COEXA: A Questioning Model based on Inquiry-based Learning and Social Web

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Keywords: Inquiry-based Learning, Social Web, Exercises System.

Abstract: Currently is seen the need of students develop various skills for good social life such as critical thinking. Aiming to find alternatives to these problem, this work introduces the COEXA model, supported by inquiry-based learning and social web for educational environments. This model encourages the student to be more active in the learning process by creating and answering questions and also interacting with other students. For this, the fundamentals of the approaches were studied and the survey of related works was also performed. This model can be applied in different educational environments, but for this work an instance of COEXA was implemented in AdaptWeb® (Adaptive Web based learning Environment), and to evaluate its applicability, an experiment was accomplished with students. From this experiment, we collected the interaction data from 89 participants and their opinion were collected through a questionnaire survey. Analyzing the answers and the data collected, it was possible to notice that students thought that the possibility of creating exercises to keep their knowledge and interact with others is very interesting, but they had difficulty with managing time, insecurity and doubts about the creation process.

1 INTRODUCTION

It is very important that children, youth and adults, to participate in an integrated and effective way of life in society, with the contribution of educational institutions (Berbel, 2011). Therefore, there is a need for students to have a critical social background, because the complexity of the different sectors of life has demanded the development of human resources to think, feel and act in an increasingly broader and deeper way (Berbel, 2011). Thus, it is necessary to look for new strategies that make students develop different skills, such as critical thinking.

A concept that can help students to increase participation and develop skills, is Inquiry-Based Learning (IBL). IBL is an active, student-centered approach where the learning is stimulated by investigation and is based on a knowledge building process (Spronken-Smith and Walker, 2010). There are several categories of Inquiry-Based Learning, such as the Structured Inquiry, where teachers establish a problem or a subject and an outline for students to address, the Guided Inquiry, where teachers provide questions to stimulate students in their investigations, and the Open Inquiry, where students act as scientists, asking questions, designing and conducting investigations, and communicating their results (Banchi and Bell, 2008).

For students, the results of the learning process with the application of Inquiry-Based Learning include the development of critical thinking, the ability to conduct research, intellectual growth and maturity (Lee, 2004).

Another paradigm that can be used in the teaching-learning process is the Social Web, which is represented by a class of web sites and applications in which user participation is the primary driver of value. (Gruber, 2008). The Social Web is in the new classes of web applications, as an example of these applications there are Collaborative Systems and Social Software, which are web-based, allow the interaction and sharing of data between its users and enable communication between groups of people (Machado and Tijiboy, 2005). In the educational context, the Social Web allows students to share knowledge in Virtual Learning Environments, without depending on the teacher as the only and primarily source of content.

This work aims to present a questioning model, supported by Inquiry-Based Learning and the Social Web. The COEXA model aims to develop skills, such as critical thinking and social interaction.

Based on this model, an exercise tool was devel-

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oped and was included in AdaptWeb®(Adaptive Web based learning Environment), a Virtual Learning Environment, and an experiment was carried out from a course of algorithms, which allowed the analysis of results from an instance of the COEXA model in a real context.

This paper presents the COEXA model and its application through this experiment. In section 2 the concepts used in the creation of the model are presented, section 3 presents the COEXA model, section 4 presents the implemented tool in AdaptWeb®, section 5 reports the experiment carried out and section 6 presents the conclusions of this paper.

2 CONCEPTS

To understand how COEXA works, it is important to understand the two main concepts on which it is based and how they work together. Section 2.1 details Inquiry-Based Learning and section 2.2 presents the Social Web concepts, benefits and ways of use.

2.1 Inquiry-based Learning

Inquiry-Based Learning (IBL) is an active, student-centered approach, where learning is stimulated by research and based on a knowledge building process (Spronken-Smith and Walker, 2010). This pedagogical approach involves students actively in a process of building knowledge through the generation of questions (Wu and Wu, 2018). IBL aims to involve students in a scientific discovery process, emphasizing active participation and the student's responsibility to discover new knowledge (Pedaste et al., 2015). It is an approach that enables learners to draw connections between curricular content and real world situations in order to attain a broad perspective to solve complex problems and foster critical thinking (Kerven et al., 2017). Thus, IBL can be seen as similar to research and as a way to integrate research and education, where students and teachers are in search of knowledge (Spronken-Smith and Walker, 2010).

