Recent Advances in Science and Technology Education, Ranging from Modern Pedagogies to Neuroeducation and Assessment

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Edited by

Zacharoula Smyrnaiou, Martin Riopel and Menelaos Sotiriou

Cambridge Scholars Publishing

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TABLE OF CONTENTS

Organizers and Supporters ix

Committees x

Preface xiii

Part 1: Modern Pedagogies in Science and Technology Education

Reflexive Return and Quality of the Language using Information and Communication Technologies 2
Michel Pronovost and Katerine Deslauriers

Community of Practice and its Applied Results in the Teaching of Science-Technology of the Secondary Sector (High School) 15
Diane Gauthier and Ugo Collard-Fortin

Teaching of the Renewable Energy Sources to Secondary School Students with Science Activities based on Socio-Scientific Argumentation 30
Gülsüm Yasemin Şahintürk and Mehtap Yurdatapan

Concept Mapping as Cognitive Tool in Science Education: An Analysis of Students' Learning using SOLO Taxonomy 43
Vasiliki Bakouli and Athanassios Jimoyiannis

Refining a Revised Bloom's Taxonomy to Enhance Student Learning in Computer Science Courses 59
Sofia Tzelepi and Isabella Kotini

Education of Roma Children: Developing Intercultural Understanding and Training Skills for Teachers through Distance Learning and a Constructivist Teaching Model 71
Christos Parthenis

Part 2: New Technologies in Science and Technology Education

Teaching the Phases of the Moon and the Seasons in a Digital Planetarium 86
Pierre Chastenay

The KITLoK: A Dynamic Interaction Analysis Model for Instrumented Learning Situations 98
Rodica Ailincai and François-Xavier Bernard

Designing and Implementing Experimental Microcomputer-Based Activities by Primary Student Teachers 116
Dimitris Stavrou and Vasilis Savvorginakis

Education of Roma Children: The Importance of Supporting Networking of Schools and All Participants through Web Applications and Social Media 125
Christos Parthenis, Eirini Tseliou and Aikaterini Tsoka

Recognizing Interesting Points in Constructionist Activities Using Artificial Intelligence 136
Marios Xenos, Chronis Kynigos and Maria Daskolia

Multi-Agent Models, Made in NetLogo, for Teaching Simple Properties of Complex Natural Systems, and their Instructional Use 146
Aristotelis Gkiolmas, Maria Papaconstantinou, Anthimos Chalkidis and Constantine Skordoulis

Developing Historical Significance using Digital Technology: An Example of Greek Ancient History 158
Elias Stouraitis

Study of the Problem “Exploration vs. Exploitation” in the Context of an Ecosystem with the “Multi-Agent” Software NetLogo 167
Georgios Gkaras, Panayiotis Costaridis, Dimitris Yiatas

Part 3: Assessment in Science and Technology Education

Assessing Students’ Knowledge on Refraction 180
Claudia Haagen and Sebastian Glantschnig

Tracing Computer Assisted Assessment for learning Capability in Greek Teachers 197
Zacharoula Smyrnaiou, Evangelia Petropoulou, Eleni Spinou and Kathrin Otrel Cass

Part 4: Teaching and Learning in the Light of Inquiry Learning Methods

Establishing a Common Pattern for Educational Tools' Design Process: The Inquiry-based Development Approach of a Tool Addressing Science Related Issues 220
Zacharoula Smyrnaiou, Evangelia Petropoulou, Maria Margoudi and Ioannis Kostikas

Responsible Research and Innovation in Science Education: The IRRESISTIBLE Project 239
Dimitris Stavrou

Development of Argumentation Skills through a Web-based Learning Environment Devoted to 'Antimicrobial Resistance' 243
Argyro Scholinaki, Constantinos P. Constantinou, Elena Siakidou and Dimitris Koursaris

Part 5: Neuroscience and Science Education

Intuitive Interference in Science and Mathematics Education 266
Ruth Stavy and Reuven Babai

