Plan-Cook-Eat: A Meal Planner App with Optimal Macronutrient Distribution of Calories Based on Personal Total Daily Energy Expenditure

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Abstract—One essential factor of a balanced diet to prevent morbidity and mortality, and promote a good nutritional status is the consumption of nutrient-dense foods with an appropriate macronutrients dispersal (carbohydrates, protein, fat) and the right amount of calories based on personal energy expenditure. While the field of dietetics and nutrition has been bombarded with food recommender systems over the years, little research has been performed on meal planner applications grounded on macronutrients compliance. Drawing from a parallel-iterative design methodology, this paper proposed the development of a web-based meal planner app called 'Plan-Cook-Eat' that can generate tailored diet plans according to individual's needs. Six Registered Nutritionists–Dietitians served as a panel of human expert validators and 24 regular users served as app testers for evaluation using mixed-methods approach. Study participants confirmed and concluded the potential of Plan-Cook-Eat web app as a personal meal planner to ensure the consumption of needed macronutrients. Suggestions and interpretations were made regarding the technical improvements that could be done to enhance the app as a complete virtual nutrition assistant.

Keywords— Nutrition Science, Meal Planner, Macronutrients Mobile Application Development, Dietetics, Nutrition

I. Introduction

The Philippine Plan of Action for Nutrition 2017-2022 is among the essential components of Philippine Development Plan in collocation to 10-point Economic Agenda of Duterte Administration [1]. Among the strategic thrusts proposed in PPAN is the assurance of adequate nutrient intake to address nutrition-related diseases (e.g., diabetes, hypertension, and some forms of cancer) and disorders (e.g., malnutrition and obesity) [2-5]. The derivation of such proposition stemmed from the societal health-related issue of inadequate nutrition which emerged from the latest National Nutrition Survey [6]. Conducted by Food and Nutrition Research Institute of the Department of Science and Technology (FNRI-DOST), the study revealed that Chronic Energy Deficiency and Anemia were uppermost among unemployed Filipinos, and high total cholesterol levels were peak among officials, amongst other disorders [7]. Albeit the relationship between nutrition and health has been established by the nutrition science field [8-10], a prevalent problem still perseveres when it comes to the willingness to ensure a good nutritional status. Problems that are known to hinder the attainment of adequate nutrition are lack of nutrition knowledge [11-15], poor appetite control [16-20], bad food choices and too reliant on family members' food preferences [21-25], which later result to inadequate nutrition.
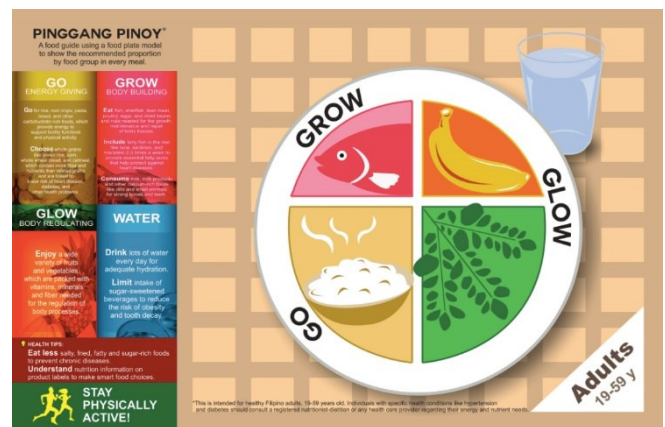

