Computer Networks Educational System: Annotation–Based Learning

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***Abstract*—One method that Internet users utilize to collaborate is annotating web content. Users can share knowledge, ideas, opinions, and skills in this way. Annotation systems can also be used for online learning. This paper proposes applying an annotation system to knowledge enhancement (network topic) by connecting the annotations to information resources and sharing the knowledge with others. Users can extract the most crucial terms from the selected online text using the annotation tool, which loads relevant YouTube videos and quizzes based on selected terms. In addition, users have the option to recommend terms to their friends as a way to spread information. The experimental test reflects promising knowledge-gaining, sharing, and dissemination results.**

Index Terms*—Annotation, Knowledge Acquisition, Knowledge Dissemination.

I. Introduction

Both learning and knowledge dissemination are considered complex processes because they involve several tools and methods used to improve understanding and skill development. Many tools are used in the field of education to support a variety of learning goals and styles. Online resources, interactive simulations, and educational applications are considered important sources of knowledge as well as textbooks, lectures, and paper assignments [1]. These sources work as facilitators, offering students a range of viewpoints, interactive exercises, and practical applications. Additionally, peer-to-peer discussion boards and group projects are examples of collaborative tools that support social learning and idea sharing. When combined, these resources offer a flexible and dynamic learning environment that meets the individual requirements and preferences of students, leading to a more thorough and successful educational process.

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The development of e-learning has been a wonderful journey, characterized by ongoing improvements in pedagogy and technology [2]. E-learning began as a traditional educational method that was digitalized, but it quickly evolved into a dynamic, interactive environment. Basic online courses and downloaded materials were the first to be introduced, and as interest grew, multimedia components like films and animations were added [3]. With the advent of learning management systems (LMS), e-learning became more widely available by streamlining the distribution of content and evaluation. The scope was further increased by the incorporation of social media, gamification, and mobile learning, which offered students individualized and varied educational experiences [4]. With the development of technology, e-learning saw the introduction of virtual reality (VR) and augmented reality (AR), which provided realistic and immersive simulations.

Digital annotation is essential for improving the online learning environment since it gives teachers and students flexible tools for communication, teamwork, and feedback. The capacity to annotate digital content, including e-books, articles, PDFs, and multimedia files, with comments, highlights, and notes is known as digital annotation in the context of online learning [5]. This feature extends beyond the conventional note-taking process, enabling a more dynamic and captivating educational setting. Students can annotate content, ask questions, or simply communicate their thoughts. Teachers can then use annotations to provide timely comments, clarification, or more resources. This encourages students to work together and feel a feeling of community, even in virtual settings. Because making insightful notes requires a deeper level of engagement with the information, digital annotation also fosters critical thinking and active reading abilities in

students. Furthermore, group discussions, peer evaluations, and collective knowledge-building are made possible by the use of collaborative annotation tools, which enhances and increases participation in online learning [6]. All things considered, digital annotation is a very useful tool for encouraging interaction, engagement, and clear communication in the setting of online learning.

Digital annotation has developed into a highly useful tool for international idea exchange. The development of various scripting languages and Internet services and tools has led to the improvement of programming capabilities. As a result, several kinds of annotations have been created to facilitate communication and collaboration among individuals by allowing them to exchange views on issues that are present on multiple websites [7], [8].

Text-based annotation is the most well-known technique for expressing thoughts through annotating digital content on websites using annotators' texts as a means of exchanging ideas about some common topics. These texts are included with digital elements of websites that deal with the topics under discussion. [9].

This tool discussed here allows users to create textual annotations for the text resources of visited websites, and it also allows users to extract the most important terms from the annotated text. When a user clicks on one of these extracted terms, the tool can provide three distinct services: (1) Watching YouTube videos, (2) Involve in a quiz, and (3) Suggest the term to the user's friends. Concerning the first service, upon the click of one of the extracted terms, a list of related YouTube videos appears in the annotation window that can be played by the user. Regarding the second, the system is capable of creating a series of quizzes that the user can respond to, after which the system makes the necessary corrections and produces a report with the user's responses. The questions of generated quizzes are selected randomly from a previously prepared list of questions saved in a dedicated database. To increase the collaboration between users, the third service involves recommending the chosen term to the user's friends since the user might think that one of these terms would be significant for his/her friends. When they check in, they will see that the user has suggested a term (or more) to them, and they can effectively share this idea with their friends as well as conducting in the first two services discussed above. We coined the phrase *"Term Flood"* for this process.

