

## ENHANCING HIGHER EDUCATION STUDENTS' XXI CENTURY SKILLS THROUGH CO-WRITING ACTIVITIES IN SCIENCE TEACHING

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**Keywords:** Critical thinking; Collaborative Writing; High Education; Education Experiences; E-learning.

As many EU documents highlight, to improve competitiveness and professional/personal development, cross-sectional skills are to be enhanced as engines for social innovation: creativity, entrepreneurship, critical thinking and problem solving. The above skills, as many studies mention, are favoured by a cooperative approach. Scientific and technologic culture, relevant element of the shared encyclopaedia and the individual knowledge, also becomes a tool for social and political participation. The purpose of this work is to demonstrate that the cooperative approach and the critical use of technology, in particular in the field of science teaching, are the keys to single out solutions able to increase development and growth, from which, in turn, the whole society can benefit. In light of what above mentioned, that of the dissemination of popular science is, today, a duty of public institutions as well as a right of the citizens. Within the above context, the students' module under investigation has been planned as a set of on-line group activities, with

for citations:

Poce A., Agrusti F., Re M.R. (2017), *Enhancing Higher Education Students' XXI Century Skills Through Co-Writing Activities in Science Teaching*, Journal of e-Learning and Knowledge Society, v.13, n.1, 51-64. ISSN: 1826-6223, e-ISSN:1971-8829

the general aim to provide useful elements to understand the typical characteristics of the language of science and create the structure of a creative text with a scientific topic through cooperative writing. Findings from the data collected after a specific assessment exercise are given and discussed, revealing as successful the combination of creativity and science topics.

## 1 State of the art

In a rapidly changing environment, success of structured organizations and, consequently, of people involved, depends on the ability to continuously self-reinvent for creating new sources of wealth and activating new opportunities of value creation. In this scenario, e-learning processes play a strategic role because they are strictly linked to knowledge production and knowledge creation, two fundamental ingredients of the innovation cycle. The added value that technological tools can give teaching can be found in the peculiarities of the tools, which are more and more innovative, favoring interaction in a more and more realistic way. New e-learning tools, in fact, have the ability to rationalise and improve learning processes, allowing possibilities, which support interpersonal exchange of knowledge and consequent building of new knowledge.

In this framework, cooperative e-learning activities, such as collaborative writing, is conceived as a new locus of competency development strategies. It enables the exploration of new knowledge domains and cooperative definition of new ideas and projects becoming an added value of knowledge society. In social cognitive theory, self-efficacy and self-regulated learning are key elements. Self-efficacy is the ability to believe in our own capabilities of reaching a given objective (Bandura, 1997). The list of sources of self-efficacy expectations includes vicarious experiences and social persuasion. Both the above sources are present when collaborative environments are developed and established. In vicarious experiences the subjects involved in the group often see the others' accomplishments as models and when the model performs well, the learner's efficacy is enhanced, while it is decreased when it performs badly. As regards social persuasion, elements in the group can benefit from the others supporting and strengthening their potentials. Increase of self-efficacy is directly connected to motivation and to the setting of higher level goals for students. This allows us to think that it should be prompted especially in virtual environments where lack of motivation and engagement is one of the main reasons for drop out. The advantage in online cooperative learning environments is the possibility of sharing and exchanging knowledge, creating new concepts and ideas, supporting each other and, therefore, fulfilling precise aims. It seems clear, however, that in such environments the continuous possibility to interact with the other subjects involved in the action of learning allows a sort of natural

path to self-efficacy and therefore leads to the enhancement of a substantial change of attitude of all the subjects involved in the process.

There are different studies (Wheeler & Wheeler, 2009; Xiao & Lucking, 2008; Shu & Chuang, 2012) which highlight the benefits of collaborative learning using wikis. Stoddart *et al.* (2016), in their review on the state of the art of facilitation frameworks, offer a precise picture of best practices “tenets of facilitation”. They deepen the nature of collaboration, focusing on different elements: motivation (e.g. Chao & Lo, 2011; Weaver *et al.*, 2010); enjoyment (Wong *et al.* 2011); individual input into projects (e.g. Davies *et al.*, 2011); peer review (e.g. Chao & Lo, 2011) and so on.

