

UNIVERSITY OF MALAGA

MASTER'S THESIS

SPECIALITY BIOLOGY AND GEOLOGY

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**The Hidden Curriculum from Critical  
Theory of Education**

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10 June 2017



*Political correctness is the most dangerous of totalitarianisms.*

Slavoj Žižek

## **Declaration of Originality**

I hereby certify that I am the author of this report, as its contents are the product of my direct intellectual contribution.

All data and references to texts, research, books, journals, theses, among others, already published, are duly referenced and cited, identified with their respective credit and included in the bibliographical notes.

Cristóbal Gallardo Alba, 7 June 2017.

Thanks to my tutors, Lidia and Arturo, for their patience, and for enabling the implementation of this project.





## Summary

If I had to choose two words to describe this work, they would be *atentadoa*<sup>a</sup> and *violentob*. This text aspires to be a critical reflection on the dominant hidden curriculum in schools, that is, it aims to denounce the depoliticisation of schools and the repression of critical thinking in the classroom.

The content is organised into three closely interrelated blocks, forming a coherent whole: contextualising framework, rationale and design of the work plan, and critical reflection.

The contextualising framework is structured in turn into five sections: teaching-learning process, characteristics of public education, curriculum, hidden curriculum and crisis of the teaching profession. The second section is devoted to the presentation and analysis of the work plan developed during the teaching intervention, which includes two components: didactic unit and research project. The main conclusion that can be drawn from the results obtained is that students in the second year of the baccalaureate in science are unable to distinguish between scientific knowledge and pseudo-scientific propaganda. At the end of this block, a new action plan is included with proposals to remedy the dysfunctions identified in the initial work plan. Finally, in the third block, the critical reflection derived from the contents of the Master's Degree in Teaching (...) specialising in Biology and Geology, taught by the University of Malaga, including both the theoretical and practical parts, is presented.

The structural divergence between the present text and some of the recommendations of the Guide to Master's Thesis is not capricious, but is intended to be coherent with the rejection of the growing standardisation regime in the field of education. The main conclusion to be drawn from this report is that the prescribed curriculum is the sublimation of the hidden curriculum, and not an independent element of the latter.

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<sup>a</sup> Del part. de atentar. Adj. Done with great care, without making noise.

<sup>b</sup>From lat. violentus. Adj. Implying extraordinary force and intensity.



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# Chapter 1

## Contextualising Framework

*Be extremely subtle, discreet, to the point of being shapeless. Be completely mysterious and confidential, to the point of being silent. In this way you will be able to direct the destiny of your adversaries.*

Sun Tzu, The Art of War

### 1.1. Introduction

People's education is the result of multiple contextual variables that have an effect on their behaviour, ideology and professional development, so it could be said that human beings, as social beings, are educated and transformed by their context (Careaga, 2007).

Tyler, quoted by Giroux (2001) points out that a statement of educational philosophy can be constructed on the basis of one of the following questions: *should schools train young people to adapt to the current society as it actually is*, or, on the contrary, *does the school have the revolutionary mission of training young people who will try to improve that same society?* Careaga (2007), quoting John Dewey, stresses that *the essence of all philosophy is the philosophy of education*, and it can be affirmed that the education proposed by society has its roots in society itself. Thus, in order to contextualise the situation

The current state of the teaching profession can be described in terms of the current state of society, the so-called *knowledge society*.

The knowledge society is characterised by interrelationships that link individuals through access to and provision of information for the purpose of generating knowledge. According to Esteve in *Aprendizaje y Desarrollo Profesional Docente* (2009), the knowledge society needs to increase the number of citizens with high levels of scientific and technical training capable of maintaining the current technological development. But is this true? According to Morgenstern (2005), knowledge capitalism can function with very few, highly qualified and highly paid employees who constitute the decisive core of the companies' activity; the remaining skills are outsourced to other companies, leaving at the bottom a mass of precarious workers whose required competences are often embodied in demands for punctuality, organisational skills, non-conflict and submission to authority (Morgenstern and Finkel, 2005).

Olssen, quoted by Saura (2015), points out that it is a reality that most industrialised countries are characterised by the fading of the welfare state, which is being extinguished by leaps and bounds as a result of the rise of globalisation and the enactment of neo-liberal policies. As a result of these processes, multiple dynamics of political change are originating in different social spheres, education being one of them (Saura and Navas, 2015). These political actions, which transcend national spheres, stem from a global education agenda that demands reform of regional policies (Levin, 2001), which are framed within what Sahlberg (2014) calls the *Global Education Reform Movement*. Ball, quoted by Saura (2015), states that the consequences of globalisation and state restructuring policies on the reform of public education systems are reflected in the development of mercantilist systems governed by the culture of performativity and the incorporation of market practices.

Ball (2009) defines performativity as:

*[...] a technology, a culture and a mode of regulation that uses evaluations, comparisons and indicators as a means to control, wear down and produce change. The performance of individual subjects or organisations serves as a measure of productivity or performance, or as an index of quality<sup>or</sup> "moments" of evaluation or promotion.*

These dynamics are part of the so-called *standardisation regime*, as standardised tests and their comparisons are the main elements for reforming education policies (Saura and Navas, 2015). Thus, educational governance, through policies converted into data, is constituted as a mechanism for monitoring school institutions and even countries (Saura and Navas, 2015). For Novoa and Yariv-Mashal, cited by Saura (2005), external evaluations function, in Foucaultian terms, as a global eye that controls national governments. The standardisation regime has been consolidated through a historical process in which the OECD has played a leading role, culminating in 2000 with the implementation of PISA (Saura and Navas, 2015).

All these arguments identify the standardisation regime as a new form of social and cultural engineering in addition to other existing ones (Saura and Navas, 2015). As Millen and Rose, cited by Saura (2015), point out, it is the extension of a regime of control through standards that has the capacity to control the population and direct educational systems without a specific government.

Despite the technological development brought about by the various scientific-technical revolutions, the main technology used in the classroom is recitation, explanation to the whole class with limited dialogue to clarify doubts (Planas et al., 2010). What Denscombe, quoted by Seron (1992), calls *hidden pedagogy*, which implies a belief in maintaining control and privacy in the classroom as a prerequisite for successful educational work, predominates in classrooms. The desire to enclose the teaching-learning environment in a controlled environment aims to ensure not only the transmission of the official curriculum, but above all the transmission of the hidden curriculum, the transmission of which is more susceptible to external influences as

The result of the characteristics of its own communication channels (Giroux, 2001).

