Towards Mobile Applications for Co-Monitoring Children's Health Condition

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***Abstract*—In this paper, we present the user-centered design process used in the design of a mobile application prototype for co-monitoring children's health while they are in school. Based on the initial results from a user study, involving 81 participants (50 parents and 31 teachers), we designed the app prototype. It allows both parents and teachers to co-monitor and manages a child's health condition. The app establishes a consistent communication between parents and teachers. It also allows for tracking children's' activities and school performance. In addition, the prototype admin access allows the school administration to perform their duty, such as student registration and setting up classes.**

Keywords— health condition, school, student's, children, medication, personalized mobile app, monitoring, tracking, health and wellness.

I. Introduction

Nowadays, as technology is thriving, many new systems have been developed to simplify the day-to-day lives of individuals and organizations' activities. These systems differ in purpose, the group of users they serve, and the platforms they use which include webpages, software, and mobile applications. Despite all the mentioned systems, we still lack systems that facilitate easy and secure communications between parents and teachers concerning the children's health and behaviors during the school hours. Often, children's health is prioritized by the parents, especially when they develop medical conditions such as allergies, diabetes, asthma, or behavioral issues which may have negative impacts on their performance in school and their adult lives [11]. Thus, many parents are concerned about ways to monitor their children while at school.

The goal of this research is to design a prototype for a mobile application to be used by teachers and parents in co-monitoring and tracking the children's health conditions while in school. The application allows parents to get reports about their children's health conditions at any time. To achieve the objective of the research, we followed the user-centered design approach. More specifically, we undertook a study of 81 participants which comprised 50 parents and 31 teachers. We collected data on whether there is a need for a mobile application that allows both parents and teachers to co-monitor and manage children's health conditions, communicate with each other, and also track children's activities as well as school performance. For detailed research, we conducted follow-up interviews with 11 participants out of the 81 who had filled questionnaires. Finally, we designed a prototype mobile application based on their feedback.

II. Literature Review

Technology has played a significant role in influencing the way health care services developed and delivered to the recipients. Some systems for tracking children's health and behavior at school have been developed over the past couple of years. They all vary in the type of platforms they use. However, all have one purpose in common, which is ensuring children's safety, whether they are in school, outdoors playing, being cared for by a babysitter or nanny, or going to and from school. For example, in a recent project [1], a system for tracking children during school bus drop-offs and pickups was developed to ensure the safety of children and send notifications to parents and authorities if a child was not present for the pickup or drop-off.

Similarly, a study [4] has a similar purpose of children's' health tracking but does not provide an opportunity for parent and teacher co-monitoring and hence does not account for when children are at school. Specifically, the system focused on tracking and monitoring a child's blood glucose for children with diabetes. It sends reminders to the child when it is time to check their levels and sends messages and updates to the parents in real-time. The outcome of the evaluation of the study shows that parents can incorporate the application into everyday life. Some participants felt that it has made tracking easy and made them feel comfortable because they were able to know what their child's blood level reads and whether they had done their test or not.

Health monitoring applications specially for Diabetes have been around for some time. A study [3] reviewed some diabetes management applications available on the App Store. The results show that those applications were mainly used by the patient and the data it collects cannot be used for the patients' health records. However, the application has definitely influenced and improved the way patients manage their diabetes in terms of taking medication on time and regularly checking blood glucose levels.

Several studies have documented the use of mobile-based applications to monitor the condition of school-going children. Sendra at al., [12] explored the effectiveness of smart architecture that was developed to monitor the health condition of a child while in school. In this study, children were given smart wearable devices that detected blood pressure, pulse, and temperature. For the functionality of these devices to be effective, they were integrated with mobile phones of teachers and parents. Their use made it easy for the condition of the child to be monitored regardless of the place where he/she was.

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Chen et al., [2] explored the use of smart clothes to monitor the condition of the people who are wearing them. According to the researchers, previous technologies were not sustainable. They claim that the use of clothes that are connected to online clouds and mobile phones could provide excellent monitoring for people with chronic conditions in the situation of emergency. Since this clothing is universal, it can as well be used to monitor children.

