Spoken Questionnaire

A Platform for Making Voice-based Surveys

Yimeng, Sun

Cornell Tech, ys992@cornell.edu

Srishti, Gupta

Cornell Tech, sg2435@cornell.edu

Traditionally, health data collections are usually done by health assessment questionnaires distributed by hospitals and clinics. These data are usually handwritten or spoken by the patients and typed in by caregivers. Leveraging the advancement of speech recognition technology and the prevalence of at-home intelligence voice speakers, we believe that health assessment questionnaires could be sent through voice assistants to help the doctors and other caregivers collect patient data.

Conducted in partnership with a geriatric oncologist at the Memorial Sloan Kettering Cancer Center, we want to facilitate doctors and other caregivers to create and send out health assessment questionnaires to their patients. We explore the design, implementation, and evaluation of Graphical User Interface tools (GUIs) to facilitate a smooth, easy experience of making custom voice-based surveys not only for health researchers and practitioners, but also for anyone who wants to create questionnaires that are sent through Alexa Echo systems.

1 INTRODUCTION

Health assessments are sets of questions that the patients answer to assess their health conditions. The current health assessment collections are usually done by doctors or other caregivers - they would ask the patients to fill in paper forms and manually translate them into an electronic record. With the rapid development of speech recognition technologies and the prevalence of voice assistants and smart speakers, we believe that collecting survey responses via smart speakers will grow to be the new norm soon. According to Voicebot.ai' s Smart Speaker Consumer Adoption survey [3], as of 2020, more than one third of the US adult population owns a smart speaker. Currently, we have a running health assessment questionnaire that is sent to patients via intelligent voice assistants like Alexa Echo and Google Home to eliminate the manual and repetitive effort of checking on their patients and help them gain a comprehensive picture of their patient' s conditions.

Although sending voice-based questionnaires makes the response collection easier and more convenient, it is difficult for the caregivers themselves to create a questionnaire for intelligent voice assistants on existing platforms. To create a skill for a questionnaire on Amazon Echo or Google Home, one usually must write hundreds of lines of code. Also, the creation and deployment of Alexa and Google skills are time-consuming and complicated to complete. Since it's a relatively new technology, few development tools and tutorials are available to people.

Conducted in partnership with a geriatric oncologist at the Memorial Sloan Kettering Cancer Center, we want to facilitate doctors and other caregivers to easily create and send out health assessment questionnaires to their patients. We would like to solve this problem by creating an equivalent Graphical User Interface (GUI) platform that is integrated with Amazon Echo. We aim to not only develop a tool specifically for health assessment purposes, but also make the platform generic enough for the creation of other voice-based questionnaires.

We have currently designed and developed a minimum viable web application that enables the user to edit and send out a single Multiple-Choice question. It is also integrated with Amazon's DynamoDB and its Alexa Developer console so that the questionnaire could be pulled out from an Amazon Echo device. We will continue the GUI development and integration, making the system complete, and evaluating the effectiveness and usability of the GUI in the future.

2 RELATED WORK

According to our study, voice assistants have been embraced by the healthcare industry, particularly after the pandemic. We have also identified several similar tools that integrate voice assistants with other services.

2.1 Voice assistants in healthcare industry

Research [1] has shown that more and more companies are working with voice surveys to complement rather than replace conventional surveys. Customers may participate in voice surveys over the internet, via smart speakers, or embed them into existing smartphone applications. A recent commentary in NPJ Digital Medicine, researchers from Nationwide Children's identified voice assistants as an emerging tool for remote care delivery. A study [4] also showed that survey experts have agreed that smart voice assistants have the potential to support elderly people and be widely used by patients and health care professionals.

2.2 SurveyLine

SurveyLine [6] is a voice survey tool for creating questionnaires with Amazon Alexa and Google Assistant. Powered by Voice Metrics [5], a tool that connects business applications to bring voice capabilities, it creates a personalized voice app with custom invocation phrases. But SurveyLine's user interface is not intuitive, and its functions are very limited, sometimes not even performing properly.

