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Intelligent System Content for learning Object Oriented Programming

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Abstract: This article approaches an existent problem related to the teaching of Object Oriented Programming. The use of Intelligent Tutors Systems with different techniques of artificial intelligence and their application for Teaching Object Oriented Programming is analysed. This author shows in the article a proposal of Intelligent System Content computer tool, which offers support to the extraction and data analysis of students´ interactions with this tool in the teaching learning process. In order to achieve this objective, the types of intelligence preponderant in each case are considered, it allows this author to achieve personalized solutions. The results show a positive impact on problem solving, which improves the learning process.

Keywords: Intelligent tutor system, learning, multiple intelligences, Object Oriented Programming.

I. INTRODUCTION

The design topics and Object Oriented Programming (OOP) are aimed at preparing students so that, knowing the general fundamentals and evolution of programming languages, students should model problems using the object-oriented paradigm, make programs using some languages that support it and others hybrids that combine them with aspect orientation and Logic Programming. Thus, students should know the fundamentals, evolution and characteristics of OOP languages, their possibilities and limitations, essential features, functional and logical principles, as well as data structures, cohesion techniques, coupling, encapsulation, heredity and polymorphism, using the defined data structures.

A previous research was analysed showing a need to achieve a sufficient students' motivation towards the subject OOP [1]. The OOP should have a diachronic approach, based on procedural programming. This approach begins with the exposition of each language construction as an evolution of another previously known, overcoming some of its limitations. As a guiding thread of the exposition, recurrent concepts are used that lay on any particular paradigm mechanism [2].

Some researchers [3], agree that learning a given language is not always easy to embrace, syntax and semantics are specific to each language, as well as the programming logic of each paradigm. Kinsumba, Becerra and Lau [4] identified a set of important factors for passing Programming subject.

According to Beltrán, Sánchez and Rico [5] different weaknesses are constantly identified in the OOP application. On the other hand, Olier [6] identifies: lack of interest, a poor OOP understanding concepts, poor stated problems understanding, and poor structures identification to be used in an efficient statement solution, poor memorization or assimilation in language syntax programming.

Based on previous statements, the main objective of this article research is to elaborate a design and evaluation of the Intelligent System Content tool to strengthen the concepts of OOP supported by the theory of multiple intelligences [7]. The validation of the used tool was done by means of a pre-test and a post-test applied to two groups: controlled and experimental. The results demonstrate that the experimental group registers higher levels of association related to OOP concepts.

II. LITERATURE REVIEW

The consulted bibliography allowed the researcher to identify researches describing a successful Intelligent Tutoring Systems (ITS) application in different knowledge skills were identified. An important improvements in students learning are described using this tool being this one better than other kind of systems used to support the teaching-learning process [6] [8] [9] [10] [11] [12] [13]. The main reasons of these positive results are the precise selection of the pedagogical method, guidance towards problem solutions and students´ feedback received during the activities [14] [15]. It´s important to high light a direct relationship between the right selection of the pedagogical method and these students´ improvements [16] [17].
There have been developed in teaching programming ITS as Lisp Tutor [18], ELMART [19], SQLT-Web [20], HESEI [21] and APA-Prolog [22]. These mentioned authors have stated solid results where it´s proved the effectiveness

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achieved in the learning process. In contrast to this effectiveness, it is good to say, from studied systems only SQLT-Web has been used extensively in real-world environments and the rest only in laboratory tests with students in conditions that can be considered controlled [23] [24].
In several works [25] [26] [27] [28] [29] is given to student support in learning by means of different activities from theoretical elements. However, this current research is involved in solving theoretical and practical problems through the use of IM. Emphasis is placed on the approaches used to integrate OOP concepts and methods, which allow the students to work on their mistakes. Among this scope were found works that aim to apply the programming in languages that belong to OOP paradigm [30] [31]. This paradigm can make easier the process, to follow goals and recognize strategies [32] [30].

III. METHODOLOGY

A. Initial Diagnosis

As a starting point before the elaboration of ITS, it was done a diagnose by 27 experts criteria (university professor) in order to diagnose the current state in this field. The following techniques were applied: surveys, in-depth interviews, focus groups and partaker observation. Surveys were applied to 27 university teachers related to this subject. Two-thirds of the polled refer the non-use of ITS due to lack of knowledge, little importance attributed to them or to consider them bothersome, although all of them recognize the convenience of their institutions assuming it, as long as it is feasible and easy updated, facing technological obsolescence processes.

