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A Budget and Nutrition-aware Mobile Application Featuring Food Menu Generation and Monitoring for the School Feeding Programme in Bangladesh

Ajoy Deb Nath
CSE Department
Chittagong Univ. of Eng. and Tech.
Chittagong, Bangladesh
debnath.ajoy1010@gmail.com

Mahfuzulhoq Chowdhury
CSE Department
Chittagong Univ. of Eng. and Tech.
Chittagong, Bangladesh
mahfuz_csecuet@yahoo.com

Mehedi Hassan
CSE Department
Chittagong Univ. of Eng. and Tech.
Chittagong, Bangladesh
mehedirony22@gmail.com

***Abstract*—The school feeding program is regarded as one of the effective solutions to solve the malnutrition problem and primary school educations dropout issue. Hence, to run the school feeding program effectively, a budget and nutrition-aware food menu generation scheme is required along with proper monitoring, students feedback, and real-time attendance facilities. At present, the existing related works related to mobile application development for school feeding programs do not consider a budget and nutrition-aware food menu generation, real-time attendance system, evidence attachment of the distributed foods to ensure monitoring, students feedback regarding the program, and the donation facility at the same time. To tackle the existing challenges, this paper presents a budget and nutrition-aware mobile application featuring food menu generation and proper monitoring for the school feeding program in Bangladesh. By using our proposed application, an authorized teacher can select the best possible food menu for students by verifying budget, nutrition, choices, and cost, and send evidence to the higher authorities regarding distributed food number, food nutrition value, and cost. Moreover, the students can give feedback to the authority regarding the school feeding program. Our evaluation results show that more than 80% of users are satisfied with the proposed system.**

***Index Terms*—Budget, Mobile Application, Meal Plan, Monitoring, Food Energy, Nutrition, School Feeding.**

I. Introduction

Among the developing countries, Bangladesh is one of the countries which suffers from higher rates of malnutrition. According to statistics, the number of stunted children (i.e., abnormally low height-forage) under the age of five (i.e., pre-schoolers) is more than nine million (i.e., 54%). Whereas, the percentage of wasted (i.e., abnormally low weight-for-height) and underweight (i.e., abnormally low weight-for-age) children (i.e., under the age of five) number are more than 17% and 56%, respectively [1]. The main factor behind this higher malnutrition rate is poverty. To get rid of such malnutrition problems and to improve the preliminary school education program effectiveness, recently the Bangladesh government's primary education departments is planning to provide a cost-free mid-day meal to the pre-primary and primary school students (i.e., between the age range of 3 to 12). To improve the attendance rate and reduce the school dropouts (i.e., due to poverty and social/economical reasons), the primary purpose of this school-based mid-day meal program is to ensure at least 30% of energy (i.e., kilo-calorie) and 50% of the nutritional needs required per day for each student [2]. Hence, to run the school feeding program properly, several challenges need to be addressed properly such as proper meal plan based on budget and nutrition, monitoring of cost per day by taking students attendance and meal number, food wastage, corruption, and time management, among others.

Currently, the Bangladesh government is trying to finalize the school feeding program by investigating several challenges including food items and budgets. Recently, at an ECNEC meeting (i.e., Executive Committee of the National Economic Council), the honorable Prime Minister of Bangladesh has shared her concerns about the operational structure of the mid-day meal program. The Prime Minister of Bangladesh has suggested that cooking khichuri (i.e, dish contains cooked rice, lentils, and vegetables) at school could hamper the school-going student's education due to time wastage and advised to review the projects by considering variation in students' platter [3]. Later, the planning minister of Bangladesh has briefed the reporters that the mid-day meal project might come up with newer formats considering the variations of food items, time, and proper fund management, among others [3]. On the contrary, India has been providing different types of hot-cooked meals to primary and upper primary school students on all functioning days since 2004 under the Mid Day Meal Scheme [4]. Mid-day meals at school are not only playing a vital role to improve parents' encouragement to send their children to school, but also they have an excellent impact on student's physical/mental health improvement and education. This could be a multi-beneficial investment in human capital and therefore the native economy. In this paper, we have proposed a more structured solution to School Feeding Programme in Bangladesh.

