that data to Unity through the Arduino Mega, which is connected to a laptop via a USB 2.0 cable.

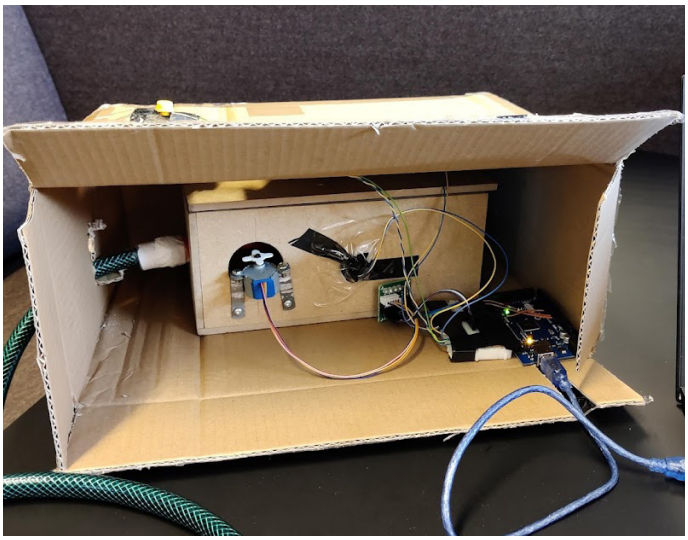

Figure 03: a) Showing the inside of the prototype.

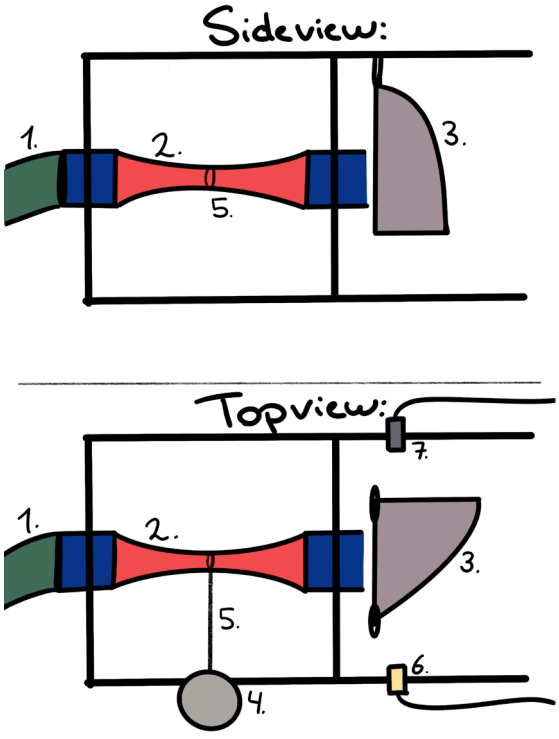

Figure 03: b) A Cross-section of the prototype, seen from the side and from the top.
1) Hose
2) Balloon
3) Light Blocker
4) Motor
5) Thread
6) LED
7) LDR

LDR Photoresistor

To detect when a user exhales into the console, we use a LDR photoresistor to detect light from a white LED which is normally obstructed by a piece of cardboard used as a light blocker. The light blocker is hanging from the ceiling of the shell, which is blown out of the way, when air flows into the shell, seen in Figure 04. When the LDR receives light from the white LED, a continuous signal is sent to Unity while the user is exhaling into the hose. This signal then allows the character to move upwards as long as the signal is received. The current build only works on a stationary console as the cardboard piece obstructing the light could move on its own allowing a false signal to be sent to Unity. It is also only possible to exhale into the hose as trying to inhale will be blocked by the cardboard between the white LED and LDR.

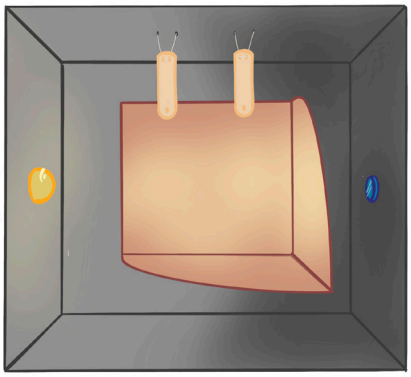

Figure 04: An illustration of the LED, the cardboard light block and the LDR photoresistor.

