JOURNAL OF E-LEARNING AND KNOWLEDGE SOCIETY
Vol. 16, No. 02 (2020), pp. 61-72

A blended learning approach for general chemistry modules using a Moodle platform for first year academic students

Chiara Schettini[a], Daniela Amendola[b], Ido Borsini[c], Rossana Galassi[a1]

[a] *University of Camerino, School of Science and Technology, Chemistry Division – Camerino (Italy)*

[b] *Univeristy of Camerino, School of Biosciences and Veterinary Medicine – Camerino (Italy)*

[c] *University of Camerino School of Science and Technology, Physics Division – Camerino (Italy)*

(submitted: 09/12/2019; accepted: 29/04/2020; published: 30/04/2020)

Abstract

Three academic years have been considered for the evaluation of the impact of an online tutoring course of general and inorganic chemistry for freshmen students of the University of Camerino (Italy). The online material mainly consists of video tutorials, other open source web tools and multi-choice self-assessment exercises. During the academic year 2016-2017, the e-Learning course was not available yet, but then the online course was first implemented (2017/18) and fully adopted (2018/2019).The online tutoring support was activated alongside a traditional general chemistry course, adopting a blended mode, with the aims of: (i) homogenizing freshmen's chemistry knowledge; (ii) fostering the most appropriate method of study in a multi access modality; (iii) implementing the Johnstone's three levels' knowledge and (iv) increasing students' self-confidence, by the means of a self-evaluation training process. Differently from previous studies, the online course herein aimed mainly to develop a correct method of study of chemistry topics, with a punctual description of what-and-how to do. The results, i.e. the exam's scores, the time spent in the platform, and the successful percentage of students per year, have been collected and analysed through qualitative and quantitative methods. Apart a general satisfaction of the students perceived by the answers to a survey questionnaire, the analysis of the data shows an increase of 11 % of students passing the final exam within three exam sessions together with an improvement and a positive correlation between the time spent on the platform and the mid-term scores achieved.

KEYWORDS: Moodle, Chemistry Education, Blended Learning, ICT, Tutorial Online

DOI
https://doi.org/10.20368/1971-8829/1135197

CITE AS
Schettini C., Amendola D., Borsini I., Galassia R., (2020), A blended learning approach for general chemistry modules using a Moodle platform for first year academic students. Journal of E-Learning and Knowledge Society, 16(2), 61-72.
https://doi.org/10.20368/1971-8829/1135197

1. Introduction

The use of information and communication technology (ICT) in Higher education chemistry teaching has expanded rapidly since its first introduction (Dori & Rodrigues, 2013). ICT can support learning processes and facilitate the transition from a teacher-centred instruction towards a flexible student-centred learning process in which students actively build their knowledge using different sources (Brouwer & McDonnell, 2009). Blended learning is a commonly adopted learning approach in higher education, which combines face-to-face teaching with online instruction and feedback. This pedagogical model fosters students to learn in an interactive and collaborative environment, offering flexible time frames that can be personalized to fit individual learning needs (Saltzberg & Polyson,1995). Learning strategies adopting blended learning models were reported and widely discussed even in the context of higher education (Collis, 2003; Garrison & Kanuka,

[1] corresponding author - email: rossana.galassi@unicam.it– address: Via Sant'Agostino 1, 62032, Camerino MC (Italy)

2004). Among the wide range of blended learning models reported, the Graham's framework with enhancing blends are the most commonly adopted at university. In this model, technology increases student productivity, extending the amount of information students can learn or increasing the richness of the material (Graham, 2007). Moreover, according to the Resource-Based Learning (RBL) pedagogical approach, materials can be delivered through study packages in a digital, user-centred learning environment (Hill & Hannafin, 2001), helping students to recognize their learning needs, locate suitable resources, assess their progress and manage their learning. A virtual learning environment (VLE), as a Moodle platform, is a software tool that provides a single framework within which students can access a wide range of online resources, allowing staff and students to interact using different communication tools at any time. Different assessment tools, as in example self-test quizzes, provide instant feedback to learners about the knowledge and the skills acquired in face-to-face lectures. Several authors have described the use of VLEs in Chemistry courses in Higher education, often addressed to first year undergraduates, reporting an improvement in student achievement and satisfaction (Vician & Charlesworth, 2003; Lovatt, Finlayson & James, 2007; Williams, Bland and Christie, 2008). On the other side, from the didactics' point of view, in the first approach to the study of chemistry, students deal with difficulties and relative misconceptions due, for example, to the overlying of three different levels (macro, sub-micro and symbolic), according to Johnstone's model (Johnstone, 1982). More specifically, since the mid-1970s, it has been established that most of the resistance to change the misconceptions of the students are due to inadequate or inaccurate mental model at the sub microscopic level (Kleinman, 1987; Lijnse, 1990), even among students who were performing well in formal examinations (Nakhleh & Mitchell, 1993). Molecular animations, video demonstrations and simulations help students to better correlate all three levels of representation, as described by several authors (Williamson & Abraham, 1995; Sanger & Greenbowe, 1997). Russell and colleagues (1997) reported that the use of simultaneous-synchronized macroscopic, microscopic and symbolic representations through a specially designed software provides an improvement of students' conceptual understanding and ability to create dynamic mental models. Velazquez-Marcano (2004) described the successful use of both video demonstrations and molecular animations in the conceptual understanding of three chemical phenomena by the students of the first year chemistry course. The constructivist VisChem Learning design (Tasker & Dalton, 2006) investigated the mental model of the students regarding a substance or reaction at the molecular level before showing animations portraying the phenomenon, enhancing a deeper comprehension of the threefold representation of matter. Task-based video tutorials are another effective way to support students in acquiring fundamental knowledge regarding chemical principles and concepts, optimizing time and resources in chemistry education in universities. Experimental results indicate that online video tutorials are a valuable, flexible and cost-effective tool to improve the ability of the students in chemistry problem solving (Tallmadge & Chitester, 2010; He, Swenson & Lents, 2012; Roggenkämper & Waitz, 2017).