Fig. 1. Pinggang Pinoy - Healthy Food Plate for Filipinos

Because of these nutrition challenges that pose threat to human life, public health interventions are being proposed in order to come up with a solution on how to counteract these problems. An example of such intervention is via the use of food recommender systems to encourage healthier nutritional choices [26, 27]. The use of online recommender systems is evidently useful in complex environments [28] to overcome information overload problem [29] by assisting users on the decision-making process and serving as a modality to change user behavior [30]. In the design and development of a food recommender system, there are several techniques to employ depending on the goals and system features needed in order to make efficient meal suggestions. Common examples are the use of content-based, collaborative, or hybrid system. As known on nutrition science, there are existing recommender systems on the healthy domain but Trattner & Elsweiler [31] concluded that these systems still remain preliminary largely due to the nonappearance of integrated nutrition knowledge (e.g., the inclusion of Pinggang Pinoy of FNRI-DOST when generating a meal plan, see Figure 1). It is likewise possible that these systems are too reliant on user preference and not on nutrition guidelines like Food-Based Dietary Guidelines. In pursuit to develop a meal recommender system grounded on nutrition knowledge, this study proposed the "Plan-Cook-Eat", a progressive web application that generates meal plans compliant to the necessary macronutrient distribution of daily calories based on individuals' Total Daily Energy Expenditure (TDEE). This progressive web application is a small part of a more intelligent system that uses forward chaining algorithm named "Virtual Dietitian – A Knowledge-Based System".
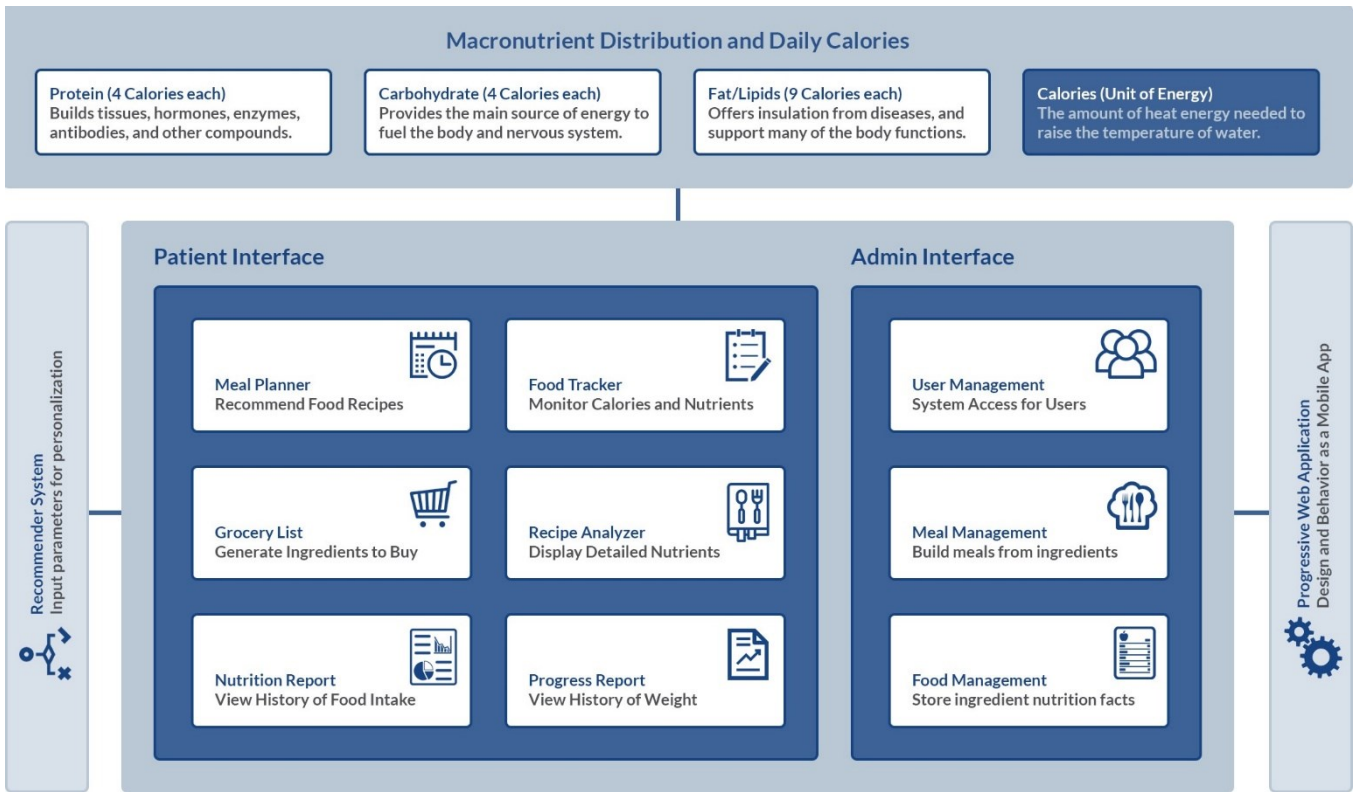
Fig. 2. Functional Architecture of Plan-Cook-Eat with Integration of System Modules to the Recommender System and Progressive Web Application.