There are several ways to divide IBL into its levels of investigation, but according to Banchi and Bell (2008) it is divided into four levels, that are defined by the amount of information and guidance that the teacher provides to students, as can be seen in Figure 1 and described:

- **Confirmation Inquiry:** It is the first level of IBL, students receive the question, the method and the results, it is useful when the teacher's objective is to reinforce an idea previously introduced or for students to practice a specific phase of research, such as collecting data (Banchi and Bell, 2008);
- **Structured Inquiry:** In the second level, the question and method are still provided by the teacher, however, students find the result supported by the evidence that they received (Banchi and Bell, 2008);
- **Guided Inquiry:** The third level, the teacher provides students only the research question and students use the method to test their question and solutions (Banchi and Bell, 2008);
- **Open Inquiry:** It is the highest level of inquiry, students have the opportunity to act as scientists, asking questions, designing and conducting investigations, and communicating their results (Banchi and Bell, 2008).

The four levels of inquiry and the information given to the student in each one.

Inquiry Level	Question	Procedure	Solution
1–Confirmation Inquiry *Students confirm a principle through an activity when the results are known in advance.*	✔	✔	✔
2–Structured Inquiry *Students investigate a teacher-presented question through a prescribed procedure.*	✔	✔	
3–Guided Inquiry *Students investigate a teacher-presented question using student designed/selected procedures.*	✔		
4–Open Inquiry *Students investigate questions that are student formulated through student designed/selected procedures.*			

Figure 1: Levels of Inquiry (Banchi and Bell, 2008).

Figure 1 shows that the higher the IBL level, the less information is provided by the teacher and the greater the student's autonomy. The levels are not evaluated as one better than the other, they can even be worked in parallel, for this reason the COEXA model covers all levels of inquiry.

2.2 Social Web

The Social Web indicates a paradigm shift from a machine-centered view of the Web towards a more user or community-centered view (Piao, 2016). More than interconnecting documents, pages or resources, the Social Web connects people, organizations and concepts (Pereira et al., 2010a). It is represented by a class of websites and applications in which user participation is the main factor (Gruber, 2008).

This paradigm is also revealed in the development and growth of a new class of web applications, such as Social Software, which is web-based and allows interaction and data sharing between its users and allow communication between people and groups (Machado and Tijiboy, 2005).

Social software is a concept that work as social mediator and supports the creation of networks of relationships through spaces where the users can join people in their relationship circle, meet other people who share the same interests and discuss different

topics, building different links (Machado and Tijiboy, 2005). On social software, users interact, communicate, create, share and organize content, demonstrating the opportunities and knowledge that can be generated by working together and interacting with people (Pereira et al., 2010a).

To help in the definition and development of social software, frameworks can be used, such as the Honeycomb Framework, that is represented by the Figure 2.

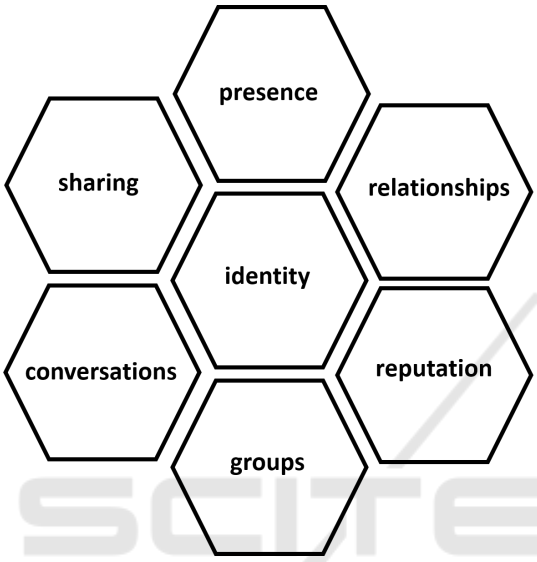


Figure 2: Honeycomb Framework (Smith, 2007).

