






# Question & Answering Interface to Improve the Students' Experience in an E-learning Course with a Virtual Tutor

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**Abstract.** E-learning courses offer, nowadays, opportunities for everyone to study wherever they are. However, asynchronous communication between students and teachers, and the lack of social engagement, leads frequently to a sense of abandonment and, in the limit, to withdrawal, as a consequence. To avoid this phenomenon, we developed an interface prototype with an anthropomorphic 3D virtual tutor in the Moodle's e-learning platform of Universidade Aberta (<https://portal.uab.pt/>). This virtual tutor helps students finding information in the page of the course, delivers speech, exhibits facial expressions and is able to answer questions about the course. This paper describes the approach used to implement this Q&A functionality. Having all the course information represented in an ontology, the idea is to transform the original question in a SPARQL query that, when executed on the defined ontology, returns the desired answer.

**Keywords:** Question & Answering · Virtual tutor · E-learning

## 1 Introduction

Nowadays, due to the widespread of internet communications, e-learning courses offer opportunities for everyone to study wherever they are. This may be especially relevant for adults longing for ameliorating their professional life. However, this educational approach introduces several challenges, such as, the asynchronous communication between students and teachers, and the lack of social engagement that is usual in the classical classroom teaching. Students' questions, even those that have a very urgent answer need, may not be instantaneously answered by the teacher or by their student peers. This may induce in the students a sense of abandonment, which increases significantly their effort to keep the motivation and leads frequently to withdrawal.

So, the existence of an online tutor 24 h/day, seems to be a valuable instrument to stimulate student's engagement and to work as an additional learning support tool. This is the main goal of our project, which involves an interface prototype with an

anthropomorphic 3D virtual tutor in the Moodle's e-learning platform of Universidade Aberta (Cláudio et al. 2018).

We explore in this contribution the possibility of allowing the user to ask the virtual tutor questions in natural language (Portuguese). This provides an easy way of finding information that might be "hidden" in the course webpage in the e-learning platform. We focus on questions regarding the course organization, but the methodology is adaptable to other topics. Having all the course information represented in an ontology, the idea is to transform the original question in a SPARQL query that, when executed on the defined ontology, returns the desired answer. A first version of this approach was already described in (Salgueiro et al. 2018). In this new version, two alternative evaluation methods are explored and compared.

## 2 State of the Art

The presence of virtual tutors in e-learning systems has positive effects in the learners' motivation and teaching effectiveness (Kokane et al. 2014). Several experiences have been made using virtual tutors in learning environments or support systems in the academic environment, ranging from 2D cartoon like virtual tutors (Maciel et al. 2014) to 3D realistic virtual humans (Currie et al. 2016; Kokane et al. 2014; Querrec et al. 2018) with diverse interaction and cognitive capabilities.

Kokane et al. (2014) developed an e-learning system (Learner Centered Design Approach of E-learning System) which integrates 3D virtual tutors to narrate to students summarized versions of the contents of the course. Together with the spoken narrative, the written text appears dynamically on the screen as the tutor speaks. Besides the help of the virtual tutors, the e-learning system provides the communication with human tutors through a real-time web-based video. Reports on the student activity and quiz results allow the human tutors to fine-tune the course contents. Maciel et al. (2014) also explored audio communication. They created a plug-in to the Moodle's e-learning platform within a HTML block that allows the automatic generation of audio and visemes for the virtual tutor. This solution enables the creation of the virtual tutor dialogues according to the current needs, for instance, message dissemination appropriate to the context. This work was later extended to enable notifications on mobile devices (Amaral et al. 2015). Silva et al. (2014) also worked with the Moodle platform, but they centered on the development of a multi-agent system to create an intelligent virtual tutor. Based on the analysis of the student's interaction with Moodle, their aim was to propose pedagogical interventions according to the needs and weaknesses of each student.

