

Table Teacher: Voice Based Application for Learning Tables using Amazon Alexa

Chinmay Subray Bhat

Abstract - With the evolution of sophisticated NLP algorithms and cloud based solutions, virtual assistants started to reach every home and office in the city. This paper proposes a technique for teaching basic mathematical tables for kids. The device will ask the questions and expect the answer in number format in return. The input received from the kid will be processed and validated. In case of correct answer, the next question will be asked. If answer is wrong, the kid is suitably notified. This ability to interact with the device in natural form like voice would keep the kid engaged to the process of learning. Proposed skill is available for enabling for all the echo family users and the result of customers using the skill is analyzed. The skill used AWS server less service Lambda as backend and Amazon Voice Service for front-end.

Key Words: Amazon Alexa, Virtual Assistants, Voice User Interface, Education, AWS, Lambda, Smart Speakers, AVS, Voicebot, Internet of Things

I. INTRODUCTION

The use of voice based intelligent virtual assistants [1] has increased rapidly since 2017. New capabilities have been added to the devices in the market. Some virtual assistants [2] accept voice as input and will produce response in the form of voice itself. It will make the interaction more natural to the user. Apple and Google have introduced them in the smart phones. Microsoft has installed its virtual assistant in the personal computers. Amazon has a large install base for smart speakers and other gadgets.

1.1 Smart Speakers

Amazon echo [3] family is the smart speaker product by Amazon. Since its launch in November 2014, Amazon has been adding new devices and futures till today. Currently Amazon echo is available in 40 countries and supports five major languages along with English. Amazon echo dot, echo show, echo look, echo spot, echo auto, echo input and echo link are the few variations available in the echo family.

These devices use voice as a primary medium of communication and are powered by Amazon Alexa. Amazon Alexa adds smartness to these devices and enables user to communicate with the device like a virtual assistant. Even low power-low cost devices like Raspberry Pi can also be integrated with Alexa with the help of a service called Alexa Voice Service (AVS). Major constraints to be met by such device are internet connectivity and capacity to listen and play the audio. Any devices which has AVS built-in is called Alexa enabled device.

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As per the report by voicebot.ai [4], a start-up based on voice first products Alexa enabled devices have increased 400% by this year, that is from 4,000 to 20,000 devices. Currently Alexa is used by more than 3,500 brands too. One potential reason for such growth can be its ability to integrate third party applications called Skills. As per the above said report, there is more than 50,000 skills world wide spread across various categories.

1.2 Alexa Skills

Alexa enabled devices have some built-in capabilities like setting the alarms, playing the music or updating about the weather [5]. However, user may want to add more capabilities to the device depending on the need. Just like installing new software onto the computer, new capabilities can be enabled to the Alexa enabled device with the help of skills. User has to just enable the required skill available in the skill store [6].

Generally custom skills have to be invoked manually by the user unlike built in functionality. Also, user has to set the information that can be shared with the third party skill. This can be simple information like sharing device location and be up to payment like Amazon pay via linking account. Special permission are required if the skill is intended to be used by children below age 12. As Alexa skill builder, developer has to take care of certification guidelines. This ensures functionality satisfaction and safety for the user information.

II. RELATED WORK

There are thousands of skills available in the Amazon skill store spread across various categories and locales. This work focuses on education and kids sections among them. As the skill development is in evolving stage, and most of the skill builders are new to the domain, finding the skill for the need is also an interesting challenge. In this work, locale is limited to India only (English being the language) and Alexa skill with minimum 10 user ratings has been considered to understand the current progress. Following are the three popular skills available.

2.1 1-2-3 Math

1-2-3 Math [7] by Sermo Labs, LLC is a popular skill available in 5 languages. It is a math challenge which tests users elementary compute skills, including addition, subtraction, multiplication, division, comparison etc. There are three modes easy, medium and hard with increasing levels of difficulty. The skills recommends having a calculator handy, as certain questions, especially in the hard mode may not be easy to solve within the time allocated. The skill stores the state of the game throughout the day. So, if the user can't answer

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the question within the allotted time, user can always come back when ready and continue from where left off. User will get one point for every correct question. Scores are calculated for each difficulty level separately. All scores are reset at the end of the day.