In Italy the development of e-Learning system in Universities has taken place in the absence of significant regulatory action but through independent initiatives for elevating the quality of traditional didactics with the support and integration of different online communication (Baldi et al., 2006; Capogna, 2012). In 2008, the University of Genoa successfully implemented an online support for first year students, undertaking an inorganic chemistry module. Students were required to afford some series of stoichiometry online exercises, supplemented by several face to face tutorials, and to complete a pre-lab online activity incorporating an explanatory video (Cardinale, 2008).

In the University of Camerino, the degree courses in Biology, Biotechnology, Geology and Natural Sciences are attended by international groups of European and non-European students with different backgrounds in terms of university entry points and prior knowledge of chemistry, and for whom English is not their first language. In the first semester of the first year, the course in General and Inorganic Chemistry is organized with lectures in the traditional way and with class sizes of more than a hundred students, making hard to give individualized student attention and timely feedback on formative assessment. A rough analysis of students' performances at the mid-term test and at the final exam of the last ten years (2006-2016) shows that, even though most students pass the exam within one academic year, the scores are low or medium-low for 50-60% of them. These results highlight a superficial knowledge of the Chemistry topics covered and, above all, difficulties in critical thinking and problem solving skills, even more evident in the resolution of stoichiometric problems, as already referred in educational research (Gulacar et al., 2013). Moreover, first year students have incomplete mental models and often represent scientific problems in a superficial way showing problems in understanding and correlating the three levels (Figure 1), described by Johnstone (Johnstone, 1991).

The heterogeneity of the initial levels of students, coming from different education systems and the related widely varying interest and motivation in the subject, combined to a mostly memory based method and a limited attitude to self-evaluation, represent further challenges for lecturers (Zusho, Pintrich & Coppola, 2003).

It becomes clear that for many of current students learning chemistry is a complex and demanding process that requires something extra beyond the material presented in a textbook or lecture.

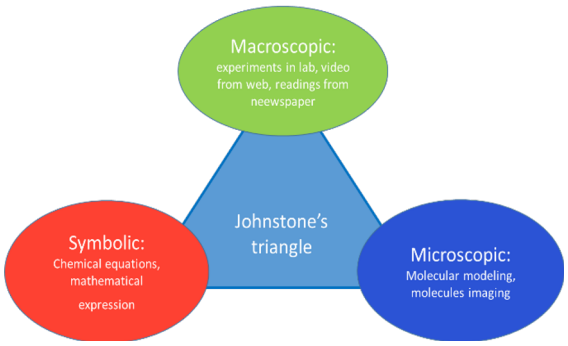

Figure 1 - Schematic representation of the three levels of chemistry and their expression in chemistry taken in consideration in this study.

Therefore, in 2017, we decided to implement a supplemental online tutoring course, in order to fill the background's gaps and to support students in their first weeks of learning path, providing guidance and organization for study in the period afore the mid-term test of stoichiometry. Our general aim was to improve student performance in terms of exam's success, consisting of both grade level and time spent to get the exam. Additional learning targets lie on the development of learning skills such as to interrelate the chemistry levels of learning, to accelerate the adoption of a proper method of study, to develop sensitivity to a self-evaluation process. For this purpose, we have chosen a blended learning approach, in which e-Learning is integrated into the teaching, the learning, the assessment and a real-time feedback of the topics, beyond to a face-to-face teaching which is still retained. Based on the previous experiences of the use of the Moodle platform in the teaching-learning process of Chemistry described in literature (Lovatt, Finlayson & James, 2007; Benedict & Pence, 2012; Milner-Bolotin, 2012; Lau González et al., 2014), we integrated them in an innovative way, designing a course in a virtual learning environment that not only delivered the needed inorganic chemistry and stoichiometry contents for the mid-term test, but that aimed to: (i) illustrate the method for solving the stoichiometry exercises through video tutorials and with the help of an "Overview" section, which details the step-by-step procedure showed in the video tutorial; (ii) show representations of the Johnstone's three levels involved in the chemical phenomena related to each stoichiometric exercise, through videos of aboratory experiments (macro level) and computer animations (sub microscopic level).

Since the 2017/18 Academic Year, the online tutoring course was structured in seven modules, designed, prepared, uploaded, and delivered in the Moodle platform of the University of Camerino. First year students of Natural Sciences, Earth Sciences, Biology and Biotechnology in two different academic years (2017/2018 and 2018/2019) have practised the modules as a preparation for the mid-term stoichiometry test. The course provides two mid-term exam on stoichiometry and a final exam on the general chemistry themes.

In this paper the platform's design and the results of these two years are discussed to evaluate the impact of the VLE in terms of exam success and the degree of students' satisfaction with the blended learning approach.

The evaluation of students' usage of the online tutoring course has been examined through the following research questions:

a. Will students use the online resources available through Moodle and, if so, how they use them?
b. Do students who access the online material have a better general performance and in the mid-term evaluation test?
c. How do students perceive the effect of online resources on their examination performance and chemical concepts' understanding?
d. What are students' opinion regarding online tutoring?

To obtain answers to these research questions, a blended teaching model has been planned and adopted. The didactics model was structured with classical frontal lessons delivered together tutoring materials (Figure 2). These latter indicate step by step how to face up the chemical reactions study correlating the three levels of chemistry, approaching the problem solving and the issue of the self-assessments. The mid-term results were extrapolated from the platform and examined on comparison with those obtained when the platform was not adopted yet. Moreover, the outputs of the final exams of the different academic years together to the answers to a survey questionnaire uploaded in the Moodle platform were analysed. The results are herein shown and discussed.