Providing intelligence to virtual assistants were also the focus of Currie et al. (2016). They developed a virtual assistant to guide students in university employability service through a text-to-speech interaction. A 3D virtual female answers students' questions in natural language communication in both text and speech. The Artificial Intelligence Markup Language (AIML) was used to interpret the rules for user interaction with the virtual assistant. Soliman and Guetl (2013) used as well AIML to implement a text-to-speech synthesis function for intelligent pedagogical agents. These virtual agents are inserted in a 3D virtual scenario where they can simulate experiments

and give tutorials. The student interacts through text messages and the virtual agent answers either in voice or text together with gestures to express emotional support.

Question and Answering systems have seen a great growth in interest from companies that have web sites and, consequently, have been subject to a great demand for the development of innovative solutions. These systems use artificial intelligence techniques to present the user a response that is as accurate as possible, based on the question received. Some even striving to be as realistic as possible and developing conversations with the user as if it were a real person, giving more realistic answers and not repeating answers to the same question.

Despite this great growth, many systems still use fairly basic question and answer techniques, where, having a set of basic questions and corresponding answers, when a question is introduced by the user the most similar question is chosen to obtain the desired answer. The answer chosen is sometimes edited in order to maintain a more realistic conversation with the user. These systems do not have a highly developed artificial intelligence component, and the only thing that is needed is an algorithm to compare strings stored in a database.

Automatic question answering systems exist in a much lower number than the systems mentioned above, but there are some that present very promising results, although using ontologies in a different way than the one proposed in this article. Those systems use ontologies in order to improve the user's question, adding synonyms and more information to the question that will be sent to the web, improving the results obtained. Jayalakshmi and Sheshasaayee (2017), Mervin (2014) e Kwok et al. (2001) present work that have some similarities among them, where all of them use ontologies to improve user questions and make web queries more accurate.

To the best of our knowledge, there is no system developed that uses a similar methodology to the one presented in this paper.

### **3 Virtual Tutor in Moodle's Platform**

Our prototype of the virtual tutor that was integrated in Moodle's platform of Universidade Aberta comprises two components: the interface for the student and the back-office for the teacher which provides a way to introduce information required to define the behavior of the virtual tutor in each specific course.

#### **3.1 Virtual Tutor Interface**

The virtual tutor interface for the student in a Moodle's course webpage contains an anthropomorphic representation, currently restricted to head and shoulders. The two 3D models of virtual tutors were produced by Didimo (<http://www.mydidimo.com/>) and are based on photographs of real people. The virtual tutor is implemented as a WebGL application inserted in the Moodle's course page within a HTML block. This application was developed using Unity3D and C# programming. The tutor is displayed inside a window that is superimposed over the Moodle's webpage of a curricular unit, it occupies a fixed position on the bottom right corner of the page, still allowing students to scroll up and down over this, as usual. The overall aspect of the interface in a

Moodle's page can be observed in Fig. 1. The tutor delivers speech (text, lips' movements, but no sound yet) and exhibits facial expressions.



**Fig. 1.** Virtual tutor's window in a Moodle's webpage.

Figure 2 displays the virtual tutor window. The text inside the balloon and the facial expression are coherent with the grades and assiduity of the student in the course, as explained ahead; the post-it lists the items in the webpage of the course with new information since the last login of the student and also remembers the utility of the six buttons at the bottom of the window, which provide information about the course. These buttons include a Q&A button and five buttons that provide direct access in the webpage to the plan of the curricular unit, and to the lists of: topics, forums, activities and e-folios (exercises that the student has to upload periodically and that are graded by the teacher). When one of these last buttons is pressed the interface uses colors to highlight the particular elements in these lists that are new since the last login of the student.



**Fig. 2.** Virtual tutor's window (in Portuguese)

According to the pedagogical model of the institution, shortly after the beginning of the semester, each student enrolled in a curricular unit has to choose among two evaluation modalities: continuous or final. The student in continuous modality is expected to solve and upload some e-folios periodically along the semester; these are

graded by the teacher and, if these grades are above a particular mark, the student gets the right to do the final written exam (called p-folio). The alternative final modality implies only one written exam at the end of the semester.

