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On-Line Tutorial Modules to Address Students to a Timely Adoption of an Appropriate Method for Studying Key Concepts of General Chemistry in an Undergraduate Course

Chiara Schettini[1], Silvia Zamponi[2], Rossana Galassi[3], Daniela Amendola[4]

Abstract

General and Inorganic Chemistry is one of the first year, first semester subjects for many academic degree courses. In addition to the basilar concepts and numerical calculation skills that students must learn, since early time they have to adopt and to take confidence with the chemistry own language which is based on the macro/micro relationships as well as on the symbolic method. The translation and the cross correlation of the general chemistry concepts in all the three languages is expensive in terms of time and commitment on the study, also because often needing of a refinement of the expressive skills of the first year students. In this context, seven customizable on-line tutorial modules on different topics were prepared and implemented in the UNICAM e-learning Moodle platform to guide students to understand a key concept such as the chemical reactions. Each module is structured using interactive tools of the e-learning environment with the following resources: an assignment related to the topic, the background knowledge needed, video of the experiment related to the assignment, submicroscopic view, overview of the resolution steps of the exercise, video tutorial on how to solve the assignment, self-evaluation multiple choice exercises and other materials, such as virtual labs, to support the learning process. The materials are in English with the additional aim to upgrade the knowledge of students coming with different high school backgrounds and from different countries. The results of the research are based on the analysis of the "learning analytics" derived by the Moodle platform (total time spent on the platform, students' preference for the materials, number of attempts in the tests, etc.) and of the questionnaires on the students' perception and satisfaction about the use of the resources, in order to understand the efficacy of the on-line tutorial actions.

Keywords: *General chemistry, Moodle, video tutorial, e-learning;*

1. Introduction

General and Inorganic Chemistry courses in Scientific degrees (Biology and Biotechnology, Geology and Natural Sciences) of the University of Camerino pose quite a few difficulties for students, in particular as regards the solution of exercises and stoichiometric problems.

The percentage of students showing unsatisfactory results in the intermediate and final tests administered in the last ten years was analyzed, both in terms of success but also on the regards of score. Synthetically, most students pass the exam within one academic year, but their analytical rational on chemistry themes is poor, due to a memory based method and superficial approach and to insufficient problem solving and critical thinking skills, affording unsatisfactory scores for a 50-60% of freshman students.

In addition to the insufficient time devoted to the acquisition of concepts and skills, the heterogenous preliminary preparation of students, coming from different countries and typology of Italian and foreign High Schools, makes it difficult to adapt the course content to their individual learning needs.

On this regard, a leveling course on the right approach to study and on minimum knowledge was designed and implemented according to the fact that video tutorials in University chemistry courses have already been experimented in different contexts, with satisfactory results, in terms of motivation and better achievements at the final tests when compared to a control group. [1]

The analysis of the "learning analytics" [2] derived from the Moodle platform (total time spent on the platform, students' preference for the materials, etc.) provides a first representation of students' use of the materials, that will be integrated by a questionnaire on the students' perception and satisfaction concerning the use of the resources.

[1] School of Science and Technology, Chemistry Division, University of Camerino, Italy
[2] School of Science and Technology, Chemistry Division, University of Camerino, Italy
[3] School of Science and Technology, Chemistry Division, University of Camerino, Italy
[4] School of Biosciences and Veterinary Medicine, University of Camerino, Italy

2. Method

2.1 Participants

The General and Inorganic chemistry course starts in the first year, first semester of the international degree courses. The students come from different countries and as a consequence they have an heterogeneous background preparation. 183 students of both degree courses (138 students of Biology and Biotechnology and 45 students of Geology and Natural Sciences) were enrolled on the platform and 108 of them (81 and 27, respectively) used it in preparation for the test.

2.2 Procedure

The procedure of the online tutoring course design was carried out following five steps: 1) identification of the most difficult topics dealt with in the first part of the General Chemistry course; 2) definition of the general structure of the tutoring course on the Moodle platform; 3) preparation of the seven modules (Net Ionic Equation for an Acid-Base Reaction, Mass Relation in Chemical Reaction, Oxidation-Reduction Reaction, Writing the Equation for a Precipitation Reaction, Theoretical and Percentation Yield, Recognizing the Common Types of Reactions); 4) opening of the platform to the students; 5) analysis and evaluation of the frequency data and visualization of the contents of the modules.

3. Discussion

The key strength of online tutoring is that students can choose timing and style of their learning and can focus on their individual difficulties.