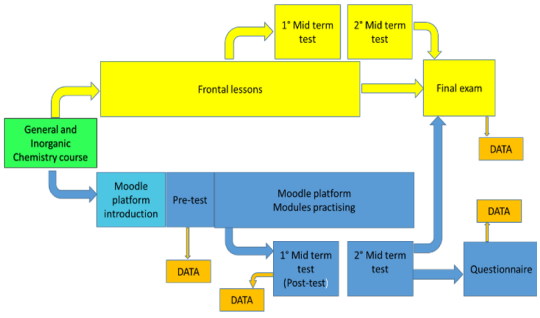

Figure 2 - Sketch of a horizontal structure of the course in the academic years taken in consideration in this study along the academic year. In yellow the learning's structure of academic year 2016/2017 and in blue that for the academic years 2017/2018 and 2018/2019. The orange arrows detail the didactics' step producing the data for the herein discussion.

2. Materials and methods

The online tutoring course design has been preceded by an accurate identification of the first part course's topics and related stoichiometric problems that students found more difficult and/or for which poorer performances in the final exam were recorded. Within the course, seven study packs or modules are included, each one addressing one of the detected issues. Our goal was to promote deeper conceptual understanding by prompting students to connect quantitative calculations to chemical processes at the microscopic level (e.g., the level of atoms and molecules) and to outcome at the macroscopic level (e.g., final concentrations, colour, temperature) (Johnstone, 1997). The VLE used in this study is a Moodle, a web based Course Management System, that it is an open source software that can be freely downloaded from the web and allows the educator to develop a course with multiple functions, including file hosting, quizzes, assignments, chats, discussion forums, glossaries and questionnaires.
Our course includes the following sections:

1. An initial test of 30 multiple choice items, checking students' General and inorganic Chemistry basic knowledge;
2. Three Forums for student-teacher interaction: a "News Forum" for general notices, a "Technical Forum" for technical problems and an "Interaction Forum with the course tutor and the professor2, for more detailed explanations and scaffolding;
3. A "Prerequisites" section with some preparatory materials (significant figures, units of measure, etc);
4. Seven Modules, organized as described below, inserted simultaneously at the opening of the VLE;
5. A mid-term evaluation test of 24 multiple choice items, in six different equivalent versions, administered to all enrolled students;
6. A survey questionnaire, consisting of 43 questions aiming to acquire variables of interest to the study and to test students' perception and satisfaction.

All course materials are delivered in English. The initial and the mid-term test were performed by students in the classroom, with mobile devices (mobile, tablet, laptop).

2.1 Structure of the Modules

The seven modules were designed to allow students to rapidly interconnect the three levels of representation in Chemistry (macroscopic, sub microscopic and symbolic). After the title of the task, the macroscopic level is being introduced using short videoclips of the experiment related to the assignment. The sub microscopic level of the phenomena is being visualized via computer animations, found in Chemistry didactics' websites. To understand the symbolic level, a video tutorial guides the students, step-by-step, in solving the stoichiometry exercises, related to the investigated chemical phenomena.

Video tutorials are based on voice and handwriting, simulating teacher's exposition and addressing students with different backgrounds of knowledge and problem solving skills. Handwriting is 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. In the video tutorials, detailed step-by-step explanations show the solution of the assigned problems or exercises, along with the principles and formulas of the symbolic level needed for the specific task. Key information about the followed method of analysis and solution, as well as theoretical references, are included in the videos, with the aim to make the student able to apply the method to similar cases, once mastered the required skills.
Within each module other sections have been added to complete the learning path:

- A "Background knowledge" section, which lists the knowledge and skills required to afford the study of the module, so that students can check and fill their gaps;
- An "Overview" section, which details the steps needed to solve the stoichiometric exercise illustrated in the video tutorial;
- An "Other material to support learning" section, in which more learning support materials (interactive guides, tutorials, tables, etc.) are added;
- A "Multiple choice exercises" section, with a multiple choice test of 10 randomly-selected questions on the topics of the module, to allow students' self-assessment.

2.2 Participants

In the first edition of the course (A.Y. 2017/18), 185 students of both degree courses (140 students of Biology and Biotechnology and 45 students of Geology and Natural Sciences) were enrolled on the platform and its use was highly encouraged, even not mandatory. In the second edition of the course (A.Y. 2018/19) 155 students of both degree courses (118 students of Biology and Biotechnology and 37 students of Geology and Natural Sciences) were enrolled on the platform. However, the data were analysed without distinguishing the frequency course. The percentage of enrolled females (2017/2018, 61.08%; 2018/2019, 57.42%) on the total number of students was higher than the males (2017/2018, 38.92%; 2018/2019, 42.58%) in both editions, but decreased from one edition to another, while that of males increased (+3.66%). Regarding their nationality, most of the students enrolled in the two degree courses were Italian in both editions (2017/2018, 62.70%; 2018/2019, 72.26%), followed by Non-European countries' students (2017/2018, 31.35%; 2018/2019 20.65%) and Other European's countries students (2017/2018, 5.95 %; 2018/2019, 7.10 %). The statistical analysis of the students' mid-term test evaluations also examined the results of the students enrolled in the 2016/17 academic year when the VLE

Academic Year	Number of students	% M	% F	% Italian students	% European students	% Non-European students
2016-2017	186	54.06	45.94	60.5	4.37	35,13
2017-2018	185	38.92	61.08	62.70	5.95	31.35
2018-2019	155	42.58	57.42	72.26	7.10	20.65

Table 1 - Demographic characteristics of students enrolled in A.Y. 2016/17, 2017/18, 2018/2019.

was not yet present. The main characteristics of the students enrolled in the three academic years examined are described in the table below (Table 1).