Step Motor 28BV J-48

To create an experience of what it feels like to have an asthma attack when playing the game, we put a balloon at the end of the hose inside the wooden shell, seen in Figure 05. Around the balloon is a piece of thread that can be tightened or loosened by a step motor. If the user hits dust clouds in the game, a signal is sent from Unity to the Arduino Mega that tells the motor to turn so that the thread around the balloon is tightened thus making it harder to exhale into the hose while the opposite happens when the character hits the blue inhaler medicine.

The Arduino Mega's CPU is not able to handle more than one job at a time, this means that the Arduino cannot both receive and execute a different task while also sending data to Unity. For us, this meant that everytime the character hits an ingame object, the game is purposefully paused while the Arduino receives a signal and turns the step motor as it cannot detect if the user is breathing into the hose at the same time which makes it impossible for the user to control the character.

Figure 05: The balloon with thread around connected to the motor.

BREATHE OUT STUDY DESIGN

Conducting our evaluation at a public school in Northern Jutland was insightful. We conducted our evaluation at a school, to gain access to multiple children without asthma but at the same time to ensure that there would be at least one child with asthma in our study, as we know 10% of all school-aged Danish children have asthma [18]. We wanted children with and without asthma to observe their different interactions with Breathe Out and with each other. The school had four 2nd grade classes, which we were allowed to evaluate with. We used lessons called UU-lessons (Understøttende Undervisning, tr. Supportive Teaching) for the evaluation. Each class has around 25 children, and in one UU-lesson, we tested one class.

We conducted a pilot test with one class (N=22). From this pilot test, we learned that our study procedure could be optimized. As an example; we learned that the 45 minutes, which is the duration of a UU-lesson, was not enough time to get the children's insights. If we were able to include their 30 minutes of recess, we would have 75 minutes for our test, which the school agreed on. We also learned the game was too difficult for the children; they did not have the same lung capacity as we did, so we had to adjust the sensitivity, for an exhale to be detected.

Procedure

In order to get the most insightful results, we contacted a school teacher student, who gave us information and material on how to design our study. To ensure that we got every child's insight, we decided to split a class into six focus groups. Thereby, also creating the possibility of a child with asthma being more comfortable talking about their asthma. The procedure for the study was split into three phases, each phase had a facilitator. Every focus group follows the phases chronologically, and each focus group had 8 minutes in every phase.

The first phase revolved around a qualitative semi-structured interview and workshop, for us to learn of the childrens' prior knowledge they can recall about asthma, and to later understand what the children had learned. We learned from the school teacher student that children are better at communicating when they are presented with something tangible, such as drawing a picture or being presented with a picture. Therefore, the children in the focus group were instructed to make individual drawings of what they thought asthma was. While the children were drawing, the facilitator asked about the drawings and the reasons for what had been drawn. The facilitator also asked if the children knew someone with asthma, and what else they could tell about asthma. The setup for the first phase can be seen on Figure 06.

In the second phase, the children played the game. Since Breathe Out is only a prototype, the facilitator gave a quick tutorial on how to control the character, without explaining the objects in the game, such as the dust cloud and inhaler. This is because we wanted the children to understand this knowledge themselves. After the tutorial, each child got to play the game once, while the facilitator observed how the children interacted with the game, and with each other. The setup for the second phase can be seen on Figure 07.

The third phase also revolved around a qualitative semi-structured interview. To understand if and how the game supports the prerequisites for learning about asthma through a conversation.

The children were shown pictures of the ingame objects. The facilitator would then ask questions about the game objects, and what happened if the player touched the object. The setup for the third phase can be seen on Figure 08.

Figure 06: Concept photo of the first phase (Photograph is not from actual test).

Figure 07: Concept photo of the second phase (Photograph is not from actual test).

