INNOVATIONS IN THE EDUCATIONAL PROCESS IN TECHNICAL UNIVERSITIES BASED ON AN ONTOLOGY FOR INTERACTIVE TEACHING SYSTEM

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This paper aims to highlight the influence of e-Learning platforms and to offer a new perspective based on students' decisions and influenced by their preferences. This is an innovative e-learning module, using a specific methodology that allows students to vote in real time, during the course, based on electronic votes. The students can choose the level of details they want for each section of the presentation and which example cases are relevant or not for them. This way, a high level of student involvement is maintained during the course and the information is provided interactively to the participants. The electronic votes of the students are managed using a Moodle platform plugin based on an educational ontology, especially created. These votes will influence the course of the teacher's oral presentation.

1. INTRODUCTION

University courses, and especially engineering courses, contain quite a lot of information and this can influence the presentation and the students' attention. The teacher has the challenging job to find a balance between the presentation of the necessary information for a specific subject and the supporting of the adequate level of interactivity.

Highlighting certain notions, clarifying them and opening up to new topics is much more important than going through a large set of information. It is preferable for students to understand a set of fundamental ideas. More importantly, teachers should arouse students' interest from the topic. In order to achieve these objectives, a presentation framework that contains these essential elements must be created. The interest shown by the students is indicating the subject of the rest of information presented further.

The paper proposes a solution that aims to increase the interaction between teachers and students. Also, to increase the student's interest in certain topics of the course, offering the possibility to make decisions based on the slide presented. The students vote in real time modifying the evolution of the course, having a choice between several possibilities: to clarify certain notions, to receive an example, to move on to another set of notions, to take a break or to discuss a current issue related to the field in which the subject is located. Current technologies are constantly evolving and revolutionizing everything that means education and also interaction between students and teacher. E-Learning platforms, various applications, platforms such as Zoom, Webex, Teams, Moodle platform bring new perspectives on education and establish an environment in which you can interact with both teachers and other students or colleagues. To improve the digitalization of the educational process we have created an ontology associated with this interactive teaching system, which aims to provide a new perspective on the interaction between students and teacher, but also to create a new method of structuring courses and laboratories for making a balance between the way information is presented and its assimilation.

Through this method, the student is involved in the process of teaching the course, he is in the position to make decisions and so, the information becomes structured, highlighting an interactive discussion between student and teacher.

Section 2 of the paper summarizes some related work about the components of our interactive system. In the section 3 is presented the specific ontology and in the section 4 this ontology was applied on a course. Section 5 details the practical use of the Moodle plug-in. Section 6 contains the results of the voting system applied on a course and section 7 presents some conclusions of our work.

2. RELATED WORK

The concept of being able to make decisions about the course of an event was first set out in a series of books written by Paul Granger and published between 1979 and 1998 called "Choose your own adventure". The stories are created in such way that the protagonist is confronted with several options and these lead to other options and to several possible endings.

The improvement and innovations of teaching activities in higher education are important topics, as we also can see in [1, 2] and so on. Many universities and educational institutions have adopted the Moodle educational platform (Modular Object-Oriented Dynamic Learning Environment) which leads to a better organization of courses, with integrated modules for tests and grades. This e-Learning platform is constantly changing and adapting through the ability to create plugins and integrate them. Within the University Politehnica of Bucharest, the Moodle platform has been used for few years to publish educational content, to facilitate the communication between teachers and students and to evaluate students' work. The use of this platform is a real success and has become a standard of good practice [3]. The Moodle platform is extremely flexible in use and has extremely varied functionalities that allow the implementation of advanced applications, such as game learning or gamification, as highlighted in [4, 5] and [6]. The students' opinion about the platform is excellent, and the teachers consider it an important help. A lot of specialized articles such as [7] presented positive reviews about Moodle Platform.

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Other e-Learning applications are: Nearpod, in which teachers can stream live, present the course, open a test after introducing certain notions or create games; Webex, Zoom, Skype, Discord or Microsoft Teams, offer the possibility to attend online meetings or courses, to be able to display the screen or to participate in webinars. They maintain a link between students and teachers and ensure the transmission of the necessary information.