The students evaluated in a continuous modality are the ones that could benefit the most from the virtual tutor in Moodle's curricular units, because they are expected to login regularly on the page and potentially need frequent synchronous support. Therefore, these students were identified as our target audience.

To provide a good support for the student, the behavior of the virtual tutor, which is expressed by facial expression and speech, has to be coherent with his/her performance and attitude in the curricular unit. To measure this, we define the state of the student, a value that depends on the following three values: (i) the evaluation, based on the grades obtained in the e-folios, (ii) the frequency of logins, and (iii) the number of messages the student posts in the forums of the course. The weighted combination of these two last values define the attendance of the student, used as a measure of participation in the course.

The teacher responsible for the course defines, in a back-office interface, two thresholds for each one of these three values. For instance, considering the evaluation, the teacher defines the minimal threshold that separates negative grades from positive ones, and a maximal threshold that separates average grades from very good grades.

Similarly, for the frequency of logins and the number of messages in the forums of the course, the teacher defines, for each one, a pair of thresholds and a weight that expresses its contribute to measure the attendance of the student.

As mentioned, the behavior of the virtual tutor is aligned with the performance and attitude of the student in the course measured by his/her state, but always in an empathic and supportive or rewarding way, never recriminatory. When a potential problematic situation is detected (for instance, a student with very low grades along the semester), the virtual tutor will exhibit a neutral expression while recommending and promoting the communication with the teacher of the course. But, if the student has very good grades and a good attendance value, the virtual tutor will show a smile and congratulates the student.

The facial expression is complemented by the speech in the balloon that also depends on the state of the student and always includes a component relative to the grades and a component relative to the attendance of the student. For the sake of variability, there are several phrases that are randomly combined.

### 3.2 Q&A Approach

The goal of the Q&A component is to provide an answer to the questions introduced by the student when she/he presses the corresponding button in the interface. To attain this, two separate modules are involved (see Fig. 3), one that processes the question and creates a SPARQL query, and the other that executes this query on an ontology and presents the resulting answer.

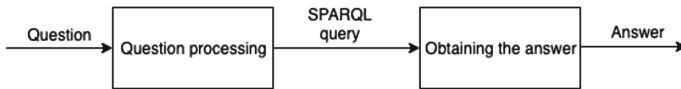


Fig. 3. Question Answering modules

The first step of the process is to find the sentence’s grammatical dependencies. For this we used the Dependency Parser provided by the NLX Group (Reis and Branco 2006). In the current version, the system is able to answer questions regarding the course organization. Some possible questions in Portuguese are:

- Qual o código da UC de Análise Formal de Redes Sociais? (*What is the code for the Formal Analysis of Social Networks course?*)
- Qual é o significado de p-fólio? (*What is the meaning of p-folio?*)

The processing of each question by the parser creates a structure that expresses the dependencies between the words in the sentence. This structure comprises the following information:

- Form – the token
- Raw – the word as it appears in the text
- Lemma – the motto as for example “dictionary form”
- Pos – part-of-speech
- Infl – bending information (gender, number, time, aspect, etc.)
- Ne – named entity information (person, organization, etc.)
- Deprel – grammatical dependency relation (using the NLX tagset)
- Parent – token index that is the “head” of this token
- Udeprel - grammatical dependency relation (using the SUD (Stanford Universal Dependencies) tagset)
- Uparent – token index that is the “head” of this token using the SUD tagset

Figure 4 shows the dependency information obtained for the first question above. From the information in the “parent” and “uparent” fields, that provide information about which token is the “head” of the presented sentence, it’s possible to visualize this structure as a dependency tree. Figure 5 represents the tree created by the previously sentence, using the NLX tagset. In this figure, we can observe a pattern that occurs in most of the tested questions. The first level corresponds to the verb of the sentence. The second level corresponds to the first word of the sentence and indicates the type of the question. In this case using the word “Qual” (*which*) we want a specific result to the question, but there are other cases that what is required is a value. For example, when the first word is “Quantos” (*How many*). This word is followed by the subject of the sentence which is one of the necessary expressions for the ontology query. Finally, the punctuation of the sentence appears, which in this case is a “?” because it is a question. The third level is an intermediate level that does not contain any information necessary to create the query.