2.3 Collection and Data Analysis methodology

The results of the study are based on the data extracted from the Moodle platform. The statistical analysis of the mid-term evaluation test administered to the students and the analysis of the results of a questionnaire on the students' subjective perception of the VLE learning activity, are all related to the second edition of the course (A. Y. 2018/19). As a matter of fact, the A.Y. 2017/18 edition was a pilot study whose results (Schettini et al., 2018) improved the next full scale implementation.
Specifically, we analysed:

(i) the students' pattern of usage of the platform, numbering the logging hits of the VLE different sections and of each section of the module;
(ii) the improvement of the results in the mid-term evaluation test for the students who used the e-Learning course (A.Y. 2018/2019);
(iii) The percentage of the students who passed the exam in the first three sessions during the three A.Y. 2016/2017; 2017/2018; 2018/2019;
(iv) The data collected through an online questionnaire on the students' experience and perception about the blended learning activity, proposed to the students at the end of the online activities.

As for (i), we also compared the number of accesses of the second edition with those of the pilot one, even relative to gender and nationality. We have analysed the learning analytics extracted from the Moodle platform after the practising of the course by the students and organized them in tables that represent the number of log to different resources and activities, in order to obtain the level of interaction that students have with each them. As for (ii), we compared the mid-term exam's results obtained from the students of the A.Y. 2018/2019, who had available the tutorial course on the Moodle platform, with the results obtained from the students of the A.Y. 2016/2017 that have not available the e-Learning course. To do that we compared the results of the two academic years by submitting them to the statistical analysis of ANOVA (Kozielska, 2004) and then, to the analysis test of Snedecor-Fisher, where the values of F-crit can demonstrate if exist a significant difference between the analyzed samples of students. As for (iii), we have considered for the three academic year under analysis the percentage of students passing the final exam within the first three exam sessions, comparing and discussing in both qualitative and quantitative way the obtained results. As for (iv), the questionnaire consisted of 43 questions and was divided into 4 sections: (a) Personal data; (b) Behaviours; (c) Intentions/Preferences/Opinions; (d) Open questions, comments. The first section (a) collects basic demographic information (age, gender, country of origin, degree course) and data regarding digital and English language skills. The second section (b) contains five questions to elicit qualitative data on students' previous e-Learning experience and mode of use of the current VLE. The third section (c) consists of 19 Likert-type statements and one closed question, regarding students' satisfaction and perception of the online course advantages and any difficulty related to materials' comprehension and usage. Finally, in the fourth section (d) we have asked to the students to give their general opinion on the platform through five open questions, while the last eight Likert-type statements investigate the preferred class modality of the students, and how the students use personal devices and social networks in the preparation for the exams. Only 50% of the active students of the A.Y. 2018/2019 answered the questionnaire (66 students). In this work we will discuss the results of the questionnaire about section (c).

3. Results and discussion

Do students use the online resources available through Moodle and, if so, how they used them?
In general, during the fully implemented Moodle platform year, that is 2018/2019, students used the platform in preparation for the mid-term test, but even more between it and the final examination (230% increase in the number of log hits after the mid-term test date). 52.90% of the students enrolled took the mid-term test (82 out of 155) and all were active students, constituting 62.12% (82 out of 132). The fact that 100% of active students took the mid-term test can mean either that the platform made them more self-confident or indeed that, being the most motivated and conscientious,

they would still have addressed it, even without the online resources. In detail, in the first edition of the course, 110 students logged in to Moodle platform and accessed to its resources (hereinafter referred to as active students), whereas they were 132 in the second edition. Comparing the two editions, the number of active students on the platform increased (+25.70%), even if there was a decrease in the number of students enrolled (-16.22%). The percentage of active females (2017/2018, 57.27%; 2018/2019, 55.30%) on the total number of active students was slightly higher than the males (2017/2018, 42.73 %; 2018/2019, 44.70%) in the two editions and slightly decreased from one edition to another, while there was a small increase in the males' percentage (+1,97%). On the other hand, the percentage of active males in the total of males (2017/2018, 65.28%; 2018/2019, 89.39 %) was definitely greater than the percentage of active females versus the total of females (2017/2018, 55.72%; 2018/2019, 82.02%), and both increased from one edition to another (Males, +24.11%; Females, +26.27%), with greater participation of females who became more active in the second edition. In 2018 and in 2019 Italian students represented the largest proportion of active students (2017/2018, 62.70%; 2018/2019, 72.26%), compared to active students' total extent, followed by Non-European countries' students (2017/2018, 31.35 %; 2018/2019, 20.65%) and Other European countries' students (2017/2018, 5.95%; 2018/2019, 7.10%). On the other hand, in 2017/2018 the most active students on the platform, compared to same nationality students' total number, were other EU countries students (72.73%), followed by Italians (64.66%) and those coming from non-EU countries (46.55%). In 2018/2019, the most active students on the platform, compared to same nationality's total number, were still other EU countries' students (90.91%, with an increase of 18.18%), now followed by Non-European countries students (87.50%, with a significant increase of 40.95%) and by Italian students (83.93% with an increase of 19.27%).

3.1 Patterns of usage of the Moodle platform

In this study, we analysed only the data of the second edition of the online course (2018/2019). An indication of overall usage can be obtained from the log of hits, demonstrating the general level of interaction students had with each resource (Table 2), even if it is possible that a student can access to the same resource several times.

The ranking of the modules with the highest number of accesses reflects the order in which these are placed into the platform, except for Module 7. The fact that the latter modules have been less visited may be due to the insufficient time students had available for their study before the exam so, following the list, they failed to complete all the modules. Moreover, students didn't use the forums at all, preferring the traditional explanation face-to-face in the classroom.

Resources	Hits
Forum news	0
Technical forum	0
Forum for interaction	0
Module 1-Net Ionic Equation for an Acid-Base Reaction	1709
Module 2-Mass Relation in Chemical Reaction	1164
Module 3-Oxidation-Reduction Reaction	1001
Module 4-Writing the Equation for a Precipitation Reaction	879
Module 5-A reaction with a limiting reactant	746
Module 7-Recognizing the Common Types of Reactions	720
Module 6- Theoretical and Percentation Yield	678
Prerequisites	182

Table 2 - Total Moodle resource hits.

Sections	Hits
Multiple choice exercises	5453
Other materials to support learning	632
Videotutorial	282
Background knowledge	200
Overview	151
Video experiment	101
Submicroscopic view	78

Table 3 - Total Module's sections hits.