This demonstrates the importance of the technology in the daily life of every student and the impact that an application can have on communication. Existing e-Learning applications offer a certain level of interaction between students and teachers, a better understanding of the notions but did not bring the decision-making issue, a voting system and a presentation system adapted to this system. Poll Everywhere [8] is a voting system. As a teacher, a question is set on the web interface or mobile app. Students can see it on their computer, tablet, or mobile phone. Questions can be polls, but also open questions. Students can respond using the web app, a text message via the phone app, or even on Twitter.

The application of ontological technology in education offers powerful benefits and changes the current education mode. An ontology benefits from a wide variety of applications, especially in the field of virtual education, so the objective of implementing the interactive course model is achieved [9]. Curriculum management and development can be improved using ontologies in curriculum tasks like aligning, comparing, and matching between universities, educational systems or relevant disciplines. Any user can benefit from concepts and entities that play an important role in a particular curriculum aimed at teaching and learning in an academic environment. In [10] they presented four learning ontologies, Curriculum Ontology, Syllabus Ontology, Subject Ontology, and Resource Ontology. In their perspective a curriculum is composed of a list of courses which are scheduled for an education period. A course can be defined as a set of syllabuses, teaching and learning activities, lecture materials, assessment, and so on. A course includes various important information instructor, learning objective, assignment, policy, teaching schedule, and so on.

3. THE SPECIFIC ONTOLOGY

The ontology of this interactive system exposes a new method the student is involved in the process of the teaching of the course or laboratory. As we mentioned the course is structured in such a way that the students can make decisions about its development, receive additional explanations related to certain topics, receive information relevant to his preferences or in other words to actively participate.

The methodology presented in [11] presents the organization of the content of an accredited course or of an educational material. This refers to the technical support that can be created for the content of a laboratory for students and contains certain elements also found in the ontology presented in the paper.

Ontology is used for the management of the notions taught in it, but also for organizing a course in which the fundamental elements and concepts related to the general context of a subject are approached. It can be reused because it contains definitions, acronyms and references.

The approach was useful for a structuring of the content covering the full field of study. Users are students and

teachers and they benefit from support for the laboratory and the course.

In the ontology implemented in Protégé (Fig.1), we have stored the information relevant to the description and development of some courses. Each course is characterized by certain standard classes, such as: *duration, evaluation, field of study, teacher.* They are relevant to the concepts and methods implemented and they follow the objective of the didactic ontology, which is oriented towards pedagogical aspects.

The course can be of two types, an *interactive* course or a *non-interactive* course. This fact is established after the first decision of the students. The interactive course is based on a voting system that contains the options, the questions addressed to the students and the slides that follow depending on the decisions taken.

The course is also defined by *notions, learning goals, scientific background* that refers to the knowledge that a student must have to understand the notions presented. The notions are structured in: *fundamental notions, secondary notions, optional notions, open problems* and *examples,* as we presented in [12].
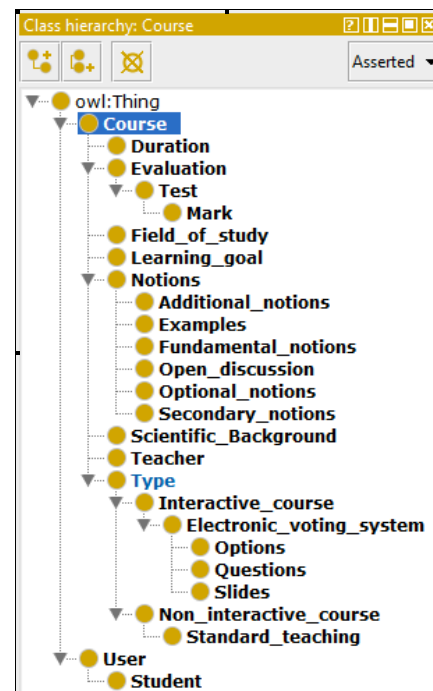

Fig. 1– The ontology classes.

The *Email, First name, Last name* classes belong to the *User* class. The *Learning goals* and *Fields of study* properties refer to the subclasses bearing their names. The *Duration hours* property is expressed in hours and belongs to the class and *Votes Number* is a property dedicated to the voting system. Questions have properties that contain current status references by identifying the current slide, the next slides, and also the past slides. They help to locate the current state of the course and scroll through the slide-based structure more easily. Depending on the options chosen by the students we jump to a particular slide, having already declared all possible slides that follow according to the current question. Questions also have options for answers that vary depending on the question and their number.