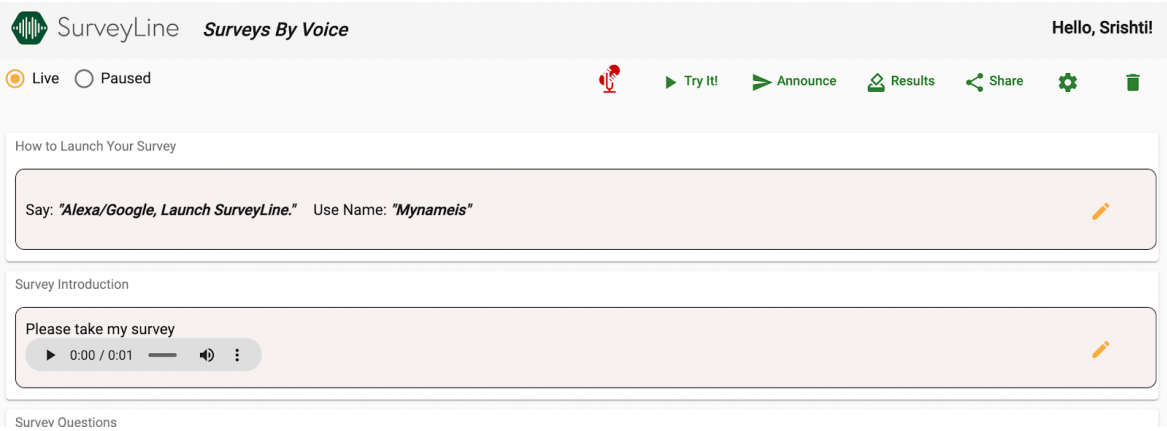

Figure 1. Screenshot of SurveyLine platform

3 METHODOLOGY

3.1 System design

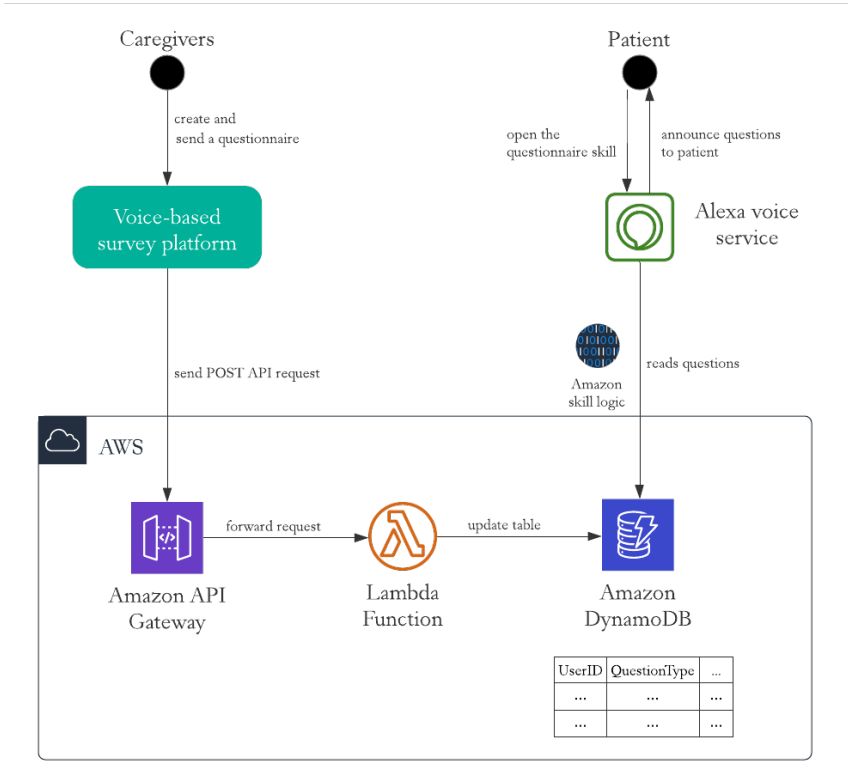

Figure 3. Voice-based survey system design

Our system serves to enable doctors or clinicians to create and send the voice questionnaire, which is automatically integrated into Amazon's Echo devices. It starts with the caregivers creating and sending a questionnaire using our platform. Once the editing is finished and the user presses the send button on the user interface, the front-end side would convert the questionnaire to a series of POST requests and send them to Amazon Web Services (AWS)'s lambda function through its API gateway. The lambda function will help to translate the requests and create items to the tables in DynamoDB. When the patient's side speaks to his/her Alexa device to trigger the questionnaire, Amazon voice service would read the questions from the database and announce them one at a time to the patient.