The most common chronic diseases in young children and extremely difficult to control is Asthma [13]. One study tested the functionality and feasibility of using mobile phones to track and manage asthma [6]. Participants were asked to take their peak flow reading and send it to the webserver, if not done by morning, they automatically get reminder text messages [6].

Other studies as well have established other mobile embedded technologies that can be used to monitor the health conditions of individuals remotely. Paraa et al. [10] explored the protocols that are used to design and develop mobile technologies such as gyroscope and accelerometer that are used to access people remotely. On the other hand, Garcia et al. [5] examined the effectiveness of applications that can be used to measure environmental conditions like humidity, temperature, noise, and luminosity that can affect health.

After reviewing previous research studies in the area, this paper contributes to filling in the existing gap of a school system that allows for co-monitoring between parents and teachers in regard to both aspect of the child's health and school performance. Also, in this prototype design we used a user-centered approach that involved the end user.

III. Methodology

The primary goal of our study was to explore whether there is a need for an app to monitor children with health conditions while they are in school. We also aim to explore what features parents and teachers would like to have in an application to help monitor their child's health. To achieve this goal, we conducted a questionnaire, then follow it up with an interview for more in-depth insights, after obtaining the results from both the questionnaire and the interview. We were able to create an initial prototype based on the feedback.

A. Questionnaire

The participants of this study are the potential users of the mobile application, divided into two groups which are parents and teachers and the school administration. We recruited a total of 81 participants, consisting of 31 teachers, and 50 individual parents , Table 1 shows the demographic information of our participants – number of females, males, and their age range.

For parents, we found that 100% of parents had children in daycare, 7% in primary schools, 67% in elementary schools, 17% in junior high schools, and 10% high schools. We also found that parents' education levels ranged from high school to graduate level and about 82% of them are working.

For teachers, we found that teachers' years of experience ranged from 1 to more than 20 years. Only 58% of teachers had a current active First Aid certificate whereas 87% of them have had students with health issues and 61% of them have handled students who require medical attention during school hours.

We collected data via an online questionnaire from parents and teachers. Both questionnaires consist of four sections. The first section is a consent letter, which describes the study's aims and assures participants of their anonymity. The second section contained demographic information and general information. The third part included questions related to information about children's health conditions and how they manage communications between parents, teachers, and healthcare personnel as well as the level of ease and satisfaction parents and teachers have about the current way of communication between them. The last section enquires about their familiarity with technology, and which system they currently use in their school (for teachers) or how parents would like the app to be designed (for parents).

TABLE 1. THE PARTICIPANTS' DEMOGRAPHIC DETAILS

Total Participants = 81 (50 Parents, 31 Teachers)		
	Parents	***Teachers***
Gender	Female (94%), Male (6%)	Female (87%), Male (13%)
Age	20 -29 (28%), 30-39 (40%), 40-49 (26%), 50 and up (6%)	20 -29 (19%), 30-39 (42%), 40-49 (32%), 50 and up (7%)

B. Interview

The participants of the interviews were parents and teachers who agreed to be contacted for a follow-up interview as email was sent to the questionnaire participants. We were able to interview a total of 11 participants, consisting of 5 teachers (4 females,1 male, aged 20 to 35), and 6 parents (5 females, one male, aged 20 to 40).

The interview questions for the parents consisted of questions about the health conditions of their children, the school awareness of the child's health concerns, as well as the current methods parents use to monitor their children and keep in consistent communication with teachers and the school staff. Also, and what can an application bring to solve some of these issues. Whereas, teachers interview questions consisted of questions about how many students with health concerns the teachers has handled during a school year, how do teachers deal with health conditions and how much does it affect the child's school performance, what are the current methods of monitoring and communication with parents, and how technology can aid teachers in their duties.