An annotation system is necessary to manage growing demands and offer a user-friendly interface. Paying close attention to scalability and usability is essential to addressing potential difficulties. High data volume and storage, real-time collaboration, rendering performance, network latency and bandwidth, server load, complicated data structures, and user interface complexity are some of the challenges that might cause scalability problems. All of these topics are taken into account during the analysis phase of our tool development and will be the set of our future development of the tool.

This is how the remainder of the paper is structured: Section II suggests earlier work. The tool's system architecture is covered in Section III. The experimental results are shown in Section IV. This work is finally concluded in Section V.

II. Related Works

There are many works in the literature about annotating web content in terms of tools and mechanisms. Numerous studies on web annotations using textual, audio, and drawing-based techniques have been carried out [10].

Since textual annotation is considered the first effort spent on digital annotation, there are several text-based annotation tools available. Examples of such tools include Doccano (an open source tool) [11], Brat [12], Prodigy [13], Tagtog [14], and MADCOW [15]. However, the works presented in [10] and [16] are related to vocal and optical annotations respectively. For example, Hypothesis [1] is an open-source annotation tool primarily used for academic and research purposes. It allows users to annotate web pages, PDFs, and other online documents publicly or privately. It supports text highlighting, tagging, threaded discussions, and group annotations. It integrates well with various e-learning platforms like Moodle and Canvas, making it suitable for collaborative learning environments. Hypothesis also supports integration with digital libraries and open educational resources. On the other hand, Kami [2] is a collaborative annotation and markup tool that allows users to annotate PDFs, images, and documents in real time. Features include text highlighting, drawing, voice and video annotations, and real-time collaboration. It integrates with platforms like Google Classroom, making it ideal for educational settings. Its ease of use and broad set of annotation types (text, multimedia) make it a versatile tool for both teachers and students.

Knowledge dissemination using digital annotation is a promising topic these days. The work of [17] is related to domain-specific knowledge communication and dissemination across new media, discussing digital technologies' impact on understanding, learning, participation, credibility, and identity construction. It emphasizes the need for multimodal and hypermodal analysis of recontextualization processes. The goal is to keep up with technological developments and increasing complexity in knowledge transmission and circulation practices.

Authors of the work published in [18] propose two updated data dissemination methods to improve data accessibility in ad hoc networks. The first method involves mobile hosts disseminating updated data items after invalidation reports, while the second method involves two newly connected hosts.

[1] https://web.hypothes.is
[2] https://www.kamiapp.com/

Online Quizzes are important in the learning process because it is important in students' assessment. The work of [19] argues the rapid pace of technological development necessitates education to adapt and innovate, using modern tools and methods effectively. E-learning can support this process, but it requires a student learning attitude. Self-quizzing, a self-monitoring practice opportunity, can improve learning effectiveness by providing immediate feedback. This research examined the impact of continuous self-quizzing on student achievement in an online course at the University of Dunaújváros in 2019. The study also examined the effect of time spent on self-reflexive quizzing on learning success.

Several tools or Internet sites are utilized to recommend key terms to other participants during a brainstorming session so they can work together or simply just exchange ideas. These resources include WordHippo [3], OneLook Reverse Dictionary [4], Google Docs [5], and Thesaurus [6]. Additionally, a variety of technologies are utilized to administer online tests, including ProProfs Quiz Maker [7], Google Forms [8], Kahoot [9], Quizizz [10], Socrative [11], and Quizlet [12].

Although there are many tools available for creating online tests and suggesting terms, none of them, to our knowledge, combines the concept of digital annotation with the capacity to identify the most crucial terms from the annotated text and link these terms to online tests and YouTube videos in addition to suggesting terms to others. This is where we contribute to the work: we've combined all these services into a single tool.