A Study of Affect and Cognition in Tutor-supported Collaborative Learning in Physics 276
Julien Mercier, Patrick Charland, Dave Saint-Amour, Line Laplante, Martin Riopel, Steve Masson and Vivek Venkatesh

Integrating the Perspective of Neuroscience in Tutoring Research in Physics: Why And How? 287
Julien Mercier

Part 6: Conceptual Understanding and Conceptual Change in Science and Technology Education

Causality of Magnetism: Development of a Video-based Intervention for Primary Students 298
Vasiliki Spiliotopoulou and Christina Lianeri

Is Touch Sensory Input Necessary for Science Learning through Experimentation among Young Learners? 310
Zacharias C. Zacharia

Engineering Students' Teaching Plans on Periodicity: Transforming School Texts 321
Vasiliki Spiliotopoulou and Chrissavgi Triantafillou

Part 7: Interest, Attitude and Motivation in Science and Technology Education

Teachers' and Learners' Perceptions of the Mathematics, Science and Technology Curricula in Austria and Cyprus 334
Veronika Rechberger, Michalis Livitziis, Judith Aldrian, Maria Hadjidemetri, Constantinos P. Constantinou and Leopold Mathelitsch

A Review on Girls and their Interest for Science and Technology: Which Questions do Researchers Ask and How do They Answer Them? 346
Marie-Hélène Bruyère, Patrice Potvin and Abdelkrim Hasni

The Effect of Technological Design Processes (TDP)-based Activities on Students' Interest in Science and Technology Classes 363
Nancy Brouillette, Patrice Potvin, Ghislain Samson and Abdelkrim Hasni

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PREFACE

Dear Colleagues,

This book you hold in your hands is a publication composed by the majority of the papers from the First International Conference on ***“New Developments in Science and Technology Education”*** **NDSTE2014** (http://ndste2014.weebly.com/), that was held in Corfu Island, in Greece, from Thursday, May 29th, to Saturday, May 31st, 2014,

The conference was organized by the **Educational Technology Lab (ETL)** of the National and Kapodistrian University of Athens (NKUA) and **Équipe de Recherche en Éducation Scientifique et Technologique (EREST)** de l’Université du Québec à Montréal (UQÀM) in collaboration with the non-profit organization **Science View,** under the auspices of the Ministry of Education of Greece. It was structured around seven main thematic axes as follow:

- Modern Pedagogies in Science and Technology Education,
- New Technologies in Science and Technology Education,
- Assessment in Science and Technology Education,
- Teaching and Learning in the light of Inquiry learning Methods,
- Neuroscience and Science Education,
- Conceptual Understanding and Conceptual Change in Science and Technology Education,
- Interest, Attitude and Motivation in Science and Technology Education

Science and technology education research not only concentrates on the teaching of science concepts and addressing misconceptions that learners may hold, but also as they co-evolve they examine and integrate into their epistemologies innovative approaches such as Inquiry-Based Science Learning that situates learning in authentic science practices. New developments in science and technology education rely on a wide variety of methods, borrowed from many other sciences such as computer science, cognitive science, sociology and neurosciences.

A lot of studies indicate that students who use new technologies, enlightened by new developments in science education, not only get better grades on exams, but also demonstrate better understanding. Constructing and using scientific conceptual models are also necessary in order to reach high levels of scientific literacy. Therefore, it is important for science courses to be designed in ways that support and help students understand the pivotal role of models in scientific episteme and of modeling in scientific inquiry.

Research consistently indicates that information and communications technology (ICT) has the potential to support education for knowledge age skills in two distinct but compatible ways. The first is through Exploratory Learning Environments including games and simulations, which hold the promise of making abstract ideas concrete and manipulable. In the last 10 years a relatively small number of breakthrough digital artifacts has been produced for students to use expressive and exploratory tools that assist in developing the learning of scientific and technological ideas. At the same time, they have illustrated ways for students to adopt an enquiry scientific stance to these subjects striving for rigor, insight and the ability to abstract and generalize. A second way in which ICT can transform learning is through computer supported learning dialogues as part of the Computer Supported Collaborative Learning CSCL. Computer supported collaborative tools have provided users with the means to engage in argumentation and the possibility to acquire skills in collectives in ways not possible before.

