

Developing an Intelligent Chat-bot Tool to assist high school students for learning general knowledge subjects

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ABSTRACT

UPDATED—11 December 2017. Artificial Intelligent Chat-bots are used in industries such as Banking systems, Customer services, Education. There are many intelligent tutoring systems currently in practice, but few of them are known to assist high school students for learning their general knowledge subjects. This project paper proposes an artificial intelligent chat-bot tool developed to assist high school students for learning their general knowledge subjects. The proposed intelligent chat-bot tool is a web based intelligent tutoring system which can be accessed by large number of students globally, the users are not required to pay licensing fees. The intelligent chat-bot tool will be available 24 hours a day at schools or public libraries or any other location which has internet access. The intelligent chat-bot tool will make use of Natural Language Processing techniques to answer the queries by high school students. The intelligent chat-bot tool will be trained on a knowledge base comprising of general knowledge questions and answers. The intelligent chat-bot tool will have ability to participate in small talks with its learners.

KEYWORDS

Chat-bot tool; artificial intelligent chat-bot; general knowledge; Natural Language Processing.

INTRODUCTION

Artificial Intelligent Chat-bots are used in different scenarios such as Banking systems, Customer services and Education nowadays. Education is an area in which chat-bots have and can make significant positive impact to learning [1]. Educational technology such as conversational intelligent tutoring systems are successful with high school students [2]. In order to retrieve information, user approaches Google, Yahoo or other information retrieving systems, but they retrieve documents or links which are not relevant or appropriate answer to their questions. With the need to address such problems, the idea of natural language dialog system arises in which a user questions in natural language and the system reverts back with concise and appropriate answer to the user's question [7]. The traditional search engines (Question Answering System) and intelligent chat-bot system are compared to derive the results on learning outcomes and memory retention of students. The results indicate that student's learning outcomes and memory

retention are significantly impacted while learning through intelligent chat-bots [4].

An analysis of a research is conducted that compared the learning outcome of students in an Intelligent Tutoring System environment and non-Intelligent Tutoring system environment. The analysis suggests that Intelligent Tutoring system has a significant positive impact on student's learning outcome at different levels of education and different subjects evaluated. But, the analysis also suggested that there is no significant variation of the learning outcome performed through intelligent tutoring system and individualized human tutoring [5]. The ultimate objective of schooling is not just to gain factual knowledge. The retention of knowledge is also as important as gaining knowledge. If the students do not remember the core idea, facts or concepts then it may be impossible for them to solve the problems related to their subject domains [6]. A research was performed on middle school students learning foreign language course through a retrieval practice software. The research reveals that personalized reviews significantly boosted the course retention in comparison to current educational practice [3]. Superior language acquisition can be effective because conversational agents can engage users more actively in learning process and encourage the learner's reflection and self-explanation, which is very constructive towards the integration in existing knowledge [8]. Human memory is not perfect and so it requires a periodic review to preserve the knowledge and skills. In almost every education level, students are challenged by the increasing amount of study materials and also to master new knowledge and skills [3]. Conversational agents have an effect on motivation which in turn can facilitate learning. Conversational Agents create a personal effect through creating an illusion of life, it makes learners believe that it is along with them through the phase of learning. This can motivate the learners to interact more frequently with conversational agents. This association may significantly increase the positivity of learner's perception towards their learning experiences [10]. Humans talk with conversational agents as if it were a human and as a result humans may feel easier to converse with them. Thus, conversational agents can help in improving human computer interaction. The presence of conversational agents has positive effect on retaining memory information [11]. There has been data from a research on chat-bot (it involves teaching basic CS concepts to high school students), which shows that there can be improvement in the high school

student engagement with the help of chat-bot system. It is claimed that in a classroom environment, chat-bot system is very efficient for improving student's retention and engagement [12]. In learning environment, conversational chat agents are considered to have the ability to increase learner's interest, memory retention and knowledge transmission [13].

NATURAL LANGUAGE PROCESSING (NLP)

Natural Language Processing (NLP) is the area of research and application that investigates and analyze how the computational techniques can be used to perceive and alter the user's human language text or speech inputs. Natural Language Processing (NLP) techniques can be used in various applications such as machine translations, natural language processing, multilingual and cross-language information retrieval (CLIR), speech recognition and Artificial Intelligent systems [20].

CHAT-BOT TECHNOLOGY

Chat-bots have the ability to mimic human conversation and can offer personalized services. There are two types of chat-bot application : First type of chat-bot is web-based chat-bot which runs on the cloud and it can be accessed through web interface. Second type of chat-bot is a standalone chat-bot application which can be accessed on a single computer [14]. The chat-bot application is requested with natural language input text, and the chat-bot application replies with the best intelligent response to the user's input text. The conversation is continued by repeating this process [15].