III. System Architecture

The only way to annotate web material is to overlay an already-marked webpage with a translucent layer. This invisible layer represents the tier that contains annotations. The client/server web-based architecture is used by the tool used in this work. Annotations are added by users to an HTML page, and when they save it, the relevant information is stored in a special database. The mechanism consists of three levels that make up the tool: **Presentation**, **Processing**, and **Database**. The Presentation Layer controls how users interact with the browser to produce annotations, which are subsequently kept in a dedicated database together with all of the annotators and the visited website's related data. Spotlight links annotations to certain passages. The Processing Layer, which sits between the Presentation and Database levels, handles all of the processing needed to store the provided data from the Presentation layer in the database layer. Last but not least, the database layer handles the actual storing of all data pertaining to the annotator, the URL, and the annotations that are produced and shown in the annotated text. The database layer is also responsible for obtaining the annotations for a particular user and website. The tool's structure, where the request/reply protocol is utilised to save and retrieve annotations, respectively, is shown in Figure 1 below [10].

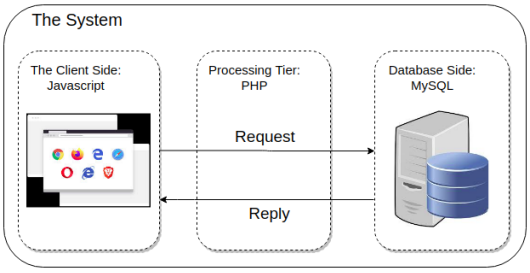

Fig. 1: The tool's architectural design.

The user-tool interaction is implemented via the Google extension. For this reason, a customized Google extension with all of the annotation features is programmed. The extension includes a collection of JavaScript functions that are embedded into every website that is visited to perform various functions such as text selection, term generation, loading relevant YouTube videos, quiz display, answer handling, and, in the end, sharing favorite terms with the user's friends. The plugin also includes functionality for user login and account creation. Figure 2 depicts the annotation creation where the selected text and the space to write the annotation are displayed in the PopUp window.

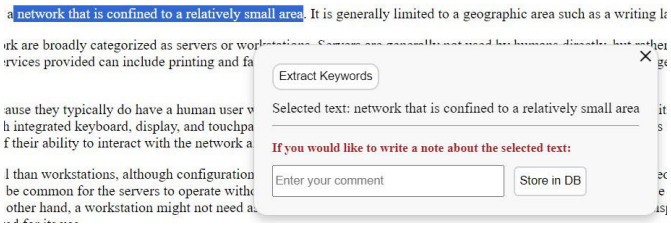

Fig. 2: PopUp Window for Annotation Creation.

The steps involved in extracting terms from the chosen text are shown in Figure 3 below. A JavaScript code is executed to remove the stop words and keep the rest of the terms in a list. TF-IDF (Term Frequency-Inverse Document Frequency) assigns each term a score related to the number of occurrences a word has in the text.

[3]https://www.wordhippo.com/
[4]https://onelook.com/thesaurus/
[5]https://www.google.com/docs/about/
[6]https://www.thesaurus.com/
[7]https://www.proprofs.com/
[8]https://www.google.com/forms/about/
[9]https://kahoot.com
[10]https://quizizz.com/
[11]https://www.socrative.com/
[12]https://quizlet.com/

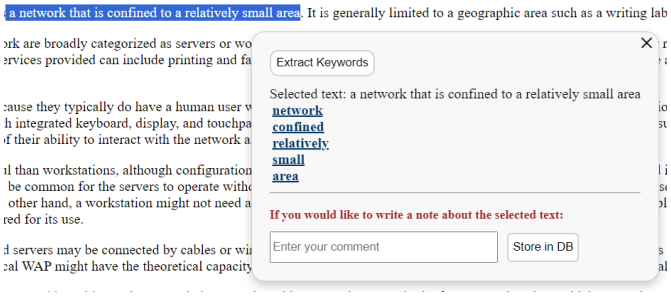

Fig. 3: Extracting Terms.

Figure 4 depicts the term selection and the display of the options related to the selected term: watching YouTube videos and involving in a quiz.