The key factor in shaping the quality of science education and technology is assessment. During the last decade within the context of educational reforms carried out in various countries around the world there has been a tendency to focus on the outcomes from assessment practices. So far, assessment has been often accumulative and generally conceived as an end to itself and it is regarded to be the responsibility of the teacher to adequately prepare students, apply assessment strategies and produce reliable and valid information from assessment. The adoption of new pedagogical theories has triggered a change of focus from assessment that focuses solely on the acquisition of knowledge/learning (assessment of learning) to assessment of the effective implementation of skills in various environments (assessment for learning), thus putting emphasis on the cognitive procedure rather than the outcome.

Science and technology education research, influenced by inquiry-based learning, not only concentrates on the teaching of science concepts and addressing misconceptions that learners may hold, but also emphasizes how students learn and tries to find out ways to achieve better learning. Inquiry-based learning is a widespread learning method being embraced by many national educational systems all over the world. It is a highly-structured and thoughtfully designed-endeavour with the potential to increase engagement in knowledge inference processes and foster deep access to cognitive aspects through the development of a hands-on, research-based procedural task. It sets an instructional frame that bridges the gap between the learning process and authentic scientific practices. As an instructional process it extends and promotes the learning of students in a way that addresses their interests while at the same time it facilitates a visible representation of their thinking and learning.

Intuitive Science and Conceptual Change are very important in science and technology education. Several explanations to students' representations (or misconceptions, etc.) were given in the last decades by researchers in science education. Students encounter difficulties in solving a wide range of problems in science education. Some of these difficulties may stem from intuitive interference of a salient (automatically/intuitively processed) irrelevant variable with the formal/logical reasoning that is needed for the handling of that is needed for the handling of the relevant variable. This interference is reflected in students' erroneous responses to numerous tasks in science education. New developments in this field are related to the neuroeducation or to the neuroscience techniques.

Another important aspect is motivation. Many researches focus on how to motivate students, boys and girls in science and technology and inspire them to follow scientific careers. Specifically, during the last decade, Europe and Canada have turned their attention to attracting young people in science education and consequently in scientific careers. Despite targeted strategies and policies that have been established for this purpose and the significant importance of science for society, there continues to appear reduced interest on the part of young people to follow this career path, setting, thus, an increasing gap between the social demand and the scientific expertise. Studying the factors that affect interest and attitude and determine the choice about their professional future, the results show that gender and discipline continue to remain key factors in shaping young people's stance as had previously emerged from the results of the Project "Rose" and other projects.

The organizers,
Zacharoula Smyrnaiou
Martin Riopel
Menelaos Sotiriou

PART 1:

MODERN PEDAGOGIES IN SCIENCE AND TECHNOLOGY EDUCATION

Reflexive Return and Quality of the Language using Information and Communication Technologies

Michel Pronovost
and Katerine Deslauriers

Abstract. *The quality of the French language is a priority for all colleges in Quebec. It has been highly studied, but this is the first time that science and non-science students have been compared regarding their quality of language. This study measures the effects of revision (auto correction and rewriting) of texts written by science students and non-science students on the perception of their capacity to improve at the language level by using information and communication technologies. During the session, students had to write three texts (the first one by hand and the others with a computer). Teachers corrected the writings by indicating the mistakes. Students then had to rework their texts using different tools, including technological tools, and hand them back to their teachers who recorrected them. The sample (n=148) was mainly composed of girls (64.9 %). It was composed of students who were registered in a pre-university program (46.9 % in science) that mainly speak French at home (73 %). The majority of the students have access to language correction software at the home (56.8 %). Science students consider themselves less competent in using Antidote than those who are not in the sciences (t=5,594, p =, 000). They thus use it less for the revision of their school work (t=4.643, p =.000). Science students consider the comments of their professors more useful than the other students (t=2.02, p=.044). They understand them better (t=2.15, p=.032) and feel more capable of satisfying the requirements of their professors (t=2.25, p=.025). Science students make more mistakes in spelling (t=3.10, p=.002), grammar (t=3.30, p=.001), punctuation (t=2.92, p=.004), syntax (t=7.20, p=.000), grammar of the text (t=4.13, p=.000), vocabulary (t=1.86, p=.064) and specific vocabulary mistakes (t=5.90, p=.000) than those who are not in science. Although they had better marks in high school (t=5.38, p=.000) and a better R score in college, students in science had no significant difference* *in French marks at high school than the others. At home, students use virtual tools more than paper ones, even though they have access to them. At the end of the session, the reflexive return on their works and the fact of having been able to rework their texts brought them an overall vision of the quality of their written French. Reflexive return allowed the students to identify the strengths and the gaps that are specific errors in French, the general quality of the contents of the text, and the precision and depth of their ideas. We can conclude that when we give them the time and the opportunity to review their texts, they get satisfaction from it and some pleasure.*