Generally, nutritionists prepare a balanced and healthy meal plan meeting the nutritional needs of children. The

current meal plan for School Feeding Programme (SFP) [2] in Bangladesh has only four items: vegetable/egg khichuri for five days along with biscuits and fruits. This type of meal plan is not much diversified. People, especially children, want variation in their daily meals. In this era of Artificial Intelligence, there's much scope for improvement. To tackle this issue, an efficient food menu planning and generation system is required to find a combination of meals considering several kinds of features such as nutrients (i.e., energy, fat, protein), budget, cost, and students attendance, among others. In our work, we will suggest an every day meal plan considering nutrients, student attendance, budget, cost, and students' food preferences. School Feeding Programme, being a nationwide initiative, needs regular auditing and monitoring. The current monitoring system has many flaws as it's done by non-government organizations (NGO's) monthly. There is much scope for disruptions like illegal supply and wastage of food. In our work, we have proposed a budget and nutrition-aware mobile application for proper running and monitoring of school feeding programme in Bangladesh. The major contributions of this paper are summarized below:

- Our proposed mobile application allows user interest-based food menu generation for the school feeding programme by verifying the available budget, the total number of present students, food monetary cost, food energy, and nutrition value.
- Our proposed budget and nutrition-aware mobile application allow administrators (i.e., central government/school authority) to monitor the number of served food, monthly cost, and served foods nutrition value.
- By using our proposed application, any parents or students can give their feedback to the government authority or school administrations regarding food menu, corruption, attendance, and served food status, among others.

Section II features the related works. The proposed system model with features is described in Section III. The user feedback results are presented in Section IV. Section V summarizes the paper by including key points of our work.

II. Related Works

World Feeding Programme in association with the Government of Bangladesh, started working with the school feeding program in 2001 [2]. Nutrition experts came up with a meal plan consisting of khichuri for five days and high-energy biscuits on thursday. But an acute illness outbreak was reported in northwest Bangladesh schoolchildren, eating high-energy biscuits under the school feeding program in 2010 [5]. This implies the significance of a balanced meal plan considering nutritional requirements, budget, preferences, etc. An automated meal plan can find a proper solution by investigating these various criteria. Although the Menu Planning Problem (MPP) is an NP-Complete problem [6]. NP-complete problems are difficult to solve in polynomial time by exact deterministic techniques. The authors of [7] developed a menu plan for Brazilian schools considering cost minimization and nutritional error minimization according to the Brazilian reference. The authors of [7] also presented a hypervolume comparison of different multi-objective evolutionary algorithms such as NSGA-II and SPEA-2. In [8], the authors developed a food recommender system based on the user's taste and calorie requirement. They created a food portal website for collecting personal information such as height, weight, age, and food preferences. But they didn't consider the cost of foods.

The authors of [9] used a Management Information System (MIS) and Interactive Voice Response System (IVRS) to strengthen the Mid-Day Meal Program (MDMP) in Uttar Pradesh, India. They ensured the total number of students getting meals per day using IVRS that automatically called users over voice and updated to the server through MIS. The authors of [10] developed a system to compare manual attendance from mobile applications with attendance via facial recognition for mid-day meal schemes in India. Their face recognition technique was good but for monitoring the whole program more features were needed. In [11], the authors have developed a monitoring system for MDMP to detect students' faces through webcam using the Viola-Jones algorithm. The authors of [11] used one computer for overall monitoring, which is a challenge for village schools. The authors of [12] developed a deep model for food recognition using Faster R-CNN model to generate RoI (Region of Interest). From the recognized results they generated a dietary assessment by analyzing the nutritional values calorie, carbohydrate, and protein from the ingredients of the foods. In [13], the authors proposed a system for automating food journaling from pictures of foods taken at restaurants by inferring geo-locations and recognizing foods from the images. In [14], the authors discussed the explicit control of diversity for the menu planning problem. However, their work is limited only to nutrition rather than both budget and nutrition. Unlike the related works, in this paper, we have developed a budget, energy, and food nutrition-aware mobile application that not only generates food menu plan but also allows monitoring of school feeding program by taking into account students attendance, verification, donation, suggestions, and the number of served food, among others.