CHAT-BOT COMPONENTS

Chat-bot software package consists of three important components : Responder, Classifier and Graph-master. The interface between the main routine and the user is the Responder. The Responder transfers the data from the user to the Classifier. The Responder controls the input and the output. The function of the Classifier is to normalize and filter the input data. The user input is substituted and split into logical components by the Classifier. The Classifier transfers the normalized sentence into the Graph-master component of chat-bot. The classifier processes the output from the Graph-master component of chat-bot. The classifier also handles the instructions of the database syntax (e.g. AIML). Graph-master component of chat-bot takes care of pattern-matching. Graph-master is responsible for organizing the storage of chat-bot's brain contents. Graph-master component stores the brain contents as graph. Graph-master also handles the pattern matching process and the pattern matching algorithms. The diagram of the chat-bot components is shown in figure 1 [16].

ARTIFICIAL INTELLIGENCE MARKUP LANGUAGE(AIML)

AIML stands for Artificial Intelligence Markup Language. The Alice-bot free software community and Dr. Richard S. Wallace developed AIML during 1995-2000. A.L.I.C.E.

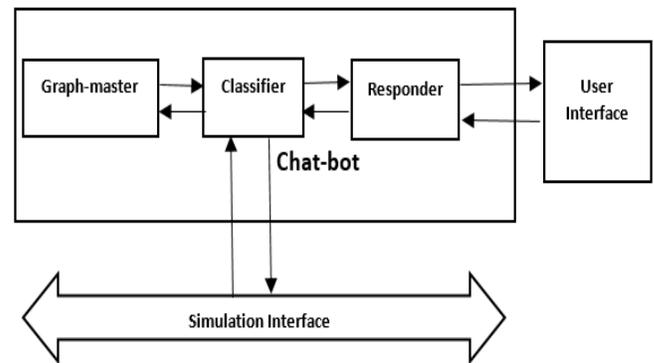


Figure 1. Chat-bot components [16].

(the Artificial Linguistic Internet Computer Entity) has the ability to characterize the type of AIML objects. These objects is comprised of two components namely topics and categories. Parsed or Unparsed data are contained in these categories [17]. AIML language simplify the task of Natural Language modelling, in respect to a "stimulus-response" process. AIML objects are language tags. An AIML object is associated with a language command. The basic components of an AIML are referred to as categories. Each category is a structural component of knowledge base contained in the chat-bot. A category comprises of : user input text, output response to the user input text and an elective context. The structure of AIML object is as follows[18] :

```
<command> List of parameters </command>
```

The structure of AIML category, pattern, and template object is as follows:

```
<category>
```

```
<pattern> User input text </pattern>
```

```
<template>
```

```
Output response to the user
```

```
</template>
```

```
</category> [18]
```

TEXT PROCESSING, RESPONSE AND ACTION

The user's text input is split into separate words for tagging the parts-of-speech labels with respect to their positions and neighbors in the input text. In the next phase, with the help of different types of grammar the individually tagged words are chunked to develop phrases. In the chunking operation phase, the important keywords are taken out from the phrases by removing the unwanted words. The keywords are checked and corrected if they are incorrect. The different phases of text processing stage are depicted in figure 2 [19].

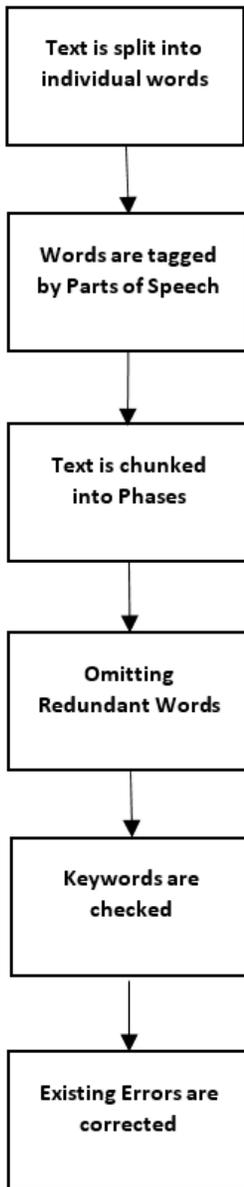


Figure 2. Different phases of text processing.

TEXT PROCESSING

Chat-bot can be designed to give the expected response to a human language text conversation. The Chat-bot engine is provided with keywords retrieved from the natural language text processing. The output is the response, which will be shown to the user. The diagram depicting the response and action taking phase is shown in figure 3 [19].

HUMAN COMPUTER CONVERSATION

A human and a computer can perform human computer conversation either by typing text or speech dialogue using the voice. A diagram depicting the important stages of

analysis and processing in order to perform human computer conversation is shown in figure 4.