Table 3 shows which modules' sections were the most accessed in total. "Multiple choice exercises" had the most number of hits, followed by "Other materials to support learning" and "Video tutorial". As shown in Table 3 "Module's sections hits", this ranking is the same within each module, as well as the number of students who accessed the single sections. The exercises were delivered on the platform at the same time as the other resources and for each of them students had an unlimited number of attempts. They were not used for formal assessment and students received solutions only after submitting their answers. Students' preference for multiple choice exercises revealed the need to assess their knowledge and to receive an immediate feedback that facilitates the understanding and learning process. Furthermore, the possibility of receiving systematic feedback gave the students the ability to complete their preparation before facing both the mid-term test and the final exam. Indeed, as these self-assessment activities are aimed to provide students information on the knowledge acquired, other authors have emphasized the use of self-assessment resources allowing the reorganization of students' self-learning strategy (Bell & Volckmann, 2007; Lovatt, 2007; Kennepohl & Guay, 2010; Lau Gonzalez et al., 2014).

Do students who access the online material have a better general performance and result in the mid-term evaluation test?

Combining a qualitative and a quantitative analysis on the data set, we observed a substantial difference in the skills acquired by students, with a clear improvement of the scores of the students when, during the second year considered (2018-19), the blended methodology has been adopted. In order to visualize the difference in scores among the two academic years, we clusterized the data in such a way to form four ranges of scores obtained by the students: 1-10 (strongly insufficient); 11-17 (insufficient); 18-23 (sufficient-good); 24-30 (very good-excellent). Comparing the two bar plots of Figure 3, we are able to conclude that the blended methodology was almost ineffective with the first and the second group of students having low (strongly insufficient) or very low scores (insufficient), except for few cases of improvements in the score from insufficient to sufficient, while there is a clear shift of a sizable number of students from the third group (sufficient-good) to the fourth group of top performing students (very good-excellent). Hence, empowering the classical teaching with online resources (the blended method) is not enough to solve the large ensemble of problems for the very outperforming students, in some way an expected result, while there is a very positive effect of the blended approach in the case of students who knows how to orient them self in the study of a discipline.

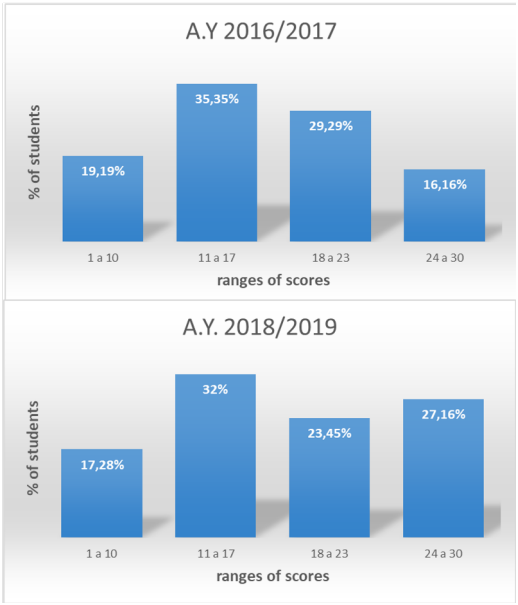

Figure 3 - The difference in scores among the two academic years 2016/2017 and 2018/2019.

The students need to have a minimal set of instruments and knowledge to benefit from a more reach teaching and learning approach. This qualitative picture coming out from a visual data analysis is then confirmed by a more rigorous statistical approach, as follows. In Table 4a and in Table 4b we reported the data obtained by applying the statistical method of Anova. The Anova is based on the Analysis of variance, a method of

ONE FACTOR ANOVA SUMMARY

Groups	Number of students	SUM of normalized score	MEAN of normalized score	Variance
2018-2019	81	54.4250	0.6719	0.0332
2016-2017	99	55.7833	0.5634	0.0494

Table 4a - Number of students for each academic year, sum of the normalized score (0-1), average of the normalized score and variance.

ONE FACTOR ANOVA ANALYSIS

Origin of the Variations	SQ	DoF	MQ	F	Significance value	F crit
Between groups	0.5239	1	0.5239	**12.4345**	**0.0005**	**3.8942**
Within groups	7.5000	178	0.0421			
TOTAL	**8.02**	**179**				

Table 4b - Statistical test of Snedecor-Fisher: the values of F and F-crit (in bold) of the academic years 2016-2017 and 2018-2019 show that the differences in the averages of the scores acquired by the students in the two examined academic years are considerable from a statistical point of view.

inferential statistics which allows to compare two or more groups of data set by considering the variance of the data within each group and comparing it with the variance of the other groups. In this work, the Anova is applied to the mid-term scores of the students of the two academic years 2016-17 and 2018-19, that are the academic years in which the two methodologies (classic and blended) were performed in their complete form. In the statistical test of Snedecor-Fisher, which is a standard hypothesis test to compare in a quantitative way the variance of two data set, the values of F and F-crit of the academic years 2016-2017 and 2018-2019 show that the differences in the averages of the scores acquired by the students in the two examined academic years are substantial from a statistical point of view.

Which is the percentage of the students who passed the exam in the first three sessions?

Regarding students' performances at the final exam of general and inorganic chemistry, the percentage of first year students passing the exam within the first three sessions of exams in the three academic years taken in consideration was analysed. If we compare the data, we can observe that in the 2016/2017 A.Y., the percentage of students passing the exam was as low as 19%. Thanks to the additional support to help students in their study organization and to give further explication of the basic knowledge needed, this percentage was then increased in 2017-2018 A.Y, where the percentage of students passing the exam was 31%, while in 2018-2019 A.Y. the percentage was 30%, very similar to the previous year, showing a net increase of 11 % (Figure 4).