Keywords. Antidote, Correction, ICT, Quality of the language, Reflexive Return, Word

1. Introduction

The quality of the French language is a priority for all colleges in Quebec. Several strategies were put in place for the improvement of the quality of the French language; however, recorrection has not been studied in depth. We believe that it is a promising way to improve the quality of the French language.

2. Theoretical Framework

Several research papers have had the study of the reading and writing skills of collegians as a subject; others have analysed the effects of the educational interventions of professors in the mastering of French [1, 2, 3, 4, 5], but few have concentrated on the metacognitive capacity of autoreflection and autocorrection.

Correction

The time and energy that is dedicated by professors to the correction and annotation of work has sense only if students take these remarks into account [6] and if corrections are made in a terminal mode and circumstantiated [7]. Formative assessment, partial correction, correction by peers and autocorrection [8, 3] are activities which modify the practices of teaching and learning related to writing.

Today, still, correction is made in a traditional way because it consists of reading the copy and formulating written comments to students. These corrections serve to note the weak points and sometimes the key points of the work as well as to justify the mark obtained by the student [9]. Furthermore, teachers who carry out the same correction several times and a little bit mechanically tend to get stuck in automatic reactions, which, it is necessary to say, are sometimes necessary for his "survival" during intense periods of correction [10]. However, the correction generally leaves both the teacher and student dissatisfied [11]. Teachers complain about the arduousness of the task [12] and of the place occupied by evaluation in teaching [13]. Students complain about the difficulty in having to understand comments on the corrected copies and the extension of the correction [14, 6].

A part of the problem is that almost all of the teachers have never received training to correct [15, 12] because correction is traditionally associated with the teacher's job. The evaluative act is an intuitive act in many ways [16] and many teachers still correct "instinctively". This absence of training does not allow the understanding of the nature of the act of correcting [10, 17]. The Upper Council of Education [18] suggests looking for means to ensure initial correction training for collegial teachers and in-service training for teachers in practice.

Autocorrection and reflexive return

The difference between autocorrection and reflexive return, in the correction of language, is mainly in the plan of the object of the correction that is to be made, and of the object of reflection [19]. If the reflexive return can be used for any learning, in an educational way, it demands good supervision from the professor.

"We often speak about reflexive return as being the act by which the metacognition becomes concrete and thus that it is included by the learner. The reflection on its own work, its own manners to proceed and its own ideas allows the learner to become aware of its models and its schemas of thought. This awareness is important, because it favours the change and the growth necessary for the learning." [20].

The correction is aimed mostly at the linguistic code, at the written language, and less often at the coherence, the fine and global logic of the structure of the text, and the sense of the text. Thanks to reflexive return, we can also make the students think about their global progress in French. According to Segreto [20], these are the main characteristics that reflexive return is aiming for:

- It is a continual process that takes place in a natural way, following the realization of the works.

- It carries on a particular theme, such as a particular work, or on skills in development.
- It is global because we can ask the students to summarize their work or to give an overview.
- It gradually gets the students accustomed to asking themselves significant questions.
- By means of the examples given by the teacher and by peers, it settles down so that everyone uses a common vocabulary and builds strategies together [20].