However, it should not be forgotten that state education was introduced during the 19th century with the aim of controlling and neutralising the popular processes of self-education; its ultimate aim was to avoid the growing problem of the deterioration of public order, largely stimulated by the non-administrative regulation of the processes of cultural transmission (García Olivo et al., 2005).

## 1.2. Teaching-Learning Process

First of all, it is necessary to clarify two concepts closely related to the teaching-learning process: intelligence and knowledge.

Gardner, in *Intelligence Reframed* (2003), defines intelligence as *a biopsychological potential to process information that can be activated in a cultural framework to solve problems or create products that have value for a culture*. In his theory of multiple intelligences, Gardner points out that there is no one intelligence, but that it is possible to distinguish at least seven: linguistic, logical-mathematical, musical, bodily-kinaesthetic, spatial, interpersonal and intrapersonal. He also highlights the existence of individual differences in the profile of intelligences; that is, no two people have exactly the same intelligences and in the same combinations (Gardner, 2003).

With regard to the concept of knowledge, this can be defined as organised information. Ryle, quoted by De Posada (2012), classifies knowledge into two types, declarative and procedural knowledge. Declarative knowledge would include descriptive or factual knowledge that can be expressed, while procedural knowledge is described as all those processes available to the individual to act on his or her environment (De Posada, 2002).

The different psycho-pedagogical paradigms have made different

educational proposals based on their theoretical assumptions (Hernández Rojas and Rojas, 1998), although as Coll points out, cited by De Posada (2012), no single theory provides a sufficiently satisfactory integrated view of development and learning.

In behaviourism, learning is seen as a gradual process of reinforcing responses; the objective is to consolidate this action in order to incorporate it into existing behaviour patterns (Ruiz and García, 2005). Here, the role of the environment is hyperbolised as it represents a set of stimuli and the active role of the subject and the psychological factors involved in this process are ignored (Ruiz and García, 2005). However, today in the educational text, we hardly speak of stimulus, response, positive effort, operational objectives, programmed instruction or educational technology; today the words in use are meaningful learning, conceptual change and constructivism (Moreira, 1997).

### 1.2.1. Constructivism

Constructivism holds that learning is essentially active; a person who learns something new incorporates it into their previous experiences and their own mental structures (Payer, 2005). Each new piece of information is assimilated and deposited into a network of previously existing knowledge and experiences (Payer, 2005).

All these ideas have been taken from different nuances, and two authors stand out: Jean Piaget with *psychological constructivism* and Lev Vygotsky with *social constructivism*. Piaget, however, does not emphasise the concept of learning; his theory is one of cognitive development; he prefers to speak of increasing knowledge (Moreira, 1997).

#### Psychological Constructivism

Flores, quoted by Dinarte (2011), mentions that cognitive psychology and constructivism state that the learning process takes place to the extent that the student is given the space and is also trained to

The students reflect on their learning and are able to integrate a series of elements into their analysis that will make it easier for them to recall and evoke this knowledge later on.

According to Mendez, quoted by Payer (2012), from the perspective of psychological constructivism, learning is fundamentally a personal matter. The driving force of this activity would be cognitive conflict; in any constructivist activity there must be a circumstance that shakes the previous structures of knowledge and forces a rearrangement of the old knowledge in order to assimilate the new (Payer, 2005). Thus, the individual learns to change his or her knowledge and beliefs about the world, to adjust to the new realities discovered and to construct his or her knowledge (Payer, 2005). Typically, in academic learning situations, it is about learning by discovery, experimentation and manipulation of concrete realities, critical thinking, dialogue and continuous questioning (Payer, 2005).

According to Payer (2005), psychological constructivism maintains the idea that the individual, both through cognitive and social aspects of knowledge as well as affective ones, is not a mere product of the environment or a simple result of his or her internal dispositions, but a construction of his or her own that is produced day by day as a result of the interaction between these two factors. Consequently, from this position, knowledge is not a copy of reality, but a construction of the human being; this construction takes place every day and in almost all contexts in which the activity is developed (Payer, 2005).

### **Social Constructivism**

According to the historical-cultural approach of Lev Vigotsky, learning is that process in which the individual assimilates certain historical-cultural experience at the same time as he/she appropriates it, which requires an active subject who gives meaning to this experience, transforming it into his/her subjectivity (Ruiz and García, 2005).

The aim of Vigotsky's theory is to discover and stimulate the zone of potential development or zone of proximal development in each student, which is defined as *the distance between the actual level of development, determined by the ability to independently solve a problem, and the level of development.*

*potential, determined through solving a problem under the guidance of an adult or in collaboration with a more able peer (Moreira, 1997).*

For Vigotsky, cognitive development cannot be understood without reference to the social, historical and cultural context in which it occurs (Moreira, 1997).

. According to this author, higher mental processes (thought, language, voluntary behaviour) have their origin in social processes; cognitive development would be the conversion of social relations into mental functions (Moreira, 1997). Learning in the school context always involves the acquisition of knowledge and the construction of meaning, which should be built through joint activity and not through the transmission of knowledge from the teacher to the students (Ruiz and García, 2005).

According to this thesis, the main actor in the process is the student, although not the only one; learning takes place in an interpersonal system and, therefore, through interactions with the teacher and classmates, the student learns the cognitive and communicative tools of his or her culture (Ruiz and García, 2005). In this context, the teacher's role is to create the optimal conditions for students to deploy their constructive mental activity and generate significant learning both individually and collectively (Dinarte, 2011).

### 1.2.2. Meaningful Learning

According to Ausubel, quoted by Moreira (1997), meaningful learning is the human mechanism par excellence for acquiring and storing the immense amount of ideas and information represented in any field. Meaningful learning can be defined as the process through which new knowledge is related in a *non-arbitrary* and *substantive* way to the cognitive structure of the learner (Moreira, 1997).

Non-arbitrary means that the potentially meaningful material is related to knowledge already existing in the learner's cognitive structure; the relationship is not with any aspect of the cognitive structure but with specifically relevant knowledge which Ausubel calls *subsumers* (Moreira, 1997). Thus, new ideas, concepts, propositions can be meaningfully learned to the extent that other ideas,

concepts, propositions, specifically relevant and inclusive are adequately clear and available in the subject's cognitive structure and function as *anchor points* to the former (Moreira, 1997).