Figure 08: Concept photo of the third phase (Photograph is not from actual test).

Immediately after each evaluation with a class, we shared our results from each phase with each other, while audio-recording our discussion. We discussed one group at a time, starting with phase one and ending with phase three. After writing what was stated in the three audio-recordings, we analyzed the data with the technique 'Affinity Diagram', seen in Figure 09, to find patterns and themes in the data [22].

Figure 09: Shows the 'Affinity Diagram', each panel consists of different categories: Trigger, Medicine, Bronchus, Triggers, Usability and Knowledge about asthma.

Participants

It was not possible for us to fully evaluate the three remaining classes. The reason for this was that a teacher wanted to follow a focus group, and uninvited, the teacher took the facilitator role, making the data unusable for us. In one class we evaluated with two focus groups because of miscommunication about including the recess.

We tested with 47 children, distributed into 13 focus groups. The groups were randomized within each class. On average 3.6 children in each focus group. The children were between the ages of 8-10 years old. Eight children mentioned that they had asthma, and could describe specific details about asthma and their own treatment. This meant that 17% of our participants have asthma.

There was at least one child in every focus group who had knowledge about asthma and one child that knew nothing of the disease or knew of anyone with it. Three groups knew much about asthma. The children that knew much about asthma, would often have asthma themselves, or someone close to them had asthma.

RESULTS

When looking to answer our research question we wish to know about the children's prior knowledge of asthma to set a foundation for us to understand if they perceive the game objects as intended and how well Breathe Out supports 'The Five Characteristics of Learning through Play' model.

The Need for Breathe Out

Before playing the game the children drew what they associated asthma with. Most drew a coughing- or otherwise sick person, see examples in Figure 10, and stated that it was not fun being sick, because then you could not play with your friends. We also found that a couple of children had no idea of the severity of asthma, as they mentioned that they wanted to have asthma, because then you will get Coca-Cola, which was what they always got when they were sick. This underlines that it is important to teach about asthma.

One child got dismissed when they told the group they have asthma, another child in the group even said *"If you don't cough right now, you don't have asthma."* This was also the case in other groups, a child saying they have asthma and the group would either not comment or not believe them, which resulted in the children with asthma becoming frustrated. Our observations and the interview before the game supports the notion that we need to facilitate a conversation between children with and without asthma.

A Satisfying Understanding of the Game Objects and a Relation to Other Triggers

In general, the children understood the game objects, which ones were good and bad for you. Some children discussed the game objects with each other while another child was playing, and noticed that the dust cloud and inhaler had an effect on which stage the bronchus was in. *"This one is the medicine."* and *"This one is bad for you"*, were some of the statements made. Our observation shows that the children try to connect the objects to asthma and start the conversation by themselves without a facilitator, which is what we ideally want Breathe Out to do.

Figure 10: A selection of the drawings by the children showing what it is like to be sick.

Through the conversation in the groups during the third phase the majority of the children understood why the dust cloud was bad for a person with asthma, and that it affected which stage the bronchus was in. Most also understood the inhaler, however, a handful of children did not understand it as some children put it; the dust cloud made sense, it was dirty air, getting down in your lungs, but the inhaler was just a sock, why would that help you breathe better?, while a few children perceived the inhaler to be a trunk or a heart pump. Because of this we can conclude that, for some children, the illustration of the inhaler could have impacted the perception of the medicine.

All groups also came to an overall understanding of the bronchi. Some groups express that the restricted bronchus is where the asthma is biggest, and when the asthma is biggest, you have problematic breathing. When talking the children stated they would rather have a bronchus with a clear passage for air as they believed it would be easier to breathe. Even though we would like this realization to happen during the game due to the feature with the restriction of the air passage, we are not convinced that all children perceived the restriction, instead we feel they got their opinion during the conversation in phase three.

During the conversation in the third phase the children also expressed understanding for other triggers to asthma other than the cloud we used. They mentioned; Smoke, Grass, Cats, Flowers, etc., as possibilities, again we believe it is due to the conversation after playing Breathe Out rather than the game itself that the children are able to think of other triggers.

