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A Novel Semi-Automated Chatbot Model: Providing Consistent Response of Students' Email in Higher Education based on Case-Based Reasoning and Latent Semantic Analysis

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Abstract **–**Learning is a process that requires interaction, asking and responding to the question is one of the most crucial interactions in learning. Students ask questions to instructors through online learning systems or emails outside the class. Providing a consistent, correct, detailed and personalised response to these questions is essential for developing their skills and abilities about the subject. Several automated chatbot models have been developed to answer students' questions consistently. However, these automated chatbot models lack the ability to comprehensively and reliably respond to students' questions. Thus, other forms of Chabot models are required to provide detailed and reliable responses along with consistent responses. This study aims to develop a semi-automated chatbot model to answer students' questions via email. This study also focuses on ensuring the consistency of answers. Therefore, a novel chatbot model is developed based on the semi-automated approach which supports new ways of answering students' questions via email. A feasibility study was carried out to investigate and demonstrate the efficiency of the proposed model. The Case-Based Reasoning (CBR) cycle is adopted in the answering process to ensure the consistency of the answer. Semantic analysis tool was used to measure the semantic textual similarity between questions/sentences. The feasibility study results confirm that the proposed semi-automated assessment approach is feasible for use in higher education. Also, these results highlighted that this model enables the instructor to provide a consistent and personalised answer to students while considerably reducing the instructor's workload.

Keywords –Chabot, Case-Based Reasoning, Latent Semantic Analysis, Consistent Response, Higher Education.

I. INTRODUCTION

Question asking is fairly important in the sense of students learning. Students ask questions about the subject to the instructor via the online system or by sending e-mail except in the classroom. Instructors may help students in terms of discovering the right answer for these questions. In this sense, students desire to get detailed, timely and consistent answers to their questions. However, instructors usually provide inconsistent and superficial answers because they do not have enough time to answer the questions [1]. Thus, students may not improve their abilities about related subjects at the desired level. However, many chatbot models have been developed to answer students' questions with the developing technology. The developed models provide instant answers automatically to students' questions and so instructors save time. Also, instructors do not see the answers provided automatically by chatbots, which is a reason to opt for them. One of the significant advantages of the chatbot systems is that it provides consistent answers for similar questions. However, the answers are often superficial and not satisfactory to students [2].These superficial answers may reduce the quality of education and keep students who are insufficient in quality at high risk of not graduating [3]. Next section provides information about some of the current chatbot models developing to answer students' questions.

In the literature, many chatbot systems have been developed for the use in education levels. The mutual purpose of these systems is to establish a logical dialogue with the user (student) and fulfil the student's request. A chatbot that automatically answers the questions about the C programming language course has been developed [4]. This system also allows students to discuss the accuracy of the answers given by the system. In another study, a chatbot system named Oscar was developed to be used in the department of Computer Engineering [5]. Oscar helps students by establishing a dialogue on the questions about program errors and code styles. It also advises students on programming learning methods. In another study, a chatbot system called AutoTutor has been proposed [6]. AutoTutor answers students' questions about computer and physical science. [7] developed a different chatbot system and used it in modules related to artificial intelligence. In another study, a chatbot system was developed for blind students [8]. This system has been developed for high school students who want to study computer engineering at the university. This system converts the voice questions asked by the student to text and provides instant answers to the student's question.

Although the current studies provide instant and consistent answers to students (which can be considered as an advantage), they may highly provide irrelevant and unsatisfactory answers that could prevent students' learning

effectively (which can be considered as a disadvantage). In this sense, the instructor should predict the question asked by students to answer the questions sufficiently and logically by the chatbot system. In other words, the chatbot system should be developed based on this prediction. However, the prediction of the asked question is very difficult because the classes have consisted of interested and/or uninterested students to the subjects [9]. Therefore, answering questions automatically can be considered as a disadvantage in the field of education [4]. For example, the instructor may not be able to predict the question asked by a student relevant to the subject. In this case, the student may get a superficial and unsatisfactory answer to the question by the system. Also, a student who is not related to the subject can ask an unrelated question using the chatbot system. In this case, the student is more likely to get a superficial and inadequate answer from the system. One of the common disadvantages of current studies is that when the chatbot system cannot answer the question, an answer is provided from the internet. However, these systems cannot benefit students at an enough level because websites, blogs etc. do not usually consist of scientifically proven information.