On the other hand, substantivity means that what is incorporated into the cognitive structure is the substance of the new knowledge, of the new ideas, not the precise words used to express them; thus, meaningful learning cannot depend on the exclusive use of certain particular signs (Moreira, 1997).

Naturally, language is extremely important in a Vygostkyan perspective; meaningful learning depends on social interaction, that is, the *negotiation* of meaning through social interaction (Moreira, 1997).

Diaz, quoted by Dinarte (2010), states that meaningful learning implies a very active processing of the information to be learned. According to the author, meaningful learning takes place when there is interaction, discussion, when there are experiences, when the senses are put to the test. In this sense, we can highlight cooperative teamwork; it is a methodology focused on the construction of knowledge in real contexts, the development of reflective and critical capacities and high-level thinking, as well as participation in the authentic social practices of the community (Díaz Barriga Arceo, 2003).

Ausubel, quoted by Dinarte (2010), indicates that meaningful learning generally arises from a process of learning to learn. If meaningful learning is achieved, it transcends the rote repetition of unconnected content and allows for the construction of meaning, making sense of what has been learned, and understanding its scope of application and relevance in academic and everyday situations.

For Ausubel, it is necessary not to overload the student with unnecessary information, and it is necessary to find the best way to relate, explicitly, the most important aspects of the content of the teaching subject with the specifically relevant aspects of the learner's cognitive structure. In this sense, the concept map, a technique which, as its name suggests, emphasises concepts and relations between concepts, becomes important (Moreira, 1997).



### 1.2.1. The Family in the Teaching-Learning Process

The educational status attributed to the family is beyond all doubt and discussion, with increasing awareness of the importance of the role of parents in the educational progress and development of their children (Díaz Barriga Arceo, 2003). Schiefelbaum and Simmons, cited by Diaz (2003), consider family background to be the most important and important individual determinant of a student's academic performance. Among the most influential family factors, the variables of social class and the educational and family environment stand out (Díaz Barriga Arceo, 2003).

As Torio (2004) points out, the school alone and without the collaboration of families will obtain poor results compared to those that can be achieved if both institutions act jointly; likewise, the family alone, without acting in coordination with the school, will also be limited in its results, in addition to provoking contradictions in the formative processes of young people.

The ideal is for the school to become an educational community, in which personal relationships, joint efforts, commitment to values, a sense of solidarity and joint management play a special role; schools should aspire to create the necessary atmosphere for coexistence to take place within a participatory democracy (Torío López, 2004). The aim of the participation of the members of the educational community in the life of the school is to seek to improve the conditions of the school in order to enable the development of the pupil, his or her learning and preparation for development and adaptation to adult life (Torío López, 2004).

The importance of education for a society is such that it **m u s t i n v o l v e** the commitment of all people and institutions in the task of education and learning (Torío López, 2004). Despite this, the real participation of parents in the life of schools is a minority and is generally assumed by small groups (Torío López, 2004).

### **1.3. Characteristics of Public Education**

The school institution provides the pedagogical action on the student's conscience with the necessary duration and continuity to solidify habits and, in this way, makes effective the absolute submission of consciences to the designs of the dominant ideology (García Olivo et al., 2005). In contrast to the traditional school model, which is predominant today, critical educational theory is emerging.

#### **1.3.1. Traditional School**

One of the characteristics of traditional schooling is its aspiration to depoliticise the language of school teaching (Giroux, 2001). The problematics of traditional curriculum theory and school instruction are centred on questions about the best and most effective ways to learn types of knowledge, to create moral consensus and to offer modes of school instruction that reproduce current society (Giroux, 2001).

Control, not learning, is what seems to have clear priority in the traditional curriculum model; a central aspect of it is the claim to objectivity (Giroux, 2001). Traditional schooling represents a firm commitment to a view that interprets rationality as an ahistorical, consensus-oriented and politically conserving dimension (Giroux, 2001).

#### **1.3.2. Critical Educational Theory**

The main task of critical educational theory is to unravel the skein concerning how schools reproduce the logic of capital through the ideological and material forms of privilege and domination that structure students' lives (Giroux, 2001). In the face of the conservative claim that schools transmit objective knowledge, school knowledge is conceived as a particular representation of the dominant culture, a privileged discourse constructed through an ideological and material form of privilege and domination that structures the lives of students (Giroux, 2001).

selective process of emphasis and exclusions (Giroux, 2001). According to critical educational theory, the dominant culture in schools is characterised by selectively ordering and legitimising privileged forms of language, social relations, life experiences and modes of reasoning (Giroux, 2001).

According to Giroux (2001) the ultimate aim of critical educational theory is to move away from conceiving knowledge simply as an ordered set of data about external reality; knowledge comes to be seen as a tool for critical understanding and emancipation.

## 1.4. The Curriculum

The curriculum is defined as the regulation of the elements that determine the teaching and learning processes for each of the teaching programmes.

*[In line with Recommendation 2006/962/EC of the European Parliament and of the Council of 18 December 2006 on key competences for lifelong learning, this Royal Decree is based on the promotion of learning by competences, integrated into the curricular elements to promote a renewal in teaching practice and in the teaching and learning process. New approaches to learning and assessment are proposed, which must involve a significant change in the tasks to be solved by students and innovative methodological approaches.]*

The above text, taken from the general provisions of Organic Law 8/2013, of 9 December, for the Improvement of the Quality of Education (LOMCE), reflects the main aspiration of the education reform: the introduction of competences as an articulating element of the Education System. According to the LOMCE, competences are conceptualised as *know-how*, which is applied to a diversity of academic, social and professional contexts. The text explicitly states that the *development of linguistic communication competences, mathematical competence and basic competences in science and technology should be promoted.*

From this it is possible to infer that the ideology that directs the current rationality of the curriculum contained in the LOMCE is interested in questions relating to the how of things, but does not question the existing relations between knowledge and power or between culture and politics; In harmony with the Traditional School paradigm, questions related to the role of the school as an agent of social and cultural reproduction in a class society are ignored, as well as those that clarify the inter-subjective basis of the fixation of meaning, knowledge, and which are considered legitimate social relations (Giroux, 2001).

The criterion governing the design of the curriculum, in line with OECD recommendations, is none other than that of favouring the adaptation of young people to the requirements of the established productive and political apparatus, which requires their psychological and cultural homogenisation (García Olivo et al., 2005). Far from remaining neutral, the dominant culture in schools is characterised by selectively ordering and legitimising forms of language, social relations, life experiences and privileged modes of reasoning (Giroux, 2001).