As regards collaboration effectiveness, Stoddart *et al.* (2016) identify as the most relevant variable the one related to the manner in which a collaborative wiki is facilitated by the instructors (Lin & Kelsey, 2009). The authors underline that wiki cannot work without careful design and implementation and, most of all, without a highly supportive learning experience, where students are instructed on how to work collaboratively using the tool. Such point is exactly the one, which guided the research group in the present study, together with the focus on the benefits collaboration should bring in terms of facilitation of entrepreneurial and developmental skills.

As many EU documents highlight, to improve competitiveness and professional/personal development, cross-sectional skills are to be enhanced as engines for social innovation: creativity, entrepreneurship, critical thinking and problem solving. (cf. “Entrepreneurship education at school in Europe” (EACEA, 2012, p. 7), OECD, 2010, Investing in Human and Social Capital”, p.2). The above skills, as many studies mention, are favoured by a cooperative approach (cf., Gokhale, 1995; Jonassen *et al.*, 1998; Poce, 2012). In fact: “collaborative learning fosters the development of critical thinking through discussion, clarification of ideas, and evaluation of others’ ideas. However, both methods of instruction were found to be equally effective in gaining factual knowledge”. Therefore, if the purpose of instruction is to enhance critical-thinking and problem- solving skills, then collaborative learning is more beneficial” (Gokhale, 1995).

Scientific and technologic culture, relevant element of the shared encyclopaedia and the individual knowledge, also becomes a tool for social and political participation. Such issue gains more importance if one takes into consideration the effects that techno-scientific knowledge, reaching the mass public, produce on behaviours, in terms of orientation, value-based choices, fruition capacity of the technology-related opportunities and the formation of a critical perspective. Field studies demonstrate the users’ deep inability to understand and manage the technological resources, as well as a profound interference of the mediated information sources to the detriment of an objective

and realistic evaluation of the access to the techno-scientific knowledge (ISTAT, 2007; Pinnelli, 2009). In light of what above mentioned, that of the dissemination of popular science is, today, a duty of public institutions as well as a right of the citizens who can, thanks to such information, actively participate in the democratic and associative life of their own community.

Within the above context, this contribution refers to the activity carried out at Roma Tre University, where a group of students took part in an experimental project to enhance their science teaching and critical thinking skills, through online cooperative writing activities.

## 2 Research Design and Methodology

The present study, realised within the module “Writing Methods and Techniques in Education”, hold out at Roma Tre University – Department of Education, starts from the assumption that students can develop their writing and critical thinking skills thanks to specific co-writing activities. The general objective of the module where the experimentation took place is to improve students’ writing skills in different disciplinary and learning contexts. Meta-objectives have been identified in the opportunity for students to improve also their correct use of the language (grammar, morpho-syntax, lexicon accuracy), argument skills and to develop critical thinking and creativity skills as well. The module was composed by a series of face-to-face classes, during which students have produced short essays on the topics discussed with the lecturer, and online co-writing activities, carried out through the *Orbis Dictus* ([www.orbisdictus.it](http://www.orbisdictus.it)) platform.

The students’ online module has been planned as a set of on-line group activities, with the general aim to provide useful elements to understand the typical characteristics of the language of science and create the structure of a creative text with a scientific topic through cooperative writing. During the online activities in their virtual area of reference, the students, divided in group from 3 to 5, were called to reflect on the levels of complexity of some proposed texts for the transmission of contents, on the choice of language used and to be used, as well as on the modes of representation of a given content. As a first task, they were engaged in the analysis of the writing techniques of the texts on the singled out topics, in the planning and definition of a working methodology and in the actual writing of a new learning/teaching text, in the form of a fictional story, solving the educational issues they were faced with during their work. All writing activities have been carried out in group and with the use of *Google Documents* as tool for co-writing.