C. Data Analysis

To analyze the quantitative data from the questionnaires, we used descriptive statistics. We grouped the related questions as follows: general screening questions, questions about children and their health needs, teachers' experiences, health conditions encountered by both teachers and parents as well as medication-related questions, and technology experience questions. We were then able to calculate the frequency distribution for each question's responses. Frequency distribution was chosen to obtain an organized summary of the grouped questions and give an overall idea of how results were distributed and where the majority of responses fall.

To analyze the qualitative data, we used a thematic analysis method [8]. This method enabled us to group similar themes together.

IV. Results

In this section, we present the results of both the questionnaire and interview.

A. Questionnaire Results

1) Chlidren's Health and Needs

We found that 25% of parents reported that their children have health conditions. The most health issues encountered by the teachers were allergies and asthma at a frequency of 45% each followed by diabetes and behavior problems at 41% and 39% respectively. Visual impairments, attention deficit hyperactivity disorders (ADHD), and cerebral palsy were the conditions least mentioned by the teachers at a frequency of 20%. Similarly, parents reported the most common health condition which their children have as allergies with the frequency of 50%, asthma at 40%, behavior issues at 22%, diabetes at 11%, and vision problems at 5%, as illustrated in Figure 1.

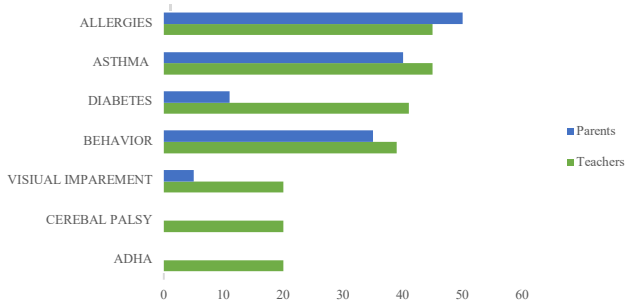

Figure 1. Health Condition Frequency as reported by Teachers

Moreover, the survey data showed that 70% of teachers have administered oral medications, 29% had given asthma inhalers, and 1% had injected students during school hours. On the other hand, 35% of the parents indicated that their children were under medication that had to be used regularly during school hours. Types of such medications varied from oral inhalers to injections. With respect to who at school keeps the medications, teachers pointed out that parents usually give those medications to their children, the school administrators or their children keep them at the desk or school bag. We also sought from the parents, the persons who take care of their child's health in school and the results showed that the following people are responsible: homeroom teachers (who are responsible for a particular class and usually teach some subjects for the class), school administrators, and the school nurse with 56%, 28%, 16%, respectively.

2) Tracking Children's Health and Lack of Communications

We found that teachers usually keep track of medications given to children in school using the school systems, phones, diaries, online documents, or emails as documented in Figure 2. However, parents' data showed that 77% of them are unable to track their children's health using the methods currently used in schools.

Moreover, we found that schools lack systems or platforms that allow communication between parents and teachers. 60% of the teachers in our study were not aware of any online school systems that allow direct communication between parents and teachers regarding their children's school

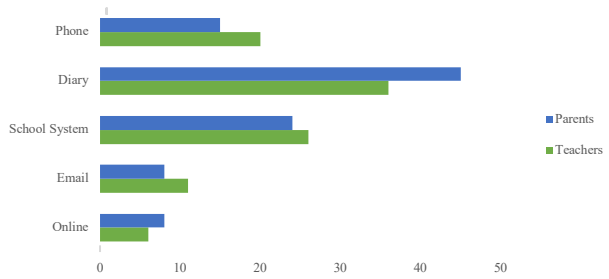

Figure 2. Tracking Methods used currently by Teachers

performance, homework, grades, behaviors, or health issues. While 40% of the parents reported that they are aware and have heard of such systems, however, their schools do not use them. We asked both groups of teachers and parents how satisfied they were concerning the way teachers and parents communicate about the students' school performance, grades, behaviors, and health conditions and the results are as shown in Figure 3, comparing responses from both groups.