Thus, a first dimension was identified concerning the need to develop a model ITS inside its components favouring technological, methodological and pedagogical factors to strengthen the management of knowledge regarding the programming subject and to improve the guidance in problem solutions.

On the other hand, polled high light the need to achieve a collaborative management of the educational resources that take part in the ITS (simulators, emulators, thematic directories, forums, communication through social networks), because it favours the exchange of experiences among students, adapting them more flexibility to their profiles and encouraging critical thinking.

Analysing the interface, it was determined that the most frequently functions selected to guarantee the content adaptability are: applying test to students, add content in a weighted way done by system, continuous monitoring in the solution of activities, featuring from databases, attachment of evaluators and methods for co-operative solution.

Considering the adaptability of ITS, the surveyed underline the need of a strategy according to those weakness aspects found in students, as well as to their progress and suggestions related to contents presentation. This second dimension was called functionalities in an ITS to guarantee the adaptability of content and guidance in solving problems.

The data obtained in the results of the surveys and focus groups showed different criteria as to what indicators should be taken into account in assessing the adaptability of ITS towards different student profiles, through methodologies and evaluation tools. Likewise, the focus group developed it was highlighted the need to incorporate different analytics from those existing in Moodle in its deployed versions, based on the users' experiences, the intelligence traces and the administrators performance.

Other results were also obtained that combined participation is deficient in resolving activities and learning content through ITS, almost half of the surveyed subjects said that it was never achieved and the rest of them just a little. This was the third important dimension to take into account, the collaboration, communication and exchange of knowledge among students who use ITS, where all agree on the necessity of ITS that makes combined elaboration possible.

B. Description of the Intelligent System Content tool

The tool was named ISCO (Intelligent System Content) and was developed as an instantiation of OOPMAC model [33] and it is an alternative to the insufficiencies in the teaching of Object Oriented Programming. It provides functionalities to support the teaching-learning process, some of them using artificial intelligence techniques.

The ISCO tool is an application developed in JAVA language with a three layer architecture (Data Layer, Business and Interface) which provides some advantages such as robustness due to encapsulation, easy of maintenance, support and flexibility, as well as high scalability.
The applied layered architectural style guarantees a logical separation between functions of a different nature. This makes it easier to protect the integrity of the components against external changes, with three well-defined layers: presentation, business and access to data.

In the ISCO tool Artificial Intelligence techniques are integrated in parallel with the changes in teaching methods and even in the way of conceiving the learning and teaching proposed by the theory of multiple intelligences. The student

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himself takes control of the learning process, the materials and resources, adapting them to their requirements and possibilities.

The ISCO tool can be used in a wide range of domains and it contains a set of inter-related components. In the presentation page, the mask administrator Thymeleaf and the jQuery and Bootstrap libraries were used. Thymeleaf, jQuery and Bootstrap assists the division of responsibilities in the presentation through a Model-View-Controller (MVC) pattern, jQuery provides plugins to handle the status of UI components, handling events in the browser and the server, validations, definition of surfing patterns and support for locating and world spread. Bootstrap provides a number of styles and components that allow students to reduce layout time and improve design quality.

In the business layer, Spring Framework [34] was used, which provides a programming and configuration model for applications in the Java EE platform, regardless of the way it is deployed. It works as a control inversion box, dependency injection is support and feature oriented programming (AOP). This framework is designed to reduce development times by allowing developers to focus on logic by delegating the necessary mechanism to integrate application components.

The application provides a REST API to handle all the information that is used from the user interface through AJAX requests. This approach allows a modern user experience and, which makes it easier to add other clients (mobile applications, web, desktop, etc.).

The data access layer works as an abstraction level between the domain model and the data sources used by the application. The Hibernate ORM [35] tool was used for object-relational mapping rather than declarative configurations and the use of the API provides the persistence of data that survives during the implementation of the program. As a data source, a relational database was used with the PostgreSQL database manager system version 9.1. As web server and Servlets box, Apache Tomcat was used in version 8.5.2.