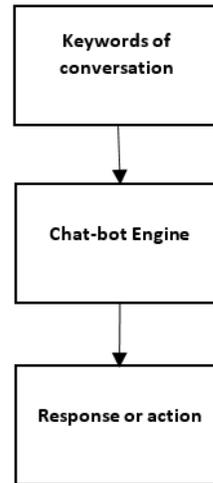


Figure 3. Different phases of response and action.

The factors which affect human computer interaction quality in chat-bot conversational systems are :

(a) the procedures used to analyze the text using different grammar sets in order to develop the keywords, (b) the pattern matching techniques of the chat-bot engine (c) the kind of response with respect to the specific application [19].

CHAT-BOT PLATFORMS

Dialogflow.com (API.ai), Wit.ai, Luis.ai, and Pandorabots.com are some cloud based chat-bot platforms.

DIALOGFLOW.COM (API.AI)

Dialogflow.com is a platform for developing chat-bots based on natural language conversations. The important concepts like Intents and Contexts are used to model the behavior of a chat-bot. Intents are the mapping between what a user inputs and what response or action should be carried out by the bot. Contexts are used for distinguishing user inputs which might have different intent depending on previous user inputs. When a user inputs data in Dialogflow.com platform, it is first checked if it matches a pre-defined intent. Dialogflow.com has a feature named “*Default Fallback intent*” to handle the user inputs that do not match any pre-defined intent. The match cases of an intent can be limited by stating a list of contexts that should be working. The match cases of an intent can create and delete the contexts. This system of intents and contexts make provision to develop chat-bots that can have large and complex flows. The limitation of Dialogflow.com is : the chat-bot cannot be designed in a way that an intent can be matched only if a particular context is not present [21].

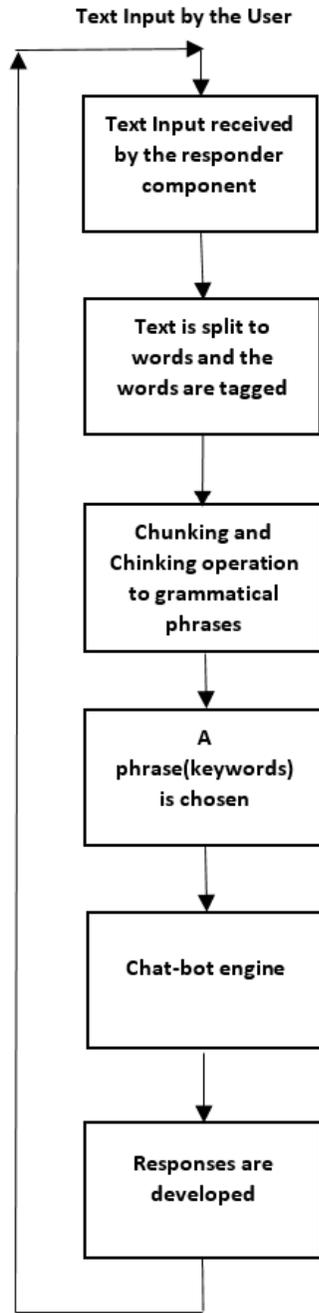


Figure 4. Human computer conversation steps.

WIT.AI

In Wit.ai platform, the important concept to model a chat-bot are stories. Each story is depicted as an example of a conversation. The "intent" is a user entity which is not mandatory. In order to model a complex chat-bot, wit.ai can group a large number of intent in stories. The NLP engine of Wit.ai is trained with examples. When a user writes a request

of similar nature, the entities are extracted and the logic implemented by the developer is applied [21].