The Honeycomb Framework was proposed by Smith (2007) and has seven combs. Theses combs represent the main aspects of Social Software, which are (Smith, 2007):

- **Identity:** it is a unique identifier of a user in the system, a way of representing elements of a person's personality and individuality. An example is a user profile;
- **Presence:** related to the resources that let you know if a certain person is online, sharing the same environment at the same time;
- **Relationships:** it is a way to determine how users of the system relate and are related to other users, like friends or followers ;
- **Reputation:** it is a way of knowing how the user is seen in the system, it can be a collective opinion of other users or a statistical measure of the system
- **Groups:** it is the possibility to form communities of users who share common interests, ideas or opinions;
- **Conversation:** related to the resources for communication between users, these resources can promote both synchronous and asynchronous communication;
- **Sharing:** refers to the possibility of sharing items that are meaningful and important to users, such as photos, documents and music.

The comb **Identity** appears at the center of the framework because it is the most basic requirement of any social software (Smith, 2007). It is important to note that not all systems that use the Social Software concept implement all the honeycombs presented and the intensity of the use of each element in the systems can vary. In general these systems implement three or more elements of the framework, but ends up focusing on one or two of them (Pereira et al., 2010b).

3 COEXA

COEXA is a questioning model to be applied in educational environments. Its proposal is to unite concepts to students learning become more active and consequently that he/she feels responsible for his/her learning and develops different skills, such as critical thinking.

To achieve the objectives, the IBL and social web are joined in a questioning model. The flow of questioning model is represented by the Figure 3. In the figure are the principals actions proposed by the model and each action have a tag to show what concept it was based, IBL to inquiry-based learning and SW to social web.

The model proposes that teacher manage all the actions carried out by the students and interferes when he/she perceives the need. Teacher can create questions to students, manage the interaction and interact with them when needed. The students can create questions to share with their classmates, and also students can answer, evaluate, give feedback and report questions. When a question is reported is necessary to be reviewed and the model suggests that other students do this when selected based on their reputation on the course environment.

The main point of COEXA are the questions, they are used to create more interaction between classmates, making them exchange experiences through feedback, evaluations and even reports. The purpose of creating and sharing questions is also to student research about the content provided by the teacher and that consequently fix concepts and become more active in the learning process.

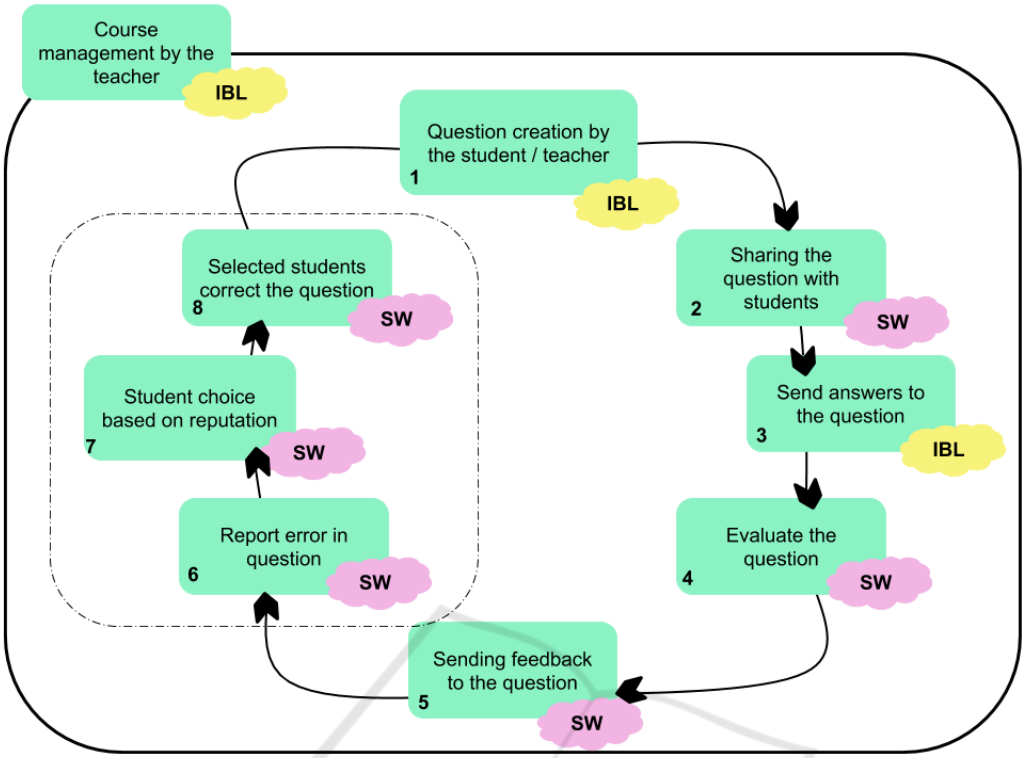


Figure 3: COEXA model flow.