II. PROPOSED NUTRITION APPLICATION

The meal planner of the proposed web-based application, Plan-Cook-Eat, is grounded on the macronutrient distribution of calories. First, the TDEE must be calculated to determine the number of calories expend and the amount needed to eat in a daily basis. TDEE is determined by four key factors of expending energy: Basal Metabolic Rate (BMR), Thermic Effect of Food (TEF), Non-Exercise Activity Thermogenesis (NEAT), and Thermic Effect of Activity (TEA). BMR is the energy expenditure to keep the body functioning at rest like using such energy for vital organs. The BMR calculation is different for men (eq. [1]) and women (eq. [2]). TEF, on the other hand, is used for digesting food and nutrients. NEAT is the energy expended for spontaneous activities (e.g., typing, working, and fidgeting). Lastly, TEA is contrasting to NEAT as it is the number of calories burned as a result of exercise. TDEE is the sum of these four factors, see equation (3), that will result to an estimate of the calorie amount needed on a daily basis in order to maintain the current weight. While the BMR commonly utilized Harris-Benedict Equation, the TEF, TEA, and NEAT are combined together and calculated using Katch-McArdle multipliers [32] as shown on Figure 2. In the BMR formulas for men and women, W stands for Weight in kilogram, H is height in centimeter, and A is Age in years.

$$Men\ BMR = 66 + (13.7 \times W) + (5 \times H) - (6.8 \times A) \quad (1)$$

$$Women\ BMR = 655 + (9.6 \times W) + (1.8 \times H) - (4.7 \times A) \quad (2)$$

$$TDEE = BMR + TEF + NEAT + TEA \quad (3)$$

Because hybrid applications (combination of native app for smartphones designed using languages for web app) seem to be the best excluded option when deciding whether apps for smartphones and/or web browsers should be used in healthcare [33], Plan-Cook-Eat is designed as a Progressive Web Application (PWA) – a type of application software that is coded using web languages yet designed to work as a native application on any platform device. Recent research on the effectiveness of PWA [34] revealed the positive impact it has brought not only to the field of world wide web industry but also to businesses and users as delivered by its features that modernize websites and make it indistinguishable from their native counterparts. To fluently create a PWA, an application manifest and service workers are needed to be integrated to harness additional features based on the device support. The application manifest dictates the behavior and look of the web application to make it mobile ready. On the other hand, the service workers make it possible for the web application to work offline by storing contents in the device cache. The user interface of PWA when displayed on mobile phones as a native app is displayed on Figure 4. The app user interface is composed of mock-up designs for different screens such as cuisine menu, today's menu (recommended food), profile settings, and meal search. Each chosen meal is automatically combined with other meals in terms of macronutrients and calories to ensure the total amount is almost equal to TDEE.

