Supporting Personal Nutrition Reporting with Configurable Goal-Setting

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Abstract—**Online survey data collection is becoming popular because it provides benefits in cost, ease of collecting and managing data, flexibility in format, and access to a diverse population. A key question is whether and how contributing to a survey may prove useful to the study subjects themselves, during the course of a study. As a testbed for exploring this question, this work presents new reporting software that illustrates how nutrition data can be reported back to survey respondents in a way that informs diet choices. These reports are configurable both by the scientists operating a given study as well as by the subjects, thus providing a means of integrating the interests of scientists and those of subjects. The system can also play a role in enabling scientists to shape the behavior of survey respondents for health science studies that call for such an intervention. A formative evaluation of the system with potential users showed that it is both usable and understandable.**

Keywords-information system; web application; nutrition; survey; reporting

I. INTRODUCTION

Online data collection is popular because it provides scientists with benefits in "reduced time, lowered cost, ease of data entry, format flexibility, ability to capture additional response-set information, and ability to access different populations" [1]. The use of surveys by scientists is usually unidirectional, as a source of data from subjects. Health scientists create and distribute surveys with the intention of collecting data to be later used for analysis. For example, scientists at Oregon State University (OSU) can conduct health studies that track subjects' nutritional and physical activities using a survey-collection tool called WavePipe [2]. Unfortunately, as with most other survey systems, WavePipe has lacked a means of automatically generating feedback to individual subjects. That is, as with many other studies, information flow has been unidirectional toward the scientists. As a result, survey respondents receive no useful information back as a result of contributing to the research study.

The current project therefore investigates how it might be possible to enable scientists to generate custom feedback to study subjects in response to survey data, thereby facilitating bi-directional communication. Such interaction could prove useful for studies where the scientists seek to change the choices of respondents over time, such as research aimed at enhancing diet and nutrition. By using surveys, scientists could benefit from collecting data, while subjects could simultaneously benefit from receiving feedback on survey responses, thereby contributing to subjects' learning and awareness about nutrition and physical health.

A new sub-system, called WavePipe Survey Reporter, was created to achieve this goal. A scientist can create a custom survey using the commercial Qualtrics tool [3], to which study subjects provide responses. The WavePipe Survey Reporter generates reports by aggregating Qualtrics survey responses for each subject over a period of time. It annotates these by analyzing each respondent's data relative to thresholds set by the scientist and by the respondent himself.

For example, in a nutrition study, the scientist can create a survey asking about diet over the past day. The scientist may set goals for how many fruits or vegetables each respondent should consume (based on data from a survey question), and each study subject can set a personal goal, as well. The resulting report compares responses to goals and provides feedback to the respondent.

The primary contribution of this paper is conceptual, specifically the integration of interests from both scientists and respondents, demonstrating the potential for simultaneously satisfying the distinct objectives of these two groups of stakeholders. The secondary ancillary contribution is the specific software and report, which provides a starting point for exploring more sophisticated forms of integration between these groups' interests. Specifically, a formative study was conducted to investigate the extent to which potential users found the report both useful and usable. The results demonstrated the viability of the approach and the usability of the specific report evaluated.

II. BACKGROUND AND REQUIREMENTS

The WAVE project offers an appropriate context for investigating how to integrate the interests of scientists and survey respondents [2]. Among other objectives, this multi-disciplinary project centered at Oregon State University aims at

discovering how to aid healthy diet and nutrition choices by athletic high school adolescents. WavePipe is the system used in this project to conduct health studies. Historically, its functionality relevant to this objective has included support for creating studies, enrolling subjects, and sending links to surveys (created in Qualtrics). WavePipe also enables scientists to organize study subjects into groups (e.g., treatment versus control, or into multiple groups with different treatments).

WAVE Project scientists often need to modify surveys delivered by WavePipe for operational adjustments to support community-based research. They need to add, remove or change existing questions in the static survey present in the system and deploy the changes again in order to collect new data. Thus, a requirement exists for an easy-to-use survey editor enabling scientists (or their health science research assistants) to create and deploy custom surveys.