3. Research questions

We wanted to answer three research questions:

- Which tools are used by students to improve their quality of French?
- Do virtual tools improve the quality of French when compared to traditional tools?
- Is the French quality of science students' better than that of non-science students'?

4. Methodology

The sample was composed of 148 college students in biology, sociology or philosophy classes, aged between 16 and 19 years old.

They had to write three essays: the first one by hand in the classroom; the second one at home with a computer and the tools of their choice; and the third one at home, with the obligation of using virtual tools to correct the language and of sending an electronic version to the teacher. These essays were corrected and annotated by their teacher. Students then had to do a recorrection (reflexive return) at home with the tools of their choice for the first essay, at home with a computer and the tools of their choice for the second essay, and in a computer laboratory with Antidote for the third one. Students were asked which tools they used for recorrection. Students in the science program were then compared with other students.

5. Results

The sample (n=148) was mainly composed of girls (64.9 %). It was composed of students who are all registered in a pre-university program and who mainly speak French at home (73.0 %). The majority of the students have access to language correction software at home (56.8 %) and 38.5 % of the students use a laptop computer in class.

Use of correction tools

The students in our sample use language correction software in their general training courses especially (66.2 %). They use them less for their specific training courses (47.3 %) and the least for their complementary training courses (28.4 %).

Two thirds of the students said that they had used virtual language correction tools before their arrival at college. The vast majority of students (80.4 %) said that they often or always proceed to linguistic revision during the writing of a text.

The girls (78.8 %) make linguistic revisions significantly more often than the boys (63.5 %) ($t = 3.553$, $p =.001$). In comparison, regarding the use of Antidote, which does not vary according to sex, the girls (80.2 %) use the proof-reader for Word significantly more often than the boys (60.9 %) during the correction of their school work ($t = 4.013$, $p =.000$).

Students proceed to the correction of their school work whether they are long (93.3 %) or short (82.2 %). They also correct their letters (79.7 %) but less so their e-mails (51.4 %) and comments on social media (45.5 %), and they correct their texts messages the least (27.7 %).

Table 1 shows that science students are considered less competent in using Antidote than those who are not in sciences ($t=5.594$, $p <.001$, $\eta^2=0.18$). They thus use it less for the revision of their school work ($t=4.643$, $p <.001$, $\eta^2=0.13$).

Table 1. Auto evaluation of competence and frequency of use of Antidote by science students (S) and non-science students (NS) (n=147)

	Gr.	N	Mean (%)	SD	t	P	η2
Auto-evaluation of competence in using Antidote	NS	78	52.15	28.23	5.595	<.001	0.18
	S	69	25.60	29.24			
Frequency of using Antidote for school work	NS	78	45.73	35.28	4.643	<.001	0.13
	S	69	21.25	28.57			

Strategies of revision

Students especially use proofreading (76.4 %) as the main strategy of revision. They use no few paper tools (21.6 %) or virtual tools (17.6 %) in the correction of their school work.

Table 2 presents the scores (%) of the use of tools to correct their writing. The use of these tools corresponds to the context of the evaluations (the first one being made in class, by hand, and the third in the laboratory with Antidote). We notice that it is at home (writing 2) that the students use virtual tools more than paper ones, and that paper tools were used the most for the correction of writing 1, which was drafted by hand. In writing 3, they were forced to use virtual tools.

Table 2. Frequency of use of paper and virtual tools during the corrections of three writings (n=132)

Tools	Writing 1		Writing 2		Writing 3	
	Mean score	STDE	Mean score	STDE	Mean score	STDE
Paper	30.3	4.0	17.7	3.4	8.7	2.8
Virtual	29.5	4.0	50.0	4.5	98.0	1.4