It can be inferred from the current chatbot models that the common purpose of these developed systems is to be able to respond instantly and consistently to students' questions[10]. These systems have been developed based on formative assessment [11]. More detailed information about assessment types is available in Section II. They automatically answer the questions of the students and chat with the students [12], [13]. However, although the answers given by the system are instant and consistent, they are generally superficial and do not contribute to the development of students sufficiently. Thus, the instructor should be included in the chatbot system to provide consistent, time-saving and detailed answers to the questions during the process of answering the student's question/email. To the best of our knowledge, currently, there is no semi-automated chatbot model proposed that enables instructors to provide consistent and detailed answers via email to students' questions and saves time for instructors. In this study, the semi-automated chatbot model means that the instructor should be included in the system to give detailed, satisfactory and consistent answers. Thus, the efficiency of the model is increased. Otherwise, the proposed chatbot model will be insufficient within the scope of formative assessment (please see Section II to get detailed information about formative assessment).

Consistent and detailed feedback has always been essential in the development of students [14]. In particular, superficial and inconsistent feedback negatively affected the development of students[15]. Novel part of the proposed semi-automated model is that the model enables to measure the similarity between the emails (questions asked by students) related to its subject and groups the mails with a high similarity rate (for example 90% and above). Then, the instructor replies to only one email from each group, and then the system replies to the other emails that are in the same group as the email that the instructor answered. In this way, the instructor gives a consistent and sufficient response to emails without wasting time. Also, it was aimed to contribute to the development of the students thanks to the satisfactory answers given to the questions. Thanks to this model, the student can ask questions to the instructor outside the lesson. The research questions of this research therefore are:

1. Can a semi-automated chatbot model be used to reduce instructors' workload?
2. Can a semi-automated chatbot model be feasible/used to respond to students' email consistently and personalised?
3. Can a semi-automated chatbot model be used to improve students' learning about subjects?

Section II introduces the proposed novel approach with the development of hypotheses examined in this study. Section III presents the results of the feasibility study of the proposed semi-automated approach and discusses the findings of this study. Section IV presents the conclusions and future directions.

II. PROPOSED SEMI-AUTOMATED CHATBOT MODEL

A. Assessment In Education

This section explains the importance of the assessment types before moving to explain the proposed semi-automated chatbot model. There are three types of assessment which are formative, diagnostic and summative. Formative assessment is carried out to improve students' abilities to the level of required standard through guidance [16][17]. Diagnostic