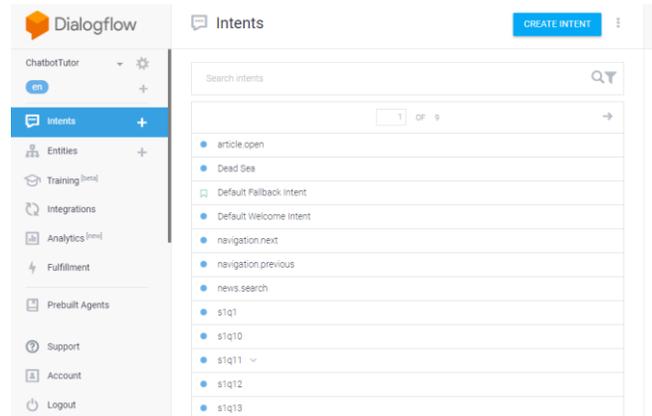


Figure 5. Dialogflow.com console

One-click integrations

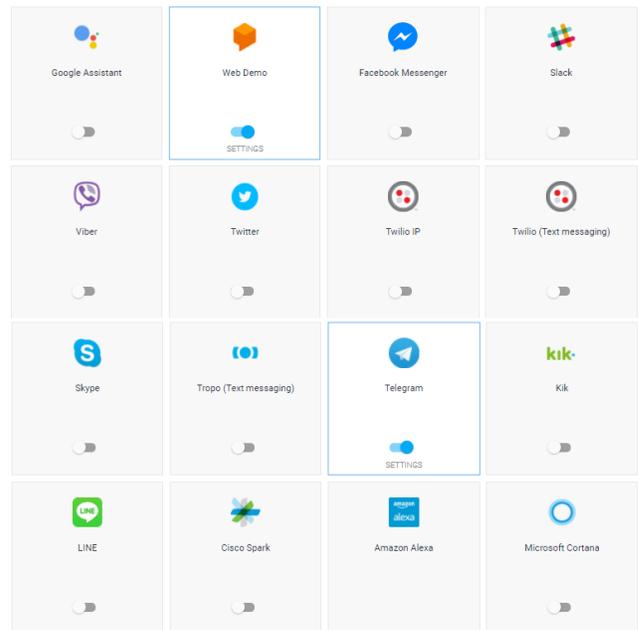


Figure 6. Dialogflow.com One-click integrations

LUIS.AI

Luis application allows the user to build their own model of chat-bot. Example phrases or utterances are supplied for the intents. In Luis application, the chat-bot developer can label the utterance examples with specific details. An intent depicts actions the user is expected to perform. The intent is a goal conveyed in a user's input. An utterance is user's input which is supposed to be understood by the chat-bot. An utterance may be in the form of sentence or speech. An intent may be mapped to many utterance variations. An entity represents relevant detailed information in the utterance [22].

Dialogflow SDK's

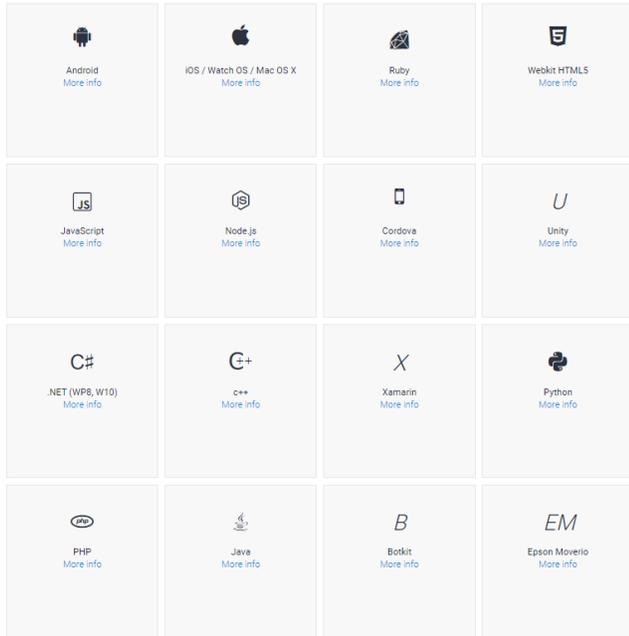


Figure 7. SDK's supported by Dialogflow.com

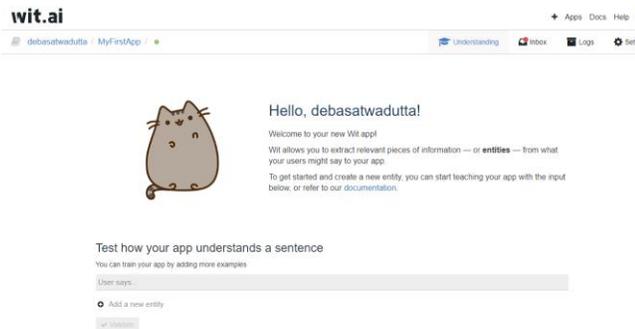


Figure 8. Wit.ai dashboard

PANDORABOTS

Pandorabots.com is a chat-bot development platform based on AIML (Artificial Intelligence Markup Language). The purpose of the platform is to enable human computer conversation without considering a task or action-oriented scenario. Pandorabots.com is an XML-based platform. It can take much effort to scale up if the conversational patterns are built manually [23].

KNOWLEDGE BASE

The knowledge base is derived from <https://www.indiabix.com/general-knowledge/world-geography/> . Traffic Statistics of www.indiabix.com from Alexa Traffic ranks (<https://www.alexa.com/siteinfo>) in figure 11. The subset of the knowledge base of the intelligent chat-bot is as follows :

Assigned Intent ID	Question	Answer
s1q1	The Homolographic projection has the correct representation of ____	Area
s1q2	The latitudinal differences in pressure delineate a number of major pressure zones, which correspond with _____	zones of climate
s1q3	The higher the wind speed and the longer the fetch or distance of open water across which the wind blows and waves travel, the ____ waves and the ____ energy they process.	larger, more
s1q4	The hazards of radiation belts include _____	deterioration of electronic circuits, damage of solar cells of spacecraft, adverse effect on living organisms
s1q5	The great Victoria Desert is located in _____	Australia
s1q6	The intersecting lines drawn on maps and globes are _____	geographic grids
s1q7	The light of distant stars is affected by _____	the earth's atmosphere and interstellar dust
s1q8	The landmass of which of the following continents is the least?	Australia
s1q9	Without ____ the equator would be much hotter than it is while the poles would be much cooler.	latitudinal redistribution of heat, cycle of air circulation, global wind pattern
s1q10	The habitats valuable for commercially	sea grass bed