4 TOOL

To see how the model works in a real context, an instance of the model was developed, which consists of the implementation of an exercise system in AdaptWeb®, and for the implementation of the tool it was necessary to adapt it to the environment.

AdaptWeb® is an educational environment, which can be used by teachers, to provide content, exercises, examples and tests of their subjects, and by students who are registered in the subjects and want to access the materials provided by the teacher.

To present the tool implemented this section will be divided into the student's view and the teacher's view.

4.1 Student's View

In the exercise system implemented, the main functionality is the creation of exercises by students. For this reason, the first step was to create a menu item that could be identified throughout the online classroom environment, leaving the creation of exercises easy to access and view, as can be seen in the Figure 4. As the system was used by people with Portuguese' mother tongue, the figures of the exercise system are in Portuguese.

From the menu item, the form for creating exercises has been added. In this form students must choose the type of question, its statement, the alternatives, including quantity and which are correct, and which topic of the subject this question should be linked to. The form can be viewed in Figure 5.

When a student creates a question, it will automatically be available to classmates on the same exercise listing page that previously existed in the environment. There is a highlight in the list to identify which exercises are created by the teacher and which are the exercises created by students. We chose automatic inclusion of the exercises to avoid overloading the teacher, in case he/she had to review all the questions. The list of all exercises can be seen in Figure 6.

When a student answers a question created by one of his classmates, he/she will have the option of evaluating the question with "like" or "dislike" and he/she will also be able to report an error, as can be seen in Figure 7. In this case, the teacher will be immediately notified and able to correct the issue.

When the student decides to report an error of a question he is directed to a form and he can list the problem of the exercise. It was decided to leave pre-

Figure 4: Menu item for creating exercises.

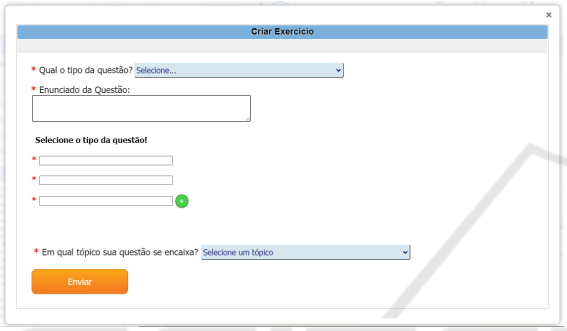


Figure 5: Form for creating exercises.

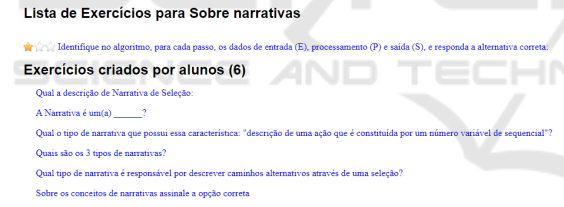


Figure 6: List of exercises.

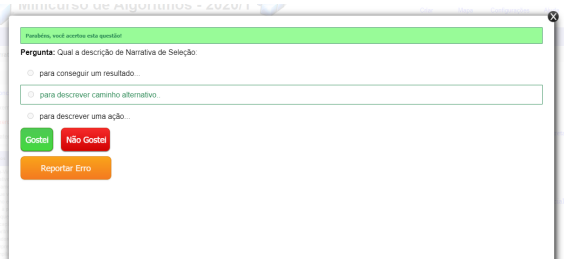


Figure 7: Exercise preview answered.

defined options and a free field for the student to be able to report what happened in details. Another decision made was that when a student reports an error in a question, it will be omitted for other students until the teacher reviews and corrects it.

From the functionalities added to the student, functionalities were developed for the teacher to manage what the students are doing in the exercise system, this is stated in details below.