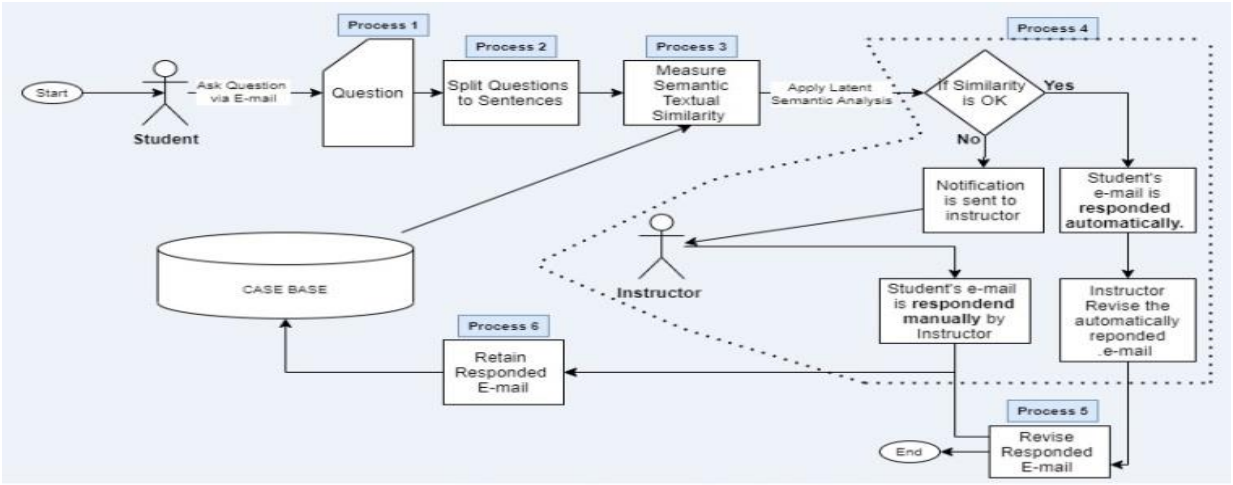

Figure 1 Semi-Automated Chatbot Model

assessment aims to obtain information about students' prior knowledge before a course of study starts [18], [19]. In summative assessment, students' knowledge and learning are measured at the end of the semester [20], [21]. This study aims to respond to students questions/email. In this context, the learning experience of students mostly depends on the response quality [22]. Formative assessment is proposed to provide targeted answers to students emails. Thus, the response should be useful for students. Otherwise, the response may not contribute to students improving their skills. Also, if the response is comprehensive and useful, students may improve their skills about the subject more efficiently [23]. It is noted that if students get a timely response to their email, they may further improve their skills on the subject. Hence, formative assessment is preferred in this study instead of summative and diagnostic assessment. In other words, the proposed semi-automated Chatbot model is developed based on the formative assessment.

B. Overview of the proposed Semi-Automated Chatbot Model

This research aims to provide consistent, detailed and individual answers to the questions asked by the students via email in a short time. In other words, repetitive (similar) questions asked should get the same answers. For this purpose, it is planned that the instructor will be used actively in the semi-automatic chatbot model. Figure 1 illustrates the framework of the proposed semi-automated chatbot model.

There are six key processes including question asking process, question splitting process, measuring Semantic Textual Similarity (STS) process, grouping process, revising process and retaining process. It is noted that these processes refer to the Case-Based Reasoning (CBR) cycle which is a kind of artificial intelligence technique. In this research, a case is composed of question and answer. More detailed information about the CBR cycle process is available after Figure 1.

- Process 1: Asking question: In this process, students send their question via email.
- Process 2: Splitting question. In this process, students' questions are split into sentences if their questions include more than one sentence. Also, more than one space in sentences are removed to increase the similarity between sentences.
- Process 3: Measuring Semantic Textual Similarity (RETRIEVE process in CBR): In this process, latent semantic analysis which is a kind of Natural Language Processing (NLP) technique is applied to measure similarity between sentences. The similarity between sentence (question) which was asked by student and sentences which were priorly answered and retained in the database.
- Process 4: Answering Process (REUSE process in CBR): In this process, the similarity measurement ratio between sentences is used to answer the question asked by the student. In this case, this question is answered by the instructor manually or by the proposed model automatically. Threshold value should be determined before the answering process. If the similarity measurement rate is bigger than or equal to the threshold value, the asked question is answered automatically by the model. In other words, the solution part of the retrieved case from the database is reused to answer the question asked by the student. It refers to null adaptation in the CBR. In contrast, the instructor provides answers to the student's question manually.
- Process 5: Revising Process (REVISE process in CBR): In this process, the question and the answer provided automatically in Process 4 create a new case. The case is revised by the instructor to confirm the correctness of the answer for the question.
- Process 6: Retaining Process (RETAIN process in CBR): The revised case is put into the case-base. Then, the case can be used to automatically answer new questions based on the similarity measurement rate. At the end, the student's question would have been consistently and detailed answered.

Rest of this section provides information about the most important parts of the proposed semi-automated which are measuring semantic textual similarity technique (latent semantic analysis), case generation and using processes.