*Article 6.3: The curricula of Compulsory Secondary Education and the Baccalaureate will incorporate curricular elements aimed at the development and strengthening of the entrepreneurial spirit, the acquisition of skills for the creation and development of different business models and the promotion of equal opportunities and respect for the entrepreneur and the businessperson, as well as business ethics. The Education Administrations will encourage measures for pupils to participate in activities that allow them to strengthen the entrepreneurial spirit and business initiative based on skills such as creativity, autonomy, initiative, teamwork, self-confidence and a critical sense.*

The theory in the dominant curriculum paradigm not only ignores the ethical function of education, but also deprives education of its political function (Giroux, 2001). In the dominant curriculum model, knowledge is basically treated as a sphere of objective facts; knowledge is presented as objective in the sense that it is external to the individual, imposed on him or her; it is not seen as something to be questioned, analysed or negotiated (Giroux, 2001).

On the other hand, standards measurement policies are governed as the key component by their capacity to agglutinate and dynamise diverse elements in the direction of privatisation and commodification of the education system, without any consideration of the historical and cultural characteristics of the context (Saura and Navas, 2015). As Giroux (2001) points out, its ultimate objective is technocratic in nature: to discover propositions in the form of laws about the design, application and evaluation of the curriculum that can be objectively verified or developed.

*Preamble VIII: External end-of-stage assessments are one of the main novelties of the LOMCE with respect to the previous framework and one of the measures called upon to most directly improve the quality of the education system. Twenty OECD countries carry out tests of this nature for their students and the evidence indicates that their implementation has an impact of at least sixteen points of improvement according to the PISA criteria.*

## 1.5. The Hidden Curriculum

The hidden curriculum is learning that is incorporated by students even though these aspects do not appear explicitly in the official curriculum. Unlike the official curriculum, with its explicitly stated cognitive and affective objectives, the hidden curriculum, in this case, relies on those organisational aspects of classroom life that are generally not perceived by either students or teachers (Giroux, 2001). What students learn from the formally sanctioned content of the curriculum is much less important than what they learn from the ideological assumptions embodied in the three communicative systems of the school: the curricular system, the system of pedagogical styles of classroom control, and the evaluative system (Giroux, 2001).

The pillar on which the hidden curriculum is built is recognised among the objectives of Organic Law 8/2013:

*Article 6.3.b: To develop and consolidate habits of discipline, study and individual and team work as a necessary condition for effective performance of learning tasks and as a means of personal development.*

In Foucauldian terms, discipline is a mechanism of power that regulates the behaviour of individuals in the social body, which acts by regulating the organisation of space, time and people's activity. Interpreting Foucault in terms of the evolution of the hidden curriculum, the result of the current machinery of control of bodies has been configured through a series of offensives and counter-offensives, arriving at the current complex configuration; the coherence of this machinery of control would not result from a project, but from the logic of repression-resistance itself (Foucault, 1992). This is why the power relations between teacher and pupil do not only take the form of prohibition and punishment, but are multiform. The child's body is at the centre of a struggle between children and controlling bodies (Foucault, 1992).

Through the hidden curriculum, students internalise values that emphasise respect for authority, punctuality, cleanliness, docility and conformity (Giroux, 2001). For Foucault, schools, as institutions involved in the configuration of power relations, are one of the foundational pillars of the so-called *disciplinary societies*. As García (2005) points out, although under democracy teachers feel impelled to strategically disappear from the scene, they place between them and the students a didactic and methodological structure which will act on the students' consciousness, insidiously moulding their personality.

It is in the assessment system that the nature of the hidden curriculum is most clearly revealed. The potential effect of assessment is clearly perceived when it is recognised that both academic and non-academic aspects are taught and assessed in the classroom, the latter including institutional adaptation and specific personal qualities (Giroux, 2001). In this sense, one of the main novelties of the LOMCE has been the introduction of control tests (known as *reválidas*) in ESO and bachillerato.

*Article 2.1: At the end of the fourth year, students will undergo an individualised assessment for the option of academic or applied education, in which the achievement of the objectives of the stage and the degree of acquisition of the corresponding competences in relation to the following subjects will be verified.*

Bowles and Gintis, cited by Giroux (2001), point out that students who are best suited to the social ordering of school also had *significantly below average scores on measures of mental creativity and flexibility*. The underlying message assimilated under the practices of the hidden curriculum points less to schools that help students think critically about the world they live in, than to schools that act as agents of social control (Giroux, 2001).

The structure, organisation and content of contemporary teaching endows students with the personality needs required in the bureaucratically structured and hierarchically organised workforce (Giroux, 2001). The social processes of most classrooms militate against students developing a sense of community, given collectivity and social solidarity (Giroux, 2001). The school architecture linked to the cellular development of education constitutes a rectangular space that reflects the authoritarian conception of life within it (Planas et al., 2010). Elements such as exposure to a core of common subjects lead to a dissolution of individuality in the mass, in the collective, to a standardisation and homogenisation of psychologies (García Olivo et al., 2005).

*Article 13.5: The minimum teaching time corresponding to the subjects of the block of core subjects, calculated as a whole for the first cycle of Compulsory Secondary Education, shall not be less than 50 % of the total teaching time established by each educational administration as a general timetable for this first cycle.*

Through the use of the hidden curriculum, differences are repressed on a daily basis and the dissemination of the values and principles of *our culture* is stimulated, and this repression is accentuated by the *moral figure* of the educator (García Olivo et al., 2005).

As Foucault points out in *Microphysics of Power* (1992), for the state to function as it does, there must be very specific relations of domination from adult to child, which have their own configuration and relative autonomy. Between teacher and pupil there are power relations that are not the pure and simple projection of the great power of the sovereign over individuals; they are rather the shifting and concrete ground on which this power is embedded, the conditions of possibility of its functioning (Foucault, 1992).

### **1.5.1. Educational Traditions**

Three different traditions in educational theory have contributed to illuminating the socialising role of schools and the meaning and structure of the hidden curriculum: the structuralist-functional, the phenomenological and the critical-essential view (Giroux, 2001).

#### **The Structuralist-Functionalist Tradition**

The structural-functionalist approach, based on a basically positivist sociological model, is primarily concerned with the problem of how social norms and values are transmitted in the context of schools (Giroux, 2001).