In this study, video tutorials were not set up to learn new theoretical concepts or review what was taught in the classroom, but to improve students' skills in analyzing and solving stoichiometric problems. The material prepared is suitable for students with different entry levels, because it provides the acquisition of new concepts or their revision and a further enhancement of problem solving skills, depending on students' prior knowledge.

Video tutorials are part of a more complex and articulated structure (Module), where they are integrated with other materials, following Johnstone's model who, since 1991, underlined how the learning of chemical concepts requires the interlinked knowledge of the relationships between the three aspects, macro, sub-micro and representative [3].

Furthermore, a set of self- evaluation multiple choice exercises and problems provides students with an essential feedback on the skills acquired.

3.1 Structure of the course

The structure of each course includes three interactive Forums: a "News Forum" for general notices, a "Technical Forum" for technical problems and an "Interaction Forum with the course tutor and the professor ", for further clarifications on the topics of the modules or support for the solution of the exercises.

A "Prerequisites" section with reference materials on some preparatory material for the course (significant figures, units of measure, etc) have been added, as well as seven modules , whose structure is explained in detail below.

A final test regarding the topics of the course has been included on the platform, in six different versions, consisting of 24 multiple choice questions with a final grade equal to 30. The test was performed by the students on the same day, in the classroom, with mobile devices (mobile, tablet, laptop), and had a maximum duration of 75 minutes.

Finally, a survey questionnaire consisting of 37 questions and divided into 4 parts (Personal data, Behaviors, Opinions, Further comments), has been added to the platform, to test the students' perception of and satisfaction with the new tutoring module.

3.2 Structure of the module

The main purpose of the modules is to provide support for the solution of some stoichiometry exercises that the initial test identified as most challenging for the students.

The core of the module is a video tutorial, based on voice and handwriting, similar to traditional tutoring, targeting students with different entry levels of knowledge and skills.

Handwriting was accomplished by using a Wacom tablet. The videos have an average duration of 15 minutes and the file size is from 100 to 150 MB.

Within the videos, step-by-step explanations are being provided to show how exercises or problems can be solved, introducing principles and formulas of the symbolic/representative level. Video tutorials do not simply show the solution to the assigned exercise, but they integrate key information on the methods of analysis and solution of the different steps, as well as theoretical references. The goal is to make the student able to apply the same solution to similar cases, once they have mastered the required skills.
The videos are in English, the same language used in the in-class course, and are aimed at students of different nationalities who can also acquire, through listening, Chemistry specific language.
Following Johnstone's triangle, the module includes all three levels of representation in Chemistry; the macroscopic level is presented with a videoclip, which allows students to observe the experiment linked to the exercise and carried out in the laboratory, often supplied by graphics or animations that, instead, show its submicroscopic level.
Each module is enriched with a "Background knowledge" file which shows the prerequisites needed to solve the assignment, a file called "Overview of the exercise's resolution steps", summarizing the steps for the solution of the exercise, and a set of materials ("Other materials to support learning") of further help to understand the topics (interactive guides, tutorials, tables, etc.), usually found on the web.
Finally, an exercise consisting of ten multiple-choice items has been included, which allows students to apply what has been learned through the video tutorial and the other materials included in the module.

3. Conclusions

The analysis of the first data extracted from the Moodle platform: (*i*) total time spent in the e-learning environment and (*ii*) preferences in the use of different materials and tools, provides an interesting information about students' behavior in the use of the on-line tutorial modules.
In Figure 1 we report the total time spent by the students on the platform classified in different sequential ranges of hours. The result is that among the 108 students, 42 students have spent from 1 to 5 hours in the platform, while a satisfactory number of 48 students spent between 5 to 15 hours in the platform, which can be considered an appropriate average time to conduct all the activities described in this paper. Instead, 18 students, less than 20%, spent on-line more than 15 hours, which can be ascribed to experiencing difficulties of different possible origins in concluding the activities.