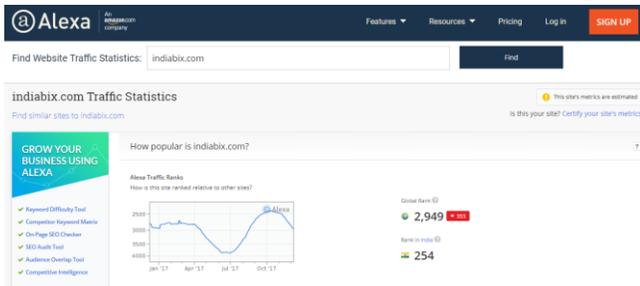


Figure 11. Alexa Traffic statistics of www.indiabix.com

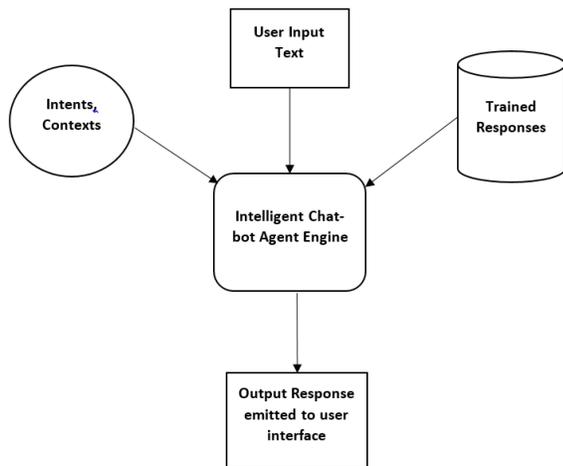


Figure 12. Architecture of proposed intelligent chat-bot

CHAT-BOT DEVELOPMENT TOOL EVALUATION

Chat-bot development tools are evaluated based on their Natural language processing capabilities and features available in the platforms. Chat-bots developed on the platforms: Dialogflow.com, Wit.ai, Luis.ai, Pandorabots.com are trained with the same knowledge base. Each chat-bot development platform is tested with the same user input texts. In the test scenarios, Intent ID : “None” refers to an intent, which has not been trained in the chat-bot Natural Language Processing platform. The test results of chat-bot development platforms Dialogflow.com (formerly api.ai), Wit.ai, Luis.ai and Pandorabots.com are as follows:

DIALOGFLOW.COM (API.AI) TEST RESULTS

Platform: Diaglogflow.com (formerly API.ai)			
Intent ID	Questions/sentences Asked	Reply (True if matched with intent ID)	Confidence scores returned (in percentage)

		False if not matched with intent ID)	percentage)
s1q1	The Homolographic projection has the correct representation of what	TRUE	85
s1q1	homolographic projection	TRUE	91
s1q1	what has the correct representation of area	TRUE	27
s1q2	major pressure zones corresponds with what	TRUE	86
s1q3	what is processed by higher wind speed and the longer fetch or distance of open water across which the wind blows?	TRUE	64
NONE	what is processed by lower wind speed and the shorter fetch or distance of open water across which the wind blows?	FALSE	57
s1q4	what is included in hazards of radiation belts?	TRUE	100
NONE	what is not included in hazards of radiation belts?	FALSE	87
s1q5	where is the great Victoria desert located?	TRUE	100
s1q6	what are the intersecting lines drawn on maps and globes?	TRUE	100
s1q7	what affects the light of distant stars?	TRUE	100

NONE	what does not affects the light of distant stars?	FALSE	87
s1q8	which continent has the least landmass?	TRUE	87
NONE	which continent has the largest landmass?	FALSE	61
s1q9	Without what the equator would be much hotter than it is while the poles would be much cooler	TRUE	100
s1q10	what do we call the habitats valuable for commercially harvested species?	TRUE	100