Among the main shortcomings of this approach are that it represents an apolitical point of view that sees nothing problematic in the beliefs, values and socio-economic structure characteristic of capitalist society, defines learners in reductionist behaviourist terms as products of socialisation, and appreciates knowledge for its instrumental value in the market (Giroux, 2001).

In this way, the conflicts between the emotions that students experience in their everyday reality and those transmitted in school generate a tension that translates into processes of cognitive dissonance, which aims to make students accept social conformity and lose the ability to grant meaning to themselves (Giroux, 2001).



### **The Phenomenological Tradition**

The social-phenomenological approach of evolutionary theory critically focuses on principles governing the organisation, distribution and evaluation of knowledge, which are no longer conceived of as abstract and objective, but as socio-historical constructs forged by active human creators and which do not merely exist in the world (Giroux, 2001). The focus of classroom studies shifts from an exclusive emphasis on institutional behaviour to students' interactions with language, social relations and categories of meaning (Giroux, 2001).

The main criticism levelled at this tradition is that it succumbs to the idea of cultural relativism by lacking a construct that explains the role ideology plays in students' construction of knowledge (Giroux, 2001). It is also criticised for its inability to clarify how political social structures mask reality and promote ideological hegemony (Giroux, 2001).

### **The Critical-Radical Vision**

Schools are seen as agents of ideological control that re-produce and maintain the validity of dominant beliefs, values and norms; schools are similarly linked to the principles and processes that govern the workplace; key to this perspective is its insistence on connecting macro-social forces with micro-analyses (Giroux, 2001).

The radical-critical paradigm emphasises two elements: the importance of the subjective role of each learner in finding meaning for him/herself, and how social and economic conditions constrain and distort the social construction of meaning (Giroux, 2001).

## **1.6. The Crisis of the Teaching Profession**

Initial teacher education, especially in developing countries, tends to be one of the most obsolete elements of contemporary education systems (Moreno Olmedilla, 2011).

The teaching profession, unlike others, has been salaried since its beginnings and created by the State (Serón, 1992). Professionalism, so distinguished in the educational activities developed in the Spanish State, has been used by the State as a means of controlling the radical actions of the teaching staff in relation to their working conditions, although it is true that in the case of teachers it has served as a means of resistance against the State itself (Serón, 1992), having maintained until the present day a privileged economic status in relation to the median salary.

Today's teachers are embedded in the process of proletarianisation once experienced by industrial workers as a result of the elimination of job qualifications as a result of the exclusion of the worker from the conceptual functions of the job (Serón, 1992). At the same time as worker autonomy is undermined, managerial controls are strengthened and the skills and ethics of the trade decline (Serón, 1992).

As Sacristán (2008) points out, the current crisis, which affects society as a whole, has repercussions on both personal and professional identity, which has to be manifested with greater intensity in the case of teachers, as their personality is implicated in their dealings with other people. This crisis converges with another remarkable fact: the depoliticisation of schools as centres of democratic power; public debate about the nature of school instruction has been replaced by the concerns and interests of management experts (Giroux, 2001).

The consolidation of the standardisation regime is causing teachers to adhere to a system of permanent control of students' academic performance; their knowledge and professional practice are redefined according to the results obtained in standardised tests (Saura and Navas, 2015). According to Sahlberg, quoted by Saura (2015), these processes are causing teachers to lose their status and autonomy.

The professionalism of the teaching profession may, over time, lead to the end of professionalism in teaching.



## Chapter 2

# Rationale and Design of the Work

## Plan

*Where no one can say anymore what is black and what is white, the light goes out and freedom becomes a voluntary prison.*

Albert Camus, *The Rebel Man*

### 2.1. Project Justification

The study of some basic aspects of where and how hereditary information is transmitted begins, in our educational system, at secondary education levels because, theoretically up to this point, students have not developed the necessary reasoning schemes, nor do they possess the relevant knowledge that would allow them to understand the elementary concepts of genetics (Banet and Ayuso, 1995). Several studies have shown the importance that science teachers attach to genetics (Ayuso and Banet, 2002).

The pedagogical paradigm adopted in this work is the *sociocultural constructivism* of Lev Vigotsky. This is why it was sought that the construction of knowledge should respond to a double orientation: personal,

in the sense of providing learners with sufficient opportunities and time to reflect, evaluate and restructure their ideas; and shared, so that this knowledge was generated as a consequence of a process in which interactions and communication played a fundamental role (Ayuso and Banet, 2002).

Several research studies have shown that, after instruction, students' learning about biological heritage is less significant than might be expected (Banet and Ayuso, 1995). According to Moreno and Gatica (2010), specific factors that hinder more adequate science teaching include the confusion between the nature of science and the processes of science, since teaching based on scientific procedures does not necessarily imply a good understanding of science. Likewise, Marba (2009) points out that identifying scientific knowledge as a fact rather than as an interpretation makes it difficult for non-experts to use science, with its theories, entities and concepts, to think, let alone to act. This is why, in addition to the contents of the official curriculum, in this project the students were offered two alternative itineraries of complementary contents:

- Nature of scientific knowledge.
- Cooperation as an evolutionary mechanism.

Both blocks of complementary contents aspired, according to the suggestions of González (2014), to propose a scenario that would make it possible to overcome the levels of superficial knowledge (instrumental, technical and methodological) and foster a dialectical vision of knowledge, to enable the critical reconstruction of visions and conceptions of the world.

As Bargalló (2015) points out, the promotion of critical thinking requires the development of competences that enable students to continue modifying and acquiring new knowledge throughout their lives, and these competences are closely related to the meaningful reading of texts and to writing. The practice of writing in scientific subjects implies that writing is conceived as a dialectical process, rather than as an instrumental skill centred on exhortations about what is to be learnt.

what to do or not to do when writing (Giroux, 2001). According to Giroux (2001), poverty in writing reflects poverty in thinking, and what teachers often consider simply *an error in writing* is in fact a reflection of an error in thinking itself (Giroux, 2001). Learning to write would mean, according to Carlos Baker, quoted by Giroux (2001), learning to think.

However, the dominant pedagogy reinforces a theoretical rather than a dialectical approach to one's perception of the world (Giroux, 2001), and it is in this context that the hidden curriculum linked to the traditional school has the greatest impact. Critical thinking, conceived as an exercise in questioning and evaluation (Zúñiga, 2014), is antagonistic to the authoritarian approach of the dominant hidden curriculum, which fosters a uni-directional vision of the teaching-learning process. Rather than actively developing critical thinkers, the traditional school produces students who are either afraid or unable to think critically (Giroux, 2001).

