Asthmon: Empowering Asthmatic Children's Self-Management with a Virtual Pet

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Abstract
Asthma is a common chronic childhood disease. Children spend a majority of their time in schools, and barriers to on-site asthma management have been reported. Previous forms of clinical intervention have regarded patients as passive subjects. However, self-management plays a significant role in caring for asthmatics. We consider asthmatic children and their parents, primary caregivers, as active participants in their treatment and care. To achieve this, we created Asthmon, a portable virtual pet that measures the lung capacity, and instructs appropriate actions to take.

Keywords
asthma, children, virtual pet

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design

Introduction
Asthma is a common chronic childhood disease, and efforts to improve the care and control are a priority because of its high rates of morbidity and mortality [1].

figure 1 The Asthmon, representing condition of asthmatic children, sings a song in its free time.

As an integral part of the routine management, people adopt asthma action plans to provide appropriate asthma care instructions based on a patient's condition at a given moment, and peak flow meters to measure an asthmatic's airflow [2]. Because children are highly dependent on their parents in the management of asthma, situations in which children are alone, particularly in school settings, are of great concern for parents [3, 4].

Barriers to asthma management in schools have been reported by both parents and school nurses [3, 4, 5]. Previous interventions have considered patients as passive subjects with little ability to manage their condition. For example, several studies concluded that the use of a peak flow meter in school is unreliable for children because of it inaccuracy and lack of adherence, despite its being considered as one of the main self-management tools for asthmatics [6]. However, parents, the primary caregivers, voiced the need of more independent asthma management for their children [3. 4]. Thus, in this study, we consider patients as active participants who can provide valuable input into the design of technology to help them overcome their problems.

Our goal in this work is to examine technological intervention as a way to empower asthmatic children to manage their disorder themselves within a school setting. We introduce Asthmon, a portable toy to encourage self-management by children in school, and software for caregivers to use to remotely monitor children's asthma conditions at the school. Asthmon uses an airflow sensor and a personal, mobile display that represents a child's condition as determined by the measured airflow values and suggests appropriate clinical actions to take. In this paper, we discuss the types of barriers to self-management that exist in schools based on the reports of caregivers, and how those barriers could be solved by technology. Then, we suggest the Asthmon toy system as a solution. We conclude with proposals for future work.

Barriers in School Asthma Management

School staff-related barriers

One barrier to asthma management in schools is the lack of sufficient personnel to manage asthmatic children. Both caregivers and school nurses remark that too few school nurses and school staffs exist to care for asthmatic students [3, 4, 5]. The lack of time available to school nurses to be involved in the care of each asthmatic student caused to fail to improve the asthma condition in one study [7]. Another barrier, according to caregivers, is that the school staff lack the knowledge of how to care for asthmatic students [3, 4]. Similarly, school nurses reported the need for more education about asthma [5]. One study reported that school staffs were unable to recognize symptoms of asthma even with the use of peak flow meters [8].

Equipment-related barriers

Asthma action plans and peak flow meters are the standard tools for asthma self-management. Although these tools are recommended for use in asthma management in school settings, two barriers contribute to difficulties in implementation. One is the lack of asthma equipment. School nurses and caregivers reported the need to use action plans and other equipment to manage asthma [3, 4, 5]. However, surveys report that at most a little more than half of schoolchildren with asthma have access to peak flow meters at school [9]. Another barrier is the reliability of

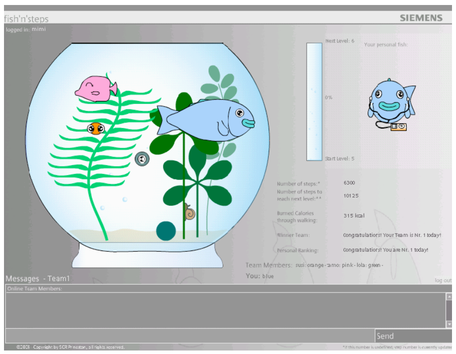

figure 2 A virtual pet of Fish 'N' Steps provides motivation by mapping individuals' daily activity progress towards their goals to the development of the fish.

figure 3 Butterflies and flowers of Ubifit Garden (left) and Trees UbiGreen (right) represent current level of desired activities and promote the activity.

peak flow meters when used by children. Although when used properly, these meters accurately measure the severity of asthma in children who are not able to perceive their degree of airway obstruction adequately. However, several studies have estimated that children's use of peak flow meters is unreliable because of the difficulties in maintaining adherence and the potential for incorrect readings [6, 10]. Sly et al. suggested that the use of a personal flow meter in school, home, and a hospital could improve the accuracy of measurement values because measurements of peak flow in an asthmatic child are likely to differ depending on which flow meter is used [6].