WIT.AI TEST RESULTS

Platform: Wit.ai			
Intent ID	Questions/sentences Asked	Reply (True if matched with intent ID False if not matched with intent ID)	Confidence scores returned (in percentage)
s1q1	The Homolographic projection has the correct representation of what	TRUE	99
s1q1	homolographic projection	TRUE	90
s1q1	what has the correct representation of area	TRUE	51
s1q2	major pressure zones corresponds with what	TRUE	99
s1q3	what is processed by higher wind speed and the longer fetch or	TRUE	97

	distance of open water across which the wind blows?		
NONE	what is processed by lower wind speed and the shorter fetch or distance of open water across which the wind blows?	FALSE	94
s1q4	what is included in hazards of radiation belts?	TRUE	98
NONE	what is not included in hazards of radiation belts?	FALSE	96
s1q5	where is the great Victoria desert located?	TRUE	99
s1q6	what are the intersecting lines drawn on maps and globes?	TRUE	99
s1q7	what affects the light of distant stars?	TRUE	98
NONE	what does not affects the light of distant stars?	FALSE	98
s1q8	which continent has the least landmass?	TRUE	86
NONE	which continent has the largest landmass?	FALSE	62
s1q9	Without what the equator would be much hotter than it is while the poles would be much cooler	TRUE	99
s1q10	what do we call the habitats valuable for commercially harvested species?	TRUE	99

LUIS.AI TEST RESULTS

Platform: luis.ai			
Intent ID	Questions/sentences Asked	Reply (True if matched with intent ID False if not matched with intent ID)	Confidence scores returned (in percentage)
s1q1	The Homolographic projection has the correct representation of what	TRUE	97
s1q1	homolographic projection	TRUE	97
s1q1	what has the correct representation of area	TRUE	6
s1q2	major pressure zones corresponds with what	TRUE	76
s1q3	what is processed by higher wind speed and the longer fetch or distance of open water across which the wind blows?	TRUE	99
NONE	what is processed by lower wind speed and the shorter fetch or distance of open water across which the wind blows?	FALSE	99
s1q4	what is included in hazards of radiation belts?	TRUE	99
NONE	what is not included in hazards of radiation belts?	FALSE	99

s1q5	where is the great Victoria desert located?	TRUE	99
s1q6	what are the intersecting lines drawn on maps and globes?	TRUE	99
s1q7	what affects the light of distant stars?	TRUE	99
NONE	what does not affect the light of distant stars?	FALSE	99
s1q8	which continent has the least landmass?	TRUE	98
NONE	which continent has the largest landmass?	FALSE	12
s1q9	Without what the equator would be much hotter than it is while the poles would be much cooler	TRUE	99
s1q10	what do we call the habitats valuable for commercially harvested species?	TRUE	99

PANDORABOTS TEST RESULTS

Platform: Pandorabots.com			
Intent ID	Questions/sentences Asked	Reply (True if matched with intent ID False if not matched with intent ID)	Confidence scores returned (in percentage)
s1q1	The Homolographic projection has the correct representation of what	FALSE	Not Available

s1q1	homolographic projection	FALSE	Not Available
s1q1	what has the correct representation of area	FALSE	Not Available
s1q2	major pressure zones corresponds with what	TRUE	Not Available
s1q3	what is processed by higher wind speed and the longer fetch or distance of open water across which the wind blows?	FALSE	Not Available
NONE	what is processed by lower wind speed and the shorter fetch or distance of open water across which the wind blows?	TRUE	Not Available
s1q4	what is included in hazards of radiation belts?	FALSE	Not Available
NONE	what is not included in hazards of radiation belts?	TRUE	Not Available
s1q5	where is the great Victoria desert located?	FALSE	Not Available
s1q6	what are the intersecting lines drawn on maps and globes?	TRUE	Not Available
s1q7	what affects the light of distant stars?	TRUE	Not Available
NONE	what does not affects the light of distant stars?	TRUE	Not Available
s1q8	which continent has the least landmass?	FALSE	Not Available
NONE	which continent has the largest landmass?	TRUE	Not Available
s1q9	Without what the equator would be much hotter than it is while the poles would be much cooler	TRUE	Not Available

s1q10	what do we call the habitats valuable for commercially harvested species?	FALSE	Not Available
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CHAT-BOT DEVELOPMENT TOOL TEST RESULTS

Natural Language Processing platforms namely Dialogflow.com (formerly Api.ai), Wit.ai, Luis.ai and Pandorabots.com are assessed on the basis of their Natural language understanding abilities and complex feature development ability. Among all of the four chat-bot development platform, Pandorabots.com has been able to match the least number of intents. So, pandorabots.com is the worst performer among all. Dialogflow.com (formerly Api.ai), Wit.ai and Luis.ai performed nearly same in terms of true positive cases of intent id matches. But, in case of false intent id matches, Wit.ai and Luis.ai maintained relatively higher confidence score in comparison to Dialogflow.com (formerly api.ai). In case of false intent id match the lower confidence score is desirable. Dialogflow.com (formerly api.ai) also have a feature to add follow-up intent. This feature is very important if we seek to develop sub-intents in context of a particular intent. So, Dialogflow.com (formerly Api.ai) is chosen to develop intelligent chat-bot to assist high school students for learning their general knowledge or social science subjects.