Breathe Out Sparks Joy

Our results showed that the children in general were positive towards the game. 45 children stated they found the game to be fun. Our observations showed the children being engaged in the game with some of the non-playing children guiding their playing group-mate and in an excited tone of voice saying: *"Don't touch that one, it's bad for you!"* and *"Aim after the blue one!"*.

In terms of the input modality of Breathe Out two children found it uncomfortable to play, resulting in them disliking the game entirely. However, multiple children enjoyed the interaction of using exhalation to interact with the game. Both during the second and third phase, one child repeatedly said *"It was so random!"*. In the third phase we found that when the child said 'random' they meant it as a positive exclamation, as the child really liked that Breathe Out has a different interaction to what they were used to.

We find that both the input modality of Breathe Out and the overall game sparked some immediate excitement resulting in Joy being present.

Breathe Out Supports Active and Engaged Thinking

When playing the game a child got dizzy the more they played the game, which the child did not find amusing and the child asked; *"Is this how it is to have asthma?"*. During the third phase after having played the game, giving the children a little time to ponder upon the game, three different groups also asked if the breathless experience they had was what asthma felt like. Showing us that the children did experience Active and Engaged Thinking during the playing Breathe Out, as they made connections about being out of breath with how it may feel like to have asthma.

A child in one of the groups even went so far as to say they wanted to have asthma in real life as a way to understand the feelings correctly, which another in the group found uncomprehending as they could not find any reason to wish for a sickness that is chronic. The child stated uncomprehendingly; *"Then you would have to take your medicine every day, for the rest of your life? I wouldn't wish that."*. Their conversation made the first child withdraw their original statement, saying *"That.. might not be so fun."*. Even though they are not actively playing the game anymore the group are still very active in the conversation after and through their discussion showed how much they thought about asthma's effect even though they only played around 40 seconds each. This discussion is also a good example of Social Interactions and what it has contributed to these children's understanding of asthma.

The Children Find Meaning with Breathe Out

Even though the children were mostly engaged in the game, two children mentioned that the game would have been more fun to play, if they knew the purpose of the game. During the conversation they understood the meaning and stated that now that they know the purpose of the game, the game was actually fun. If we had made the meaning with Breathe Out clear from the beginning the children may have been more engaging with the game. As only two of the 47 children state this, we are unsure if it needs to be clarified more, nonetheless it may have been even harder to understand the reasons for the game if Breathe Out was to be placed without our presence.

Breathe Out Supports Social Interactions Between the Children

Both during the game and the conversation after the children engaged in social interactions. As mentioned, the children would guide each other during the game. An example of Social Interactions is that four children with asthma in four different focus groups were asked about their asthma by the group members, making the children with asthma an active part of the conversation. Showing that the children without asthma in the groups are curious and want to gain understanding for those with asthma. We saw an instant change in the four children with asthma as they were happy for someone to be interested in their asthma. They gladly shared how they felt, and how they found out they had asthma in the first place.

Summary

To sum up 'The Five Characteristics of Learning through Play' the majority of the children were positive towards the game and enjoyed playing Breathe Out, even though some children found the game to be difficult. Some children did experience Active and Engaged Thinking during the playing Breathe Out, as they made connections about being out of breath with how it may feel like to have asthma. In terms of finding meaning in what the children are learning or what they are doing, the majority of the children understood the game objects, and some connected them to asthma. They understood that the inhalator was a good thing when a child with asthma had been affected by the dust cloud. However this could have been more optimized as two of the 47 children stated that they did not know the purpose of the game. Both during the game and the conversation after the children engaged in social interactions. Making the children with asthma an active part of the conversation, showing that the children without asthma in the groups are curious and want to gain understanding for those with asthma.

DISCUSSION

As mentioned in §Learning through Play we set our prerequisites for learning to be the five characteristics from the model 'The Five Characteristics of Learning through Play' [33]. We will therefore be discussing the characteristics.