In addition, the WAVE project's research goals call for monitoring subjects by asking them to fill the same survey every day for a certain period of time. Giving subjects feedback about their survey data would be helpful because the project's approach involves providing educational interventions and healthy-lifestyle reminders to subjects, then measuring the extent to which these affect behavior. More precisely, providing feedback to subjects might help to reinforce healthy behaviors and discourage undesirable behaviors.

Finally, the project recognizes the potential value of having study subjects set their own nutrition goals. A feature supporting this functionality could aid in studying, for example, whether giving adolescent athletes the ability to set their own goals increases the likelihood that they improve their diet choices over time. Such research questions bring together the interests of the scientists with the interests of the study subjects themselves: the latter may value the health improvements that can result from improved nutrition, while the scientists wish to measure the effectiveness of approaches aimed at achieving that result. Supporting research like this consequently requires giving study subjects some control over the goals against which their data are compared.

III. SOLUTION

The Survey Reporter extends WavePipe with support for the requirements outlined in Section II. This new sub-system provides functionality for (1) scientists to configure surveys, (2) study subjects to set personal goals, and (3) survey respondents to view reports. Sub-sections below describe these three areas of functionality.

A. Functionality for scientists to configure surveys

Because all faculty members on the WAVE project have access to the Qualtrics survey tool and have used it in the past, Qualtrics was the choice for providing a means whereby scientists could create customizable surveys. The Qualtrics system offers an Application Programming Interface (API) that gives developers access to Qualtrics data (including both surveys and responses) via web services [5]. This made it possible to read surveys into the WavePipe Survey Reporter

and display relevant Qualtrics survey-related information to the health scientists in a web user-interface. This would enable scientists to change surveys frequently and view the survey responses.

Consequently, the first step for a scientist to configure a survey is to log into Qualtrics and to create the survey through that tool's form-based interface. For example, the scientist might ask questions about how many servings of fruit the respondent has had in the past 24 hours, how many servings of vegetables, how many minutes of walking or similar low-intensity exercise, how many minutes of running or similar high-intensity exercise, and so forth. In addition to such questions, the survey must contain a question asking for a respondent identification number, in order that the system can compare each respondent's data to the right study subject's personal goals (as Sections III.B and III.C discuss in detail).

After saving the survey in Qualtrics, the second step of configuring the survey is for the scientist to log into the WavePipe system and accesses the new Survey Reporter component. There, the scientist enters authentication credentials enabling the Survey Reporter to access the Qualtrics API on the scientist's behalf. The Survey Reporter retrieves the list of surveys owned by that account and displays them to the scientist, so that the scientist may select the survey that will be sent to study subjects.

The next step is for the scientist to decide the goal questions for the survey. Goal questions are items in the survey for which the scientist wants to specify what the subjects' answers ideally "should" be. The scientist might want to set goals for some questions but not for others. These goals are entirely at the discretion of the scientist and could be set, for instance, based on government-issued and/or research-backed diet or exercise recommendations. For example, based on federal nutritional guidelines, the scientist might want to specify that a question about servings of vegetables is a goal question, and that the ideal answer is in a certain range.

The Survey Reporter enables the scientist to accomplish this by reading the list of numeric-input questions from Qualtrics and displaying them (Figure 1). These questions can be multiple-choice (with corresponding integer values specified within Qualtrics), textual numeric input, or any other question that generates a numeric value. The scientist can check off which questions should be goal questions and, for each question, may edit the text of the question if desired.

For each question, the scientist can divide the range from 0 to infinity into three sections. These correspond to a "good" range, a "neutral" range, and a "bad" range, represented in the user interface with green, orange and red. The user interface automatically validates inputs and updates neighboring values for consistency. (If only two ranges are desired, the scientist can omit one of these ranges by entering numbers that shrink the range to a point where no respondent would ever enter a number within the range.) For instance, the scientist might consider eating vegetables 0 times to be negative (red), 1-3 to be neutral (orange), and 4 or more to be positive (green).

Figure 1. User interface enabling the scientist to configure goal questions in the WavePipe Survey Reporter for a survey imported from Qualtrics.

The scientist can then save the list of goal questions, including any updated text (which is propagated via the web service API to Qualtrics) and goal settings.