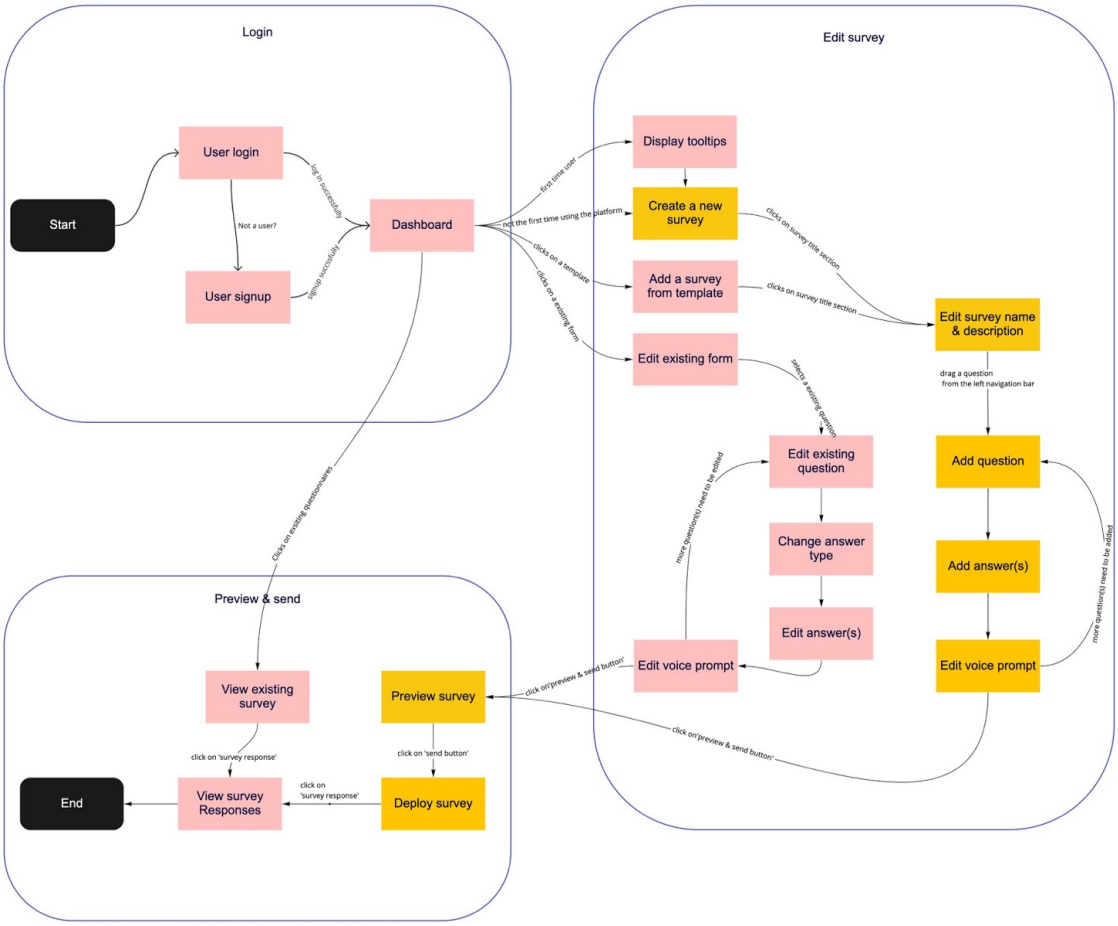

Figure 4. System flow chart

As shown in the flow chart, the complete user flow and states of our platform are divided into three parts: user log-in, editing the survey, and previewing and sending out the survey. The states in yellow are the basic flow that we focus on for the first version of the application, which facilitates a simple questionnaire creation, preview, and deployment.

3.2 User Interface Design

After studying on other survey-making platforms (e.g., Google forms and Qualtrics), we made a UI prototype that would fit into our voice-based scenario. We also want to make sure that our design is easy to understand for users with different familiarity levels to technology, therefore our design tries to explain the terms to avoid confusion while retaining a rather simple and minimal style.

We want to help the user who enters this interface for the first time to go through a series of tooltips to locate and explain where things are at. The user also has the freedom of closing the tooltip and enters the main screen anytime.