III. Our Proposed Scheme for School Feeding

This section contains the detail of our proposed budget and nutrition-aware mobile application for school feeding programs in Bangladesh. Our proposed scheme consists of several parts: (a) account creation and login system, (b) attendance system, (c) food menu generation, (d) proper monitoring, (e) feedback system, (f) donation, and (g) statistic report. The flowchart of our proposed system architecture is shown in Figure 1. We can see that initially, users can create their accounts or log in. The main part of our application is food menu generation which is done by the teachers. The respective teachers can take the attendance of the students and generate a food menu by verifying the per-day budget and food nutrition value. The necessary evidence submission regarding the number of food served can be sent to the government authority by the respective teachers. Moreover, a summary of the month or per day nutrition and cost can be generated by

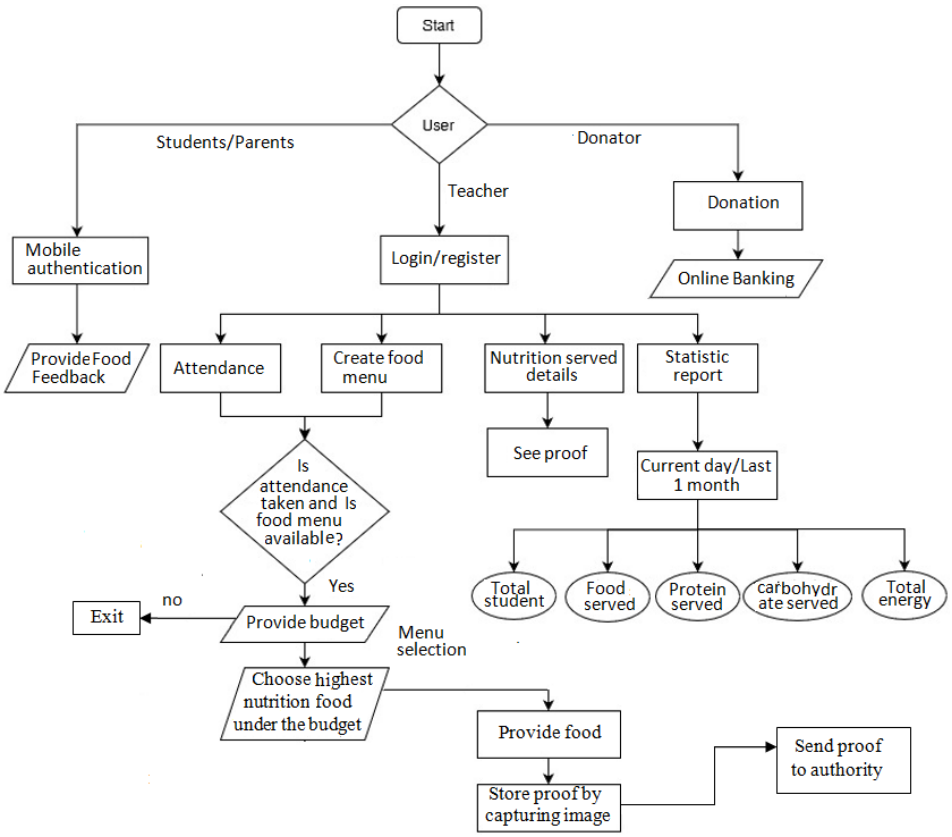

Fig. 1. Proposed System Model

using our application. The students can send feedback and the donors can donate to the school feeding program. In the following, we will discuss the major steps of our application.