Technology to Encourage Consistent Daily Activity

Few studies have investigated technology as a way to empower self-management by asthmatic children. However, we are able to learn from several studies in the Human Computer Interaction (HCI) field how to increase patients' awareness of their current conditions, and how to encourage users to take appropriate actions on a daily basis.

Fish 'N' Steps is a social computer game that links a player's daily footstep count to the growth and activity of an animated virtual character, a fish in a fish tank, in order to promote an increase in physical activity [11]. Fish'n'Steps uses pedometers as a portable sensor to detect a person's current activity level and a virtual pet game as a representation of daily progress to provide additional motivation and incentives. Similarly, UbiFit Garden is a system to encourage physical activity. This system uses on-body sensing technologies and a personal, mobile display. Its Mobile Sensing Platform automatically detects physical activity in real time [12]. Its non-literal aesthetic representation of physical activity on a mobile phone is designed to motivate more physical activity by the users. UbiGreen is a mobile tool to track and support environmentally sound transportation habits [13]. Transportation data are detected from a Mobile Sensing Platform, the phone's own GSM cell signals, and the participants themselves. Desirable transportation activity is mapped to the development of a tree or a polar bear on a mobile phone display. The UbiGreen Transportation Display provides personal awareness about environmentally sound transportation activities and promotes desirable behavior.

Ubiquitous sensing technologies that infer daily behaviors ranging from physical activity to transportation behaviors have been used to determine levels of such activity or behaviors. Interactive representation of the absolute sensor data contributes to encouraging consistent daily activity. A virtual pet contributes to heightened engagement and attachment to these systems because of its emotional aspects. Lieberman also employed attachment to a virtual pet, such as Tamagotchi, to design technological health education for children with a chronic disease [14]. Asthmon, presented here, uses a portable sensing technology, and its Asthmon character corresponds to sensor data as a way to encourage asthmatic children to manage their disease as a part of the daily activities.

Asthmon System

We designed Asthmon, a system that combines the ubiquity of a mini peak flow meter and the simplicity of an asthma action plan into a blowing game with a virtual pet. Asthmon directly empowers children and caregivers because patients would be their own best helper. An ubiquitous toy (a virtual pet) would help encourage adherence and provide instructions to improve accuracy. The Asthmon system consists of two components: a portable toy for asthmatic children and a software module (remote viewing) for caregivers.