The main screen of the interface consists of a top navigation bar, a left sidebar, and the main question section. The top navigation bar displays the platform name and a ‘preview and send’ button. The sidebar lists out different types of questions so that the user could drag a question to the main section to add it to their survey. It also gives a simple explanation and example of how each question type looks like. The main section, in light green background, has two columns - one for screen display, where the user can edit how the Amazon Echo device will show on the screen; the other for voice prompt, where the user decides the voice prompt Alexa will say. A play button is also displayed on the screen so that the user could click on and listen to the voice prompt when he/she wants to.

After a user drags a question to add to the main section, the user can edit the screen display and the voice prompt. For grid questions, the user can also click on a button to add another question to the grid and edit each sub-question if needed.

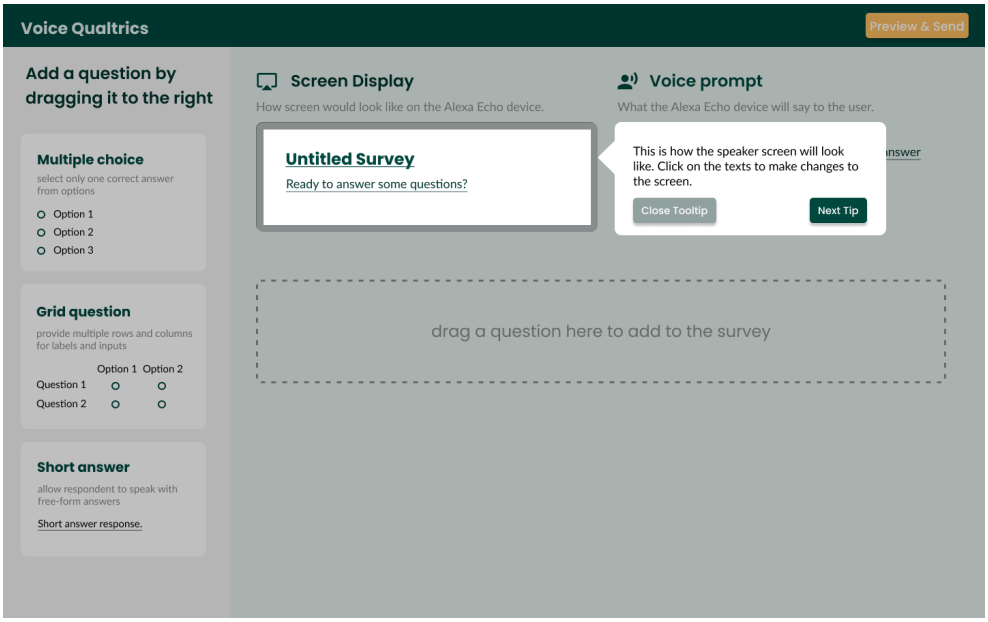

Figure 3. UI prototype screen – tooltip display

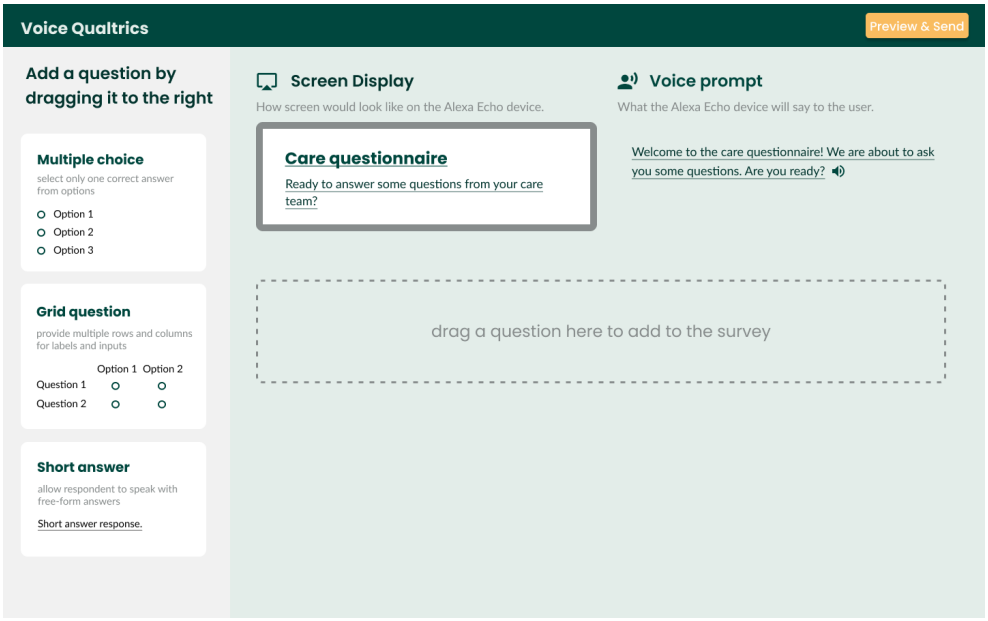

Figure 4. UI prototype screen – main screen display

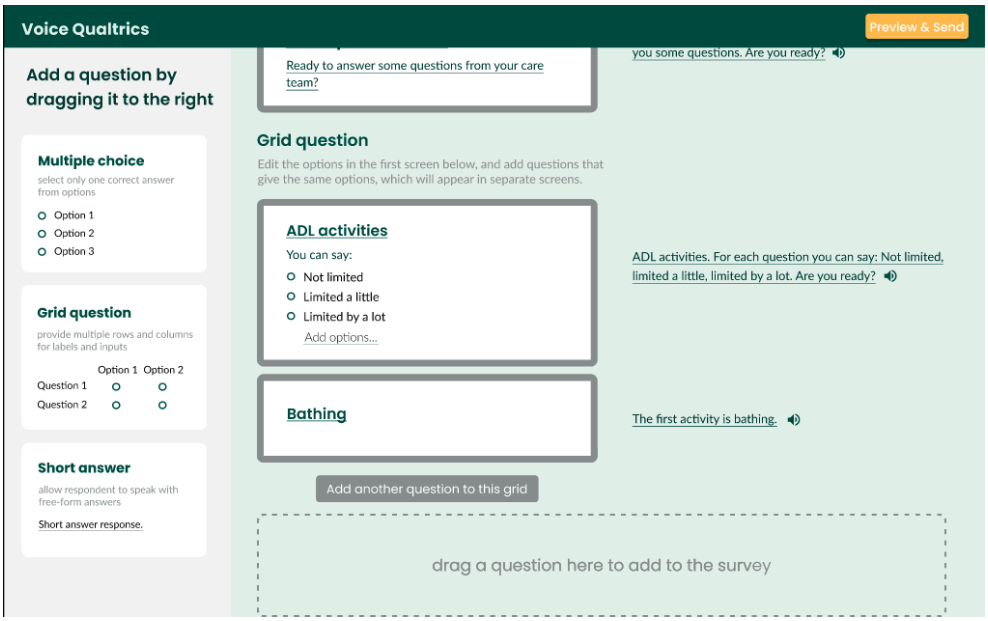

Figure 5. UI prototype screen – grid question display

3.3 Back-end design

The structure of our back-end is composed of services from the AWS suite, namely DynamoDB, Amazon's API gateway, and the lambda function.

We use DynamoDB to store the questions for their distributed nature, inherent scalability, and NoSQL qualities. A table in DynamoDB is created for storing survey questionnaires sent from the front-end. A table in DynamoDB is created for storing survey questionnaires sent from the front-end and connected with Alexa Developer Console. This enables the synchronized questionnaire update from the client-side.

Event triggers are made possible by using AWS Lambda function and Amazon's API Gateway. The API Gateway enables automatic scaling to different amounts of user requests. Our endpoints include the standard CRUD operations but are grouped by a unique UserID and qID (question ID). All APIs that make a new update on the database adds a new row in the table. All of these are connected to the frontend web app via API endpoints. DynamoDB relates to Alexa Developer Console to update the survey questionnaire whenever they are designed by the user on the frontend.

We also implemented event triggers with AWS Lambda function and Amazon's API Gateway which enables automatic scaling to different amounts of user requests.

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3.4 Alexa Skill

Our system also includes a skill interaction and application logic model. When the end user speaks, Alexa processes the speech part in context to the interaction model to determine the user request. It then sends the request to the application logic, which acts on that request. In that case when a user invokes Alexa by saying "open survey questionnaire", Alexa processes the invocation request and accordingly responds to the request which in our case is asking survey questions.