B. Functionality for study subjects to set personal goals

After the scientist saves goal questions, she may click a button that causes the Survey Reporter to invite each study subject to set personal goals. In a typical study, health scientists have a list of study subjects who have chosen to participate in the study, have signed appropriated documents indicating informed consent to participate, and have provided contact information, including either email address and/or phone number (for texting). In many studies, health scientists assign each study subject a unique identifier; in the WAVE project, this is an 8-digit number, though in other health studies it could be another identifier such as each study subject's email address. WavePipe has already provided functionality for scientists to enter the names, identifiers and contact information of study subjects. Therefore, when the scientists clicks the button for inviting study subjects to set personal goals, the Survey Reporter loads the list of study subjects, iterates over them, and sends each of them a message with a personalized link to a website.

At that web page, the study subject can review the list of goal questions and, for each, indicate a personal goal (Figure 2). Internally, the user interface also tracks which study subject

is filling out the form, as the link (above) contains an encoded representation of the participant's unique identifier, as well as the survey identifier. Thus, when the user submits the form, the system can validate inputs and associate goals with the correct person. Each person may specify different goals for different surveys. For example, if a study involves an exercise survey and a diet survey, then each study subject can specify goals for each question in each survey. Study subjects may choose to omit goals for some or all questions of some or all surveys.

C. Functionality for survey respondents to view reports

During a study, scientists will prompt study subjects to complete each survey at an interval appropriate for that study. They can accomplish this manually using features of Qualtrics or using an existing scheduling service that has been provided elsewhere in WavePipe.

Each night, the scheduling service of WavePipe invokes a function within the Survey Reporter, which in turn accesses Qualtrics and caches new data from respondents. In addition, at a pre-defined time (currently, the 1st night of each month), the WavePipe Survey Reporter generates a consolidated custom report for each subject as follows. It first retrieves all survey responses of the subject for that survey for that particular period. Next, it retrieves the list of saved goal questions. Then, for each of these questions, it checks the retrieved responses

Figure 2. User interface enabling the study subject to set personal goals for each goal question in a study's survey.
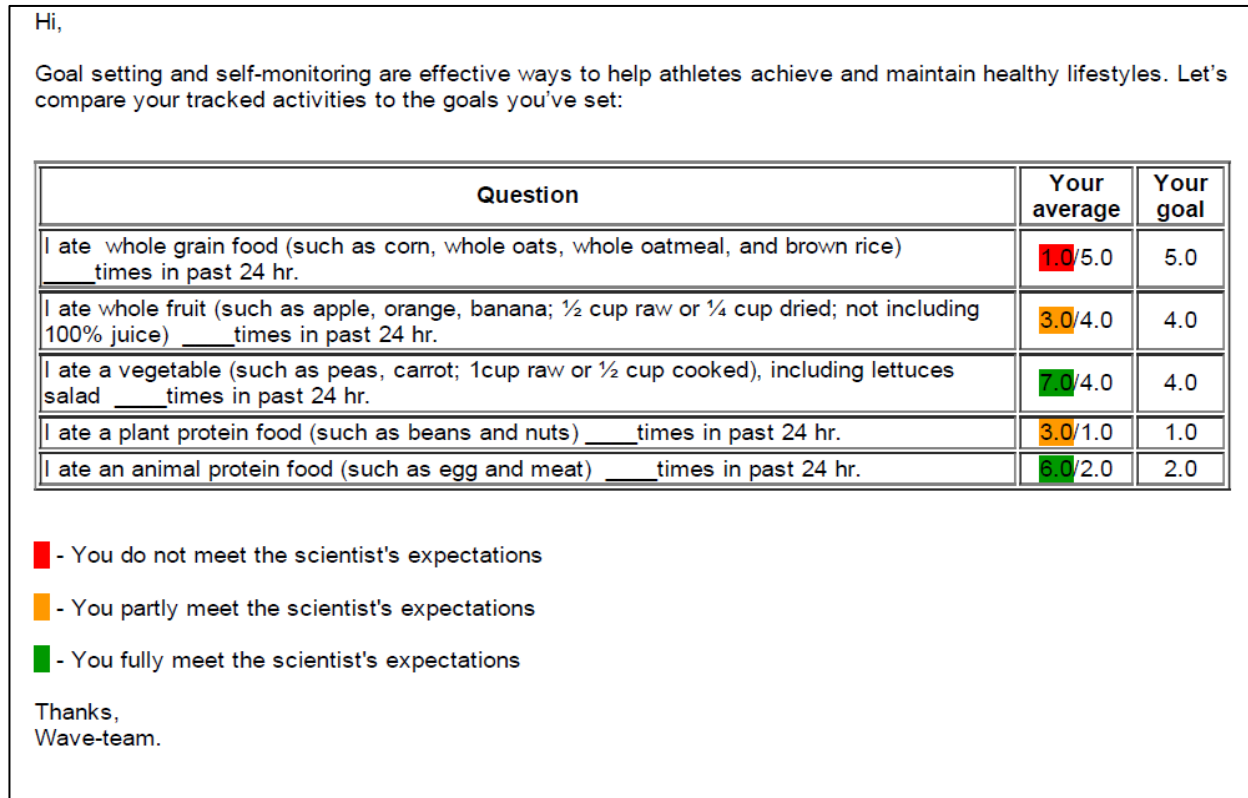
Figure 3. User interface enabling a survey respondent to view recent data relative to personal goals and compared to the scientist's specified goals, with average number of servings per day for each diet-related question, the scientist's recommended number of servings, and the study subject's own personally-defined goal.