For the organization of the system in logical components, the OOPMAC conceptual model was transposed (Machín, 2017a). Four modules were defined: Pedagogical Services, Dynamic Student, Interactive Learning and Artificial Intelligence. The characteristics and functioning of the modules are beyond the scope of this article and about them it is deepened on their works [33] [36].

The Dynamic Student module is composed of two differentiated blocks, one that models the issues that have little variation over time (IM and learning preferences) and another that reflects the dynamic characteristics (student's knowledge situation), which are updated Constantly because it depends on students´ interaction during the course or Interactive Learning Module.

In order to achieve the identification of the intelligences the IM test proposed by [7] is used for the classification by learning styles the test proposed by Felder is covered [33], in both cases the previously defined rules are applied, and the system indicates the inference result, showing the classification.

The Interactive Learning module is composed by the Learning Path that is defined by the Pedagogical Services Module. This learning path holds the LOM (Learning Object Metadata) and the sequencing to be applied in the didactic unit. So, it must be conceived in a series of tasks (activities, workshops, resources, practices, etc.) that are designed and conditioned by the course which is offered to the student through a user interface, adapted to their characteristics, thanks to the data provided by the Dynamic Student Module.

The students interactions with the tasks in the interface produces an amount of information, where this interaction is stored (log files) as well as the results of the task accomplishment, when comparing the answers or actions of the student and those from the Module Pedagogical Services defined in the course.

The analysis of this information (log files and results) using data mining techniques provides the progress of the student, which can be take it apart into results or achievements that will move the students' motivation and the current knowledge level or current learning acquired.

The Pedagogical Services Module codifies teaching methods that are appropriate for the objective field and student. It is the implementation engine from the adaptive system. Initially the pedagogical method is most appropriate (which responds to the question how to teach?) due to the data provided by the Dynamic Student Module (IM and learning style). One of the most relevant functions in the Pedagogical Services Module is to select the most appropriate educational intervention. This is done by comparing the Dynamic Student Module with the expected results of the Interactive Learning Module (Course), the different points of view observed are pointed to the Pedagogical Services Module that takes a corrective action according to a set of possible alternatives to guide the student in the problems solution.

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The Artificial Intelligence Module provides the data mining techniques to use and uses the Weka tool to perform the mining tasks. The objective of this module is to integrate data mining techniques applicable to the ISCO tool to improve content assimilation, knowledge management and problem solving orientation. The inputs to the module are defined by the records generated by the Dynamic Student module, the Pedagogical Services Module and the Interactive Learning Module, while the outputs are the reports showed by the student's behaviour during the course.

The User Interface Module allows communication between user and system to be established.

The main administration interface allows including new resources, and the management of the existing ones as it is shown in figure 1.