C. Latent Semantic Analysis (LSA)

Latent Semantic Analysis is one of the fully automated mathematical/statistical techniques. In this technique, which is not a traditional natural language processing or artificial intelligence program, the relationships of the expected contextual use of words are inferred and inferences about them are made in passage [24]. This technique does not involve any human-created dictionaries, knowledge bases, semantic networks, grammars, syntactic parsers or morphologies, etc. Data entries are only raw text that is defined as unique character strings and is broken up into meaningful passages or examples such as sentences [25].

The first step in this method is to represent the text as a matrix with a unique word in each row and a text snippet of each column. The entries of the cell that contain the frequency of occurrence of the word in its line in the specified paragraph are pre-transformed [26]. LSA then applies singular value decomposition (SVD) to the matrix, which is a mathematical generalization in which a factor analysis is a special case [27]. SVD parses a rectangular matrix into the product of three other matrices, and then the component matrix defines the original row entities as vectors of derived orthogonal factor values. Another component matrix is multiplied by the three-component matrix to recreate the original matrix [28]. There is a mathematical proof that each matrix can be parsed correctly without using more factors than the smallest size of the original matrix. If factors are used less than the required number, the reconstructed matrix least-squares is the most fitted. Generally, the dimensionality of the solution can be reduced by simply deleting the coefficients in the diagonal matrix, starting from the smallest [29]. Practically, the number of dimensions that can be created for extremely large corpora is limited due to computational difficulty.

D. Case Generation and Using Process

Figure 2 shows the Case generation process. First, the instructor responds to the email/question, and then the question and answer generate a new CASE.

1. The question is sent to the instructor via email.
2. Instructor provides an answer (replies email) to this question.
3. CASE is generated. Example: CASE (question, answer)
4. Finally, CASE is generated and saved in the database (case-base).
5. The answer is automatically used by the system for similar (repetitive) questions/e-mails.

Figure 2. Case Production Process

The number of cases directly depends on the number of questions/emails. Generated cases can be used to answer new questions/emails. As mentioned in Section II, generated cases can be retrieved according to the Semantic Textual Similarity rate to respond to new emails automatically. This accelerates the answering process of the proposed model. Figure 3 shows the case usage process.

The_most similar_CASE (question, answer)
1. From the case-base, the_most_similar_CASE (question, answer) is retrieved.
2. **if** the question part of the retrieved most_similar_CASE and the newly asked question / email have sufficient Semantic Textual Similarity,
the answer is adapted to the new question so that the CASE retrieved from the case-base is used automatically.
else the instructors generate an answer (replies to the email) manually.

Figure 3. CASE usage process

The generated CASE can be used for many new asked questions/emails. The questions do not need to be the same. However, the number of the automatically responded emails depend on Semantic Textual Similarity rate. In this way, students receive consistent and detailed responses through the accelerated answering process.

III. FEASIBILITY STUDY OF THE PROPOSED SEMI-AUTOMATED CHATBOT MODEL

In this study, a feasibility study of the proposed semi-automated chatbot model was carried out manually. The feasibility study aims to highlight the benefit and importance of the proposed semi-automated chatbot model.

A. Data Collection

An assignment related to a data mining course was given to computer engineering students in the 2019-2020 spring semester. The assignment aims to achieve the best result by applying different data mining algorithms and methods on the data set. During this assignment time (2 weeks), the students asked many questions to the instructor by email. As a result of the observations made by the author/instructor, it was understood that the asked questions were high in terms of semantic similarity in the case of forming different groups. Thus, all questions asked by students to the instructor were recorded to justify the benefit of the proposed semi-automated chatbot model during the assignment time. Thirty-two students asked 141 questions via email to the instructor in total. Please see Section III-B to get more detailed information about the asked questions/emails.

B. Results and Discussion

1) Results about Semantic Textual Similarity (STL) Process

Semantic textual similarity was measured between emails/questions/sentences (141) using the Latent Semantic Analysis Tool which has been developed by University of Colorado Boulder (http://lsa.colorado.edu/). Figure 4 displays a screenshot of the Latent Semantic similarity result of two questions/emails. As it can be seen from this figure, a similarity matrix of the submitted text' is presented which is 19%. Document to document comparison type is applied in the Latent Semantic Analysis Tool.