The objectives of the module’s didactic path are outlined as follows:

- Analysis of the lexicon, syntactic and grammatical structures of the

examined texts

- Choice of the writing style
- Production of an original text
- Development of argumentative abilities in written production
- Development of critical thinking and creativity
- Effective use of technology

In fact, the online module addressed the aspects related to creative writing, by providing the basic elements and techniques of various genres, with the aim of making clear to the students what the necessary knowledge for the proposed writing activities was and allowing them to get to know and understand, with specific competences, the world of narrative and the basic theories of narratology. The writing module was outlined as a moment of organised and specific confrontation in a relation of stimulus, perception and internal elaboration of mental images. During the on-line activities, students were provided with the necessary instruments to create the characters, structure the plot and avoid the most frequent narrative traps.

The didactic path within the online module was divided in three units, each one with its specific objectives:

- First unit: analyse a narrative scientific text according to the elements of narratology, scientific language and creativity
- Second unit: plan and realise the creative scientific writing through the actual writing of the end to a short story provided
- Third unit: create, plan and realise a creative scientific text related to the themes connected to the *Observatory of marine Biodiversity*

In this regard, it is important to mention the choice to use, as reference models for the creative writing with a scientific topic, some short stories from the collection *Narrare la scienza* ("Narrating Science"), a volume gathering some of the writings by high-school students who took part in last edition of "*La scienza narrata*" ("Science narrated")<sup>1</sup>. The choice of such texts aimed at providing reference models written by peers, useful during the on-line activities, with the goal to improve the capacity of analysis and argumentation of the students during the whole working process. Indeed, the winner of the Merck Serono Literary price, *Golden Eyes*, was provided to the students as a reference text and model of analysis of a creative scientific short story. Such analysis, created with the aim of showing the linguistic and narratological aspects of the abovementioned short story, was used as a supporting tool for

<sup>1</sup> The competition, promoted by the Merck Serono Academy of Biotechnologies, was born from the narrative scientific writing lab aimed at promoting the students' reflection on the tight relationship between the world of science and that of literature and creativity (<http://www.premioletterariomerck.it/>).

both the first and the following activities.

The objective of the exercise of analysis of the narrative text (Activity 1) is to put in practice the knowledge and the analysis techniques in relation to two fundamental issues: the structure of the narrative text and the scientific sectorial language. Those constitute the core of the proposed activity. Through the contents, presented through the dedicated materials, the students are directly called to single out the topic of the story and the fundamental stages of the narration, the role of the characters, the setting, the kind of narrator, together with any peculiarity of language, provided that it can be considered literary and “creative” (denotation and connotation; expressive function of rhetoric figure) or to a sectorial-scientific field (use of a specific lexicon; particular morphological situations used).

The second activity involved the group of students in the co-writing of the ending to a short story with a scientific topic to which the conclusion had been cancelled. Such exercise aims at using the knowledge gathered about the characteristics of narration within a restrained writing activity, in which it is obligatory to respect the original features and, at the same time, to be coherent with the story provided. The students are obliged to pursue two fundamental objectives: creative writing, an activity that must be carried out following many operative phases, and the insertion of such text in a set narrative framework, in which many elements have already been defined and must be rightly developed within the final part. More in detail, the idea of the story’s ending, fantastic or realistic as it may be, must fit in an already given narrative scheme in which the characters, the narration phases, the setting, the narrator and the organisation of the plot are for the most part defined. The epilogue must effectively end the narrated story, by completing all the sub-stories and not forgetting events or characters fundamental to the plot. Everything must be *coherent*, i.e. clear and appropriate to the circumstances in which the text was produced. Such coherence must be expressed on various levels: thematic (connection to the main topic); semantic (use of words specifically required by the context); logical (right logical connection between various concepts); stylistic (use of a register appropriate to a certain kind of text).