and computes the average.

Finally, it constructs a report for each subject (Figure 3). The first column in the report contains the goal questions. The second column contains the calculated average for each question. In addition, the average is highlighted with a color computed based on where the average falls on the color range set by the scientist for each question (scientist's expectations). If the scientist does not set a goal for a given question, the corresponding average does not get highlighted. The third column contains the subject's goals, for each question in which that person has set a goal. The Survey Reporter emails the report to each survey respondent (i.e., those for whom data exist). Typically, some but not all study subjects will choose to complete surveys, so the survey respondents will be a subset of the study subjects.

The key primary contribution of this work is not in the specific report generated here but rather in the conceptual integration of interests from both scientists and respondents, demonstrating the potential for simultaneously satisfying the distinct objectives of these two groups of stakeholders. A particular survey respondent's dietary objectives might differ considerably from those specified by the scientist based on government guidelines. The WavePipe Survey Reporter illustrates the feasibility of gathering objectives from both scientists and study subjects into a unitary display.

At the same time, the software served as a tool to facilitate our formative study (Section IV), affording an opportunity to obtain guidance from participants about how to enhance the report and underlying functionality in the future.

IV. PRELIMINARY USER FEEDBACK

A. Study participants and methodology

We emailed a study invitation to graduate students in the College of Public Health and Human Sciences at Oregon State University. When they replied, we provided a copy of the formative study consent document and arranged a time for each of 6 graduate students to visit us individually in a usability laboratory. Half were Master's students and half Ph.D, and they were predominantly from the nutrition department (with others from exercise and sport science or general public health).

We provided each participant with a copy of a survey that a typical health science study subject would receive, as well as a sample report. We then presented a feedback questionnaire that included the four questions shown in Table I about usability. For each question, participants could select from a Likert scale ("Yes," "Mostly," "Somewhat," and "Not at all"). We then interviewed participants to obtain additional qualitative feedback and suggestions about potential improvements for the report and underlying software.

TABLE I. FEEDBACK QUESTIONS FOR THE FORMATIVE STUDY

- The 'Your goals' section of the report states the goals that person filling out the report has set for each question at the start of the study. Does the column 'Your goals' state the personal goal clearly?

- 'Your average' summarizes the mean frequency of a targeted goal during the week. Does this feature make sense to you?

- Notice the feedback message at the top of the report. We want to give meaningful feedback to all who complete the survey that is used to create this report. Is this feedback message clear?

- Here is our final question. It's about the color code we use to indicate the level of achievement in meeting the set goals. Looking at these ranges, are red, orange and green acceptable to you?

B. Results

Participants provided generally positive feedback while also offering very helpful guidance about enhancing the report.

Four of the six participants considered the personal goals section of the report entirely clear, while two reported it was "mostly" understandable. These two participants noted that in some studies it might not be appropriate to let subjects set their own goals, for example because it is possible that subjects might set a goal that could be unattainable or otherwise excessive.

Five participants indicated that the "averages" portion of the report was entirely clear, with the remaining one indicating that it was "mostly" understandable. This participant did not have a specific reason why the averages might sometimes not be clear.