A. Account Creation and Login System

In this subsection, we will discuss the account features of our proposed mobile application. Figure 2(a) shows that three types of users can use our mobile applications: teachers, students/parents, and donors. After that, we will discuss the sign-in option. For sign-in, the user needs to create an account first by using their valid email address and unique password (see Figure 2(c)). In this work, the food menu generation and attendance system can be operated by the respective assigned teacher. But for this, the respective teacher needs to log in to their account by using their email address and password (see Figure 2(b)). Teachers can log in by using their mobile number and name (see Figure 2(d)). After that, the teacher can get access the home section that includes the attendance system, food distribution, menu selection, and evidence/proof submission (monitoring) part. Figure 2(e) shows the home section for the respective assigned teacher.

B. Attendance System

In this sub-section, we will discuss the attendance system of our application. After clicking the attendance button from Figure 2(e), a class selection screen will appear with available classes. If a teacher wants to take attendance of class three, he/she will choose class three (see Figure 2(f)). Note that, by clicking the '+' icon at the top part of Figure 2(f) screen, the respective teacher can add a new class name. Figure 2(g) depicts that, for the addition of a new class, the respective teacher has to input the class name and number of total students. After clicking on the classes inside Figure 2(f), the teachers will see a pop-up window screen, in which he/she can select the date for attendance record (see Figure 2(h)). Next, by inserting check marks for the present student roll numbers and absent marks for the absent students, the teachers can take the class students' attendance (see Figure 2(i)).

C. Food Menu Generation

In this sub-section, we will present the food menu generation feature of our proposed application. After clicking Menu by teachers in Figure 2(e), Food menu details will appear. Figure 2(j) shows the different types of food menu details with add food item option. From the Figures 2(k) and 2(l), we can notice that the assigned teacher can create new food menu by combining any of the items from the list. For example, the teacher can select egg (Dim), milk, and breed (Pauruti) items to create a new food menu. After clicking the food distribution feature in Figure 2(e), a pop-up window screen will appear that contains select class and enter the budget option (see Figure 2(m)). Here, only the class's name that