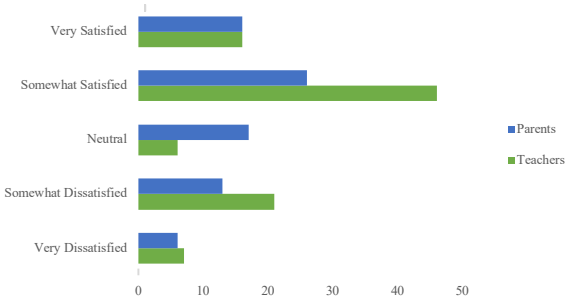

Figure 3. The Degree of Satisfaction of Parents and Teacher about Communication between them

3) Familiarity with Technology Among Parents and Teachers

Most of our sampled participants from both groups were familiar with technology. Most teachers, about 94% of our sample, regularly use digital devices with smartphones being frequently used by 96% of the teachers followed by laptops at 52%, and desktops at 19% as displayed in Figure 4. Similarly, the smartphone was the device often used by parents at 100%, followed by laptops at 50%, and desktops at 22%. In addition, 2% of the parents and 3% of the teachers agreed to using tablets for their regular communication as seen in Figure 4.

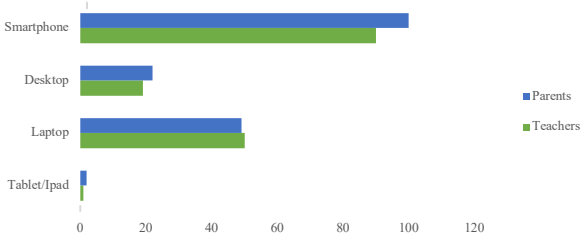

Figure 4. Devices Frequently used by Parents and Teachers

Additionally, about 43% of parents reported using many mobile applications, and they mentioned enjoying using them because mobile apps are easy to use, convenient, and is fast modes of communication. For instance, this is some sample responses from the teachers in why they liked mobile applications, [P1] stated that "*apps are very handy, convenient and helpful*," and [P5] mentioned, "*apps are a quicker way to communicate and real-time reporting*." Moreover, the majority of the teachers at about 87% use computers to help them with schoolwork, and about 60% use some mobile applications to help them with school duties. They also liked how it helps them organize their work, set up everyday reminders and to-do lists, speeds up processes, and is easy to learn. For example, [P7] "*I like those apps that organize my tasks and appointments*." [P17] "*I like those apps that provide quick access to information*."

4) Features Needed in Co-Monitoring Children's Health Application

Parents who took part in our study highlighted that child health monitoring application needs to include some functionalities or features that would help them keep track of their children's health conditions and any health incident while they are in the school. They suggested a **personalized application** that would send **reminders** to teachers about each child's health condition and remind them to administer the required medications at the right time and in the correct dosage. For instance, [P20] said, "*It would be handy to have an app that can send reminders and notes about my child's condition. Such as reminders for teachers about medications*," and [P29] said, "*It will allow immediate notification. It needs to be something that doesn't require human people to input data*". Another parent suggested that the application should generate medication and health reports to be printed out easily and shared with the child's health care personnel. For example, [P24] stated: "*It would be beneficial to be able to show the doctor exactly when medication is given, so the doctor can make decisions if the medication needs to be changed or altered if not working.*" Also, parents wanted an application that would also allow them to follow their children's school performance, daily activities, and homework. For instance, "*The app would give an immediate report on their daily class activities, homework, and assignments, attendances*" [P10]. Some parents were eager to include a social network in the application that would keep everyone in the school involved, from teachers to administrations. As [P30] said, "*A social application might help that can all the parents, teachers, lunchroom supervisors, and social workers get in one loop*."

B. Interview Results

The themes we extracted from the interview data via thematic analysis falls into four main categories: health conditions encountered by parents and teachers, health as well as school performance concerns, current tracking methods, and the technology.