In the fourth level we can observe that there is an important word for the query that is the object of the sentence, being present with a “deprel” of C or DO-ARG2 and being a child of the subject of the sentence. This object will be used in the query in conjunction with the other expression presented earlier.

form	raw	lemma	pos	infl	ne	deprel	parent	udprel	uparent	space
Qual	Qual	—	INT	gs	O	SJ-ARG1	2	DEP	4	R
é	é	SER	V	pi-3s	O	ROOT	0	COP	4	LR
o	o	—	DA	ms	O	SP	4	DET	4	LR
código	código	CÓDIGO	CN	ms	O	PRD-ARG2	2	ROOT	0	LR
de	da	—	PREP	—	I-ORG	OBL-ARG1	4	CASE	7	LR
a	—	—	DA	fs	—	I-ORG	7	DET	7	R
UC	UC	—	PNM	—	I-ORG	C	5	POBJ	4	LR
de	de	—	PREP	—	I-ORG	N	7	MWE	7	LR
Análise	Análise	—	PNM	—	I-ORG	N	7	MWE	7	LR
Formal	Formal	—	PNM	—	I-ORG	N	7	MWE	7	LR
de	de	—	PREP	—	I-ORG	N	7	MWE	7	LR
Redes	Redes	—	PNM	—	I-ORG	N	7	MWE	7	LR
Sociais	Sociais	—	PNM	—	I-ORG	N	7	MWE	7	L
?	?	—	PNT	—	O	PUNCT	2	PUNCT	4	

Fig. 4. Information about a sentence obtained from the NLX Dependency Parser

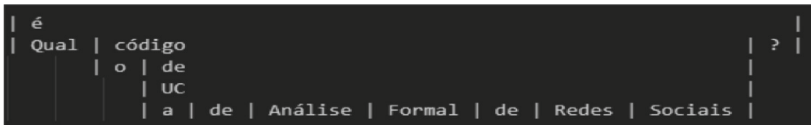


Fig. 5. Dependency tree created using the NLX tagset

Level five presents complementary information that can be used to improve information present in the ontology query. If any of the words present in this level have a “deprel” of N and is a child of the object, this indicates that it must be grouped with the predicate of the phrase because it is the continuation of this one. In the presented case the object would be “UC de Análise Formal de Redes Sociais”.

The query to be sent to the ontology would then consist of the expression “code” (the predicate) and the expression “UC de Análise Formal de Redes Sociais”.

There are some exceptions to note when there is no verb defined in the sentence, which changes the structure of the tree, passing the first word of the sentence that indicates the type of question, to the first level.

Other exceptions in which none of the cases mentioned above presents a valid result, is needed to make other comparisons using the “pos” column, where we can observe that the first expression necessary for the query is normally represented by “CN”, and in the “ne” column we can confirm that the second expression is usually within the group that has the value other than “O” (Fig. 4).

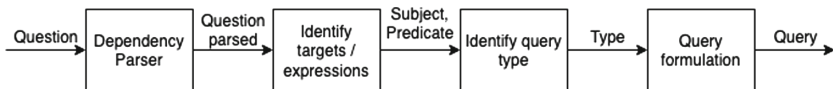


Fig. 6. Query creation process

## Query Creation

The ultimate goal of this process is to create a SPARQL query in order to get, from the ontology, the answer to the user's question (Fig. 6). The main challenge is to find the components of the RDF triple that constitutes the query.