Table 3. Frequency of mistakes per 900 words of three writings

Categories	Writing 1		Writing 2		Writing 3	
	Mean score	STDE	Mean score	STDE	Mean score	STDE
Spelling	6.6	0.8	3.2	0.4	2.1	0.3
Grammar	6.7	0.7	5.9	0.7	4.3	0.6
Punctuation	1.9	0.3	1.1	0.2	1.5	0.2
Syntax	5.4	0.6	5.0	0.6	4.2	0.5
Text Grammar	4.2	0.5	2.6	0.3	2.1	0.3
Vocabulary	2.1	0.3	1.1	0.2	1.2	0.2
Specific Vocabulary	2.0	0.3	1.9	0.2	1.7	0.3
Total Mistakes	28.9	3.5	20.8	2.6	17.1	2.4
Word Total	283.1	7.7	347.0	9.7	360.4	10.5
n	144		142		130	

In table 3, we observe a reduction in the total number of mistakes from writing 1 (by hand, without tools) to writing 3 (in the laboratory, with Word), particularly in spelling, grammar, the grammar of the text and the vocabulary. By hand and without tools, students make more spelling mistakes than with a computer. Their use also allows the reduction of the number of mistakes in grammar, the grammar of the text and the vocabulary. There is no difference for the punctuation, syntax and the specific vocabulary, and this is true even when the last two writings were made using a computer.

Table 4 shows that science students make many more mistakes than non-science students ($t=-7.21$, $p<.001$, $\eta^2=0.29$), even after recorrection ($t=-5.38$, $p<.001$, $\eta^2=0.18$). Effect size is quite important.

Table 4. Number of total mistakes by science students (S) and non-science students (NS) (n=147)

	Gr.	N	Mean (%)	SD	t	P	η2
Total mistakes	NS	70	7.7	11.7	-7.21	<.001	0.29
	S	60	28.3	19.3			
Total mistakes after recorrection	NS	70	2.0	5.8	-5.38	<.001	0.18
	S	60	10.3	10.6			

Marks at high school

Students in science had better marks in high school (84.20%, SD = 5.92%) than non-science students (78.83%, SD = 5.67%) ($t=5.38$, $p<.001$, $\eta^2=0.18$). There was no significant difference in French marks at the high school level between science and non-science students.

Language quality

Table 5 presents the percentage of mistakes that were corrected during the recorrection. At home, during the recorrection of a handwritten text (writing 1), students succeed especially in correcting mistakes in spelling and punctuation; then, they corrected the grammar and vocabulary, and in a smaller proportion, the syntax and the grammar of the text. During the recorrection of the second writing (electronic text), on average, the percentage of the correction of mistakes is lower than for the first writing, except for specific vocabulary. Let us note that students made fewer mistakes in the second writing than in the first. Recorrection of the third writing (electronic text corrected in the laboratory with Antidote) gave by far the best rates of correction, except for the syntax and grammar of the text. Students dedicated more time to recorrecting the last writing (approximately 50 minutes) than to the others (approximately 30 minutes).

Table 5. Percentage of the correction of mistakes by category and by writing during the recorrection

Categories	Writing 1 (%)	Writing 2 (%)	Writing 3 (%)
Spelling	72.4	61.5	86.1
Grammar	67.2	63.0	79.7
Punctuation	78.3	58.5	80.2
Syntax	52.3	54.4	39.8
Text Grammar	38.5	37.6	52.5
Vocabulary	66.0	56.0	66.2
Specific Vocabulary	60.4	67.5	76.1

In figure 1, the number of mistakes before and after recorrection is compared for each category and for each piece of writing. As in the case of the first correction by the teacher, the categories of spelling, grammar and syntax are the weakest. We can say that on average, students corrected at least half of their mistakes in all categories. It is always the categories of the grammar of the text, syntax and vocabulary that would benefit by being corrected more. It should be noted that the best level of recorrection was realized in the laboratory, by using Antidote for a period of 50 minutes, and that on average, students said that they usually take no more than 30 minutes to correct at home.

Table 6 presents the statistical differences, according to the students' program (science or non-science), of the mistakes for writing 3 before its recorrection. Science students systematically made more errors in the identified categories than non-science students, except for vocabulary. The categories where we find the most errors for the science students were syntax and specific vocabulary. The effect size is quite important for syntax.