4.2 Teacher's View

The first feature created for the teacher was a menu item that redirected him to choose which of his subjects he wants to see the questions created by the students. If the teacher chooses the "manage questions" option, he/she is directed to a list that shows all the questions created by students in the subject, as shown in Figure 8. In this list, the teacher has the option to delete or edit a question and he is able to see information like the number of "likes" and "dislikes" and the question creator.

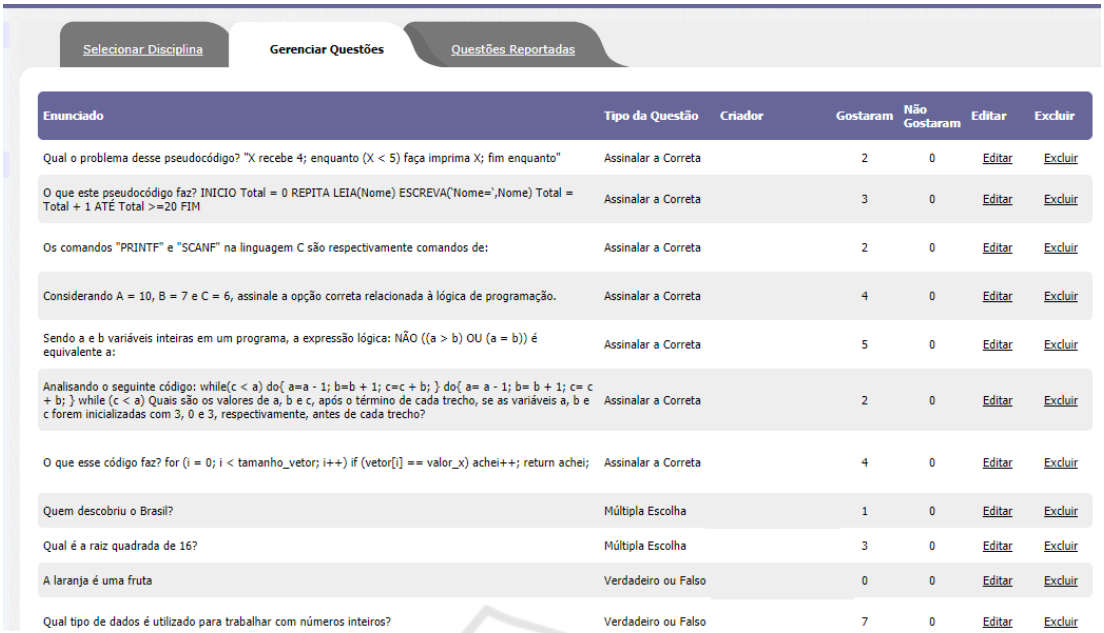
If the teacher chooses the "reported questions" option, he/she is directed to a list that shows only the questions reported by students. He/she also has the option to edit or delete questions, if he decides to edit a question, it will automatically be made available to students again.

The last functionality implemented for the teacher's view, can be seen in Figure 9, is the form for editing a question. The teacher can edit the statement of the question, the description of the answers and what are the correct alternatives.

In the next section is reported how the experiment was carried out to evaluate the tool and the results obtained.

5 EXPERIMENT

The experiment provided a course of Algorithms and Programming Language on AdaptWeb®. The course invitation was made from 25 to 28 August 2020 through social networks, emails to academics and teachers and University' website. Before the experiment actually started, there was a pre-registration



Enunciado	Tipo da Questão	Criador	Gostaram	Não Gostaram	Editar	Excluir
Qual o problema desse pseudocódigo? "X recebe 4; enquanto (X < 5) faça imprima X; fim enquanto"	Assinalar a Correta		2	0	Editar	Excluir
O que este pseudocódigo faz? INICIO Total = 0 REPITA LEIA(Nome) ESCREVA('Nome=',Nome) Total = Total + 1 ATÉ Total >=20 FIM	Assinalar a Correta		3	0	Editar	Excluir
Os comandos "PRINTF" e "SCANF" na linguagem C são respectivamente comandos de:	Assinalar a Correta		2	0	Editar	Excluir
Considerando A = 10, B = 7 e C = 6, assinale a opção correta relacionada à lógica de programação.	Assinalar a Correta		4	0	Editar	Excluir
Sendo a e b variáveis inteiras em um programa, a expressão lógica: NÃO ((a > b) OU (a = b)) é equivalente a:	Assinalar a Correta		5	0	Editar	Excluir
Analisando o seguinte código: while(c < a) do{ a=a - 1; b=b + 1; c=c + b; } do{ a= a - 1; b= b + 1; c= c + b; } while (c < a) Quais são os valores de a, b e c, após o término de cada trecho, se as variáveis a, b e c forem inicializadas com 3, 0 e 3, respectivamente, antes de cada trecho?	Assinalar a Correta		2	0	Editar	Excluir
O que esse código faz? for (i = 0; i < tamanho_vetor; i++) if (vetor[i] == valor_x) achei++; return achei;	Assinalar a Correta		4	0	Editar	Excluir
Quem descobriu o Brasil?	Múltipla Escolha		1	0	Editar	Excluir
Qual é a raiz quadrada de 16?	Múltipla Escolha		3	0	Editar	Excluir
A laranja é uma fruta	Verdadeiro ou Falso		0	0	Editar	Excluir
Qual tipo de dados é utilizado para trabalhar com números inteiros?	Verdadeiro ou Falso		7	0	Editar	Excluir