DIALOGFLOW (API.AI) RESPONSE

```

{
  "id": "0f07b174-81fc-42d2-af93-fc490481ba3b",
  "timestamp": "2017-10-20T16:39:43.663Z",
  "lang": "en",
  "result": {
    "source": "agent",
    "resolvedQuery": "The Homolographic projection has the correct representation of what",
    "action": "",
    "actionIncomplete": false,
    "parameters": {},
    "contexts": [],
    "metadata": {
      "intentId": "257f2e3c-7bc3-4cbc-a974-ba8287e64092",
      "webhookUsed": "false",
      "webhookForSlotFillingUsed": "false",
      "intentName": "s1q1"
    }
  },
  "fulfillment": {
    "speech": "The Homolographic projection has the correct representation of Area.",
    "messages": [
      {
        "type": 0,
        "id": "715cf2f0-c181-411a-a690-25059c233622",
        "speech": "The Homolographic projection has the correct representation of Area."
      }
    ]
  },
  "score": 0.8500000238418579
},
{
  "status": {
    "code": 200,
    "errorType": "success"
  },
  "sessionId": "e61a4a89-f1be-4eb1-b6e6-b200f65db454"
}
}

```

Figure 13. Dialogflow.com (API) response

NODE.JS

Node.js is an open-source, cross-stage platform built on Google Chrome V8 JavaScript runtime engine for developing fast, scalable, and lightweight web applications. The runtime condition translates JavaScript with use of Google's V8 JavaScript motor. Node.js is highly scalable because it is capable of handling a large number of simultaneous connections with high output [24].

BOTUI JAVASCRIPT FRAMEWORK

BotUI javascript framework is used to create conversational chat-bot User Interfaces [25].

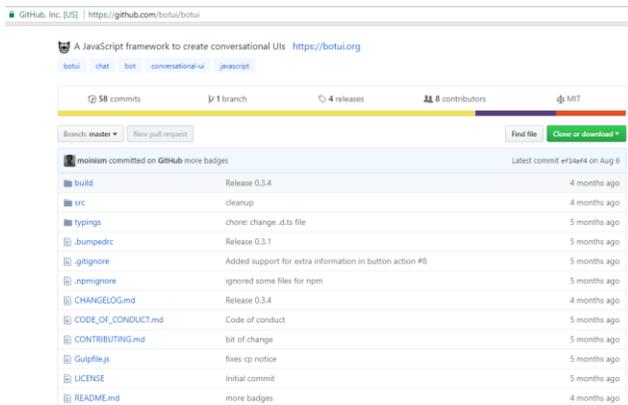


Figure 14. BotUI javascript framework github repository [25].

DIALOGFLOW (API.AI) HTML5 SDK

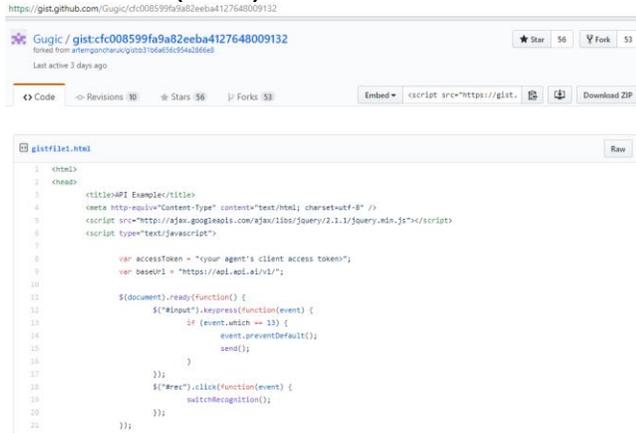


Figure 15. Dialogflow.com HTML5 SDK github repository [26].

EDUCATIONAL USE OF MOBILE DEVICES

A research study suggest that majority of the survey respondents are aware of educational use of mobile phone. The research study also uncovered a significant relationship between the students' level of awareness and their usage of mobile phone for education purpose. The research study also advocates for encouraging the use of mobile phone as a tool for learning among secondary school students [27]. Personalization is crucial for efficient learning outcome through mobile devices. Mobile learning outcomes are fruitful only when its use in the course is distinctive and logical. Mobile tools' instant communication abilities also present new communication opportunities that younger students have already adopted [28].

CHAT-BOT RESPONSE

The chat-bot is developed with Dialogflow.com (Api.ai), Node.js and BotUI javascript framework. The user inputs text : "which continent has the least landmass?". The intelligent chat-bot tool correctly matches the intent ID: s1q8.

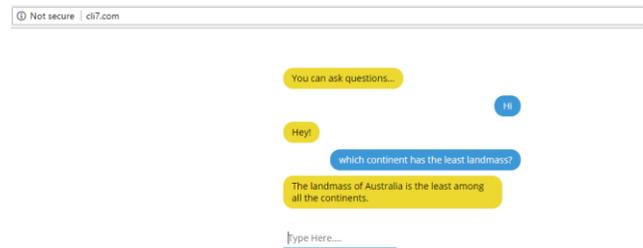


Figure 16. Developed chat-bot's response on Node.js server and BotUI javascript framework in web browser[29].