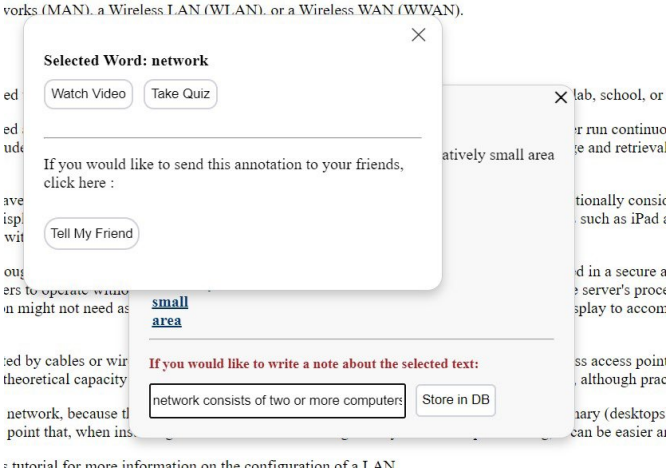

Fig. 4: Selected Term Options.

Figure 5 lists 2 YouTube videos related to the selected term *Networks*.

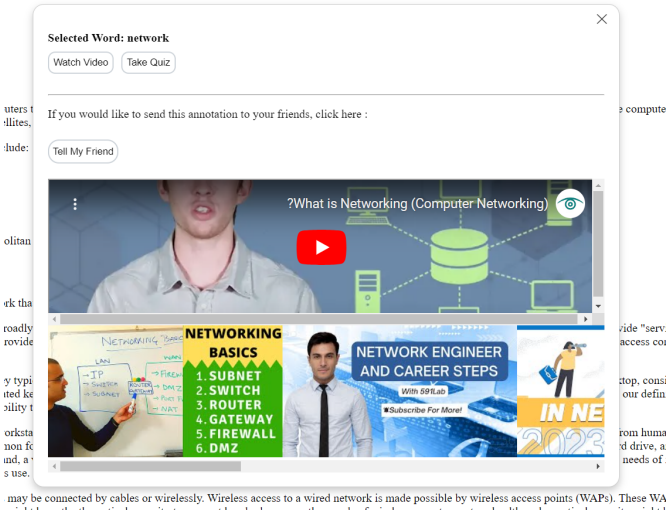

Fig. 5: List of YouTube Videos.

Figure 6 displays a set of generated questions (Quiz) for the term *Networks* with the answers the user submits while Figure 7 depicts the correction process of the mentioned quiz.

Fig. 6: List of Quiz Questions.

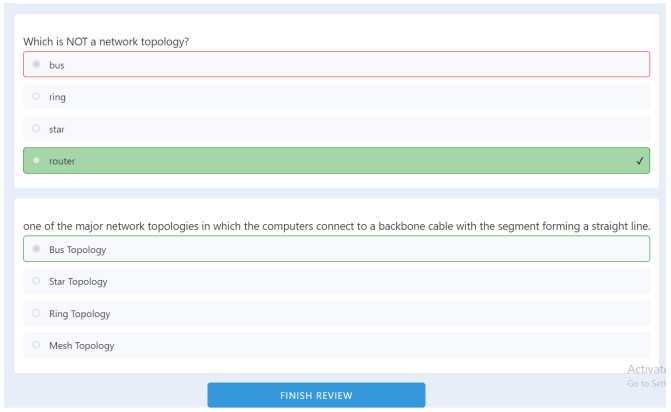

Fig. 7: The Correction Result.

Suggesting some terms between users of the system is considered a process of brainstorming as well as a method of knowledge dissemination. When some user believes that a term could be useful for others, s/he can propose this term (these terms) to them. This process involves a spotlight on the term(s) in which the involved users can also watch related videos and be involved in quizzes with different questions. Figure 8 depicts the process of terms' suggestions. *User* icon represents the currently logged user who suggests some terms. *F1* represents the direct friends of the *User* (the first level of friends, *F2* represents the friends of the user's friends, the second level of friends. The edges represent the friendship relation between friends.