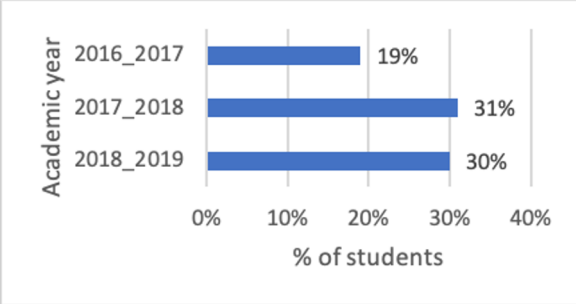

Figure 4 - Percentage of first year students passing the final exam of general and inorganic chemistry, within the first available three sessions of exams, in the three A.Y. taken in consideration.

How do students perceive the effect of online resources on their examination performance and chemical concepts' understanding?

In this section we report the results of the data extracted from the questionnaire proposed to the students of the A.Y. 2018/2019, the period during wich the online tutorial course was completely adopted. The 50% of the active students in the Moodle platform answered to the questionnaire (66 students).

Students' perception and satisfaction

Students were asked to report on their perception of usefulness of the platform as a whole and of the different module's sections and results are showed in Table 5 (legend: SDA = strongly disagree; DA = disagree; NAND = neither agree nor disagree; A = agree; SA = strongly agree).

Most of the students considered useful for the mid-term test the platform as a whole (A + SA = 53.03%), also for the topics' deeper awareness (A + SA = 48.49%; NAND = 39.39%), according with other studies' results on Chemistry blended learning courses (Lovatt, Finlayson and James, 2007; Tekane, Pilcher and Potgieter, 2019).

The ranking of the perceived usefulness of the different modules' sections (A + SA: Multiple choice exercises 74.25%; Overview 69.69%; Video tutorials 56.06%; Other materials 51.52%; Videos of the experiment 37.88%; Sub microscopic views 22.73%) almost reflected the log hits' ranking (Table 3).

It is noticeable that students reported greater difficulties in understanding the sub microscopic level (SDA + DA = 22.73%), compared to video tutorials (SDA + DA = 10.61%) and videos of experiments (SDA + DA = 7.55%). This could explain the lower number of accesses and the lower perceived usefulness, possibly due to a lack of familiarity with this type of representation of chemical phenomena, with respect to the macro and symbolic level. Being first year and first-semester students, simultaneous shift between the three levels of chemistry represents a long-term educational goal, rather difficult to achieve in just over a month of study without an adequate background. Regarding the accessibility of materials, students mostly considered adequate their previous knowledge to understand the material (A + SA: 46.97%; NAND 25.76%; SDA + DA: 27.28%) and also to respond to the initial test (A + SA: 45.45%; NAND 31.82%; SDA + DA: 22.73%) and to the choice exercises (A + SA 53.03; NAND 25.76%; SDA + DA 21.22%).

Questions	SDA	DA	NA ND	A	SA
The platform has been useful for the test	0.00	9.09	37.88	30.30	22.73
The videos have been useful for the test	4.55	16.67	40.91	27.27	10.61
The submicroscopic views have been useful for the test	10.61	16.67	50.00	12.12	10.61
The overview of the resolution steps of the exercise has been useful for the test	0.00	6.06	24.24	27.27	42.42
The video tutorials have been useful for the test	1.52	13.64	28.79	21.21	34.85
The multiple choice exercises have been useful for the test	1.52	4.55	19.70	22.73	51.52
Other materials have been useful for the test	3.03	6.06	39.39	31.82	19.70
The platform has been useful for topics' deeper awareness	1.52	10.61	39.39	31.82	16.67
I had no difficulty in understanding videos	3.03	4.55	36.36	30.30	25.76
I had no difficulty in understanding the submicroscopic level	3.03	19.70	36.36	25.76	15.15
I had no difficulty in understanding video tutorials	3.03	7.58	31.82	28.79	28.79
My previous knowledge was adequate to understand platform materials	7.58	19.70	25.76	31.82	15.15
My previous knowledge was adequate to address the initial test	4.55	18.18	31.82	30.30	15.15
My preparation was adequate to address the multiple choice exercises	4.55	16.67	25.76	37.88	15.15
The difficulty of the final test was comparable to the level of the multiple choice exercises	4.55	9.09	30.30	43.94	12.12

Table 5. Students' perceptions on the usefulness and difficulty of the platform.

Questions	SDA	DA	NA ND	A	SA
Online tutoring can replace traditional lectures	30,30	25,76	24,24	12,12	7,58
Online tutoring helps me better understand course materials	3,03	13,64	31,82	36,36	15,15
Online tutoring helps me better understand course requirements	0,00	12,12	30,30	39,39	18,18
I hope more course modules available on the platform	3,03	1,52	24,24	27,27	43,94
I hope more online tutoring courses available	1,52	3,03	30,30	28,79	36,36

Table 6. Student's perception on this online tutoring facility.
legend: SDA = strongly disagree; DA = disagree; NA/ND = neither agree nor disagree; A = agree; SA = strongly agree.

Finally, most of the students reported the same level of difficulty in the mid-term test and in multiple choice exercises (SA + A 56.06%), confirming their validity for an adequate preparation. As a matter of fact, the mid-term test was designed according to the structure of the modules and considering the three Johnstone's levels.

The overall difficulty of the mid-term test was weighted with tests administered in the past.

Five statements in the questionnaire explored the students' perceptions about online tutoring and their suggestions for future improvement. The results are shown in percentage in Table 6. Although the majority of students (SDA + DA = 56.06%) believed that online tutoring could not replace traditional lectures, most of them considered it useful for understanding both the course materials (A + SA = 51.51 %) that knowledge and skills' requirements (A + SA = 58.17%). With a high percentage (A + SA = 71.21%), students agreed with the need of more online modules covering the other topics of the course and, in general, with a higher number of online tutoring courses (A + SA = 65.15%). These first results underline as the students' perception on platform's use was absolutely the expected one (Vishnumolakala et al., 2017; Abrahim et al., 2019; Stowe, 2019).