Even though the skill provides sophisticated mathematical challenges, it may not be suitable for kids who just started learning the tables. Also, multiplication tables are learned in continuous manner like “two two jaa four, two three jaa six...” in the traditional academics.

2.2 Byju's

Byju's [8] by Think and Learn is one of the popular educational skills in Amazon Alexa skill store India. Currently it has 71 ratings by the users and averages 4.5 stars. Byju's is a platform that helps the learner to discover and learn well researched content across mathematics and science fields. This skill will give interesting facts in physics, chemistry, biology and mathematics to the user.

However, the functionality is limited to interesting facts only. For the actual teaching-learning mechanism user has to download the mobile App.

2.3 World Mathematics League

World Mathematics League [9] by Sermo Labs, LLC is a global level mathematics competition. Every day user will get a chance to contribute to team's score by solving simple math questions. User will have a fixed amount of time within which he/she can answer as many questions as possible. Based on device location, user will be auto-enrolled into user's national and regional teams and individual score will be added to overall team's score. The more members in the league, the better are the chances of winning.

This is a long competition and kids may not have patience to participate every day. Also, the questions are comparatively tough for the starters.

2.4 Other Skills

Times Table Quiz by Mark Dobbie is a skill available in 4 locations including India. It is a quiz skill to test users knowledge of the times table with a set of 10 randomly chosen questions.

Times Table Battle by Robot And I Ltd is a skill where the user and Alexa will play as opponents. The skill is focused on age group six to twelve. However, the conversation model is not like teacher- student but instead Alexa is playing the role of moderator and player as well.

III. SYSTEM DESIGN

Problem statement identified based on studying the existing skills is to build an Alexa skill for kids which enables them to learn basic tables. It should follow teacher-student interaction model and should evaluate the result. Building an Amazon Alexa skill includes following standard steps:

- Step 1: Design a Voice User Interface(VUI)
- Step 2: Set up the skill in the developer console

- Step 3: Build interaction model
- Step 4: Write and test the code
- Step 5: Beta test
- Step 6: Certification

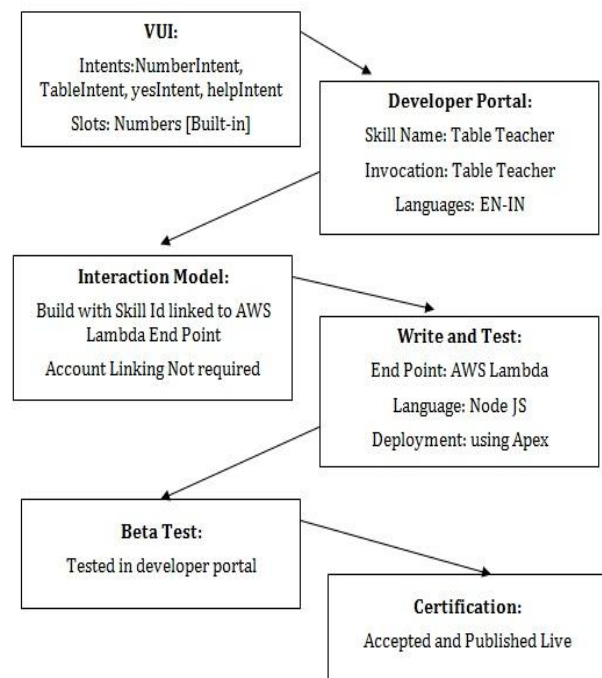


Fig- 2: Step by step design of Table teacher Alexa skill

Above figure shows the design flow of Table teacher skill. It is based on standard steps suggested in the developer portal. This skill will doesn't include any screen related entities. Hence Alexa Presentation Language (APL) is not considered. And also there is no emphasis on Cards as well.

This skill is developed for the Indian Locale with English as a language of communication. Hence suitable option should be chosen in the developer portal. Invocation name for the skill remains Table teacher as it fulfils the guidelines.