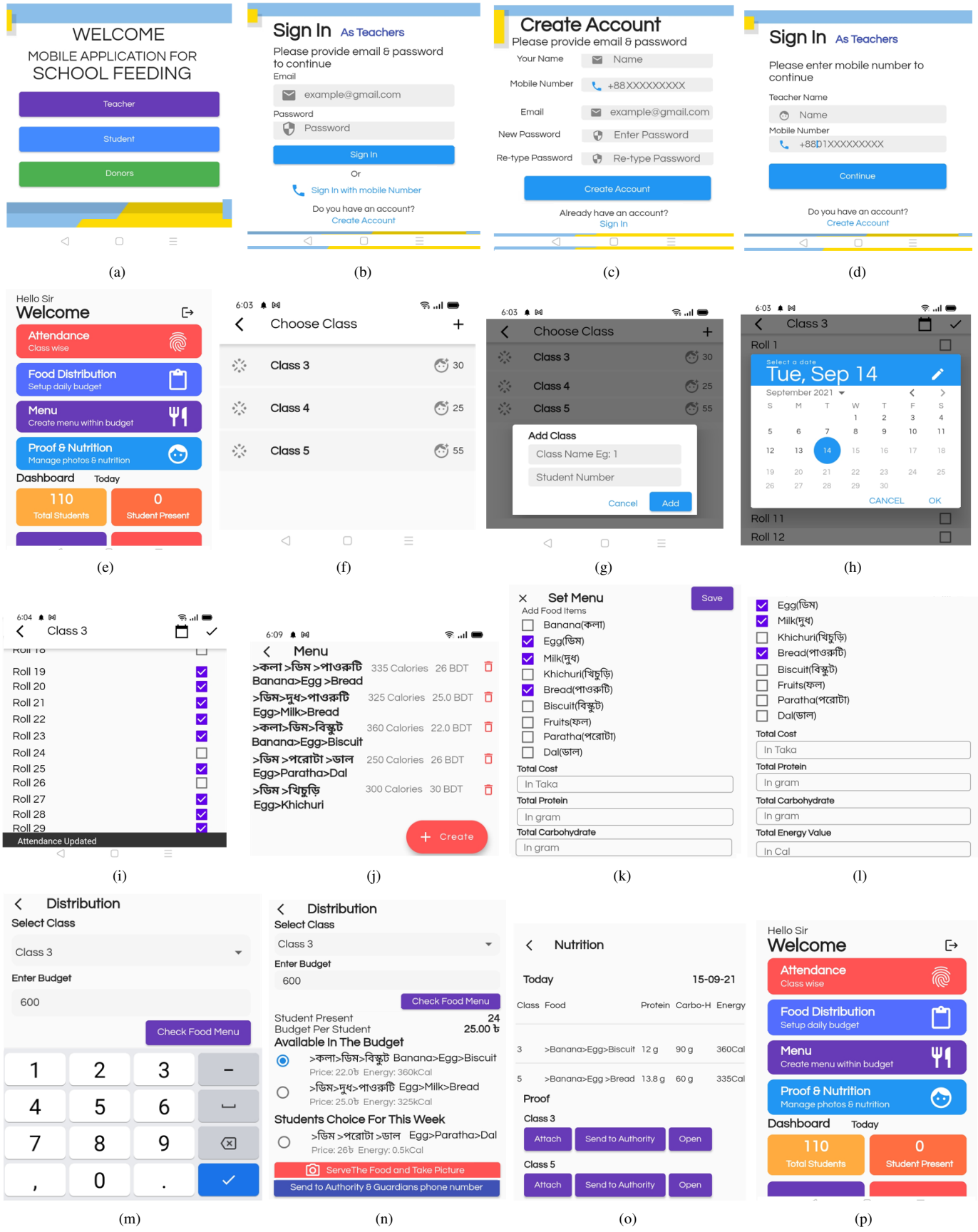

Fig. 2. (a) Initial screen of the app, (b) Teachers account login (using email), (c) Users account creation, (d) Teachers account login (using mobile number), (e) Teachers homepage, (f) Attendance system (initial), (g) Attendance system (class selection), (h) Date selection for attendance, (i) Mark the present/absent students, (j) Different food menu details (old entry), (k) Food menu selection (new), (l) Add new food menu, (m) Class and budget entry for menu selection, (n) Available food menu display within budgets, (o) Nutrition value per class, (p) Teachers dashboard with statistics data (per day)

Fig. 3. (a) Teachers dashboard with statistics data (last 30 days), (b) Sign-in option for students/parents, (c) Verification code for registration confirmation, (d) Rating per menu, (e) Users complain option, (f) Donation, (g) Users feedback, and (h) Application friendliness evaluation system

TABLE I
USER'S REVIEW OR FEEDBACK REGARDING PROPOSED APPLICATION

Features	Positive Review (High)	Positive Review (Medium)	No Comments	Negative Review (Below Average)
Attendance System	76%	10%	10%	4%
Food Menu Generation	84%	8%	6%	2%
Proof Attachment	80%	4%	10%	6%
Account/Login System	90%	6%	2%	2%
Dashboard Statistics	80%	10%	6%	4%

completes attendance will appear (i.e., if the teacher already completed taking attendance). Next, the teacher can insert the budget and check the available food menu within the budget range. Figure 2(n) visualizes the available food menu within the range of budget per student. The total budget per day is divided by the total present students. There is also a food item which is recommended by students. If the students recommended food menu is within the budget and nutrition range, it can be offered one day each week. Otherwise, the food menu that satisfies per day budget range and offers the highest nutrition value will be selected by the teachers. Figure 2(n) also shows that the teacher can send the proof/evidence of each day's food distribution (ie., stored pictures) to the higher authority or monitoring team by using the red button at the down part of the screen. By clicking the nutrition and proof button in Figure 2(e), the teachers can monitor all the distributed food details with nutrition value (see Figure 2(o)). Figure 2(o) shows the nutrition value details for the served food of different classes. These include proteins(gram), carbohydrates (gram), and energy (calorie). The teachers can also see proof/evidence images by clicking the open buttons. This evidence can be sent to the authority for verification.