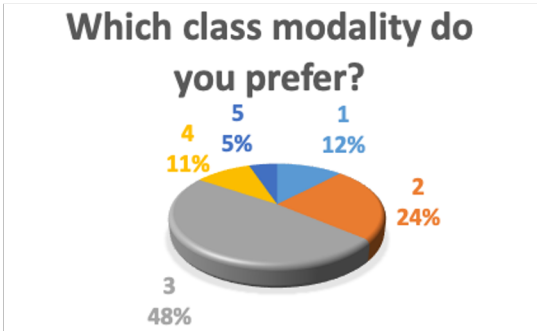

Figure 5 - Students' opinions on the didactics experience and their preferences. The number relative to the entries represent: 1 (pale blue): entirely face-to-face, 2 (red): minimal use of the web, mostly held in face-to-face format, 3 (grey): an equal mix of face-to-face and web content, 4 (orange): extensive use of the web, but still some face-to-face class time, 5 (dark blue): entirely online with no face-to-face time.

Freshmen students feel the need to be guided for very first approach to study chemistry, for their knowledge gap filling and to individuate a method of study to have success in chemistry exam. Furthermore, when asked about the preferred class modality mostly they chose frontal lessons blended with equal or minimal use of online facilities (Figure 5).

In detail, 48 % of students opted for a blended learning with equal distribution of online content and face-to-face lessons, while only 12 % indicated entirely face to face modality as the preferred one and 5 % would like only online contents.

4. Conclusions

The first year students in an academic course are obviously very different from each other with heterogeneous backgrounds both from a cultural and a scientific point of view. Generally, this is expressed with a plurality of approaches to the learning and difficulties in organizing the study. Moreover, in the first semester of the first year, students are distracted by many stimuli often concerning adaptation to a new lifestyle as well as to the reconstruction of a new social life. Furthermore, data extrapolated from input tests (pre-test) performed by freshmen on the basic knowledge in chemistry reveal a variable percentage of students who do not reach the minimum knowledge about chemistry and therefore they have the so-called additional educational objectives (OFA). For a teacher of the first semester of the first year the need to teach a proper approach to the study, for example, the use of modelling, the need to introduce a specific language, the implementation of problem solving, becomes therefore a priority.

Hence, any resource that remains available to students and that can be enjoyed at any free moment, becomes an opportunity to stimulate and motivate the study of needy students.

The preparation of tools and materials on virtual learning environment, as discussed in this work, responds to the aforementioned needs by providing tutorial support to all students regardless of their incoming situation, bringing in them a perception of utility and satisfaction although shared with the attribution of a fundamental value to the frontal lectures

in teaching. However, from the data of this study, we can see some salient aspects.

For example, students like to study online, even though not exclusively, but, surely the most intriguing aspect for them is the possibility of having multiple access to a quick self-assessment. This leads us to think that freshmen may approach the first study quickly, perhaps roughly, to then study what they failed to answer in the self-assessment, but they correct their style upon practising the tutorials to get success in the mid-term exam. However, after passing the mid-term exam and having spent extra time following the tutorials, there is a certain loyalty to the subject so that a smaller percentage of students leave the chemistry course to devote themselves to something else. This is highlighted by the higher percentage of students (+11%) who pass the final exam in the first exam sessions once they have practiced the platform. Moreover, the statistical treatment of the exam score reveals as the students of the three years are significantly different in terms of outcomes. The positive correlation between the time spent on the platform and the outcome of the exam reveals how there is still a positive correlation between the use of the platform and the overall outcome in terms of score.

On conclusion of this work, we can assess that the Moodle platform facility is a useful device because makes available materials without any limit of time, leaving freshmen to consult it in a customizable fashion. Moreover, the teacher has ready feedbacks about the commitment, the perceive and the self-assessment outcomes of the students. In this work we implemented a Moodle platform with tutoring modules covering only initial topics, making easier for first year chemistry students, to get in a rigorous method of study to achieve a win-win output.

References

Abrahim, S., Mir, B. A., Suhara, H., Mohamed, F. A., & Sato, M. (2019). Structural equation modeling and confirmatory factor analysis of social media use and education. International Journal of Educational Technology in Higher Education, 16(1), 32.

Bell, P., & Volckmann, D. (2011). Knowledge surveys in general chemistry: confidence, overconfidence, and performance. J. Chem. Educ., 88(11), 1469-1476.

Benedict, L., & Pence, H. E. (2012). Teaching chemistry using student-created videos and photo blogs accessed with smartphones and two-dimensional barcodes. Journal of Chemical Education, 89(4), 492-496.

Brouwer, N. and McDonnell, C. (2009). Online Support and Online Assessment for Teaching and Learning Chemistry. in Eilks, I. & Byers, B. (Eds.), Innovative Methods of Teaching and Learning Chemistry in Higher Education. Cambridge UK: RSC Publishing, pp. 123-152.

Capogna, S. (2012). University and E-learning Classes in Italy. E-Learning and Digital Media, 9(2), 143-156.

Cardinale, A. M. (2008). A way to improve undergraduate engagement when learning chemistry: An online support for exercises and pre-lab activities. Message posted to online workspace for this chapter at www. surfgroepen. nl/sites/ECTN/default. aspx.

Collis B., (2003), Course redesign for blended learning: modern optics for technical professionals, Int. J. Cont. Eng. Educ. Life. Learn., 13 (1-2), 22-38.

Dori Y.J., Rodrigues S., Schanze S. (2013) How to Promote Chemistry Learning Through the use of Ict. In: Eilks I., Hofstein A. (eds) Teaching Chemistry – A Studybook. Sense Publishers, Rotterdam.

Garrison, D. R. and Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education, Internet High. Educ., 7(2), 95-105.

Graham, C. R. and Robison R. (2007). Realizing the transformational potential of blended learning: Comparing cases of transforming blends and enhancing blends in higher education. in Picciano A.G. and Dziuban C.D. (Eds), Blended Learning: Research Perspectives. New York: The Sloan Consortium, pp 83-110.