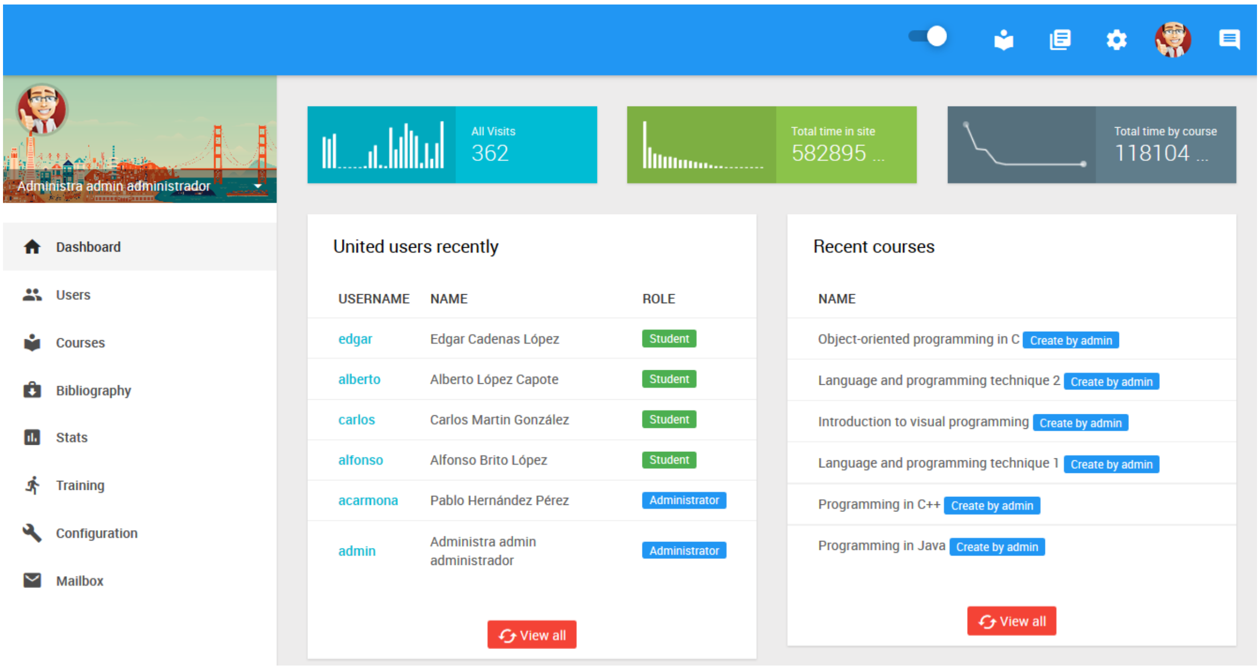

Fig. 1 Main administration interface of ISCO tool. Source: own elaboration.

Figure 2 shows the analysis of intelligence corresponding to each student based on concepts learned, which details the implemented algorithms, which allows the learning trajectory visualization.

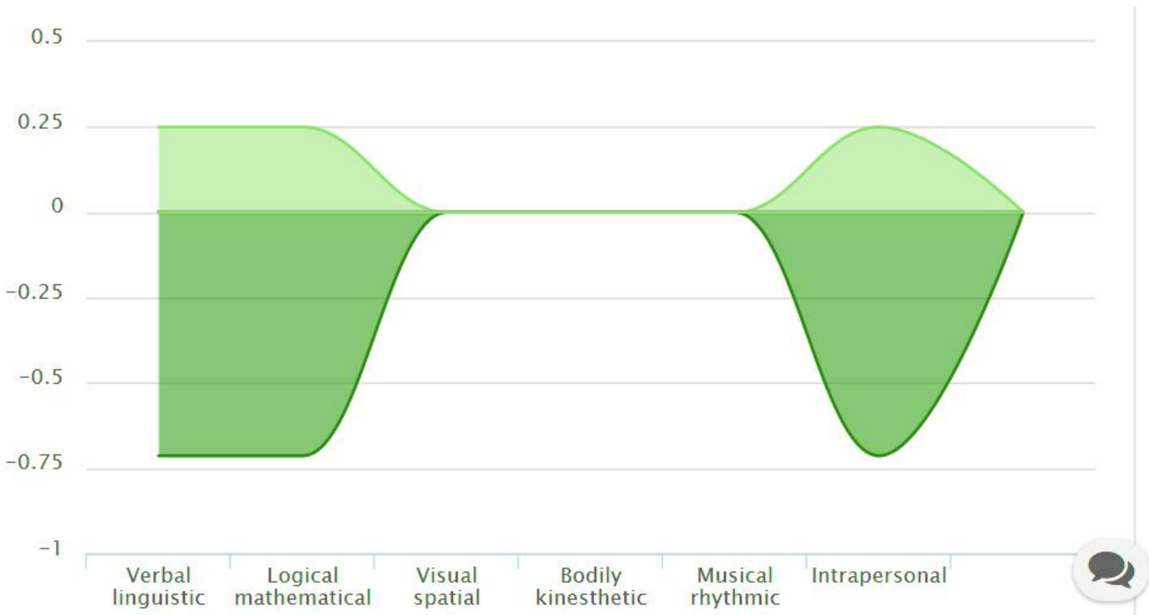

Fig. 2 Analysis of multiple intelligences during work sessions for each student. Source: own elaboration.

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The way in which users and services are managed is shown in figure 3.