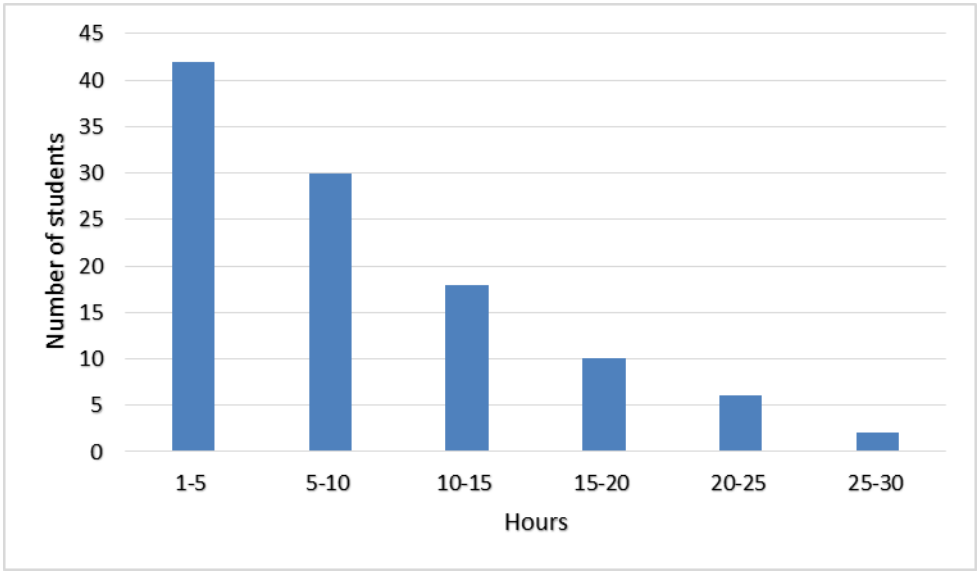

Figure 1. Number of students spending a range of hours in the platform.

In Figure 2 the total number of students who have done the different activities to complete the 7 modules of the course is reported, with the detail of the number of students doing a given activity per each module represented with a specific color code. Interestingly, the total number of activities realized in the different modules decreases considerably with the increasing number of the module. In

all the modules, the multiple choice questions has been the most used activity. With the exception of module 1, in the other modules the activity on the background materials and the video tutorial have been used by an almost equal and large enough number of students.

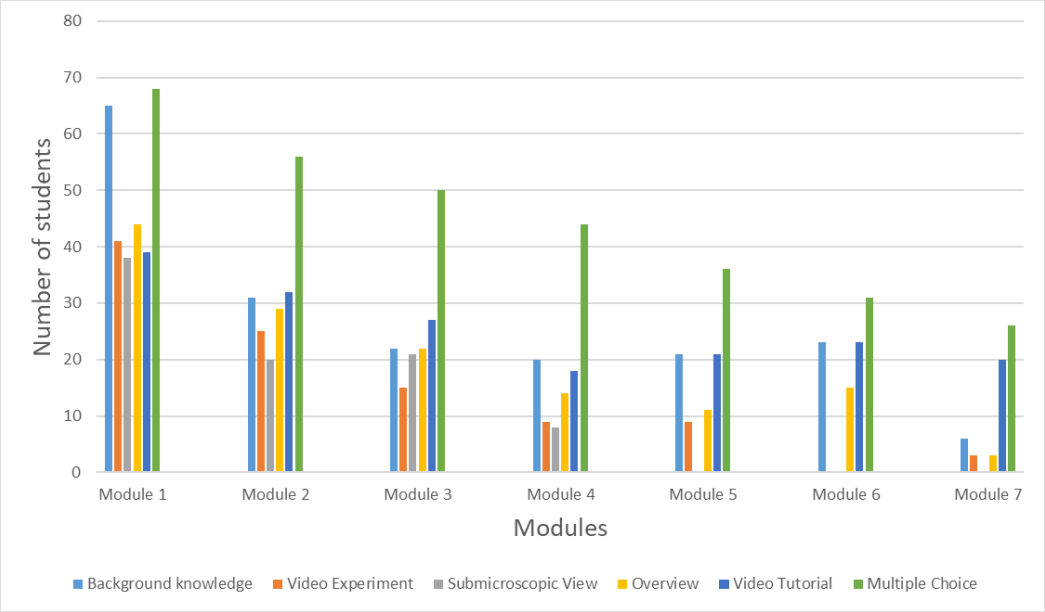

Figure 2. Number of students realizing the different activities in the seven Modules of the course.

The students clearly have the perception that these two activities contains the key elements and concepts to understand the contents of the modules. The other activities (video experiment, submicroscopic view, overview) are used almost uniformly by the students for modules from 1 to 4, while for the last modules, from 5 to 7, the usage of these activities does not indicate a regular behavior or a distribution from which meaningful information could be extracted.
Being optional the use of the resources and activities, designed in the Moodle platform, the analysis of the above data allows us to highlight the big interest of the students about the tutorial modules.

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