The third activity, the *ex novo* writing of a creative scientific short story, was the one that put more to the test the linguistic and scientific knowledge gathered during the didactic process. After a series of activities of increasing difficulty, the students reached the end of their path, and were asked to create and write their own short story from scratch as a group effort. Each group was assigned an animal species that, in order to be narrated in a creative way, had to be meticulously studied and analysed.

The students’ activities were constantly monitored by an e-tutor (Rotta & Ranieri, 2005) who worked with the participants and adapted his supporting

functions according to the evolution of the didactic process. In detail, the role of the e-tutor was to ease the learning process for the students by providing information useful to the use of the platform and the analytical explanations of the activities to be carried out. Furthermore, the e-tutor constantly monitored the work of the participants, by promoting participation of less active groups and suggesting organisational and methodological solutions in relation to the cooperation among students. Following are the themes assigned to the groups of students for the realisation of the final story: Turtle, Dolphin, Seahorse, Octopus, Sea Star.

The short stories written by the students were evaluated by an *ad hoc* board to assess the achievement of the objectives foreseen by the learning path. The last activity must be regarded to as the summative task of the didactic path in the online module. Consequently, the evaluation of the task was deemed necessary to analyse the entire course of the didactic intervention. According to the objectives and the meta-objectives singled out within the activities and the module in general, an evaluation grid was created for the assessment of the short stories, which is presented in the dedicated content.

### 3 Analysis and findings

In order to set the assessment exercise of the creative short stories written by the group of students, the LPS research group moved from ideas related to the evaluation of critical thinking. The purpose of the creative feature was to support the focusing and emotional internalisation of the scientific topics that were objects of study. Paul and Elder (2012) claim that students that think critically use writing as a useful tool for communicating ideas important for learning. To elaborate a concept by writing is useful to clarify it and to acquire a higher level of precision, accuracy, relevance, depth, width, logic ability and meaning. Through writing, pupils find it easier to carry out a process of analysis and evaluation of the ideas they had while studying. Paul and Elder also state that such process can help both the learning and writing abilities, and those activities influence one another. The assessment tool created by the LPS researchers aimed, in this phase, at finding the following abilities in the products of the students' work:

- Reflection
- Writing
- Analysis and Synthesis
- Exemplification
- Connection of Ideas
- Development of a Thesis
- Understanding of the Proposed Scientific Elements

The assessment tool, therefore, has been structured in five sections that contain elements whose focus shifts according to the aspect object of interest.

**Table 1**  
**ASSESSMENT TOOL**

Pertinence (the topic under issue is mentioned)		
High	The outline is complete, deep and original	8-10
Medium	The outline is generally correct	5-8
Low	The outline is partial or out of line	0-4
Content (Each element is assessed with a score from 0 to 2. The total score is 10)		
Narrator and focusing	Narrator's choice is consistent with the narratological choices	2
	Narrator's choice is not always consistent and the relation between narrator and narratological focusing is not clear.	1
	Narrator's choice is not consistent with the narratological choices and the relation between narrator and narratological focusing is incorrect.	0
Structure of the text	The structure of the text is clear and original.	2
	The structure of the text is merely confused.	1
	The structure of the text is not well defined and text phases are not clear.	0
Time	Time is well defined in relation to the different phases of the text. The temporal scanning is appropriate.	2
	Time use is not precise and the relation between time and plot is not clear.	1
	Time use is not correct and improper. The relation between temporal scanning and text phases is contradictory.	0
Setting	Set description is complete, deep and original.	2
	Set description is essential, simple and not well defined.	1
	Set description is partial or absent.	0
Characters	Characters are described accurately and their role in relation to the plot is clear.	2
	Characters are described sufficiently but their role in relation to the plot is not always clear.	1
	Characters' description is superficial or not sufficient.	0
Form		
High	Expression is original and appropriate.	8-10
Medium	Expression is mainly correct.	5-8
Low	Expression is not correct or improper.	0-4
Originality		
High	The topic under issue is elaborated in a critical and creativity way.	8-10
Medium	The topic under issue is elaborated in a simple and essential way.	5-8
Low	The topic lacks of creativity and personal elaboration.	0-4