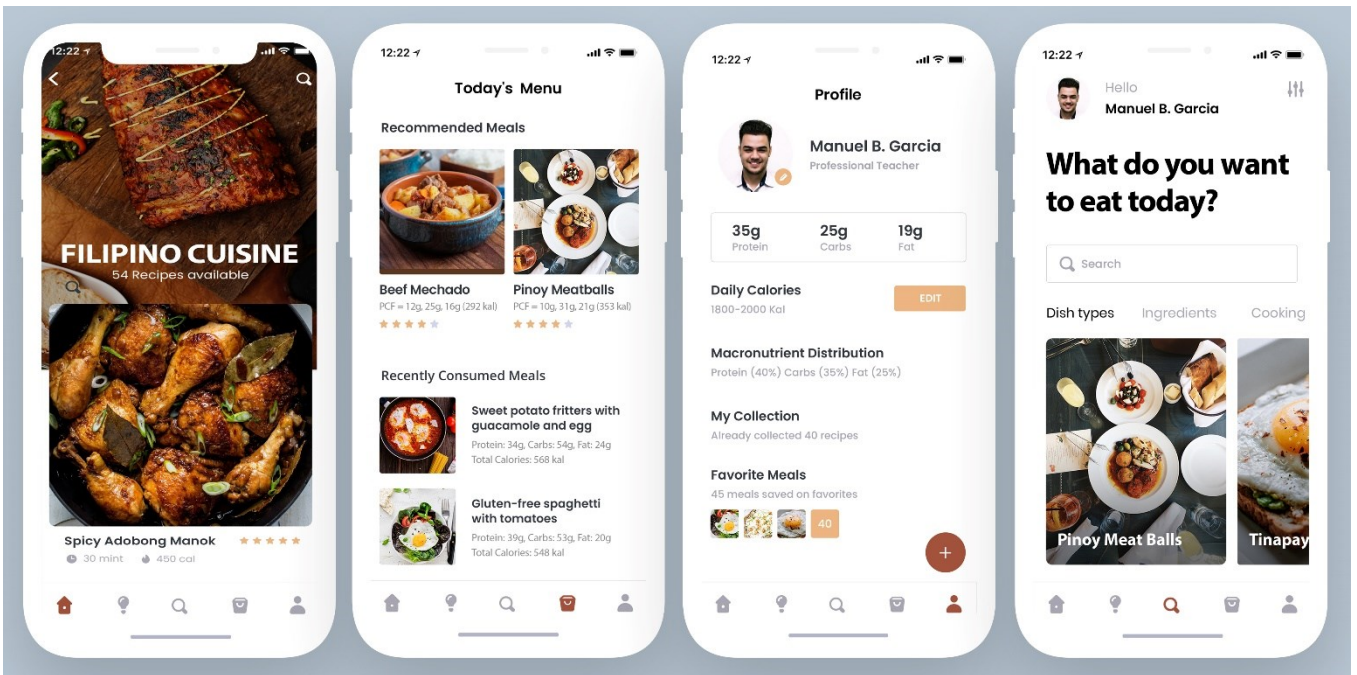Fig. 3. Katch-McArdle Multipliers for Calculating TDEE.

Fig. 4. Plan-Cook-Eat PWA Screen Interfaces as Native Application: Cuisine Menu, Today's Menu, Profile Settings, and Meal Search

III. METHODS

In this study, Rapid Application Development, or known as RAD, was utilized as the project methodology of the study to accommodate iterative processes needed in the systems development particularly on refining meal plans and recipes. Both quantitative and qualitative methods were also used to evaluate the final web application, involving six Registered Nutritionists–Dietitians as a panel of human expert validators and 24 regular users as application testers. Quantitative data was retrieved from application testers using task performance and rating that are based on AQEL – a nutrition app quality evaluation tool [35] while qualitative data was collected from human expert validators using individual interviews. In total, 3 sessions were conducted from May to July 2019 where two dietitians and eight application testers were assigned on each of the session. According to Faulkner [36], discovering 90% of the problems in a test using 15 participants as the sample size is already enough. In this study, 30 participants (testers and experts) were recruited for a higher statistical power.

With regards to the macronutrient distribution, the default ratio used is based on Acceptable Macronutrient Distribution Range (AMDR) created by FNRI-DOST [37] in Philippine Dietary Reference Intakes. Nevertheless, app users could still set their own preferred macro ratio to meet their personalized nutrient intake needs. On the other hand, The dataset used for food, ingredients, and meals are from different sources such as FooDb [38], Philippine Food Composition Table [39], My Food Data [40], USDA Food Composition Databases [41], as well as custom coded information like recipes and instruction for meals. In the formulation of individualized meal plan, the web app decomposes each recipe based on the nutrition facts of every ingredient, as shown on Figure 5. On that way, each macronutrient type (protein, carbohydrates, fat) is accounted for to ensure that the total calorie amount is correct. For each meal plan, the food is divided by the number of meal spacing as set by users. No matter how many times a user wants to eat in a day, calories are still restricted by their TDEE.