One-to-Many Comparison Results

The submitted texts' similarity matrix (in **document to document** space):

Texts	Do I need to preprocess the data set?
How many regression models should I use?	0.19

Figure 4. Latent Semantic similarity result of two questions/e-mails

Different threshold values (70%, 80%, 90%) were tested to find the optimal threshold value. In this sense, the emails were grouped based on the semantic textual similarity measurement rates manually by the author of this paper. The grouped emails were satisfactorily similar when the used threshold value was90%. However, the grouped emails were not satisfactorily similar in the case of using the threshold value as 80% and 70% respectively. In other words, the questions are considered semantically similar if the threshold value is equal or more than 90%. Table 1 provides information about the number of groups, their populations and only one question from each group. Note that questions were converted from Turkish to English.

Table 1. Information about the number of group, group populations and a question from each group.

No	Population	Question / Emails
1	6	Hello teacher, will all the parameters in the data set be used?
2	7	How many regression models should I use?
3	1	Do I need to preprocess the data set?
4	6	How can I find articles related to the project?
5	4	What should I do to read articles easily?
6	4	Sir, how many pages should the article be?
7	17	What resources can I use other than the article?
8	10	Could you send sources/articles about the assignment?
9	5	Could you explain the differences between linear and logistic regression?
10	3	Could you explain AUC in more detail? I do not know how I should interpret it.
11	8	How should I fill the missing values in the data set?
12	5	You already explain how literature should be reviewed but could you explain it again, please?
13	4	Can I use any article format when I write my article?
14	9	Can I do this assignment in two or three groups?
15	8	Can I use ready-made tools such as Weka or Orange DB?

16	1	Can you extend the submission deadline for me because I was sick and I have a health report?
17	6	Could you explain the preprocessing techniques I have to apply to the dataset?
18	5	Could you explain how I should fit a random forest algorithm?
19	11	I did not understand the assignment. Could you provide more detailed information, please?
20	9	Could you extend the submission deadline?
21	7	Can I use a different data set for this assignment?
22	5	Is it possible to demonstrate how I can use Mendeley?

Note that more than one space between words and spelling errors are fixed before the semantic textual similarity measurement process to increase the similarity between emails. As it can be seen from Table 1, twelve groups have been created when the threshold value is 90%.

2) Results about Response Time to Emails

In the answering process (Process 2 in semi-automated chatbot model), the instructor's response time to emails is recorded. The instructor responded to each email in an average of 4 minutes and spent 564 (141 * 4 = 564) minutes in total. This situation can be considered as a serious waste of time for the instructor and may reduce the efficiency of him/her. However, it should be considered that if the proposed method is applied, the instructor will reply to only one email from each group. Then the instructor's response will be used through the proposed method to reply to the emails of other members of the group. In this way, the instructor will reply to 22 emails in total instead of answering 141 e-mails. In this case, the instructor will have answered 141 questions in 88 (22 * 4) minutes instead of 564 minutes (the total time savings of the tutor is approximately 84%). It means that the instructor's workload reduces (research question 1). Table 2 provides information about the comparison of the proposed model with the existing solution.

Table 2. Comparison of the proposed model with the existing solution

Solutions	Time
Existing Solution	564 min
Proposed Solution	88 min

Through the proposed approach, the instructor will be able to respond to similar emails consistently and personalised responses are provided for students. Also, since the instructor knows that the time savings are high, it can be more beneficial for students by spending more time replying to emails than usual and responding in more detail. Considering the students' perspective, knowing that the response given to the email is provided by the instructor rather than automatically by the system, will increase students' confidence in the system and affect their development positively (research question 3).

3) Findings and Implications

In fully-automated chatbot approaches, an instructor does not provide an answer for students' questions. However, the proposed semi-automated assessment chatbot approach enables responding students emails to instructors. In this sense, the instructor's experience plays an important role in terms of providing a quality answer. This research can contribute towards responding to email using the traditional way of answering technique through the proposed semi-automated computer-based model. Also, the instructor provides consistent and personalised answer while saving significant time (research question 2).