Joy as a Result of the Input Modality

As mentioned in §Results, 45 out of 47 children found the game to be fun to play, while the last two children did not like the game as they found it uncomfortable, both were due to experience of the input modality. Although many children found it fun to play the game, a majority of them also thought it was difficult and five children even felt like they were out of breath after playing it. Although it might seem like it could take the joy out of the game, Zosh et al. states that in learning through play there can be negative or neutral emotions. This is because frustration with something is a necessity to feel joy of solving or overcoming an obstacle [33]. So if the game was easy to learn and play, it might take away from some of the joy of the game and thereby one of the prerequisites for learning through play.

The Exploration Supported the Active and Engaging Thinking, Creating Meaning

As shown in the results some children were out of breath after playing the game and afterwards asked if that was what it feels like to have asthma. Another child wished they had asthma so that they would know what it feels like, which seems to suggest that they were making reflections on the game based on their engagement with the game. We feel we could increase this engagement with a video explaining what happens when the player hits an inhaler or a dust cloud, as mentioned above. We would, however, have to consider the children's exploration of the game. Bonawitz et al. made a study on a novel toy with hidden features, where some children were told what all the features could do while others were left to explore the toy. The study showed that the children who had to explore the features were more engaged with the toy [5]. Therefore, a video could prove to be a mistake, but that would require more testing to determine.

Some of the children were able to make connections between the game objects and their own prior knowledge of asthma. However, not all of the children were able to make this connection, as they were unsure of what the purpose of the game was. When the goal was revealed to them, they instantly made a connection to the game and also expressed that it was fun to play. It could be argued that in this instance, it would have been logical, that the children should have received more instructions prior to playing the game in order to understand it better. However, according to Fisher et al. when children have to explore, they are better at putting a topic into a context but also retaining information a week later compared to children who are just told facts about a topic [8]. In that way, learning through play can help children use their existing knowledge and enable them to make connections.

How to Include the Prerequisite Iterative Thinking

As for optimizing the game a short video of how the bronchi gets affected when the player hits a dust cloud or an inhaler, could be displayed. We believe this would better the understanding of how asthma affects the body. The video could be shown when the motor is tightening or loosening the balloon with the thread, because of the natural stop when sending information to the Arduino Mega. Another perspective to take into account, as mentioned in §Results, is that some of the children misinterpreted the illustration of the inhaler. To demonstrate that triggers and medicine have many shapes and colors. We could include multiple characters a child can play with. Where the characters have different triggers and types of medication.

Understanding Asthma Created Social Interactions Among the Children

As mentioned in §Results, the children engaged in social interactions with one another both during phase two and phase three. Four children with asthma were asked about their asthma by the group members, showing that the children without asthma in the groups are curious and want to gain understanding for those with asthma. This is a core aspect for making the children with asthma everyday life easier, as stated by Trollvik [29].

LIMITATIONS

Several aspects of the study show promise, however, we did encounter possible limitations, which we will discuss.

Other Parameters From the The Inclusion Flower

As mentioned in §Introduction, Bohr introduced four parameters of inclusion: 'Presence', 'Acceptance and Recognition', 'Participation' and 'Development' [4]. Although we focus on 'Development' in this paper, the other parameters must be present to create an inclusive community. In terms of 'Presence' the children were engaged with each other and the game, we observed that all of the children actively took part in the study together and we did not observe that any were left out of the groups. 'Acceptance and Recognition' was present as well, as four children with asthma were asked by their peers about their disease. Here the children asked what asthma was and what it feels like to have the disease. All of the children actively played the game. 45 children tried their hardest at performing well in the game, two children gave the game a try, but disliked the input modality, which indicates that 'Participation' was also present. Another perspective to consider when creating inclusion could have been one of the other parameters of 'The Inclusion Flower'. We did observe some aspects of the parameters during our evaluation, and it could be interesting to study these as well.

Restricted Evaluation Time Frame

Another limitation of our evaluation was the time that we had available for each focus group. Since we were testing with the children during their recess and UU-lessons, we only have a limited amount of time to get all of the focus groups through the three phases. If we were able to have more time with each group, it might have given us other valuable insights since the children would have time to play the game for a longer period of time and thereby, hopefully get more out of the experience.