Figure 8: Visualization of all questions created by students.

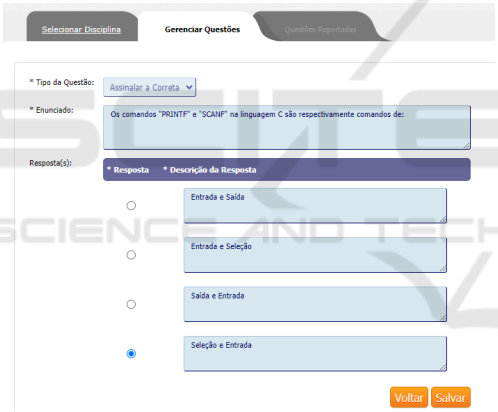


Figure 9: Edition of a question created by a student.

stage, in which students had to fill out a form with personal data. The form got 504 answers from interested students.

It is also important to report that the role of teacher was performed by one of the researchers, so it was possible to be closer to users to assist them in the process of creating exercises and also to manage the interactions carried out within the platform.All content was previously elaborate by the teachers of the subject.

On August 30, 2020, 504 interested people were asked to register on AdaptWeb®, of these, only 266 students actually registered. The course took place from August 31 to September 4, 2020, during this period students had access to all the available content and could create and answer exercises, including those created by their classmates.

During the course period, interactions were made with students by email, encouraging them to access the content and create exercises. The students did not realize the possibility of creating exercises in the first days and the first questions that were created by a student were totally out of context, but these questions were kept, in order to understand what the behavior of the other students would be in relation to them. Some students even liked the question, but during the course all ended up being reported as error by other students.

Of the 266 students, 185 accessed at least one content, 36 created exercises and 11 reported exercises created by their classmates. In total there were 78 exercises created by students and 25 reported. The ”like” and ”dislike” options was not popular with students, only 50 questions were evaluated, none of them received ”dislike”, the maximum positive evaluations with ”like” that a question received was 11, but the average was between 3 or 4 ”likes” for each evaluated question.

On September 5, 2020 it was the test day, where students were also able to answer a questionnaire survey about their participation, leaving their opinion about the exercise system, in total 89 students answered the questionnaire.

According to the analysis of the responses to the questionnaire survey, it was possible to better understand the profile of the students who completed the course. It is interesting to highlight the diversity among the participants, there were high school and technical students, undergraduate and master stu-

dents. It is also interesting to note that the experiment covered people from different areas, in addition to technology participants, who had or will have contact with programming languages, there were participants in areas such as gastronomy and history.

In the questionnaire, most questions were focused on the exercise system and the course itself. The first question aimed to find out what the students thought of the course. Of the 89 respondents, 84 were satisfied with the content and progress of the course, the other 5 reported that they expected more interactivity and more detailed explanations and examples.

It was also asked if the student created questions for the course, 40 students reported that they created at least one exercise, it can be seen in Figure 10, but according to the analyzes made on the platform, 36 students who answered the form really created questions by the exercise system.

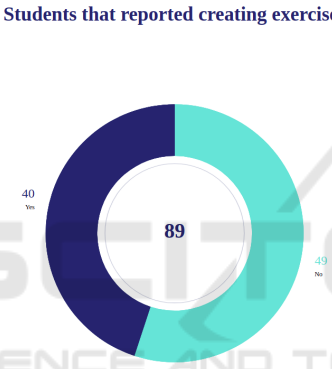


Figure 10: Representation of students that reported creating exercises.