According to Giroux (2001), group work is one of the most efficient ways to overcome the authoritarian nature of the teacher by providing students with social contexts that emphasise social responsibility and group solidarity. Through group dialogue, norms of cooperation and sociability act to displace the traditional emphasis of the hidden curriculum on competitiveness and excessive individualism (Giroux, 2001).

In line with the above, and with the aim of encouraging critical thinking, it was decided to use cooperative writing as a methodological tool within the framework of teaching evolutionary genetics, establishing two alternative itineraries of free choice for the students. With the aim of assessing the degree of critical thinking of students in the second year of the baccalaureate and the validation of potentially useful tools for its promotion, a research project was carried out in the field of complementary activities.

This paper aimed to rethink pedagogy in accordance with the categorical saying once enunciated by Nietzsche, quoted by Giroux (2001): *a great truth wishes to be criticised, not idolised*.

## **2.2. Work Plan Developed**

### **2.2.1. Context of the intervention**

The work plan was implemented in the subject of Biology in the second year of the baccalaureate; the focus of this subject is molecular biology. The textbook used as a reference was *Biology 2*, by José Alcamí and collaborators, published by SM. The main block of conceptual content developed corresponded to topic 17: genetics and evolution. According to Iñiguez (2013), genetics is one of the most difficult sections of biology for students to understand and one of the most conceptually difficult.

The class consisted of 22 students with very different profiles; it is worth noting that this group was considered by the other teachers linked to some of the subjects to be *extraordinarily competitive and hard-working*. Among the students was a pupil with Asperger's syndrome characteristics and a pupil diagnosed as having high abilities, although at her own request she did not receive any special attention. Likewise, in terms of geographical origin, the group was made up of two pupils of South American origin, one pupil of Moroccan origin and one pupil of Romanian origin.

### **2.2.2. Summary of Original Planning**

The complete original planning is detailed in the appendix ?

#### **Objectives**

The didactic proposal was designed taking into account the general objectives of the stage, area and subject. In the case of the stage objectives, two of them played a predominant role: the promotion of cooperative work, and the promotion of self-learning and research to develop basic skills in the use of information sources. In the



In the case of the area objectives, a predominant role was given to the promotion of reading and writing skills, as well as an understanding of the fundamental elements and procedures of the scientific method.

## Contents

The conceptual contents addressed in the didactic unit are included in the budgets of the official curriculum, set out in Royal Decree 1105/2013, of 26 December, which establishes the basic curriculum for Compulsory Secondary Education and Baccalaureate. Together with these, and in accordance with the provisions of section 2.1, two alternative sets of complementary conceptual content were established (table 2.1).

TABLE 2.1: Alternative content pathways.

Alternative routes	
Group A	Group B
Altruism	Science
Black Queen Hypothesis	Truth
Social immunity	Scientific method
Superorganism	Objectivity
Mutualism	Postmodernism

In relation to the procedural content, those which played the most important role during the development of the didactic unit were the cooperative production of texts, the reading and comprehension of popular science articles and the use of online writing tools.

## Methodological Principles and Strategies

In harmony with the socio-cultural constructivist paradigm, the basic methodology implemented in the work plan was cooperative learning. The purpose for which this methodology was chosen was mainly to promote cognitive tasks, to foster open learning environments that favour divergent reasoning and the redistribution of power relations.



FIGURE 2.1: Timing of teaching intervention.

The choice of cooperative writing as a pedagogical tool in the context of cooperative learning was determined by the essential role that language plays in the construction of ideas.

### Organisation of Time and Space

Given the pressure placed on students in the second year of secondary school as a result of the entrance exams and the limited time available for classroom activities, it was decided to set up a virtual platform (*peer-instruction.moodlecloud.com*) as an instrument for the development of training activities. The platform was also intended to act as a meeting and discussion space. The time distribution is described in Figure 2.1. The interventions took place between 3 and 7 April. The fifth intervention corresponded to the review, which took place on 3 May.

## Activities

The activities implemented are classified into four groups:

- Master classes: developed during the classroom sessions.
- Cooperative writing workshop: in accordance with the itineraries of complementary conceptual content set out in section 2.2.2, two themes were proposed for the development of the activity:
  - Group A: Cooperation as an evolutionary mechanism.
  - Group B: The nature of science and its relation to truth.
- Informative documentaries. ■

Computer simulations.

## Contribution to Core Competences

The main means used to contribute to the development of the basic competences included in the LOMCE was the online cooperative writing activity; thus, the set of activities proposed contributed to the development of linguistic communication, mathematical competences and basic competences in science and technology, digital competence, learning to learn competence and social and civic competences.

## Evaluation Procedures and Grading Criteria

In order to assess the progression of the students' learning in relation to the basic conceptual contents of the didactic unit, the use of questionnaires implemented on the *Moodle* platform was used. The cooperative writing task was assessed using a rubric (appendix C). In addition, a written test on the conceptual contents was carried out as an auxiliary instrument for the evaluation of the teaching-learning process.

With regard to the assessment criteria, the specific weight of each of the activities in the mark assigned to the didactic unit developed was: online questionnaires (15 %), cooperative writing workshop (35 %) and final exam (50 %).

### **Attention to Diversity**

Among the measures deployed in relation to the attention to diversity we can highlight, in addition to the use of inclusive language, the provision of extra time for the student who showed asperger's characteristics to take the written exam.

### **Hidden Curriculum**

The ultimate aim of the hidden curriculum deployed was to undermine the authoritarian effects of the traditional hidden curriculum as a means to stimulate critical thinking. The following strategies were used to achieve this:

- Restructuring power relations in the classroom and building a sense of community, for which cooperative working groups were used.
- Encouraging doubt in the face of absolute truths; special emphasis was placed on the fact that in science, theory is the most rigorous, reliable and complete form of knowledge possible.
- To stimulate the active participation of students in the design of the teaching-learning situations, students were encouraged to edit the slides prior to the lectures.
- Cultivate self-criticism, for which self-evaluation rubrics were used to assess the work carried out.
- Establishment of alternative pathways of complementary conceptual content in order to dilute the effect of cultural homogenisation characteristic of traditional schools.