TABLE I. RECOMMENDED MACRONUTRIENT RATIO

Life stage/ age group	Acceptable Macronutrient Distribution Range		
	Protein	Total Fat	Carbohydrate [a]
Infants, mo			
0–5	5	40-60	35-55
6–11	8-15	30-40	45-62
Children, y			
1–2	6-15	25-35	50-69
3–5	6-15	15-30	55-79
6–9	6-15	15-30	55-79
10–12	6-15	15-30	55-79
13–15	6-15	15-30	55-79
16–18	6-15	15-30	55-79
Adults, y			
19–29	10-15	15-30	55-75
30–49	10-15	15-30	55-75
50–59	10-15	15-30	55-75
60–69	10-15	15-30	55-75
≥ 70	10-15	15-30	55-75

[a.] The AMDR for carbohydrate is the percentage of total energy available after taking into account that consumed as protein and fat, hence the wide ranges. Source: FNRI-DOST.
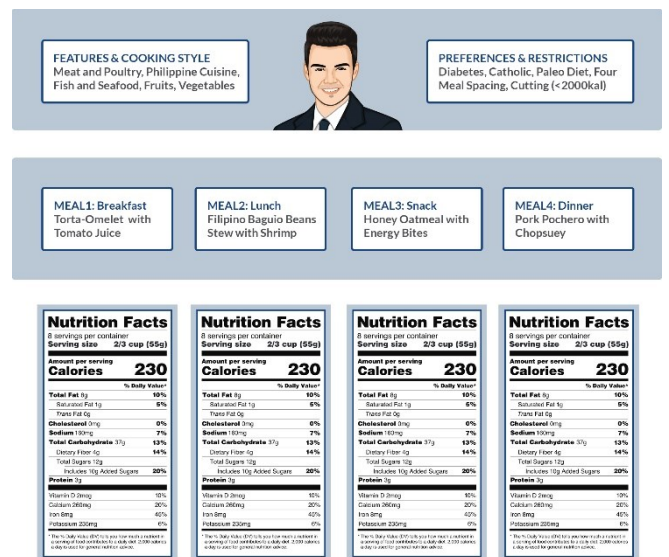

Fig. 5. Visualization of Meal Plan Decomposition with Nutrition Facts.

TABLE II. Quantitative and Qualitative Findings Based on AQEL and Individual Interviews

Construct	Mean, SD	Qualitative Feedback	Enhancements based on Mixed Methods Findings
Behavior Change	4.12, 0.21	• Because on the application, I am now somewhat familiar how meal planning works and, perhaps, develop my own meal plan based on my own preferences [P16] • I realized that it is not really hard to eat healthy. All you have to do is to learn what and how much to eat [P24]	The Plan-Cook-Eat web app should consider adding more health-related modules that can either encourage people to patronize the use of web app or change their outlook towards nutrition and diet, and its impact and importance to their lifestyle and health.
Knowledge	4.45, 0.19	• I never thought that I am in fact eating way beyond the suggested TDEE. Now I know why I am fat! [P21] • I love the recipes on Filipino cusine. There ares so many choices and ways on cooking popular pinoy meals. [P25]	The Plan-Cook-Eat web app should integrate more nutrition knowledge because it opens the eyes of users on how nutrition science works and makes them more engage on using the application.
App Function	4.89, 0.34	• The app has a smooth flow of animation and interaction when loading meal recipes and food list [P4] • The design of the user interface is visually appealing and the pictures of the food are engaging me to click it [P7]	The Plan-Cook-Eat web app should ensure the usage of modern website application design and standards to maintain the loading speed that results to a smooth flow of animation and interaction within the app.
Skill Development	4.11, 0.20	• The recipes on the application makes me enhance my cooking skills and on preparing meals [P12] • I believe that this web application could be beneficial if certain preferences, and restrictions are included [P26]	The Plan-Cook-Eat web app should foster a culture or community within the web app that can enhance the skills and techniques of a user based from the skills promoted by other users and professionals.
App Purpose	4.43, 0.41	• I like how the meal plan is generated based on my actual nutrient needs or my TDEE [P9] • The good thing about macro distribution is by default it is based on actual nutrition guideline [P18]	The Plan-Cook-Eat web app should strengthen its purpose by adding more nutrition-related modules in the system to make it more helpful for people who are non-experts in the nutrition field.