We may say that Table 1 describes several situations. A course lasts a certain period of time. Electronic voting system involves questions, voting options and slides. The

student is rated by a grade. The student has certain information to understand the concepts presented in the course. The course contains notions. The student is studying a course. The teacher teaches a course.

Table 1

Some Course object properties/Domains/Ranges

Course Object property	Domain	Ranges
Lasts	Interactive course/ Non interactive course	Duration
Implies	Electronic Voting System	Slides/ Questions/Options
Grading	Student	Mark
Has	Student	Scientific background
Contains	Interactive course/ Non interactive course	Notions
Study	Student	Interactive course/ Non interactive course
Teach	Teacher	Interactive course/ Non interactive course

We may say that the table above describe some situations. A course lasts a certain period of time. Electronic voting system involves questions, voting options and slides. The student is rated by a grade. The student has certain information to understand the concepts presented in the course. The course contains notions. The student is studying a course. The teacher teaches a course.

The integration of the course is achieved by filling the instances with the values of the existing concepts in the ontology and the questions are oriented towards secondary concepts, additional and examples, because the fundamental concepts are followed without allowing students to decide on them. The main constraint of the ontology is that information on questions and their answers must be entered manually.

The teacher does not have to have knowledge in the field of ontology because the structure is very easy to understand and the course easy to integrate. It must manually enter in the Individuals section certain information relating to the course to be taken in an interactive manner. Finnally, the users of the interactive system will have the opportunity to resume all the questions and change the answers to complete all variants of the course.

4. APPLYING THE ONTOLOGY ON A COURSE

As we specified, the current e-learning tools bring great advantages in the educational process, but even in this way there are some situations that can cause learning problems for the students. These are the large amount of information and the rapid pace of the presentation. In this case, the teacher has to decide to sacrifice certain transmitted knowledge in favor of a better level of understanding. This option to "choose your own learning path" allows students to choose information of greater interest and of greater importance and allows them to make useful connections with the knowledge they already have.

The implementation of the proposed solution was done in

the "Microprocessor Systems" course from year 3 of the Faculty of Automatic Control and Computers Science, System Engineering specialization. We have analyzed the concepts of a section of this course, we created the questions and depending on the students' decision they will choose the next slide to be covered. The time it takes to display each question is about one minute, the time they must vote.

Each category contains the presentation time for all the elements, in order to appreciate the total probable duration of the exposure.

The methodology was applied on the "Pipeline Microprocessors" section of the "Microprocessor Systems" course. The presentation time was 150 minutes. The elements of the presentation were cataloged as presented in Table 2.

Table 2

The questions from the "Pipeline Microprocessors" presentation

		Category	Duration
1.	Pipeline Microarchitecture	Fundamental	10 minutes
2.	Exploiting parallelism at the instructional level	Secondary	10 minutes
3.	Execution time for a program	Example	10 minutes
4.	Hazard situations in execution	Fundamental	10 minutes
5.	Structural Hazard	Secondary	5 minutes
6.	Data Hazard	Secondary	5 minutes
7.	Solutions and Examples	Example	5 minutes
8.	Tomasulo Method	Example	10 minutes
9.	Scoreboard Method	Example	10 minutes
10.	Control Hazard	Secondary	5 minutes
11.	Branch prediction	Example	10 minutes
12.	Multiple prefetching	Example	5 minutes
13.	Superpipeline, superscalar, VLIW architectures	Complementary	10 minutes
14.	Intel x86 family pipeline microarchitecture	Fundamental	10 minutes
15.	Intel Pentium I (P5) microprocessor	Secondary	10 minutes
16.	Intel Pentium II & Pro (P6) microprocessor	Secondary	10 minutes
17.	Out-of-Order execution architectures	Fundamental	10 minutes
18.	Registers Alias	Secondary	5 minutes
19.	Microcode Instruction Sequencer	Secondary	5 minutes
20.	Intel Netburst Microarhitecture	Example	10 minutes
21.	Intel Core Microarhitecture	Example	10 minutes
22.	EPIC: Intel Itanium	Open	10 minutes

The total duration of the inventory items sums 185 minutes, which is more than the available time. In order to solve this, students are invited to make two types of decisions: choosing one certain topic from several and either discussing a topic or not. The deployment diagram used in the presentation is shown in Fig. 2.