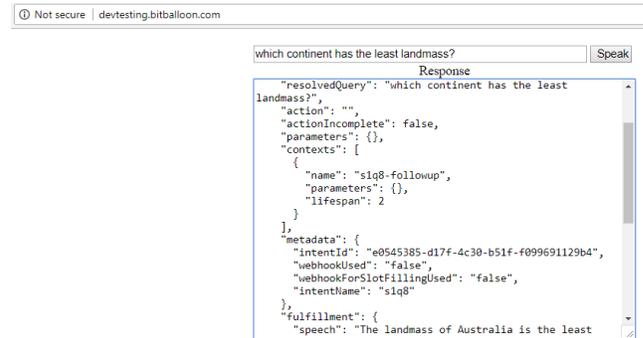


Figure 17. Developed chat-bot's response on Dialogflow.com's supported HTML5 SDK [30].

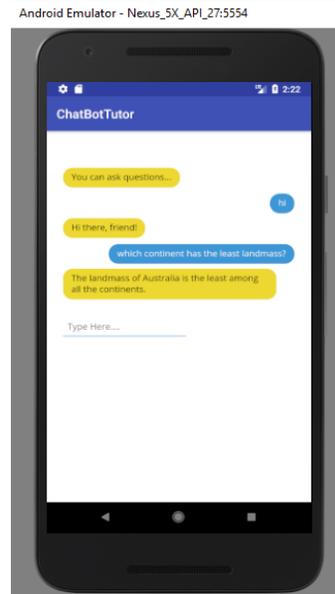


Figure 18. The intelligent chat-bot's response on Node.js server and BotUI javascript framework in Android application [9].

CHAT-BOT SUB-INTENT FEATURE

The sub-intent feature of the chat-bot can cater to further learning interest of the learner.

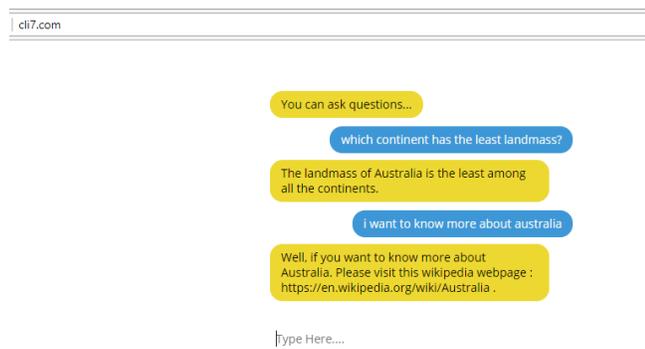


Figure 19. Chat-bot demonstrating the sub-intent feature.

CHAT-BOT SMALL TALK FEATURE

The small talk feature is implemented in the intelligent chat-bot. This feature can create a personal effect through creating an illusion of human-like nature, which can make learners believe that the intelligent chat-bot agent is along with them through the phase of learning. This feature can motivate the learners to interact more frequently with the chat-bot. This connection may significantly increase the learner's interest towards their learning experiences.

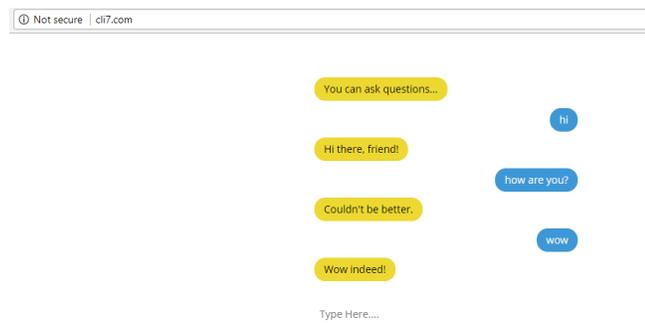


Figure 20. Engaging the chat-bot in a small talk

SUMMARY

In this paper, different chat-bot platforms are compared based on their Natural language processing capability and complex feature development ability. The chat-bot platforms compared are Dialogflow.com (Api.ai), Wit.ai, Luis.ai and

Pandorabots.com. Based on the evaluation results, Dialogflow.com (Api.ai) was selected to develop the chat-bot. The intelligent chat-bot is capable of handling sub-intent goals of the user's input texts. The intelligent chat-bot is also capable of engaging in small talks with the learners. The intelligent chat-bot is accessible through the web browsers and android application. Node.js runtime environment has been used to process the server side and client side requests. BotUI javascript framework is being used to develop the User Interface.

Further work is involved in developing the session models based on each user's login session and previous conversations, so that the chat-bot is able to provide personalized learning experience.

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