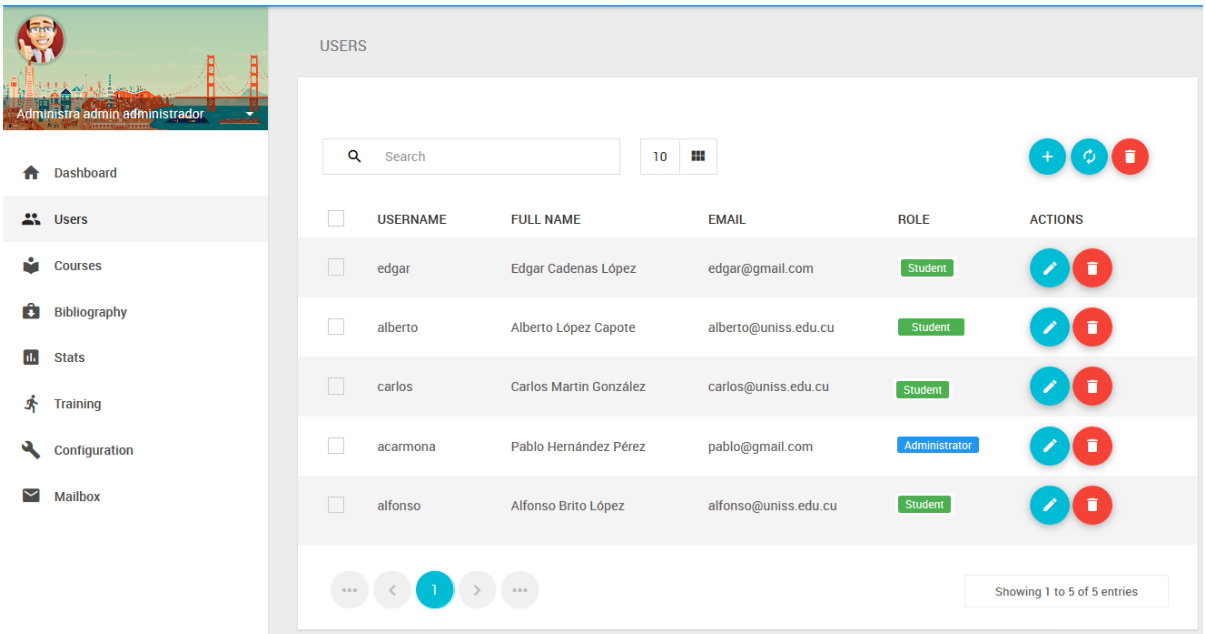

Fig. 3 User and Service Management. Source: own elaboration.

On the other hand, Figure 4 shows the main interface referring to the courses where the user can be registered taking into account his preference.