If we had made an in-game tutorial, showing how to control the character, without the facilitator, we could have made a study, where the game could be placed at the school for a certain amount of time without us having to facilitate the game experience. Then we could return and find what the children learned from playing the game in the time frame. This would take the playful learning from the 'guided play' we use now to be more 'free play' as they are able to play the game on their terms and make conclusions without our presence. There are, however, disadvantages to this study, as we would not be able to observe the children while they were playing the game, which was something that also gave us some insights during our current evaluation.

Procedure Changes

When conducting the pilot test, one facilitator followed the same focus group through all three phases. We learned that we got a variety of inputs, some children had learned a lot and others had been helped a lot by the facilitator. We changed the procedure to one stationary facilitator at each phase to make our procedure more uniforme in how they were conducted. It could be argued that the procedure for the pilot test had an advantage in that we would more easily be able to track each individual child from phase one to phase three. To understand how the child interacted with the rest of their focus group, in different phases, and to follow up on earlier statements a child had made. However, we chose to focus more on how they learned as a group, being able to discuss and work together to figure out how the game worked. Therefore the more uniform approach worked well for us, as each focus group was receiving the exact same information, and evaluated the exact same way.

Restricting the Air Flow Through the Balloon

The resisting of the air flow was a core feature of our game, as it was the feature that differentiated our prototype the most from previous breath-based controllers. However, during our evaluations none of the children noticed a difference in the difficulty of breathing. There could be many reasons as to why this happened. A reason could be that the tightening of the balloon after the player hits the dust cloud could be too minor to be noticed. Instead it might have been interesting to completely close off the air flow on the restricted bronchus, so they get the feeling that it was impossible to exhale into the hose. Other factors that might have overshadowed the tightening could be that the game was too short, that they are not used to breath-based games or if the children were too engaged in the game to notice the air flow getting increasingly restricted.

CONCLUSION

The motivation for this study derives from the insight that the lack of understanding from the peers of a child with asthma, often affects the child negatively. Our research question is;

"How can we, through digital technology, support the prerequisites for learning about asthma in primary school settings?"

Our aim is to give insight into the challenges children with asthma can face, along with proposing a solution supporting the prerequisites for learning about asthma to ultimately support the social inclusion of the children with asthma. The prerequisites for teaching about asthma were taken from 'The Five Characteristics of Learning through Play' model. In this study we presented Breathe Out, a game that facilitates learning about asthma through breath-based interaction.

We evaluated Breathe Out at a Danish public school. The evaluation was conducted with 47 2nd graders, divided into 13 focus groups. 17% of the children in the groups have asthma. Each focus group would undergo three phases in the evaluation. The first phase would revolve around understanding the children's prior knowledge and first impression about asthma. In the second phase the children would play the game Breathe Out, and we would observe their interaction with each other and the game. The third phase would revolve around understanding the children's newly learned knowledge and how they communicate about asthma.

Breathe Out did not directly teach the children about asthma in itself but rather facilitated a conversation within the focus groups. Most of the children understood the game objects and the purpose of them through the game, and got a deeper understanding of the objects through the conversation with their group members. Breathe Out supported four of the five prerequisites for learning. The prerequisite around Joy was present as the majority of the children were positive towards the game and enjoyed playing Breathe Out. In terms of Active and Engaged Thinking, some of the children made connections about being out of breath with how it may feel like to have asthma. The children found Meaning as the majority of them understood the game objects, and connected the objects to asthma. Social interactions were also apparent as some of the children with asthma were asked about their asthma, and how it affected them, demonstrating that the children without asthma were curious and wanted to gain an understanding for those with asthma. However, the prototype of Breathe Out did not support the prerequisite Iterative Thinking. Theoretically, children with and without asthma, would learn about asthma from Breathe Out. The children's learning would create a high level of 'Development' from 'The Inclusion Flower', which as mentioned increase the potential of an inclusive community in the primary school.

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