One of the implications of the feasibility study may be related to the non-use of question templates. They could be used by students while they were writing email/question in order to increase the similarity between questions. Thus, instructors could save time because of the reduced number of groups. Also, if question templates were used in the question asking process (Process 1 in Figure 1), string matching technique could be used rather than semantic textual similarity. The reason behind this is that students could select any question template in the emails writing process. The templates may include one or more than one empty space. Then, these spaces could be fulfilled with suitable keywords. In this sense, the instructor could prepare the keyword list related to the subjects discussed in lecture. Thus, the proposed semi-automated chatbot model could be more efficient for both students and instructors. Also, the templates may contribute students in terms of asking logical and sensible questions relating to the subject. The last implication for the proposed semi-automated chatbot model is that instructors may respond to students' email incorrectly. It means that all emails which are in the same group are responded incorrectly. However, the incorrect response by the instructor does not indicate that the system is useless. In this case, the instructor may be insufficient in terms of knowledge or the instructor may have given incomplete or incorrect responses due to the different reasons such as illness.

4) Limitations

A potential limitation is the small sample size is used in the feasibility study. Even if the proposed semi-automated assessment approach achieved promised results based on the feasibility study, the sample size could be increased as much as possible. Another limitation is that single sentences were used in the feasibility study. Thus, the used dataset could be improved with questions composed of more than one sentence. Ten Instructors' opinions about the proposed semi-automated chatbot approach were obtained through an interview presented in following Section. However, if students could get responses to their emails through the proposed semi-automated chatbot approach instead of the traditional way of email responding, their opinion about the proposed approach would be received based on a questionnaire.

5) Instructor's Comment about the proposed approach

The proposed approach was explained to ten researchers in detail to obtain their ideas about the approach. Initially, students' emails were displayed them before asking a question. The academic researchers were from the faculty of engineering (5 researchers), faculty of science (3 researchers) and faculty of literature (2 researchers). The following question was asked to each of them: Could you provide opinions about the proposed semi-automated chatbot approach? The rationale behind this question is to obtain the researchers' suggestions which can be used to improve the

responding way of each students' email and user interface of semi-automated chatbot tool in future. Their response to this question was similar and they generally made positive comments about the proposed approach. Also, they highlighted that the proposed approach is an innovative idea and the reusability of the instructor's response to semantically similar emails encourage researchers in terms of providing consistent response and time gain. However, they have some concerns related to this approach which is that a sufficient amount of semantically similar emails must be responded to and put into the case-base in terms of efficiently working on the proposed approach and this is so the process takes time. It can be inferred from the researchers' comments that they desire to both provide consistent response to students' emails and save time without leaving the traditional way of email responding.

IV. CONCLUSION AND FUTURE DIRECTION

The feasibility study of the proposed semi-automated approach in order to respond to students' questions via email were evaluated in this study. Students sent the email about an assignment of a data mining module to the instructor. Instructor responded to each email manually. On the other hand, a semantic textual similarity tool was used to measure the similarity between questions asked by students. Then, they were grouped based on 90% threshold value to highlight the efficiency and benefit of the proposed semi-automated assessment approach. The findings show that the instructor saves more time (84%) than manual/traditional way of answering through the proposed approach. In other words, the instructor is able to provide consistent and personalised answers using the proposed approach, since this approach was designed based on CBR cycle. Also, latent semantic analysis was used in the similarity measurement process between questions/emails. Additionally, ten researcher's ideas were obtained about the proposed assessment approach. They highlighted that this approach is an innovative idea.

A number of future directions related to this research are presented in the rest of this section. Different adaptation techniques could be used instead of null adaptation technique in terms of accelerating the automated answering/responding process. Even if the used null adaptation technique is remarkably reduced the answering/responding time, different adaptation techniques could be also applied in order to accelerate this process and so it can be considered as a future work. Finally, the feasibility study is carried out in this study manually. However, an answering/responding tool could be developed and adapted to respond to more emails about not only for the field of education but also the field of different areas such as health, tourism etc.

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