Voice User Interface (VUI) will be used to build interaction model. Generally it comprises of conversation entities such as intents, slots and utterances. Slots are just like variables which can hold specific value. For example in the skill proposed, a slot named numberSlot is used. It is a built-in slot and can hold numbers. Depending on the need skill builders can create their own slots.

Intents will trigger the appropriate functions in the backend. “What is the user's intension?” is the primary concern and it has to be distinguished accordingly. For example, in the proposed skill numberSlot is used twice in the skill. One, to ask the user which multiplication table Alexa should ask and the second, to get the answer for the current question (Example: “Twelve four jha?”). VUI should successfully identify these contexts and give information to the backend.

Even though intension is same, the sentence formation can vary from user to user. This group of common ways in which users can refer to

intent is called utterance. Intent should be provided with enough utterances so that Alexa can recognize them clearly. In the proposed skill, when the question is asked about which multiplication table to start, users can give following answers:

- “Five”
- “I will go with Five”
- “Go with Five”
- “Hmm...Five”
- “How about Five”
- “It is Five”

All these answers should map to a same intent since user wants the table of five. Easy way to design VUI would be to write down the best case conversation first and gradually include all the scenarios. It will help the builder to understand the intents and utterances in a better way.

In order to deploy the dialog model, Alexa skill should be linked with suitable end points unless it is self hosted. There are two options, one is to link with secure http endpoint or second one is use AWS Lambda. Proposed skill uses the second method. Skill id is linked with AWS Lambda function and vice versa.

Backend code must be able to handle all the intents and give appropriate responses. These will be spoken by Alexa as voice response. Proposed skill uses Node.js as programming language for the backend. Each response has to be carefully tested to handle all the possible inputs.

Finally, the skill has to be certified [10] before going live for the public. It must fulfil guidelines set and must pass preset test cases. Once the certification is obtained, it will be published in the Alexa store within few days. Before certification if required, there is option for beta testing too. Proposed skill doesn't use this option.

IV. IMPLEMENTATION

4.1 AWS Lambda environment setup

AWS provides server less service called Lambda [11] for backend code execution of voice bots [12]. Developer has to create function in Lambda along with the necessary code setup. Whenever these functions are triggered a new instance is created and execution will be started. Once the function terminates, instance is dissolved.

When user invokes a particular skill, a function linked with AWS Lambda end point has to be triggered. So each skill in the developer portal will have either Lambda or custom address as end points. By using Lambda, developers need not to worry about security certificates. After creating a function in the Lambda an address called Amazon Resource Name (ARN) will be generated. This address must be carefully pasted in the skill frontend. First end point will be default region and additionally skill builder can many more regions.

Also, in the backend Lambda configuration must be added with Alexa as a trigger. In order to identify the skill which triggered the Lambda function an id called Skill Id is used. Skill Id is unique for every Alexa skill. This skill-id is

linked with Lambda function. It will help to prevent the misuse of the resources.

Now, this function is ready to accept the request from the linked skill from any of the Alexa enabled devices in the world and gives back the response. Any number of devices can invoke the same skill at any given time. The response must be converted into voice by the device itself.

4.2 AWS Lambda function deployment

AWS Lambda supports various ways of code development mechanism. One is to code in the provided editor supported by web browser. It can be done for simple applications. As code gets complicated, this methodology is less suited.

Next option is uploading the zip file which contains all the libraries and codes. This will work fine but skill builder has to zip the file every time the change is made.

Good option would be allow the local computer to update the Lambda function. In order to allow third party to modify the Lambda resources permission should be granted. In AWS environment this kind of permissions are granted by using Identity and Access Management (IAM). IAM will enable the builder to manage access to AWS services resources in a secured way.

IAM will create roles through which resources can be user. These permissions can be stored in the form of keys. First, keys needs to be downloaded in the local computer and generally these are stored in environment variables. Whenever updated code is to be uploaded, it must be provided with IAM role keys.

This process can be done is various ways and the proposed skill uses a tool called Apex. Apex will upload the code on behalf of the skill builder in the AWS Lambda function. Also, basic framework for an AWS Lambda function is generated when project is initialized.