Scientific language		
High	The scientific language used is appropriate and rich.	8-10
Medium	The scientific language used is mainly correct.	5-8
Low	The scientific language used is not correct or improper.	0-4
<b>TOTAL</b>		<b>/50</b>

The following table shows the scores assigned to the students' short stories. Each work group is indicated with a letter of the alphabet in the first column on the left, while the lines contain the points given by evaluators to each indicator of the assessment grid. Groups from A to D were enrolled in the 2014-15 academic year; groups E, F, G enrolled in the 2015-16 academic year. All the students were at the third year of their degree programme taking the "Writing Methods and Techniques in Education" module.

Table 2  
STUDENTS' SCORES

Group	Pertinence	Content	Form	Originality	Scientific language	TOTAL
A	8	10	9	9	9	45
B	9	10	9	10	9	47
C	8	9	9	9	8	43
D	10	10	10	10	10	50
E	10	8	8	10	10	46
F	10	9,5	8,5	9	6	43
G	10	9,5	9,5	10	9,5	48,5

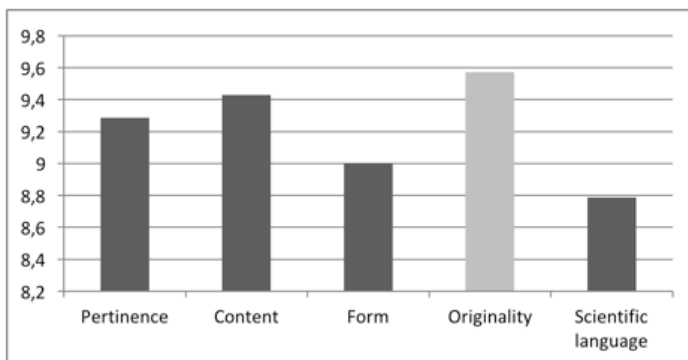


Fig. 1 - Average students' score per category.

The *originality* category has shown the best results: the knowledge on creative writing and the scientific topic were used in an original way and were inserted in a context that was carefully created and never banal.

The *content* category highlights good results, with peaks of excellence, in all the stories submitted: excellent and brilliant has been, has previously underlined, the ability to make use of the key elements of creative writing.

The *form* and *expression* indicator revealed, in some productions, the use of a correct and fluid form, which also was original and strongly connotative, thanks to the use of a literary and rhetorically inspired language. In some productions the form was generally correct. Statistically minimal is the presence of punctuation and syntax errors.

#### 4 Lexicometric Analysis

The readability analysis of each produced text were conducted using the DyLan TextTools v2.1.9 provided by the “Antonio Zampolli” Institute for Computational Linguistics (ILC) of Pisa. The results of these analysis are reported in the table hereafter:

Table 3  
READABILITY ANALYSIS

Group	Number of sentences	Number of words (token)	Average lenght of sentences in token	% of VdB lemmas	% of FO	% of AU	% of AD
A	56	1805	32,2	79,4	83,8	11,9	4,2
B	67	1545	23,1	80,8	87,3	7,9	4,8
C	48	1222	25,5	78,8	82,3	13,1	4,6
D	142	3683	25,9	71,2	72,6	20,6	6,9
E	168	1925	11,5	76,8	82,3	14,1	3,7
F	210	4278	20,4	80,9	80,2	15,4	4,3
G	66	2399	36,3	78,8	82,8	14,6	2,6

As shown in the table, the texts were compared with the Basic Vocabulary of Italian (VdB) by Tullio De Mauro (De Mauro *et al.*, 1980). The version of VdB used in our analysis is the most recent one and it counts about 6,700 lemmas, organised in three vocabulary ranges (De Mauro, 1999):

1. *Fundamental vocabulary (FO)*: it includes the highest frequency words that cover about 90% of all written and spoken text occurrences in the Italian language.
2. *High usage vocabulary (AU)*: it covers about 6% of the subsequent high

frequency words.