Gulacar, O., Overton, T. L., Bowman, C. R., & Fynewever, H. (2013). A novel code system for revealing sources of students' difficulties with stoichiometry. Chem. Educ. Res. Pract., 14(4), 507-515.

He, Y., Swenson, S. and Lents, N. (2012). Online video tutorials increase learning of difficult concepts in an undergraduate analytical chemistry course. J. Chem. Educ., 89(9), 1128-1132.

Hill, J. R. and Hannafin, M. J. (2001). Teaching and learning in digital environments: The resurgence of resource-based learning, Educ. Technol. Res. Dev., 49(3), 37-52.

Johnstone, A. H. (1982). Macro and micro chemistry. Sch Sci Rev, 64, 377-379.

Johnstone A. H., (1991), Why is science difficult to learn? Things are seldom what they seem, J. Comp. Assist. Learn., 7, 75-83.

Johnstone, A. H. (1997). Chemistry teaching-science or alchemy? 1996 Brasted lecture. J. Chem. Educ., 74(3), 262.

Kennepohl, D., Guay, M., & Thomas, V. (2010). Using an online, self-diagnostic test for introductory general chemistry at an open university. J. Chem. Educ., 87(11), 1273-1277.

Kleinman R.W., Griffin H.C. and Kerner N.K., (1987), Images in chemistry, J. Chem. Educ., 64, 766-770.

Kozielska, M. (2004) Developing creativity of students in a computer-assisted learning process, Eur. J. Phys., 25 (2), 279-285.

Lau González, M., Jáuregui Haza, U., Pérez Gramagtes, A., Fariñas León, G., & Le Bolay, N. (2014). Supporting students' learning to learn in general

chemistry using Moodle. J. Chem. Educ., 91(11), 1823-1829.

Lijnse P.L., Licht P., Waarlo A.J. and de Vos W. (Eds.), (1990), Relating macroscopic phenomena to microscopic particles, Proceedings of Conference at Utrecht Centre for Science and Mathematics Education, University of Utrecht, and references therein.

Lovatt, J., Finlayson, O. E. and James, P. (2007). Evaluation of student engagement with two learning supports in the teaching of 1st year undergraduate chemistry, Chem. Educ. Res. Pract., 8, 390-402.

Milner-Bolotin, M. (2012). Increasing interactivity and authenticity of chemistry instruction through data acquisition systems and other technologies. J. Chem. Educ., 89(4), 477-481.

Nakhleh M.B. and Mitchell R.C., (1993), Conceptual learning vs problem solving, J. Chem. Educ., 70, 190-192.

Roggenkämper, D. and Waitz, T. (2017). Connecting Exercises and Video Tutorials to Support Teaching/Learning Processes in University Chemistry Education. Libreriauniversitaria. it Edizioni, New Perspectives in Science Education, Florence, Italy, 16-17 March 2017, (p. 290).

Russell, J. W., Kozma R. B., Jones, T., Wykoff, J., Marx, N. and Davis, J. (1997). Use of simultaneous-synchronized macroscopic, microscopic, and symbolic representations to enhance the teaching and learning of chemical concepts, J. Chem. Educ., 74(3), 330.

Saltzberg, S. Polyson, S. (1995). Distributed learning on the world wide web. Syllabus Journal, 9(1), 10-12.

Sanger, M. J. Greenbowe, T. J. (1997). Students' misconceptions in electrochemistry regarding current flow in electrolyte solutions and the salt bridge, J. Chem. Educ. , 74(7), 819-823.

Schettini C., Zamponi S., Galassi R. and Amendola D. (2018). 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. Libreria universitaria. it Edizioni, New Perspectives in Science Education, Florence, Italy, 16-17 March 2017, (pp. 172-176).

Stowe, R. L., & Cooper, M. M. (2019). Assessment in Chemistry Education. Isr. J. Chem. 59, 598-607.

Tallmadge, W. and Chitester, B. (2010). Integrating concepts using online tutorials in a freshman chemistry course, Transformative Dialogues: Teaching and Learning Journal, 4(2), 1-7.

Tasker, R. and Dalton, R. (2006). Research into practice: Visualisation of the molecular world using animations, Chem. Educ. Res. Pract., 7(2), 141-159.

Tekane, R. R., Pilcher, L. A. and Potgieter, M. (2019). Blended learning in a second year organic chemistry class: students' perceptions and preferences of the learning support, Chem. Educ. Res. Pract., DOI: 10.1039/C9RP00099B**.**

Velázquez-Marcano, A., Williamson, V. M., Ashkenazi, G., Tasker, R. and Williamson, K. C. (2004). The use of video demonstrations and particulate animation in general chemistry, J. Sci. Educ. Technol., 13(3), 315-323.

Vician, C. and Charlesworth, P. (2003). Leveraging technology for chemical sciences education: an early assessment of WebCT usage in first-year chemistry courses, J. Chem. Educ., 80 (11), 1333-7.

Vishnumolakala, V. R., Southam, D. C., Treagust, D. F., Mocerino, M., & Qureshi, S. (2017). Students' attitudes, self-efficacy and experiences in a modified process-oriented guided inquiry learning undergraduate chemistry classroom. Chem. Educ. Res. Pract, 18(2), 340-352.

Williams, N. A., Bland, W. and Christie, G. (2008). Improving student achievement and satisfaction by adopting a blended learning approach to inorganic chemistry, Chem. Educ. Res. Pract., 9 (1), 43-50.

Williamson, V. M. and Abraham, M. R. (1995). The effects of computer animation on the particulate mental models of college chemistry students, J. Res. Sci. Teach., 32(5), 521-534.

Zusho, A., Pintrich, P. R., & Coppola, B. (2003). Skill and will: The role of motivation and cognition in the learning of college chemistry. Int. J. Science Educ., 25(9), 1081-1094.