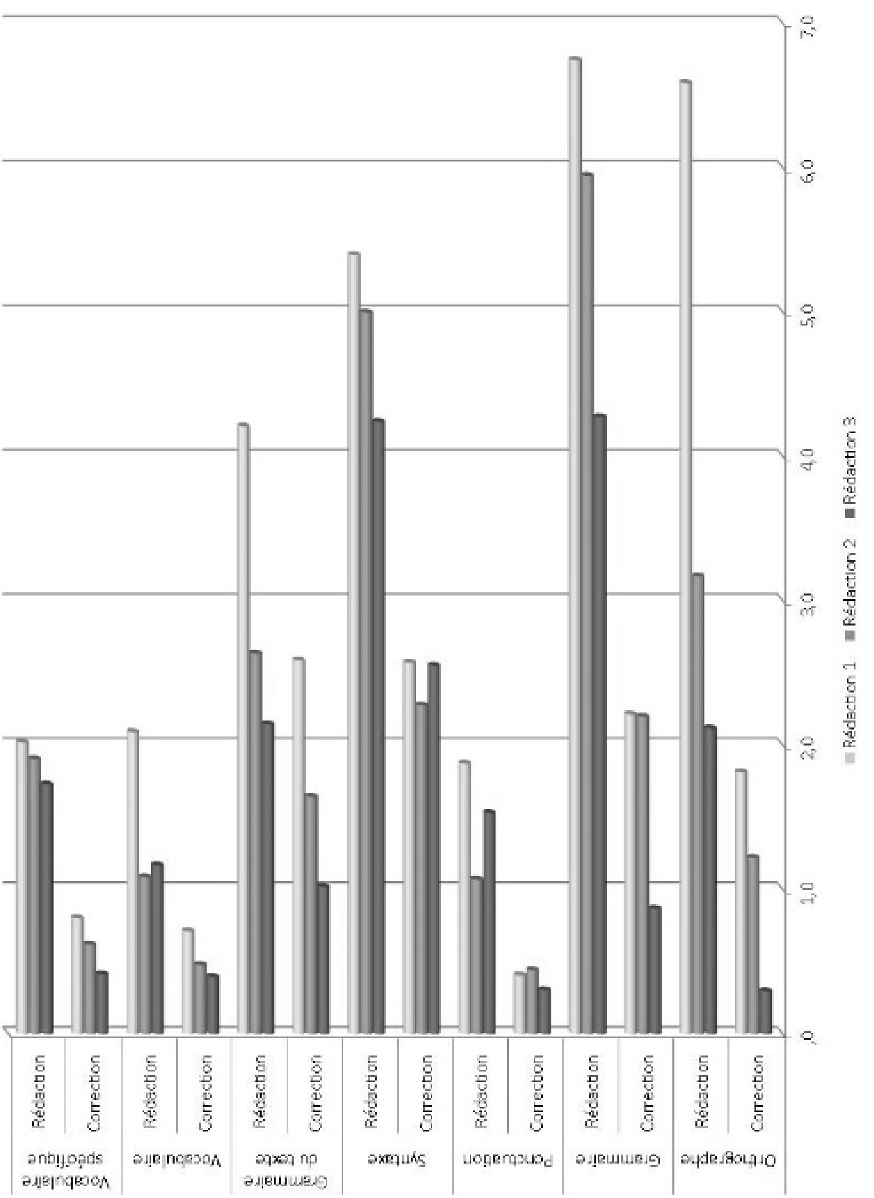

Figure 1. Number of mistakes according to the category and the writing before and after recorrection

Table 6. Frequency of mistakes that where statistically significant different according to program before recorrection for writing 3