The chart contains nine decisions; each decision question gives a different course to the presentation. For example, decision question (3) allows students to choose between the detailed presentation of Data Hazard or Control Hazard. In this way, the students can direct the discussion depending on their own decisions. The dynamism of the method and the engagement of the students in the discussion compensates for certain omissions in the curriculum of the subject. All the information omitted will be searched and assimilated by the students after, if the discussion has woken up their interest.
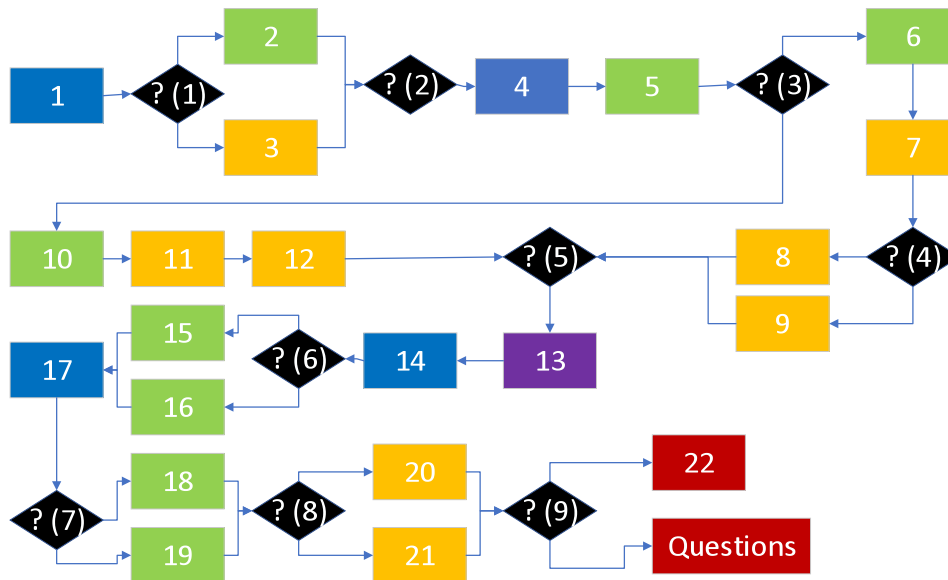
Fig. 2 – Choose your own technical adventure diagram for the presentation of " Pipeline Microprocessors".

5. DETAILING THE PRACTICAL USE OF THE MOODLE PLUGIN

A plugin is a structure that allows you to add new features to Moodle, such as new tasks, new types of test questions, different types of reports, or integrations with other systems. The type of plugin described is an activity module which is the most predominant type within Moodle modules.

The main feature of the plugin refers to the interaction between teacher and student. Thus, its most important functionality is to allow students to vote and to choose between at least two options, to answer different questions asked during the course. The details of the steps for the interaction between teacher and student through the Moodle plugin are as follows:

Step 1. *Installation and configuration of the plugin for the desired course.*

In order to use the plugin, it must be installed on the desired Moodle instance. The installation can only be done by an administrator, in the same way as any standard Moodle plugin is installed, namely from the court administration settings, the plugins installation section, where an archive will be replaced, .zip containing a directory with all the files in the module architecture. Once installed, it can be added by teachers in any course. By activating the edit mode, it can select it from the list of available plugins. Immediately after the addition, a configuration page of an activity module will be loaded, which will be loaded just like any other activity module. Here the name of the court will be added and, if you want to add questions manually, the Questions section will be extended, where the names of the questions and the answer options for each of them will be entered.

The plugin can be added to any course, in any section. It can also connect to the Moodle internal database and is derived from a Basic Moodle activity module, providing the basic functionalities inherited from it.

The only preparation for defining an interactive course within this plugin is the creation of a course that is, in itself, interactive, and which can be taken in several ways, defining the questions in the presentation that influence the change of direction of travel and branching the linear course and completing the slide ranges corresponding to each option, using intuitive dedicated graphical interface.