To cover all the questions, it was necessary to create six different types of queries:

1. Basic query following a standard pattern.
2. Definition query
3. Values query
4. Dates of components
5. SPARQL query with month filter
6. SPARQL query for UCs with month filter

The first three are domain independent queries, while the last three are domain dependent. Each query type corresponds to a different way of finding the relevant components in the result of the dependency parser. For instance, the first type corresponds to the creation of a basic query using the first and second expressions. For the case of the question “Qual o código da UC de Análise Formal de Redes Sociais?”, mentioned earlier, the query would indicate which Individual (in this case “UC de Análise Formal de Redes Sociais”) and then what Data Property (“código” in this case) will correspond to the “subject” and “predicate” of the query, being the answer obtained as the possible values for the “object” part of the triple. Figure 7 shows the query built for this question.

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX tv: <https://tutoria-virtual.uab.pt/>
SELECT ?a
WHERE {
    tv:UC_de_Análise_Forma_de_Redes_Sociais tv:código ?a
}
```

**Fig. 7.** Basic query for the question “Qual o código da UC de Análise Formal de Redes Sociais?”

## Answering the question

The previously created query will be executed in an ontology, previously filled in, that contains all the information related to the course where the Virtual Tutor operates. When executing the query to the ontology it will return the result to the question asked by the user, if the query is correct, or a blank reply, otherwise.

With the response obtained it will be necessary to edit it in order to provide a response to the user that seems realistic. There are special cases that need to be edited, for example if the question indicates that the user wants a specific value instead of a list of the answers, it will be necessary to change the obtained values of the ontology so that the answer is a numerical value. Other special case that needs to be looked at is in case there are dates in the answer, where it will need to be formatted to an easier to read date format, since the format returned by the ontology is not commonly used.



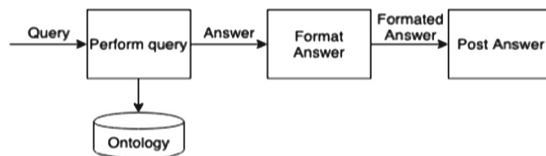


Fig. 8. Obtaining the answer

With these changes done it is finally necessary to make the responses more human, this is done using parts of the question asked by the user in order to construct a more complete answer (Fig. 8).

## 4 Evaluation and Discussion

In order to evaluate the methodology, a set of 1065 questions were processed. These questions were automatically created through a system which, using default questions and queries made to the ontology, creates questions similar to those a student may pose to the Q&A system. Additionally, some more specific questions were also entered manually.

Testing this method of obtaining expressions presented very good results. For the tests using the two tagsets, we can observe quite similar values between both methods, but concluding that the method using the NLX tagset was the one that presented the best results where in 48 of the sentences, the first expression was not obtained successfully and in the second expression it occurred 171 times. The value relative to the first expression occurs because the type of question to which it refers to, being a question of the type “O que significa ...” (“*What is the meaning of...*”) and “O que é ...” (“*What is...*”). Of the 171 wrong expressions referring to the second expression necessary to perform the query to the ontology, 150 of these are due to an error in the categorization by the NLX Dependency Parser, where the system does not classify some names of the “Unidades Curriculares” as an expression, but rather as independent words, creating cuts in the expression. The remaining 21 expressions occur in the same sentences as those related to the errors presented in the first expression.

## 5 Conclusion

We presented a novel approach to improve the students' experience in e-learning contexts. The use of a graphically enhanced virtual tutor, capable of expressing emotions and able to answer questions posed in a natural language is an upgrade regarding previous work in this area. In what respects the question answering component, the results that were obtained from the presented project are quite good and within our expectations, only being found some failures in the response to the user and in cases where the question presents orthographic errors.

In the case of a query with a misspelling, the program will present errors, because the values that will be introduced in the ontology query will be different from the one in

the ontology, thus causing the ontology results to be empty and the response returned to the user to be incorrect or empty. One way to solve this problem would be the use of dictionaries that allow you to store a set of keys and values, the keys being the words of a common dictionary and the values the definitions.

Regarding the failures presented in the user responses, they happen because it is necessary to find a better way of not giving a response to the user that seems automated, that is, the tutor responds in the same way to all the types of question not creating a conversation with the user.

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