D. Dashboard, Feedback, and Donation System

After completion of every day's food distribution, the teachers can see the statistics data regarding served food items' nutrition value. Figures 2(p) and 3(a) show the teacher's home page dashboard with statistics data that includes the total student's number per day, nutrition data per day, last 30 days statistics data, total number of food served, and total served foods protein/carbohydrate/energy value amount, among others. Figure 3(b) shows the mobile number-based login system for students/ parents. This screen appears by

clicking the student button in Fig 2(a). To log in, the students must provide their roll number and mobile number of their parents. Next, a verification SMS is sent to the registered mobile number and the students should insert this verification number to the pop-up screen (see Figure 3(c)). After that, a new pop-up window will appear, in which the student can give a rating and provide their feedback regarding foods (see Figure 3(d)). Figure 3(e) shows that the students can send their complain to the higher authority. Finally, Figure 3(f) depicts that any donor can donate to the school feeding authority by clicking the donor's button in Figure 2(a). Here, several types of online banking gateway are used. This donation will be added to the school's remaining budget. By allowing the donation facility, good quality foods can be served to the school-going students. For the n numer of users and n number of features, the time complexity of the mobile application would be $O(n^2)$. Note that, to get the best results from the proposed application, the minimum memory requirement (i.e., mobile phone) would be approximately 20 MB.

IV. Results and Analysis

In this work, we have developed a flutter-based mobile application. Flutter is a cross-platform framework that can support both android and iOS operating systems. Email, login, and mobile number authentication are done by the Firebase Authentication service. For the backend service, Firebase Firestore is used. This section presents the evaluation results of our proposed mobile application via users feedbacks, reviews, and ratings. To understand the efficiency of our proposed system, we have collected a review of fifty users that includes school-going students, parents, and teachers. First, the user's review ratings regarding several mobile application features (i.e., attendance system, food menu generation, proof attachment, account/login system, and the dashboard statistics) are collected. Table I visualizes the user's review percentages regarding several application features. Table I depicts that the attendance system gets more than 85% positive reviews. Whereas, for the food menu generation, dashboard statistics, and the account information system, the positive review percentages are equal/more than 90%. From Table I, we can infer that overall negative review percentages are below 10% for all the examined features. The negative review rating is high for proof/evidence attachment. This is because some users suggested improving the food detection and students' face identification system by using an intelligent learning policy. To evaluate our system, we have asked fifty users regarding the feedback submission system. By using our feedback system, users can give suggestions related to users' menu choices or any other positive/negative feedback regarding the school feeding program. Fig. 3(g) shows that our user feedback system receives more than 80% positive reviews and the negative review percentage is below 10%. Figure 3(h) depicts the number of users versus application usage friendless evaluation. The figure presents that among fifty participants, more than 70% of users give a positive review and 10% users give negative review regarding application usage friendliness.

V. Conclusion

This paper presents a budget and nutrition-aware school feeding system for the school-going students in Bangladesh. This paper discussed a mobile application that offers a budget, cost, and nutrition-aware food menu generation system. Our proposed application also supports several important features such as account creation and login system, attendance system, proof attachment system regarding the number of food items served, donation system, and dashboard statistics that contains the summary of daily and monthly nutrition status. Our collected user's positive reviews and feedbacks regarding the developed mobile application suggested that more than 80% of users are satisfied with the food menu generation system, application usage, and user feedback systems. To improve the food detection and automatic students verification system along with system security, in the future we will try to incorporate advanced learning and blockchain techniques.

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