Step 2. *The teacher uploads the course material / course presentation and associates the decision information for the students.*

The course administrator can add intervals or questions using text files generated from ontology or manually. Specialized functions have been developed and used to extract information from ontology for later use in the plugin.

When a new instance of the plugin is created by the teacher, a new entry is created in the database with a unique ID associated with it. Thus, a new voting system is created. To add the appropriate questions, the teacher must choose between two ways: manually inserting them from the course configuration page, along with the possible options for each of them or by adding a special text file

Step 3. *The interactive presentation – it consists in the cyclical resumption of the following activities:*

   a) presentation,

   b) student vote,

Students can vote from any device that can connect to the Moodle interface. The teacher can also set a time frame for students to fall in order to have a valid vote.

Teacher can add with this module is the presence of a timer that can be set according to the start of the course and which shows the time remaining until its completion, so that he can make a decision about the speed of the course. The timer is updated every second and is not influenced by updating the page or changing the slide. It can also be reset if a reason for this action arises.

The module can only be accessed by persons with an active session on Moodle if they are connected with their own login data, and it does not allow multiple accesses by the same person simultaneously.

If the voting system is started by the teacher, then students can vote. When they choose one of the options, an insert is made in the database that contains information about the ID of the student who voted and the option they chose, so that, later, this information can be used in the decision of a winning option. If the voting system is not activated, students cannot vote.

   c) establishing the new information to be presented by

evaluating the result of the vote.

An important feature of the plugin implemented is displaying the current slide within the presentation, and automatic slide jumps corresponding to most student responses. This functionality avoids the problem of manual selection of the slide corresponding to student votes and replaces it at the touch of a button, the internal logic being automated behind the graphical interface. Also, if you can go forward along the course, there will also need to be the return functionality to the previous slide.

The goals to be achieved after using this plugin in a specific course are: increasing the notions retained by students during the course; increasing students' interest in certain topics; strengthening the desire to participate in the course for their own reasons, and not just for attendance.

The specific objectives of the plugin include: to have a minimal interface that complies with the graphical standards imposed by Moodle; to have constant charging times lasting no more than 3–5 seconds; to define control sections accessible only to the privileged users.

To check the time left by the teacher until the end of the class, we used a list of options where the teacher can choose an interval between one minute and three hours, equivalent to the real time left until the end of the class, which after pressing the start button of the timer, will be saved as a Unix time slot in a file in the directory named after the plugin instance. Specifically, the Unix time interval for the current time, at which the teacher-selected interval is added, will be saved. At the same time, there is the option to reset the timer, which can be used for various reasons or if the wrong range is selected.
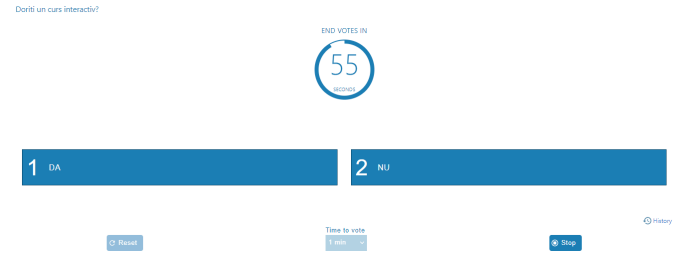

Fig. 3. – Active session of the voting system, with time for voting.

6. THE RESULTS

In [13,14] are highlighted the advantages of the interactive educational system that contains a voting method (Fig. 3). In practice, the implementation proved a major increase of the interest in the subject presented by the better results obtained at tests and by the feedback provided at the end of the semester.

The methodology was tested in May 2020. The comparison has been made between the test results and the students' feedback and those of 2019 and 2018, which were handed by the students in a classic way.