- To critically analyse hegemonic scientific theories in relation to alternative theories, using Pyotr Kropotkin's idea-force <sup>1</sup> of *mutual support* as opposed to Darwin's *survival of the fittest*.

### Complementary Activities: Research

Within the framework of complementary activities, a research project was carried out with the aim of analysing the critical thinking skills of second-year Baccalaureate students. The study group was the class whose characteristics are detailed in section 2.2.1.

The research carried out during the implementation of the didactic unit aimed to test two hypotheses:

- a) Hypothesis 1: Students on the science track in upper secondary school are, for the most part, unable to distinguish between reliable sources of information and sources of dubious origin.
- b) Hypothesis 2: It is not possible to improve the competence linked to the identification of rigorous scientific news through the implementation of activities aimed at this end.

This study was carried out during the month of April 2017, coinciding with the development of the didactic unit and within the framework of the complementary activities. The class was divided into two groups, corresponding to the alternative itineraries of complementary conceptual content.

- Group A: Control (n=11; 4 girls and 7 boys)
- Group B: Experimental (n=11; 7 girls and 4 boys)

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<sup>1</sup> The idea-force is what constitutes the essence of a message. It is usually made up of a few words with a strong symbolic character and which alone reflect a complete meaning.

In the research project developed, it is possible to distinguish five stages: design of the methodological sequence, the initial questionnaire, the actual survey, the final questionnaire and the analysis of the results (details in Appendix D).

Two activities were proposed to contribute to critical thinking: the cooperative writing workshop, the characteristics of which are described in section 2.2.2, and the viewing of one of the following informative videos:

- Group A: Darwin and Kropotkin: Competition or Solidarity?
- Group B: Identifying Fake News Workshop

It should be noted that the video "Workshop on Identifying Fake News" was developed *ad hoc* for this project.

The questionnaires were implemented on the *Moodle* platform and each consisted of twenty questions. Students were invited to assign a degree of confidence to the news presented in the questionnaire (Fig. 2.2).

### 2.2.3. Description of the Development of the Intervention

Broadly speaking, it can be said that the activities were carried out according to the previous planning. The didactic unit was divided into four blocks, so that each one corresponded to one of the master class sessions:

- 03.05.17 - Block A: Mutations.
- 04.05.17 - Block B: Mutants, Mutagens and Cancer
- 05.05.17 - Block C: Evolutionary Genetics I
- 07.05.17 - Block D: Evolutionary Genetics II

**A** ¿Qué grado de confianza le asignarías a este artículo científico publicado en la revista *Nature Reviews Genetics*?

**Functional variomics and network perturbation: connecting genotype to phenotype in cancer**

Song Yi, Shengda Lin, Yongsheng Li, Wei Zhao, Gordon B. Mills & Nidhi Sahni

**Affiliations** **Corresponding authors**

*Nature Reviews Genetics* (2017) | doi:10.1038/nrg.2017.8  
Published online 27 March 2017

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**Abstract**

[Abstract](#) · [Accession codes](#) · [References](#) · [Author Information](#) · [Supplementary information](#)

Proteins interact with other macromolecules in complex cellular networks for signal transduction and biological function. In cancer, genetic aberrations have been traditionally thought to disrupt the entire gene function. It has been increasingly appreciated that each mutation of a gene could have a subtle but unique effect on protein function or network rewiring, contributing to diverse phenotypic consequences across cancer patient populations. In this Review, we discuss the current understanding of cancer genetic variants, including the broad spectrum of mutation classes and the wide range of mechanistic effects on gene function in the context of signalling networks. We highlight recent advances in computational and experimental strategies to study the diverse functional and phenotypic consequences of mutations at the base-pair resolution. Such information is crucial to understanding the complex pleiotropic effect of cancer genes and provides a possible link between genotype and phenotype in cancer.

Select one:

a. Absoluta confianza


b. Moderada confianza.

c. Ninguna confianza.

**B** ¿Qué grado de confianza le asignarías a este artículo publicado en el portal web theSciencePost.com?

**Breaking: Childhood vaccines soon to contain 65% mercury**

By SP Team on September 20, 2016 [Big Pharma](#)



NEW YORK, NY – Big Pharma is ready to roll out it's latest vaccine, a shot with upwards of 65% mercury, supposedly to protect against mercury poisoning. "Look, we have a bunch of left over mercury and we're not really sure what to do with it to be honest," said GSK CEO Doug Hamilton. "So [...]"

Select one:

a. Absoluta confianza

b. Moderada confianza.

c. Ninguna confianza.

FIGURE 2.2: Questionnaire for assessing the competence of critical analysis of information. Two examples of the format chosen for the questionnaires in the research project. A corresponds to a news item from a reliable source, and B to a source considered to be unreliable.

The average duration of the master classes was 40 minutes, slightly less than previous estimates. In the first session, the beginning of the class was devoted to explaining the basic lines of the didactic unit, as well as the details for accessing the virtual platform. The lectures were accompanied by *PowerPoint* presentations; the first two blocks of content were developed using the sections of the textbook as a guide, although the content was re-elaborated from various bibliographical sources. In all cases, an attempt was made to use examples from everyday life.

In the third classroom session, corresponding to the first part of the contents of evolutionary genetics, a non-conventional lecture format was used; with the intention of involving students in the construction of meanings, it was decided to explain the bases of evolution by questioning the main arguments of creationism <sup>2</sup>:

- Isn't the Theory of Evolution just a theory? ■ Which came first, the chicken or the egg?
- Why are there no fossils of trilobite ancestors?
- Why does the record lack many of the transitional forms between species?

The diversity of levels of prior knowledge among the students made the work of didactic transposition difficult in some cases, since some of the concepts presented were known to some of the students, although not to all of them, which hindered the development of the lectures as it was not possible to guarantee that all levels were adequately matched.

The degree of participation in the online questionnaires implemented on the *Moodle* platform is shown in figure 2.3. The high level of participation in the questionnaires belonging to the research project is noteworthy, despite the fact that the students were aware that these would not have any impact on the final grade. In all cases, the degree of

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<sup>2</sup> Philosophical doctrine that defends that living beings have arisen from a creative act and that, therefore, they are not the result of evolution.