Soon after, students were asked to justify why they created or not exercises in the subject. Of the 89, 24 students answered that they did not create exercises due to lack of time and time management, 34 students created exercises and the main reasons commented were: to test the knowledge acquired, contribute to the course, participate, interact and contribute with classmates and study the concepts, the others 31 students created it because they thought it was mandatory, others did not understand how the creation process worked, some were insecure with the idea of creating and sharing exercises with their classmates.

The next question on the form was to understand what the students thought of the dynamics of answering questions from their classmates, 66 students liked the initiative, commented that it is good to increase the number of questions in the course, interesting to have an exchange of experience among students and there are questions from people who are at the same time and level of learning. The remaining 23 reported that they do not believe that the option is interesting because the questions are created by students and without a teacher review, they could be poorly formulated, confusing and contain errors. It is also interesting to report that of the 78 questions created by students, only 30 were answered by at least one user, it can be seen in Figure 11.

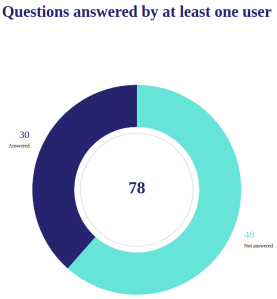


Figure 11: Representation of questions answered by at least one user.

Regarding the importance of being able to report questions created by classmates, 81 students replied that they think this possibility is important, justifying that wrong questions could harm someone in learning and motivation, is important to maintain the consistency of the course and also that the reporting of questions can help the creators of the question to improve their knowledge.

When asked the students if they thought it interesting to be able to evaluate their classmates' questions, the majority with 89.9% answered yes, it can be seen in Figure 12, but in the exercise system no question was evaluated with "dislike" and of all the questions created, just 50 were evaluated.

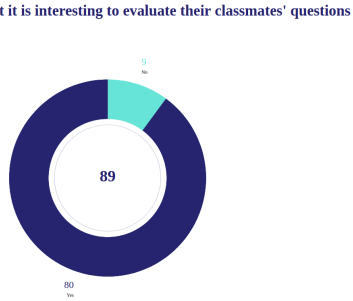


Figure 12: Representation of students that thought it is interesting to evaluate their classmates' questions.

Students were also asked what they liked best about creating the exercises. It was mentioned that they liked to see it as a challenge, to have freedom to choose the type of question and the topic of the subject, to be able to contribute with the course, the possibility of interaction with classmates and to be a new way of studying.

Finally, students were asked for suggestions to improve the process of creating exercises on the platform, the ideas were: upload files and images to the questions, use a mark-down statement to facilitate the elaboration of the questions, the possibility for students to edit their questions, help from the teacher in this process, possibility to create essay questions, promote more interaction between students, chat to exchange ideas with the question creator, make the option to create questions more visible and intuitive on the platform and there were also some suggestions for exchange the platform to increase the usability and responsiveness.

6 CONCLUSIONS

The COEXA model focuses on increasing student interaction during the use of educational environments through questioning and consequently develop skills such as critical thinking and responsibility for their own learning. Therefore, its main proposal is to allow students to create their own questions and to answer and evaluate the questions of their colleagues.

Based on the model, a tool was developed in AdaptWeb®, where the creation of questions by the students and the management of the exercise system by the teacher was implemented, the students also has the possibility to answer, evaluate and report the questions of their classmates.

After the tool created, an experiment was carried out, and analyzing the results it was possible to notice, based on the responses to the questionnaire survey, that the students thought it is interesting to be able to create exercises to test their knowledge and interact with others, but they had difficulty with time management, insecurity and doubts about the creation process. Based on the results obtained, it is believed that the results could have been better if the experiment had been carried out over a longer course, because the course of the experiment last just five days, so that students would have more time to dedicate to the exercise system, and not just focus on the content provided.

As future work it is suggested the use of the COEXA model combined with other techniques to support learning such as learning analytics and gamification, and the implementation of other elements of the model in the tool, especially the social elements, because as a suggestion many students reported that they would like to interact more with their class.

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