3. *High availability vocabulary (AD)*: it is derived from a psycholinguistic insight experimentally verified, and is to be intended in the tradition of the *vocabulaire de haute disponibilité* (Michéa, 1953; Gougenheim, 1964).

From the lexicometric analysis, mainly carried out to analyze the lexical conformation of the texts, it emerged that: irrespective of the length of the text, the 70 to the 80 percent of words used is part of the VdB, this means that the non-basic language used is restricted to the 20-30 percent of the texts.

Since language is a context-bound phenomenon, a qualitative analysis was carried out, investigating scientific terms used in texts looking for words in the third range of VdB. We decided also to include words not present in the VdB, since the main aim of the *Basic Vocabulary of Italian* is to identify terms for common usage and not necessarily related to the scientific biodiversity terminology under issue.

Hereafter, numbers of nouns that are included in the third range of the VdB (second column) and that are not present at all in the Vdb (third column) are shown. In the brackets number of nouns related to marine biodiversity or scientific terminology are highlighted (names of fictional characters and neologism were not considered):

Table 4  
NOUNS ANALYSIS

Group	no. of VdB nouns	no. of nouns not included in VdB	ratio in-VdB of scientific nouns	ratio not-in-VdB of scientific nouns
A	10 (6)	40 (16)	1,7	2,5
B	9 (5)	14 (7)	1,8	2
C	7 (2)	23 (10)	3,5	2,3
D	13 (6)	61 (20)	2,2	3
E	8 (2)	29 (15)	4	1,9
F	11 (2)	17 (2)	<b>5,5</b>	<b>8,5</b>
G	7 (2)	25 (13)	3,5	1,9

In the above table the ratio between the number of scientific related terms on the total of terms considered has been reported also. The lower the better and the best value 1 indicates that all the terms considered in the text are scientific language related.

The main aim of these two lists is to determine from the noun-choices, if the requisite of using a scientific language has been fulfilled by the students

in writing the short stories: group F shows the lowest number of scientific language terms and this confirms the score obtained and mentioned above.

## Conclusive remarks and possible developments

It is useful to underline that the use of the *Orbis Dictus* platform allowed the students to work in a flexible and dynamic environment (Vertecchi *et al.*, 2010), that supported the didactic path by providing all the necessary tools. The use of an e-learning group process and co-writing activities (Google doc use), constantly supervised by the e-tutor, required strong coordination among the students, which resulted in a stronger boost by the participants in the presented activities, mainly thanks to the motivational expectations of the fellow students of the group. The cooperative learning and working mode has been, indeed, accepted since the very beginning by the students. This led to remarkable results in terms of participation and organisation of the work, as well as, as shown by the reported results, in terms of quality of the products.

The students were able to challenge themselves facing the core elements of their learning path: the creative short story and the technical-scientific language. The use of such material proved to be important both in the initial phase, that in which students became acquainted with the proposed contents, and in the final one, that of the actual, written production of an original short story.

Results related to good performances in the originality category support the starting assumption according to which students can develop their writing and critical thinking skills thanks to specific co-writing activities.

Data presented here can be considered as a start in this kind of research and represent directions which support a further development of the studies, that, being related to such a complex ability as critical thinking, need careful deepening of the subject. Such analyses, therefore, will be repeated with in coming cohorts of students, in order to understand if results keep stable in the long term and contribute to confirm the findings herewith presented.

## Acknowledgments

A. Poce coordinated the research presented in this paper. Research group is composed by the authors of the contribution that was edited in the following order: A. Poce (State of the Art, Research design and methodology, Conclusive remarks), F. Agrusti (Lexicometric Analysis), M.R. Re (Analyses and findings).

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