Also, command line interface for entire skill development is available in the form of Alexa Skills Kit Command Line Interface (ASK-CLI). It is more sophisticated way of skill building and builder can change front and backend in the same tool.

Newly introduced option is to build Alexa hosted skills. In this, builder is given with AWS resources in the developer portal itself. Hence AWS login is not required in this approach. Also, backend code editor is available in the next tab of the front end development portal. This is a new feature and proposed skill was already published before this was made publicly available.

4.3 Alexa SDK

Currently Alexa skills in the Lambda can be written in Node.js, Java, Python, C# and Go. Proposed skill uses Node.js language with version 6.0 and higher. A library package called “ask-sdk” should be imported to make use of all the resources. A new folder called “node-modules” will be created in project file. And Apex tool take care dependencies.

Services supported by this SDK includes Amazon pay, audio player display – body templates for devices with a screen gadgets game engine – echo buttons directive service (progressive response)

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messaging monetization video device address lists request for customer contact information obtain customer settings information account linking entity resolution dialog management location services reminders. Currently it is available in the git-hub with version 2.0.

4.4 VUI to Code

After completing the VUI design process, intents used in the skills are clearly identified. These intents must be handled properly in the backend.

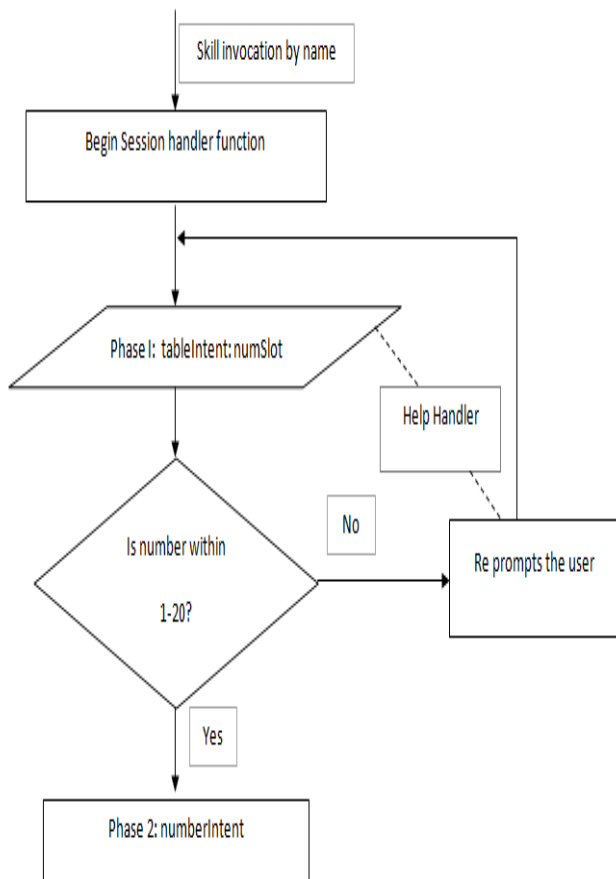


Fig -3: Setup phase of the skill

Primarily the skill has to be operated in two phases.

- Setup phase
- Game phase

Once the user invokes the skill with the name (“Alexa open table teacher”) lambda function in the backend is triggered. Invocation is handled by launch request function. In the proposed skill it will greet the user and will explain about the skill in brief.

After the response for the skill invocation, user is expected to tell the multiplication table choice. Since the response is expecting an input in return, a field in response object called “should end session” must be set to false. Input given by the user at this step will be mapped with tableIntent. If the user’s response is not a number then numSlot will be set to null. tableIntent will be handled by a function which will dig numSlot from the request object.