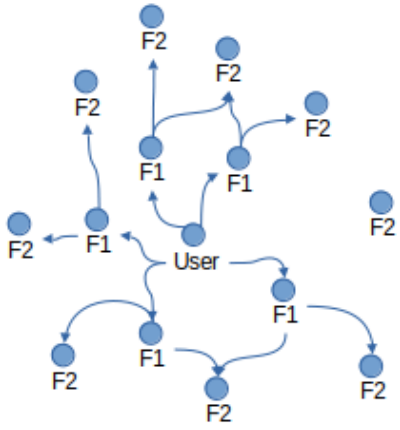

Fig. 8: Term Flooding.

Figure 9 lists the list of terms sent to the current user from his/her friends while Figure 10 depicts the terms sent by the user to his/her friends.

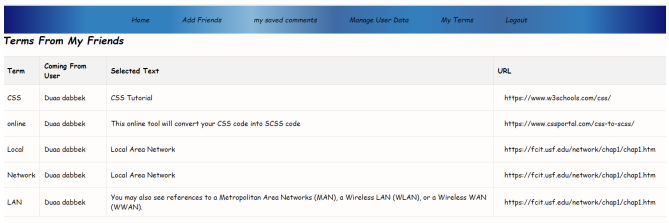

Fig. 9: The Correction Result.

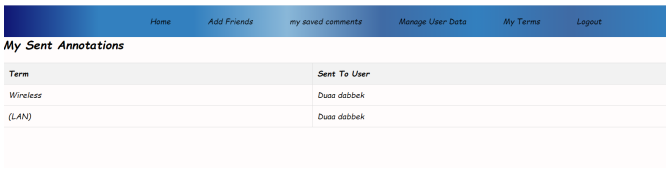

Fig. 10: The Correction Result.

Figure 11 depicts the list of annotations submitted by a user viewed from his/her portal.

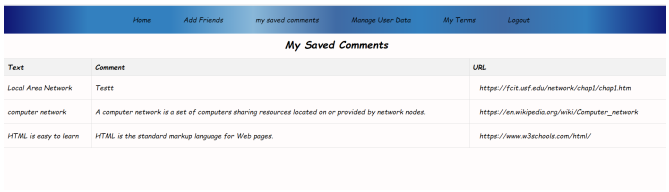

Fig. 11: List of user's Annotations.

The database's logical schema is depicted by an entity-relationship diagram in Figure 12 below. There are six distinct entities in the diagram: **Users** that contains attributes to users (annotators), **Annotations** contains necessary data for annotations like annotated text, annotation text, and URL, **Terms** contains the extracted terms for some annotation, **Quizzes** contains the quiz title and date and time for some selected term, **Questions** contains the list of questions for some quiz, and **Friends** that contains mappings between the users who suggest some terms to other users. The reflected relationship **FriendShip** over the entity **Users** is to depict the list of friends for some user.

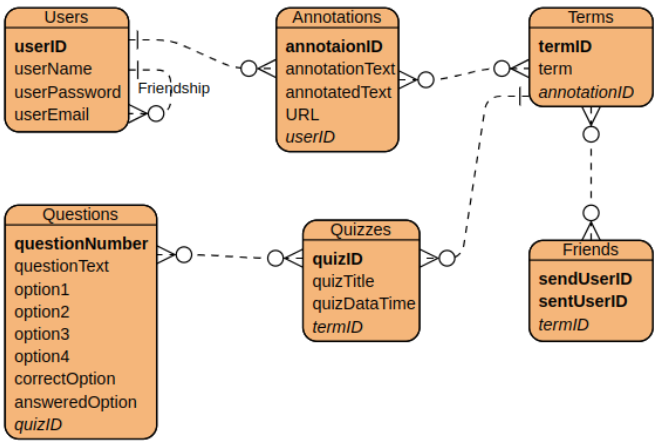

Fig. 12: The diagram of entity relationships.