Half of participants considered the introductory remarks at the top of the report to be clear, and the other half said it was "mostly" clear. It was suggested that the text might need to be adjusted based on the need to be more understandable to members of particular study populations. For example, one participant noted the need to indicate distinctions between "diet" and "eating habits" depending on the situation; another noted the distinction between "activity" and "exercise" in some studies.

Finally, four participants indicated that the color ranges were entirely clear, one said they were "somewhat" clear, and the sixth considered them "not at all" understandable. This last participant explained that he was color-blind and suggested using other colors such as light-blue instead of orange. The participant appreciated that the shades of red and green used in the report were not close, making it easier to distinguish between those. It was also noted that orange is so similar to red that it conveys a similar sense of negativity. Their emphasis

was that it is important not to be too hypercritical, which can unnecessarily discourage rather than reward good progress.

C. Discussion

The participants' feedback emphasizes that developing a universally appealing report is not a trivial challenge. The report's strongest aspect appears to be in its integration of goals from the researcher and the study subject. Its weakest aspect appears to be in its over-reliance on colors; the application of different icons could address this limitation. Another area for future work is customizability, in terms of providing scientists with the ability to tailor not only the message at the top of the report but also other aspects of the report itself (e.g., what colors and icons appear). We note that all participants found the use of averages to be mostly or completely clear, so classifying survey respondents' inputs based on averages appears to be a reasonable way of enabling scientists to specify the rules that determine the report's visual appearance.

V. RELATED WORK

Numerous tools exist for helping scientists and others to create surveys [4]. These include, for example, commercially-available web-survey tools such as Qualtrics [3][5], SurveyMonkey [6], Formsite [7], SurveyGizmo [8], and LimeSurvey [9]. Other survey tools provide specialized features for particular research communities. For example, CLICK (Component-based Lightweight Internet-application Construction Kit) is a web-based application development tool that supports a broad range of functions for creating custom web applications, including survey functions, with Excel data export functionality [10][11]. Another specialized survey system, Surveyman, provides dynamic analysis functions for automatically locating likely input errors [12]. A third, TopSl, provides a language for implementing novel control-flow (skip logic) conditions [13].

All of these tools have in common the limitation of not providing a means of generating reports back to subjects. In particular, none of them provides a means whereby the scientist or subject can specify expectations or goals for converting subjects' survey data into reports.

Conversely, other tools exist for generating reports but lack support for displaying surveys. For example, Crystal Reports offers a highly-customizable reporting framework to query a database and generate reports in PDF or HTML format, which may include embedded charts and graphs [14][15]. The Business Intelligence and Reporting Tools (BIRT) is another charting and reporting tool, in this case integrated with the Eclipse platform, for generating reports within Java applications [16]. Extensive research has investigated methods for enabling users (e.g., scientists) to specify reports. For instance, one is programming-by-example, whereby the report designer creates a report using example data from a relational database table, and the system infers queries for retrieving the right data at run-time [17]. Another approach is "pattern-directed" reporting, where users specify report fragments with a textual template language [18].

These tools, unlike the WavePipe Survey Reporter, support only output of data, rather than the full spectrum of data acquisition and reporting supported by our integrated system. Moreover, to the extent that it is possible to integrate tools above (e.g., Qualtrics with BIRT), the result would still not generate reports that take into account each individual respondent's personal goals for each question. Hence, our system illustrates a useful new concept for extending the range of tools that currently exist.

VI. CONCLUSION

This work has demonstrated the feasibility of generating customizable reports back to survey respondents for monitoring nutritional data based on dietary recall surveys. The resulting functionality, implemented as a sub-system within the WAVE project, illustrates the potential usefulness of providing study participants with a concise representation of the data that they have provided. The added functionality also offers the scientists control over goals set for study participants. Formative feedback was largely positive and provided some suggestions for enhancing the user interface. These results indicate the viability of this approach as a means for giving study participants a useful level of detail about their data while still taking into account the goals of the scientists.

This system provides a basis for further enhancement and evaluation. The WAVE project has embarked on a two-year study applying the WavePipe, which will facilitate a future summative evaluation of its sub-systems, including the one presented in this paper.

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