4 CURRENT RESULTS

By this time, we have finished off on our first iterations of design and have built a slice of the system that is functionally running.

We have finalized our design through rounds of preliminary UI prototype testing. We have encoded our platform into a web application using React and Bootstrap, integrated it with AWS components through REST APIs, and connected to Alexa Developer Console so that it could access the questions from the database.

We decided to go for a simple design and make it intuitive, but in doing so, we faced a lot of hurdles. As AWS is a cloud platform and has a lot of services and features that any other cloud provides, it's hard to navigate the features that will be useful in designing the architect of the application.

Moreover, developing the REST API calls took us some time to figure out as there is not enough documentation to help us. Also, when there are many options to choose from it is a difficult to know which service/language is better than the other. That led us to a path where we had to retract our steps to start from scratch, three or four times to ensure that we are on the right path.

5 FUTURE WORK

Next semester, we plan to continue developing our system and target for a more complete, concrete, and easy-to-use system. We will also conduct rounds of testing on the platform and evaluate the functionality and usability of our system.

We will improve our user interface by both cleaning up the layout and expanding the functionalities. Currently, the system only supports editing one short-answer question, and no preview of how questions will look on Alexa is available. We will expand the questions to Multiple Choices and grid questions and enable the preview of the questions. If possible, we will also add the feature where the user could listen to the voice prompt using text-to-speech APIs.

We will also re-design the DynamoDB database so that it supports different types of questions. Our current table only has two attributes - userId and qId. The qId data field wraps all the input from the web application (i.e., title of question, question description, voice prompt) and sends it in one go. We will reference other NoSQL database designs, re-design the attributes to separate different data fields, and better adapt to the conversion to Amazon Echo.

Since we have now only developed the web app to support a single question, if there is only one item (i.e. only one question is added to the database) on DynamoDB, the Amazon Echo device could read it out to the user without a problem. Should there be more than one question, the current code on Amazon Developer Console will read out all the questions at once. We will also make it possible to support multiple question entries and allow the user to change questions by saying ‘next question’ to change to the next question.

After the system is complete, we will also evaluate the tools on established Patient-Reported Outcome Repositives (PROMIS) metrics and test the system with caregivers and other potential users if possible.

The detailed Gantt chart of our next semester’s plan could be found in **Appendix A.2**.

REFERENCES

[1] Mary Bates, PhD. 2020. The Role of Health Care Voice Assistants During a Pandemic and Beyond. https://pediatricsnationwide.org/2020/11/10/the-role-of-health-care-voice-assistants-during-a-pandemic-and-beyond/

[2] Alena Ermolina, Victor Tiberius. 09.04.2021. Voice-Controlled Intelligent Personal Assistants in Health Care: International Delphi Study. Journal of Medical Internet Research. https://www.jmir.org/2021/4/e25312

[3] Bret Kinsella. 2020. Nearly 90 Million U.S. Adults Have Smart Speakers, Adoption Now Exceeds One-Third of Consumers. Voicebot.ai. https://voicebot.ai/2020/04/28/nearly-90-million-u-s-adults-have-smart-speakers-adoption-now-exceeds-one-third-of-consumers/

[4] Sezgin, E., Huang, Y., Ramtekkar, U. et al. 2020. Readiness for voice assistants to support healthcare delivery during a health crisis and pandemic. npj Digit. Med. 3, 122 (2020). https://doi.org/10.1038/s41746-020-00332-0

[5] Voice Metrics. https://www.voicemetrics.io/

[6] SurveyLine. https://app.surveysbyvoice.com/

A APPENDICES

A.1 Technical Details

Git repository link: https://github.com/ysunaw/voice-questionnaire

UI prototype link: https://www.figma.com/proto/muG4NGDatAY6zFcb1fAXEf/voice-qualtrics?page-id=220%3A173&node-id=323%3A69&viewport=-98%2C95%2C0.0760488510131836

List of system components

Component / Subsystem	Usage	Tool(s) or platform used
Web app	Interface and communication with back-end	React, Bootstrap
Database	Store the questions in table	AWS Dynamo DB
Logic	Forward API requests	API gateway
Serverless function	Translate request to data in the table	Lambda function
APIs	Send requests and fetch data from backend	REST APIs
Alexa IDE	Develop Alexa skills	Alexa Developer Console

A.2 Next Semester's plans and milestones