1) Health Conditions Encountered by Parents and Teachers

Through the interviews with the teachers and parents, we were able to get more in-depth information to elaborate on the results obtained from the questionnaires. We uncovered that the most recurring health conditions encountered at school, as reported by parents and teachers, were severe allergies, asthma, autism, learning disabilities, vision problems, and ADHD. Most parents report health conditions to the school administration at the time they registered their child to the school and also give out their contact details to be used in case of emergency as reported by teachers. For example, [P5] said: "*The students who were on EpiPen had health plans set up as well as plans for academic progress. Any student who has serious medical conditions had to have meetings with the principal and teachers before the school year starts*". Also, [P3] mentioned: "*Parents 'contact information is always in the classroom; it is part of the schools' emergency plans*." The parents' interviews reported the same health conditions encountered by the teachers as specified in Figure 5.

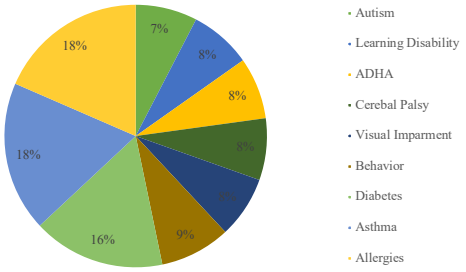

Figure 5. Health Conditions reported by Teaches Interviews

2) Health and School Performance Concerns

Teachers showed some concerns about the performance of students with health conditions in the classrooms. When we asked them about having a child with health conditions in their class, [P3] expressed: "*Yes, all the time especially with allergies, during mealtime it is very hard to be 100% sure if the child takes some food from a friend. It is always a point of concern!*'' Not only health concerns but they were also concerned about how well the children perform in class and how their health conditions affect their school performance. For example, [P1] mentioned: "*It has a negative impact on the student performance and school achievements, missing grades, and more absents days*." Similarly, [P4] said that "*Allergies do not affect so much unless the student is missing school days. But children with learning disabilities or mental disorders find it very hard to socialize. For example, autistic children tend to be anti-social and get frustrated. Also, children with asthma cannot participate in all physical activities and miss school a lot*". Not only does it affect children with health conditions but it also has an impact on their peers, as [P2] said: "*When we stop lessons because we need to attend to a sick child, it takes time out of the period and the class gets behind in progress, and we need to catch-up to timely finish lessons*."

All parents showed concerns in the way these health conditions affect their children's school performance and achievements if not controlled. [P2] said: "*My daughter misses some classes. She also fears school lunch and snacks which have impacted on her achievements in school. Sometimes she does not eat dreading allergic reactions*." Also, [P4] mentioned that his child misses a lot of school days due to her severe asthma saying, "*My child is absent from school for many days due to his asthma, especially in the colder months. She almost misses a quarter of the days during the school year*." Parents also mentioned that the schools are

working hard to provide some solutions to ease their concerns. But these solutions such as daily reports which were mostly mentioned by the parents are not sufficient. [P1] said: "*The school has my contact information and other alternative contacts in case I am not reachable which is somewhat assuring. However, I still do not feel fully assured of my child's conditions. They also provide me with daily reports*". Another parent [P4] said: "*My daughter has severe allergies and thus the school has put up her picture everywhere in the school to make sure that all teachers and staff are aware of her condition. But it was not the best solution as her privacy was affected*".

3) Current Tracking Methods Used by Parents and Teachers

We asked teachers if they follow particular systems in reporting incidents or students' health conditions and how they keep the parents in the loop or stay in contact with them. It was indicated that 100% of the participants use email regularly to keep track and report students' information. Roughly 20% of the participants mentioned that they use a school system to report incidents along with school-related details, grades, homework, and lessons. For instance, [P5] said: "*We constantly use the school website as a portal. Teachers use it to update grades and upload completed assignments for the students and report incidents*." "*I usually email the parents!*" [P1] said. [P2] held: "*I sent email messages and some parents sent to me mail as well while some others prefer to come in person*." Other parents stated that they use text messages, email, WhatsApp, and letters to keep of communication between them and the teachers. [P3] said in response to the communication question: "*Mostly I visit the school in person*" and another [P5] said: "*I usually text the teacher!*".