Categories		N	Mistakes per 900 words	SD	t	p	η^2
Orthography	NS	70	1.2	2.2	-3.10	.003	0.07
	S	60	3.2	4.8			
Grammar	NS	70	2.5	4.2	-3.30	.001	0.08
	S	60	6.3	8.2			
Punctuation	NS	70	0.9	2.4	-2.92	.004	0.06
	S	60	2.2	2.7			
Syntax	NS	70	1.1	2.4	-7.20	<.001	0.29
	S	60	7.9	6.9			
Grammar of the text	NS	70	1.0	1.8	-4.14	<.001	0.12
	S	60	3.5	4.4			
Vocabulary	NS	70	0.8	2.5	-1.87	.064	0.03
	S	60	1.6	2.8			
Specific vocabulary	NS	70	0.2	0.9	-5.91	<.001	0.21
	S	60	3.5	4.1			

Table 7. Frequency of mistakes that where statistically significant different according to program after recorrection for writing 3

Categories		N	Mistakes per 900 words	SD	t	p	η^2
Orthography	NS	70	0.2	1.0	-0.725	0.470	0.00
	S	60	0.4	1.3			
Grammar	NS	70	0.5	1.4	-2.024	0.046	0.03
	S	60	1.3	3.1			
Punctuation	NS	70	0.2	1.1	-0.950	0.344	0.01
	S	60	0.4	1.5			
Syntax	NS	70	0.6	1.9	-5.162	<.001	0.17
	S	60	4.8	6.1			
Vocabulary	NS	70	0.3	1.5	-0.507	0.613	0.00
	S	60	0.5	1.2			
Grammar of the text	NS	70	0.2	0.9	-3.582	0.001	0.09
	S	60	2.0	3.7			
Specific vocabulary	NS	70	0.0	0.0	-4.454	<.001	0.13
	S	60	0.9	1.6			

In table 7, we see that even after recorrection for writing 3, science students still had more mistakes than non-science students in all categories. Effect size is still important for syntax.

6. Discussion

Students preferred using virtual tools than traditional tools for electronic texts and traditional tools for handwritten texts. Globally, they make more mistakes when writing by hand than when using a computer.

Science students consider themselves to be less competent in the use of the Antidote software for language correction. They use it less than non-science students. They make more mistakes, particularly in grammar and syntax, even though they had no significant difference in French marks at high school.

The rewriting of text by students improved their quality of French but also their methods of recorrection. This recorrection was made as much in the structure as in the contents and not only in the linguistic code. According to the students, the recorrection allowed them to detect errors “not seen before” while identifying their gaps and by correcting errors of inattention. “I now know what kind of mistakes I make most” said a student. In brief, they mainly say: “We learn better by rewriting”.

Several people also noted that this rewriting allowed them to find synonyms, to correct vocabulary and to check the correctness of the terms used.

They said that they can also integrate the comments of their professors, so they are then able to improve their understanding of the subject. They think this would increase their marks.

Finally, reflexive return allowed students to identify the strengths and gaps in their specific errors in French, improve the general quality of the contents of their text, and add precision and depth to their ideas. It also allowed student to get better marks.

We have suggested to the students that they diversify their correction strategies more and choose them according to their efficiency. We also advised them to learn to use the virtual tools well, to be concerned with a global look at their text (reflexive return), and to plan more time to recorrect before handing in their work to teachers.

For teachers, it is necessary to continue to offer students various strategies of revision so that these can be put into practice in a personal method so that the feedback can be more dynamic. All professors are responsible, not only those teaching French literature, for the quality of French.

It is worth giving students time to recorrect mistakes and encourage rewriting, even if it means improving the mark. It increases the students' feeling of skill, allows them to learn from their mistakes, and encourages reflexive return with regard to written texts.

Furthermore, this recorrection work gives students the time and opportunity to take a step backward in order to identify their strengths and linguistic weaknesses, choose the right words and learn from their errors. All these elements improved, in a single session, the quality of the language of our students, and gave them, they say, satisfaction in reworking their texts that increased their feeling of skill at the linguistic level.

7. Conclusion

For electronic texts, students preferred to use virtual tools than traditional tools for improving their quality of French. We observed the contrary for handwritten texts. The use of virtual tools does improve the quality of French when compared to traditional tools. Students make fewer mistakes with virtual tools. Non-science students' quality of French was better than that of science students, even though there was no significant difference between marks in French in high school between those two groups.

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