The sequence diagram for the annotation creation task and the quiz answering procedure is shown in Figure 13. A user chooses some text on a webpage to start the activity. When the **Google Chrome** object delivers a **popUpWindow** to the user who writes his annotation, the Browser object that performs the method **selectText(selectedText)** is triggered. The user then asks the **Google Chrome** object to extract the important terms in the selected text that returns the list of extracted terms stored in the **terms** array. After that, the **terms** array is displayed to the user who selects one of these terms and asks **Google Chrome** object to generate a quiz for the selected term by executing the function **generateQuiz**. Consequently, the function **loadQuestions** found in the **PHP Engine** object is executed by the **Google Chrome**. The latter executes the function **loadQuestions** on the **Database** object that in turn loads the **listOfQuestions** to he **PHP Engine** which returns

these questions to the **Google Chrome** object and finally to the user. The user answers the questions and submit the answers to the **Google Chrome** object by executing the function **submitAnswers** which sends the answers as well to the**PHP Engine** by executing the function **sendAnswers** and loads the correct answers for the quiz by executing the function **loadCorrcectAnswers** on the **Database** object. The array of the correct answers for the quiz is loaded from the database and returned to the **PHP Engine** as **correctAnsweers** array. The **PHP Engine** executes a self-identified function **compare** that compares the submitted answers saved in **answers** array and between the correct answers saved in the **correctAnswers** array. The result of the comparison is saved in the array **results** that returned to the **Google Chrome** object to the user to see the result of the quiz s/he did.

The process of suggesting terms to some user buddies is summed up in the pseudocode segment that follows. The function **createAnnotation(selectedText)** is the first thing the code does. The function's body begins by creating the object **annotation**. Next, it uses the member function **generateTerms** to generate the most significant terms of the **selectedText**, which are then saved in the array **terms**. This array is then sent as a parameter to the function **selectTems** that returns the selected terms (by the user) and saved in the variable **term**. After that, the list of user friends is loaded by executing the function **loadFriends** that takes the **userID** and saves it inside the **friends** array. A connection with the system database is created by instantiating the object **db** and the term is saved for all friends appearing in **friends** database. The suggested term is displayed for all friends upon their login to the system.

```
1  function createAnnotation(Text selectedText){
2      Annotation annotation = new Annotation(
           selectedText)
3      Term terms[] = annotation.generateTerms()
4      Term term = selectTerm(terms)
5      Friend friends[] = annotation.loadFriends
           (userID)
6      Database db =  new Database()
7      db.suggestTerm(term, friends)
8  }
```

Of course, issues like user data privacy and security are taken into account in the tool. We implemented the tool to have robust access control mechanisms like role-based access (by the different types of users each of which has its role in the tool), and data encryption (before saving data annotations in the database).

IV. Experimental Test

To test the effectiveness of the implemented tool, we conducted a simple experimental test to measure the amount of knowledge gained and the amount of knowledge dissemination between users. A set of users (50) were chosen to participate in the test. The users were asked to visit a set of websites related to networks (Routing and Switching) and they were asked to exchange ideas, thoughts, and findings and do some online quizzes related to the topics they read. After that, we asked the same users to visit the same websites and use the annotation tool to exchange ideas and thoughts and we asked them to do the quizzes implemented in the tool and use the terms suggestion facility between them. The number of submitted annotations was 72 with 24 quizzes involved and 262 terms were suggested up to the average of 4 levels (the flooding radius).

TABLE I: Results of the questionnaire.

Question #	Before using the tool	After using the tool
Q1	26%	89%
Q2	92%	18%
Q3	23%	85%
Q4	125 minutes	30 minutes
Q5	113 minutes	24 minutes

After the testing process was completed, we asked the users to fill in a prepared questionnaire to measure the amount of knowledge they gained and the amount of collaboration they had with each other before and after using the tool. The list of questions were:

1) How much (in percentage) has your knowledge increased?
2) How much effort (in percentage) was spent searching for terms related to the network topic?
3) How much (in percentage) do you value cooperation with others?
4) How much time (in minutes) was taken to find the related topics?
5) How much (in minutes) was taken to find the appropriate quizzes?

Table I and Figure 14 reflect the results of the questionnaire answers. The amount of collaboration and knowledge increased after using the tool while the time and effort spent searching for related materials and quizzes were decreased.