4) Technology Usage

Teachers showed interest in including technology in everyday teaching. They believed that using technology would make things easily accessible. For example, [P2] said: "*Technology is crucial in the classroom and helps enhance the student learning experience. It is easier for me to teach when I can access information from anywhere*." Another question we asked was how a mobile application could aid the teachers in their duties as well as monitoring students' health and [P1] said: "*A mobile application would help in accessing information faster in a short time*." Likewise, [P4] said: "*I would use an application to keep track and report information to parents, students, and the school administrators. It would make tasks easier and would allow follow-ups of past tasks and keep information stored for easier access*".

Parents also showed great interest when we mentioned technology and [P2] said: "*I wish the school would include and use technology in everyday tasks. I think it will provide great help*." We asked if a mobile application would help to monitor and keep track of their children's health. All parents said that it would be helpful to manage information, get notifications, and daily reports. [P3] said: "*A systematic mobile application would help to keep me in touch with the teachers who can send notifications and provide me with daily or monthly reports which will especially help in doctors' visits*." Moreover, [P1] stated: "*An application could help me become aware of my child's condition and making regular checkups. What would be helpful also is allowing the doctors to monitor children's conditions as well*." Lastly, [P2] said: "*An application will act as a network between teachers and parents!*"

V. Mobile Prototype Design

Based on the data we collected from teachers and parents, we came up with an application prototype, as presented in the flow chart, see Figure 6, tailored to each child and their health condition.

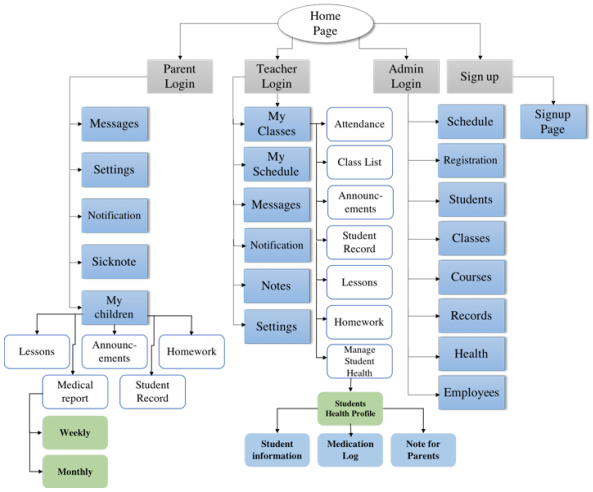

Figure 6. Prototype Flowchart

The prototype application was created via proto.io[1] which runs on Android devices, Windows, and Apple. In the prototype, teachers, parents, and school administrators have their login accounts with different dashboards and access levels. The teachers' dashboard shows all classes taught by a certain teacher. When a class is selected, a list of options appears in which the teacher can take attendance of the selected classroom, get a list of all students enrolled in the class, and manage lessons. A teacher can also send announcements to the classrooms and maintain students' health records. In the class list options, the teachers can see the enrolled students and a "Red heart" sign appears next to students with registered health conditions. Once a teacher selects a student from the class list, their profiles which include a photo, general information, contact information, and an outline of their health information are opened, see Figure 6. To check only those students with registered health conditions, a teacher can use "The manage student health" menu or page. Base on that, a list of students with health conditions in the same class appears. The teacher can select any student and view his or her health profile which may consist of the student's name, health conditions, prescribed medication, and medication log options. In the medication log option, a teacher can record the registered medication once they are administered to the child. A teacher can also add a note to the parents under the student's health profile.