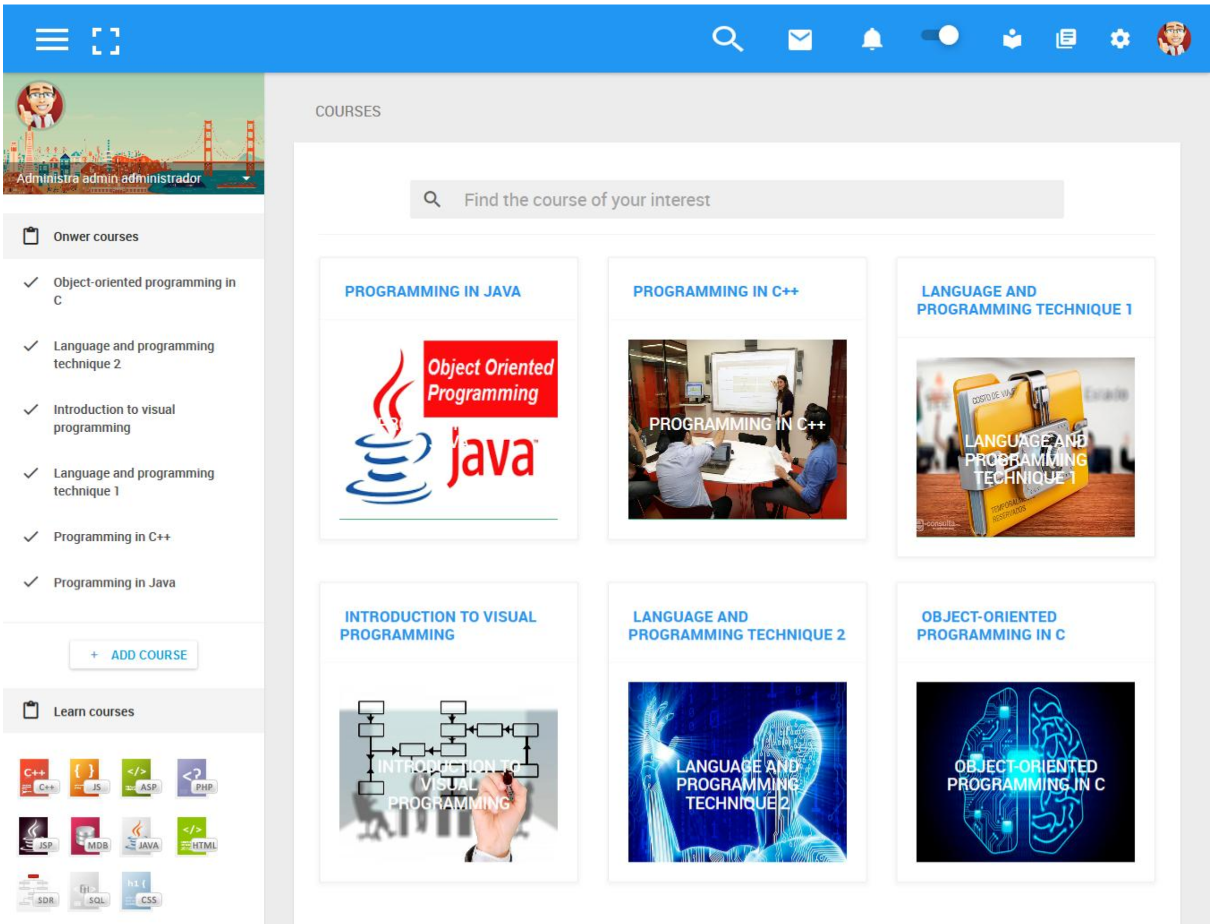

Fig. 4 Interface of the courses. Source: own elaboration.

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Figure 5 shows the interface of handler class version corresponding to one of the courses that are available in the proposed tool.

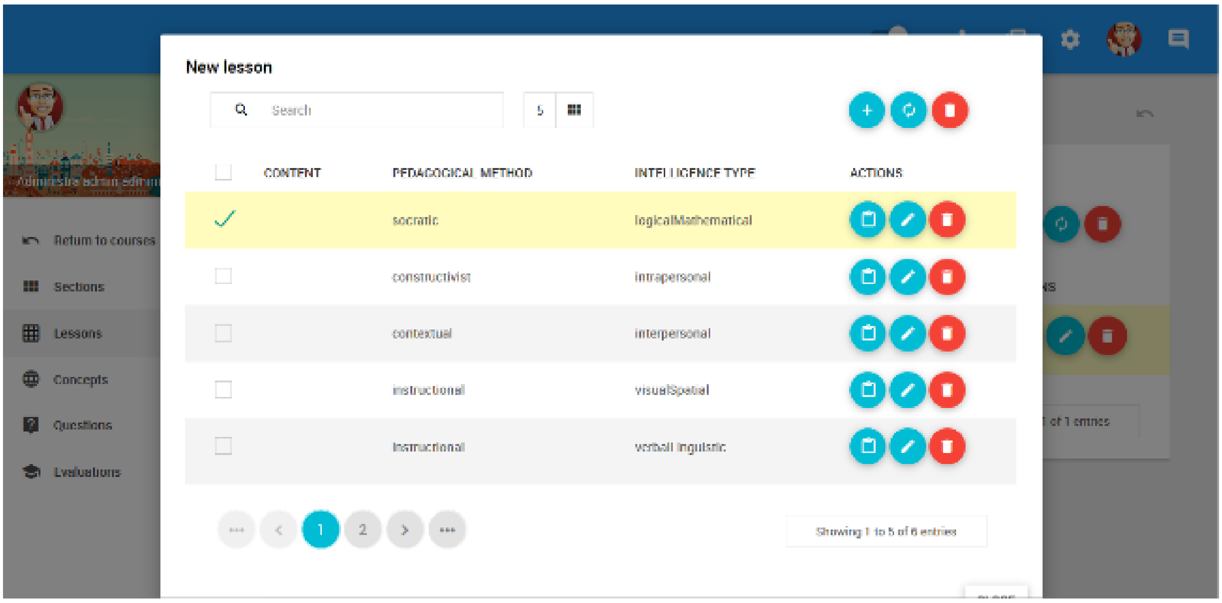

Fig. 5 Class handler interface. Source: own elaboration.