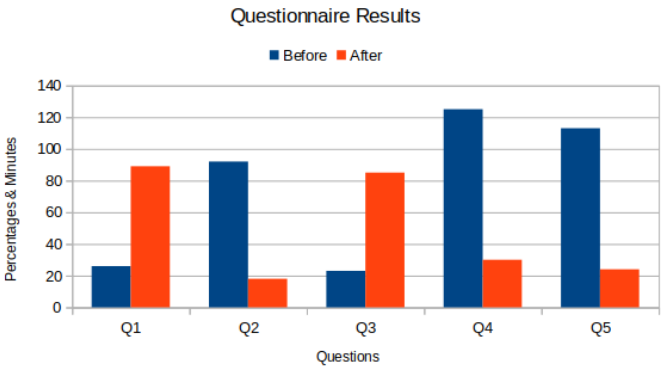

Fig. 14: Questionnaire Results

V. Conclusion

Annotating online web content becomes a vital approach to knowledge acquisition and dissemination. We enriched

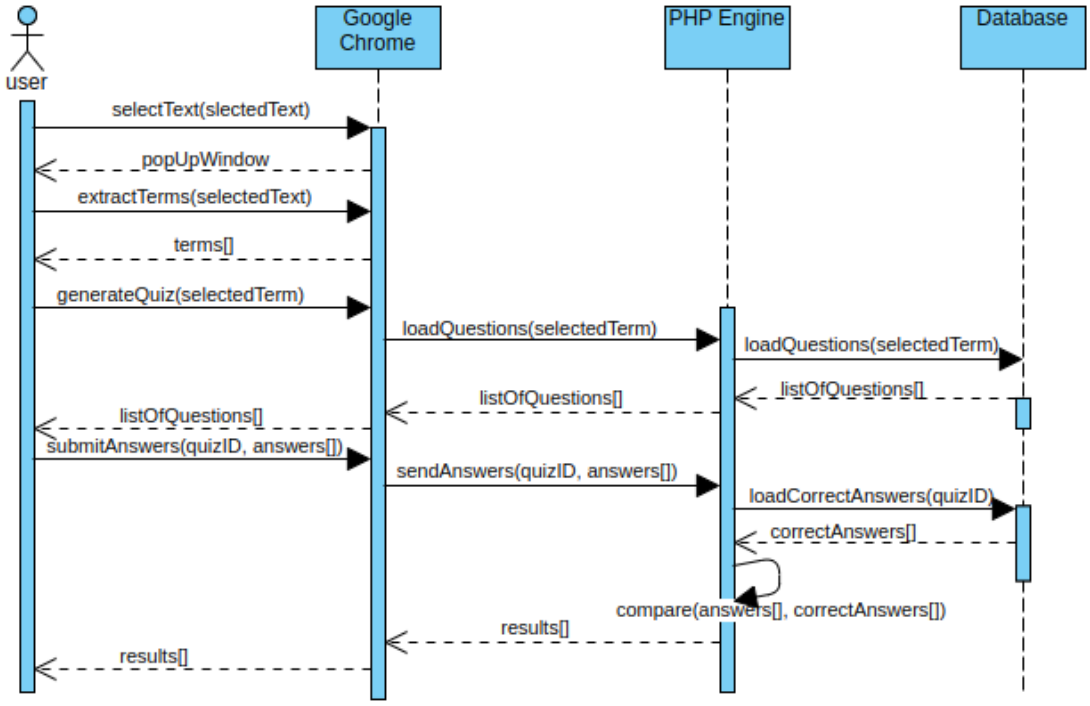

Fig. 13: The activity's sequence diagram for creating annotations.

our simple annotation system with the feature of terms extraction and displaying appropriate YouTube videos as well as enabling users to enroll in specific quizzes to test and enrich users' knowledge. The term flooding process is also implemented to notify others of the importance of some terms and as a means of conducting online brainstorming between users.

To test the effectiveness of the tool and the importance of knowledge spread between users, we conducted an experimental test to measure the amount of knowledge sharing between users before and after using the tool. Promising results were achieved, encouraging us to go on with additional features as future works. We plan to relate the results of quizzes with the YouTube videos so that when users get low results in their quizzes, the system suggests a list of suitable YouTube videos to enrich their knowledge. Moreover, integrating the system with existing e-learning platforms is one of our plans because this can offer significant benefits like an enhanced learning experience, personalization and feedback, tracking and analytics, and provides rich media support.

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