[1] https://proto.io/

At the bottom of the prototype, a notification reminder option is presented. This option sends personalized notifications on when to administer the medication to any child that requires medication during the day to the teachers. The appearance of this option is based on the information provided by the parents about their children's medication timelines. Moreover, parents can manage all their registered children. They can check lessons, projects, homework, announcements, and can send a note directly to the teacher.

There is a unique profile for each child that includes their health conditions, medication needs as well as treatment schedules, and grade levels. They are also able to upload any sick note documents and view their child's medication logs on a weekly or monthly basis. The weekly option shows a graph which gives a general idea of how the child's week progresses in terms of his or her health and medication. In the monthly option, the parents can download or export reports that include the time medications were administered or missed as well as any notes provided by the teachers.

The administrators' account can be managed by the school Information Technology staff or any person from the school administration. The administration account can register new students, view as well as manage the students, and send announcements to parents. It can also send messages to students or teachers, manage courses, handle students' records, and manage the schools' employees. The administrator is also responsible for the students' health information and recording of any health condition and medication.

In all the accounts, the application prototype allows for personalization by the teachers, parents, or administrators to change the application color themes and font sizes. They can as well manage or change their information such as email addresses, phone numbers, photos, and their account passwords as demonstrated in Figure 7 which illustrates several screens from the proposed monitoring application prototype.

VI. DISCUSSION

The purpose of this study was to investigate whether there is a need for a mobile application system for schools to help co-monitor children's health with parents during school hours. This will allow consistent communication between parents, teachers, and school administrators by obtaining feedback from teachers and parents about the health conditions of children attending school or daycare centers. We collected data using a survey questionnaire given to parents and teachers and some of them were also interviewed.

The results of our study showed that there are many school-going children with health conditions and hence there is a significant need to have an effective way of allowing teachers to co-manage their health together with their parents while in school. This can be achieved by providing an app that will enable teachers to track children's health issues and their medications as well as their care needs. The application