C. Evaluation of the ISCO tool

With the objective of evaluating the effectiveness in the selection of the pedagogical method that is created with the ISCO tool, the same was validated by the experimental method. An experiment was carried out on 54 students belonging to the Computer Engineering career of the Computer Engineering course. Two groups were formed, 27 students as an experimental group and a control group of 27 students who finished the first period in the subject "Programming".

At the beginning of the study, an activity was carried out where the surveyed were explained how to use the tool and other exercises were jointly developed to test their understanding from the implemented functionalities in the exercise. The objective was to verify how the variable quantity of necessary attempts is affected, to solve a problem when receiving the instruction through a proposed tutor module. The usefulness in selecting the pedagogical method was measured according to the attempts required to reach the correct solution of the exercise.

During 10 days students from both groups, formed by a random way, students faced one exercise per day, the same for each group. For the experimental group (EG) was applied the described tool. For the control group (CG) the selection of the pedagogical method was given from static analysis information.

IV. RESULTS

Among the results achieved is an initial version of the tool ISCO to improve the content assimilation in the programming and validation of its use. In total, 2059 solutions were sent, resulting in 48.27% (994) are correct solutions. From the 994 problems solved, 442 did so on their first attempt.

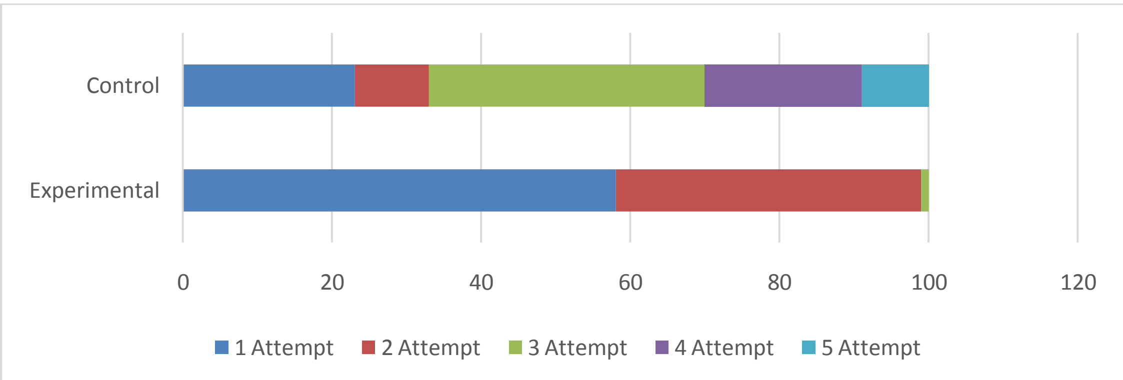

Fig.5 Proportion of cases according to number of repetitions to achieve the correct answer in the first testing

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When comparing the results of the experimental group with the control group, it was observed that cases proportions with fewer repetitions (one or two) to reach the correct solution were higher in the experimental group than in the control group. Figure 3.10 shows the proportion of students in each category in the first testing.

The differences found between the experimental group and the control group in these two testing were statistically significant (at the $p < 0.05$ level) when applying the comparison test in samples proportions from binomial distributions, so the hypothesis could be rejected Null with high levels of confidence.

It is appreciated almost all of the cases in this group achieved the correct solution on the first or second attempt, except for the 1% that succeeded in the third.

V. CONCLUSION

The diagnosis process in the ITS as a reference for the OOP teaching focuses on identifying the elements that take part and the techniques used, which is an important element to consider.

The ISCO tool that is proposed does not break definitively with the classic structure, but uses multiple intelligences, joined with artificial intelligence techniques, which provides student personalized teaching, flexibility and adaptation to new domains.
The results of the experiment show the developed ISCO tool favors problem solving, and helps to enhance the intelligence as well as the creative capacity of students.

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