Generally slots are embedded in the intent field of the request object. After reading value validity must be checked. If the value field is null or out of range (one to twenty) then user must be prompted again. If user wants help at any stage, simple phrases like “Alexa, help” and “Alexa, help me” will trigger helpIntent related function. Game instructions along with example are given as help response in the proposed skill. After getting the correct value, table value is set and game phase will be started.

read the value of table_value

outer loop:

Initialize table_index to 1

while table_index is less than or equal to ten

*Ask for table_index *table_value #initial value*

if stop_intent #check for end of conversation

set stop_flag

break_loop

end if

if help_intent

prompt help_message

end if

read the answer #Expecting answer

if timeout event triggered

reprompt with reprompt_message

end if

if answer is invalid #wrong data

prompt with validity_message

end if

*if answer is not equal to table_index*table_value*

prompt with wrong_answer_message

else

increase table_index

end of while

if stop_flag not set #All inputs are valid

increase table_value

goto outer loop again

else

respond with good_bye_message

end if

end game phase

Table -1: Algorithm for game phase

In the game phase table index is kept in the loop from 1 to 10. On correct answer this index is incremented. If answer is wrong, then suitable message is prompted and cycle is repeated. Once the index value passes 10, table value will be incremented.

In the above process, if user wants to quit in between then input will be in the form “Alexa, stop” or “Alexa quit”. In these cases, stopIntent handler will be triggered and skill ends with exit message. It is important to keep in mind that user can ask for help at any time. The skill must be able to provide instructions and restart the cycle from appropriate point.

Additional Speech Synthesis Markup Language (SSML) can be included in the response to enhance the effect of communication. Various speechcons can be used to engage the user. Proposed skill is intended to use them in the future enhancement.

V. RESULTS AND DISCUSSIONS

5.1 Skill publication:

Publishing a skill in the Alexa skill store has to pass through following requirements:

- Making sure that the skill fulfills the Alexa policy guidelines. These will ensure that the skill is suitable for all customers. Being aware of these guidelines protects Alexa user’s privacy and also welfare
- Making sure that the skill meets the security requirements for the method of hosting the service for the skill. Fulfilling security requirements is must for an Alexa skill as it deals with customer data
- Performing all required functional tests: The instructions given in the description must reflex in the functionality of the skill. Hence various testing has to be carried out
- Performing UI and VI test: User Interface test is required for cards and Voice Interface test is required to get customer satisfaction.
- Screen test: If the Alexa skill is using screen, for example playing a short video then it has to test. For this purpose APL can be used.
- Reminders and List: If the Skills demand the usage of list or if it uses reminders, their usage must be properly tested. If not, it may wake up the user midnight.

Above mentioned points were considered for the development of the skill and was sent to the certification. During initial submission there was a problem with empty re prompt on few intent handlers. Those were rectified and sent again for the certification. The certification was successful and the skill is live on the Alexa skill store.

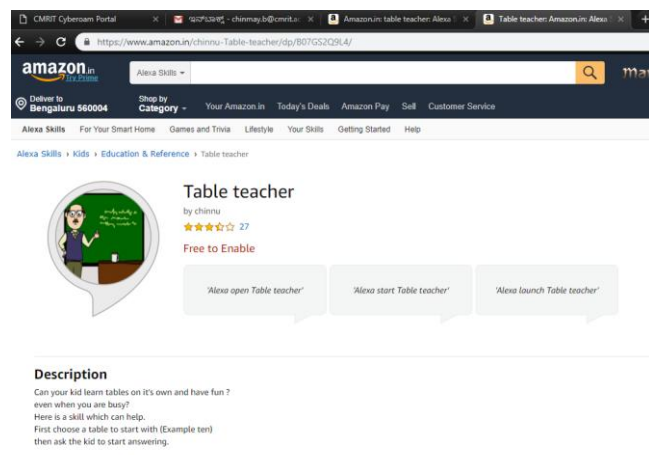


Fig -4: Skill available in the Alexa skill store India

The skill can be browsed through following link:
<https://www.amazon.in/chinnu-Table-teacher/dp/B07GS2Q9L4/>

5.2 Skill Analytics:

Analytics about the skill can be found in the Amazon developer portal. In the Alexa skills section, skill builder can see the status of the skill along with the analytics.