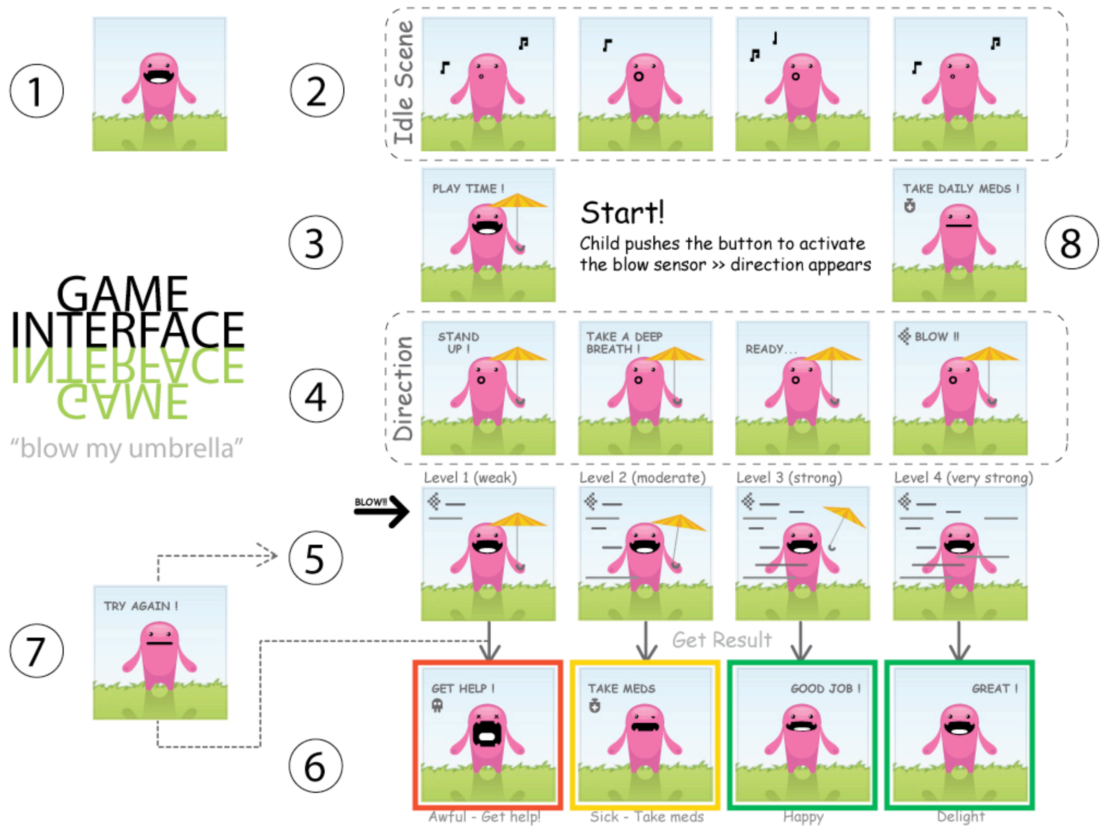

figure 4 Asthmon sings a song during free time as a live pet. When the scheduled time comes, Asthmon makes a 'beep' sound and asks an asthmatic child to play a blowing game called "blow away my umbrella." Asthmon instructs the child to inhale maximally and exhale maximally while standing up, all standardized techniques used with a peak flow meter. The amount of airflow from a child maps to the amount of virtual wind. The value of airflow is compare to past records and Asthmon recommends appropriate clinical action to take. If the value is out of range (erroneous value), Asthmon ask a child to "try again."

A portable toy for asthmatic children

One of the major limitations of peak flow meters is the lack of adherence. Because virtual pets engender complex attachments (e.g., Fish 'N" Fish, Ubigreen), Asthmon displays the key behaviors that Donath specified as characteristics of a virtual pet [15]. First, Asthmon acts autonomously. Its actions seem to be internally motivated. For example, it likes to play with its owner and sings a song in its free time. Second, Asthmon is a kind of "infant" that elicits nurturing and affection. If an asthmatic child does not inhale as much as he or she can, the pet feels sad. Its dependence makes the owner feel responsible for it. Third, Asthmon interacts with its owner. Playing with the pet involves interacting with it, and the pet becomes integrated into asthmatic children's daily lives. Asthmon follows the essential rules of standard self-management tools, asthma action plans and peak flow meters. When an asthmatic child starts to play a blowing game with Asthmon, it instructs the child to inhale and exhale maximally while standing up —the standardized techniques used with a peak flow meter. The processor in Asthmon provides clinical messages such as "take medicine" or "get help!" by comparing the current value of the peak flow measurement with past values contained in the child's asthma action plan.

The 4.5-inch x 2.6-inch x 1.5-inch portable toy, Asthmon, is a battery-powered computer with a sensor chosen for its capability to facilitate peak flow meter values. Its sensor is a microphone. Additionally, the system includes an Arduino Nano Microcontroller, a Nokia 6100 color LCD, a piezoelectric speaker, a push button for user input, a real time clock for scheduling peak flow measurements without interrupting school activities, and a micro SD module for caregivers to retrieve data from the toy. Asthmon serves as a peak flow meter, which is derived from a sensor that in this case is a microphone. After asthmatic children blow into the toy as part of a "game," the results are scored according to values stored in the asthma action plan. The ability to blow 100% to 80% of past best peak flow registers as green, 80% to 50% as yellow, and below 50% as red. Although a toy cannot provide results as accurate as a device in a hospital, it could increase children's essential notion of their condition and encourage them to take appropriate action. Also, parents are able to remotely monitor their children's condition at school by retrieving data from Asthmon.

Software application for caregivers

The toy is bundled with software that is for use by parents. The software helps parents monitor their children while they are at the school and can also schedule times at which the child should use the toy. This peak flow data is retrieved using a USB link to a computer. A software module for scheduling the game is also provided for the parents. Parents can use the scheduler to schedule the days and the time at which the game can be played by the child.

Conclusion & Future Work

A series of studies within the medical field have tried interventions with asthmatic children within school settings. Most of these studies regarded parents and students as passive subjects in the control of asthma because parents were remote from the schools and students were thought less capable of self-management. However, both school nurses and parents voiced the need of more independent asthma management from children. Thus, we designed Asthmon, a portable toy that is with children all the time, and a software module that enables parents to monitor children's condition while they are in school. We consider asthmatic children and their parents as active participants in the care and treatment of asthma.

As a next step, we would like to conduct user studies with children and caregivers in order to prove the concept of Asthmon: How portable Asthmon is, how much Asthmon can be integrated into children's lives, and how useful the instruction from Asthmon is. We would approach proving this concept by comparing Asthmon with previous management tools, asthma action plans with peak flow, and how Asthmon influences parents' and children's lives. Additionally, we plan to add more sensors to Asthmon in order to monitor not only the medical condition of asthmatic children but also the environmental conditions in schools. We hope our work would contribute to more studies in the HCI field in which investigators would focus on developing technologies for asthma patients by considering them as active participants in their own care.

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