IV. RESULTS AND DISCUSSIONS

The utilization of mixed methods approach in this study was intended to deliver a more in-depth understanding of the results by corroborating the research elements of quantitative and qualitative data. Grounded from this idea, the assessment of Plan-Cook-Eat was designed to verify authenticity of the web application with regards to its nutrition-related concepts. Using a five-point Likert scale, the web app was assessed by the participants (N=30) based on constructs of AQEL, to be followed by qualitative informal interview. The questions on the interview are in conjunction with the AQEL constructs to support the quantitative value with qualitative measurements. Table 1 illustrates the quantitative analysis result using mean and standard deviation supported by a number of qualitative feedback aligned on each construct. Based on three different sessions conducted from May to July 2019, the results show that app users manifested the presence of behavioral change towards nutrition and food by using the web app (4.12, 0.21). This change in behavior is essential because modification of dietary behavior is a prerequisite of an improved nutritional quality and health outcomes [24]. It also means that users are now equipped to alter their poor eating habits. Moreover, the rating of knowledge construct (4.45, 0.19) revealed that users are appreciative when there is a chance to acquire knowledge that they were not aware of. Quaidoo, et al. [42] posited that acquiring such awareness of knowledge concerning nutrition including wellbeing and adequate food intake is paramount in making positive nutritional choices. Furthermore, the app functionality received the highest rating (4.89, 0.34) among all constructs which signifies that app users are looking at the technical and user experience dimension such as interaction, navigability, user-friendliness, loading speed, etc. In terms of skills development (4.11, 0.20), web app users acquire new, or enhance existing skills largely due to the inclusion of the step-by-step meal cooking preparation in the recipe section. This feature becomes very useful especially for people who are not used to cook, and/or not good in cooking. Lastly, the app purpose (4.43, 0.41), which is to generate meal plan with optimal macronutrient distribution of daily calorie received a lot of positive feedback as well. The integration of evidence-based dietetic practice harnessed the willingness of people to follow and like the meal plan generated by the system. It also led to the construction of trust between the app and its users.

V. CONCLUSION AND FUTURE WORKS

The integration of information technology and computer science concepts (e.g., games [43] and video analysis [44]) in the field of medical care has been capturing the attention of many people. Because of this, many software and application are being developed to enhance the quality of life within the society. Plan-Cook-Eat is an example of installment of how these areas of computing could aid people to be health-aware and achieve a good nutritional status. Experts and app testers offered exceptional ratings and feedback to the web app that results to its acceptability. Based from the scores, additional enhancements were highlighted based on the mixed-methods approach. These enhancements are towards the development of "Virtual Dietitian – A Knowledge-Based System". Future works of this study will cover the inclusion of grounding the web application into an international standardized framework called Nutrition Care Process, and the practice of evidenced-based dietetics to personalized nutrition care for formulating tailored dietary interventions based on personal preferences (e.g., dietary type like Vegan or cooking style like Filipino cuisine), health-related restrictions (e.g., allergy and disease-related barrier), and fitness objectives. Lastly, a clinical trial will be piloted to test the effectiveness of the nutrition app.

In summary, Plan-Cook-Eat will redound to the benefit of humanity, that is, anyone who consider nutrition as a key aspect of leading a long and healthy life. The digitalization of meal planner with respect to optimal macro distribution will provide a better patient care and improve public health as the advancement of nutrition knowledge and the development of personalized nutrition intervention are available to all. As a society that experiences public health challenges, it is pivotal to promote solution be it in a form of information system like Plan-Cook-Eat or the consistent dissemination of food-based dietary guidelines like Food Pyramid or Pinggang Pinoy. The rise of modern computing concepts and techniques now pave a way for a more exciting avenue of research in the nutrition science field. Advancements such as expert system, machine learning, big data, and Blockchain are starting to conquer the medical field. It is only a matter of time when technology is deeply and prevalently embedded in the society and in our life, and Plan-Cook-Eat is a small step towards the creation and development of a smarter nutrition application.

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