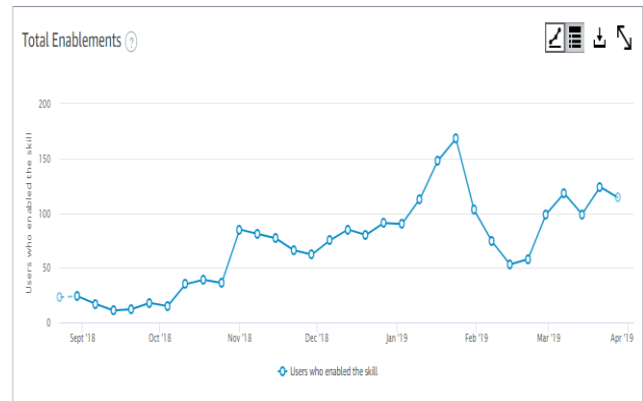


Chart -1: Skill activation done

The proposed skill was published in August month in the Amazon Alexa skill store India and got attention gradually. Maximum number of skill activation was done in January last week. The skill also got qualified for the developer promotion starting from the month of February.

Session analysis will describe the flow of communication within the skill. As shown in the above chart, the number of successful sessions was higher than expired sessions in the beginning. However as the number of customers increased suddenly, the skill usage by adults might also be increased. Whenever the user takes more than predefined response time the skill will terminate. As the skill is intended to be used by the kids, it should not be a major concern.



Chart -2: Session analysis

Intents invoked will give insight on the data flow within the skill. As shown in Chart 3, majority of the share for the intents is number Intent. It is because of the fact that the response from the user will mostly be a number. However the fallback intent invoked is also high. This has been observed up to 25%.

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AMAZON.Fallback intent will be invoked when the response does not match any of the defined utterances. It acts like default intent for the miss match. The reasons with respect to the proposed skill can be problems with the pronunciation of the English numbers such as four ('r' should be spelled out explicitly for Indian version). Help Intent is expected to be 5% but since the skill is not that complex, it may not be invoked that much.

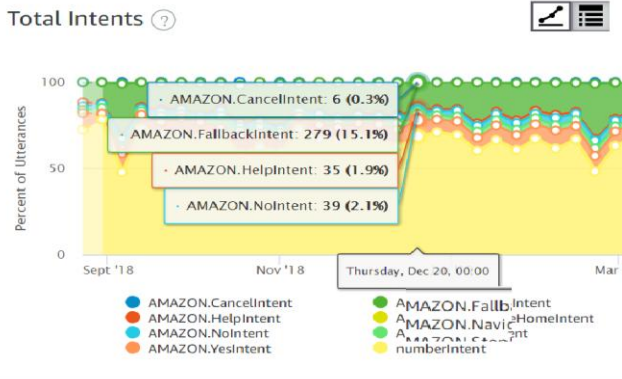


Chart -3: Intents analysis

Yes intent and No intent are one of the default intents supported in the Alexa skill development environment. In the intent analysis of the skill, AMAZON.NoIntent was observed within 5% and this shows that the kid is getting engaged with the skill. Hence the learning process can be treated as effective and further analysis can be done at the classroom level to evaluate the knowledge of the mathematical tables.

Skill retention ratio explains the number of customers who are continuously engaged with the system. Generally the first column values will be high as it is all about the customers who have activated the skill and explore the entire skill about a week. When data for the next individual weeks is considered, retention ratio varies from 15% to 45%. Also, it is important to notice that many columns are showing 0%. The cause can be, the skill being activated by the adult and they are not so curious about mathematics



Chart -4: Skill retention ratio

Customer retention is of the major challenge that has to be addressed. Customer retention can be improved by giving responses that may surprise the customer. However, the proposed skill not a typical quiz skill which updates at the

backend every day and it is limited for the mathematical aspect and its correctness.

VI. CONCLUSIONS

The proposed skill is designed to help kids to learn mathematical tables by using Amazon Alexa enabled devices. The interaction is designed in a such way that the kid can feel the real teacher and hence saving time for the parents. The skill has already been published in the Amazon India skill store and being used by significant number of customers. Advantage with the approach proposed is its ability to interact with the kid like a real teacher and no screen is required. However the skill can be further improved on handling the input and giving hints on repeated mistakes by the kid. Also, the skill responses may look monotonous and hence SSML can be used to include the element of surprise.

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