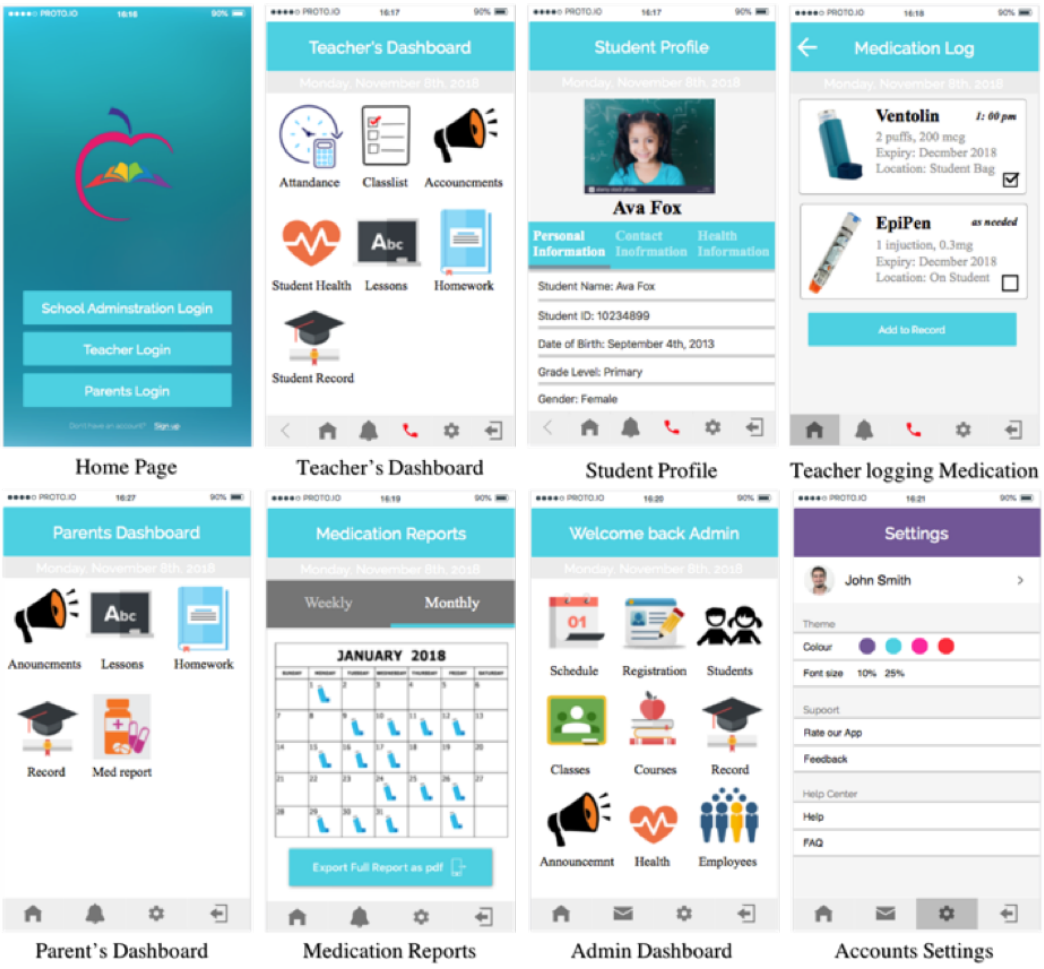

Figure 7. Prototype Screenshots

also allows parents to access their children's data, schoolwork, grades, homework, and health data.

Although some schools use tools such as emails, online dairies, and manual diaries to track children's health when in school, they are not sufficient and effective enough. Parents are not able to keep track of this data and most teachers find it inconveniencing to use as the parents may require different methods to be used to track their children's health. For example, some parents prefer diary logs on paper whereas others would prefer using online diaries. This places a significant burden and unrealistic expectation on the teachers.

Based on this research, we designed a prototype of a mobile application to monitor children's health conditions and facilitate teacher-parent communication. The application will be suitable for both teachers and parents because nearly all of them use smartphones regularly and many of them are familiar with different types of smartphone applications. Moreover, our study revealed that such an application is needed to facilitate other school-related duties and activities such as preparing lessons and sending homework and not only monitoring health. Also, the application will address some other school-related needs which include record-keeping for teachers and administrators as well as allowing parents to have an overview of what their children have learned at the end of a school day.

It is essential to integrate both health and education monitoring as users would only be using one platform for both and not having to go back and forth between two applications or different platforms.

A. Limitation

The most significant limitation of this study was the sample size. Although we had more than 30 participants in each group for the survey, we were only able to recruit 12% of parents and 16% of teachers in the follow-up interviews. The interview feedback was meant to obtain more details, recommendations, and suggestions provided from both the parents and teachers. This helped us in the design and implementation process. Given that we were only able to recruit teachers from only two private schools in Halifax, NS, we obtained more similar results about the concerns, health conditions, and school systems currently used. It also posed another limitation since teachers from those two schools were not representative of the teachers' population.

Although we recruited parent participants from the two schools as well as from Dalhousie University Computer Science community, parents from the schools do use similar tracking methods. They also use the same school system if there is any. Dalhousie Computer Science community parents are more experienced and more familiar with technology and so they were not representative of the total population.

B. Future Work

In the future, we plan to implement the application and evaluate it with respect to its usability, usefulness, and ability to facilitate effective child health condition co-monitoring and management between parents and teachers.

CONCLUSION

In this research, we present the results of a study of 81 participants (50 parents and 31 teachers) to investigate the current practices in the area of child health monitoring, the need for a mobile application, and the required functionalities of mobile applications. Based on our findings, we designed a prototype of an application.

The prototype is for a mobile application that allows parents and teachers to co-monitor and manages the children's health conditions, communicates, and monitor each child's school activities. It can be personalized to each child's health condition and medication needs. Teachers can use it to track children with health conditions during the school hours and parents can access this data at any time. To ensure that the application is easy to use and useful, we used a simple layout and included some functionalities that allow users to adapt some of its features.

ACKNOWLEDGMENT

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