The route chosen by the student vote is presented in Fig. 4. The presentation lasted, according to the Table 2, 120 minutes. The vote consisted of nine decision rounds, each round lasting 1 minute. The issue opened at the end of the presentation generated debates that occupied the last 20 minutes of the meeting and a bit of a pause between courses.
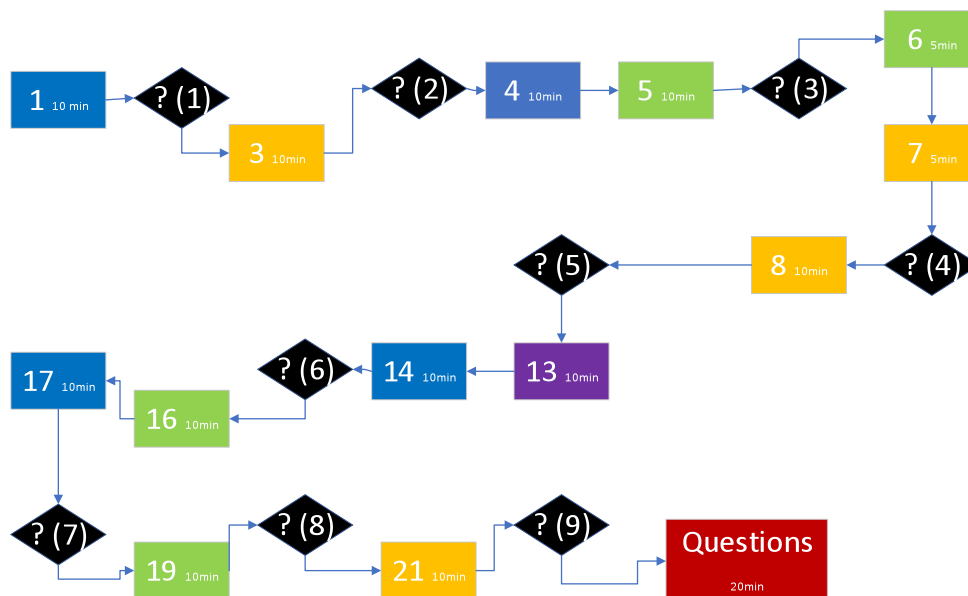

Fig. 4 – The route chosen by the students votes.

At the final test, out of 110 students attending the exam, 80% correctly answered the question referring to pipeline microprocessor. A year ago, in 2019, only 70 % succeeded to answer the same question, and in 2018 only 67 %. Despite the fact that the students from this year were presented only some of the information required for the exam, they managed to answer correctly in a larger proportion than in previous years.

In the feedback offered at the end of the semester by the students on the Moodle platform, at the "Microprocessor Systems" course, the following elements were found:
• At the question: "Was the exposure method appropriate?", 60 % of the students answered: "Completely agree". In 2019 only 44 % answered this, and in 2018 only 40 %.
• At the question "Did the course stimulate discussions and did the teacher clearly answer student questions?" students answered 65 % "Completely agree", in 2019 where only 45 % gave the same answer and in 2018 only 39 %.
• In the section "What are the positive aspects of this discipline?", section with a free answer, this year there were appreciations of the type "presentation of the course was interesting and it focused on specific

concepts", "the course was easy to follow and to understand", "the presentation was not boring".

7. CONCLUSIONS

This paper aims to present an interactive system, that have a component, an e-learning module, based on a specific methodology, which uses an ontology created specifically for this purpose, in which students vote in real time (during the course, by electronic voting), the level of detail for each section of the presentation and which example cases are relevant or not to them. In this way, a high level of student involvement is maintained during the course, and the information is provided interactively to the participants. The electronic voting of the students was done through a plugin of the Moodle platform and it dictated the course of the oral presentation of the teacher.

The module intended to eliminate the stress generated by a busy and complicated curriculum that harms the passion for learning of the students. The feeling that the choice of the topic of interest keeps students motivated to learn further. Although, this plugin has more complex elements related to the organization of course presentations itself, it introduced an element of quality and interactivity.

The main objective of the developed plugin was to improve the interaction between teacher and students by giving students the choice to vote and decide the topics they are interested in during class hours. On the other hand, the teacher, indeed, although he will devote more time to the eventual restructuring of the presentation of a particular course in order to be able to give the feeling of a "choose your own path" story, in the end, the effort led to a much more interesting presentation that contained a unique element of interactivity, which increased the interest of students and motivated them to get involved in order to influence the fate of the course , at first, in the form of a game, and, in the future, under the desire to learn and develop a real interest in certain subjects that students are interested in.

This paper proposed a solution that eases the teacher's effort, allowing students to decide which of the concepts are interesting to them and which they want to explore in the time available.

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