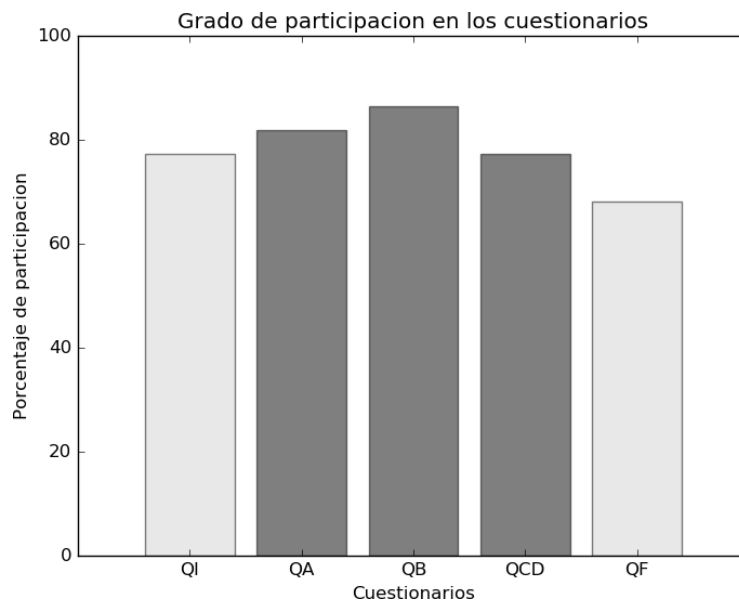


FIGURE 2.3: Level of participation in the questionnaires. The graph shows the results for the five questionnaires carried out. Questionnaires QA, QB and QCD (dark grey) correspond to the evaluation of the content blocks. The QI and QF questionnaires (light grey) correspond to the initial and final questionnaires of the research project.

participation was above 70 %. In the case of the continuous assessment questionnaires, it should be noted that the deadlines were extended at the request of the students in order to facilitate their participation.

#### 2.2.4. Evaluation of the intervention

The main dissatisfaction on the part of the students as recorded in the work placement diary was the excessive workload. Most of them felt that the cooperative work task had not been productive as it had required too much time; some students also felt that the activity had not been adequately explained. The pupils' comments, recorded in the practice diary, suggest that most of the difficulties encountered during the cooperative writing workshop were due to a combination of two factors: lack of familiarity with cooperative work and the size of the groups.

Despite this, the outcome of the cooperative writing workshop for both groups was quite positive, so that both groups were awarded the highest marks. However, it became evident that the strategy chosen by the majority was the individual division of tasks, with each group assigning one or more of the proposed bibliographical sources to each member.

With regard to the strategies implemented within the framework of the hidden curriculum, the initial resistance of students to altering the power relations and giving them more autonomy, mainly in relation to the task of cooperative work and the grading formula, was striking. Students who tended to get better marks considered that it would be better to limit marking to a final exam, as this would give them better results; they also defended individual work as opposed to cooperative work and considered it pernicious to distribute the responsibility for part of the marking between the working groups, arguing that some of their peers would take advantage of the situation. Generally speaking, they showed great difficulty in organising themselves and taking the initiative.

During the presentations, and despite the effort to maintain the students' interest and attention, it became evident that lectures are not very efficient if they last longer than 30 minutes. On the other hand, not having carried out a pre-assessment questionnaire before the start of the didactic unit meant an added difficulty when designing the master classes, as we did not have the necessary data to carry out the didactic transposition in the most deficient way possible. It should be noted that the choice of the master classes as the central activity of the practical sessions was highly conditioned by the enormous pressure on the students with a view to the entrance exams.

All in all, it is possible to consider that most of the objectives set out in the initial action plan were met. In the case of the research project, it is worth highlighting the involvement of the students, most of whom participated in the proposed activities.

The average marks obtained for the total number of students in the different activities are shown in figure 2.4.

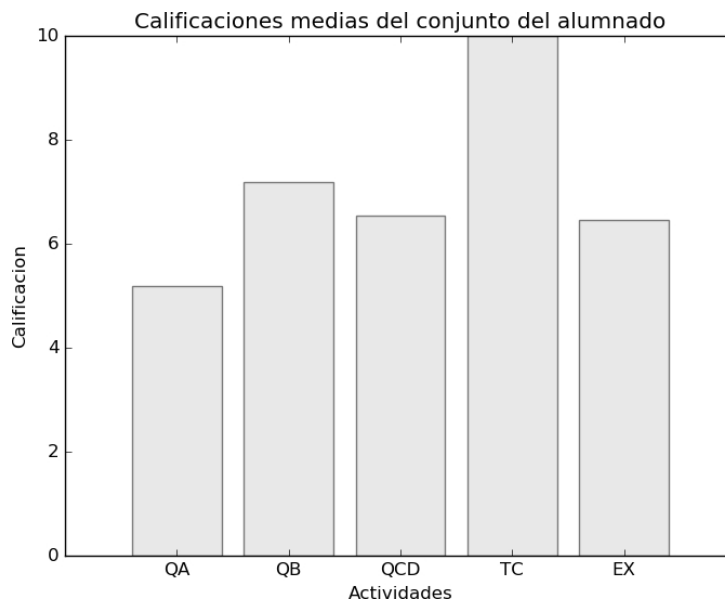


FIGURE 2.4: Average marks of all students in the different activities. The acronyms correspond to the evaluation questionnaires (QA, QB and QCD), the cooperative work (TC) and the final exam (EX).

## Results of the Research Project

The results were analysed using scripts developed in the programming language *Python* and *R*. In order to test hypothesis A, we tested whether there were significant differences between the results obtained by all the students in the initial questionnaire with respect to chance, making use of the Central Limit Theorem<sup>3</sup>; to carry out the test we implemented a *Student's t-test for one sample*.

To determine whether there were significant differences in the results obtained in the initial questionnaire between groups A and B, a *Welch's test* was implemented for two unpaired samples. In order to test the second hypothesis (students are not able to improve competences with the proposed activities), we compared whether there were significant differences between the final questionnaire and the initial one, for which a *Student's t-test for related samples* was implemented.

<sup>3</sup> The theorem states that the distribution of  $\bar{x}$ , which is the mean of a random sample from a population with finite variance, has an approximately normal distribution when the sample size is large, regardless of the shape of the population distribution.

Figure 2.5 shows the result of the test statistic implemented with the intention of falsifying hypothesis A. The result indicated that there were no significant differences between the probability distribution corresponding to the results obtained by the total number of students in the initial questionnaire and the probability distribution of the randomised experiment, obtained using the Central Limit Theorem, assuming that both distributions were homo-chedastic ( $p$ -value = 0.1692, Appendix A).

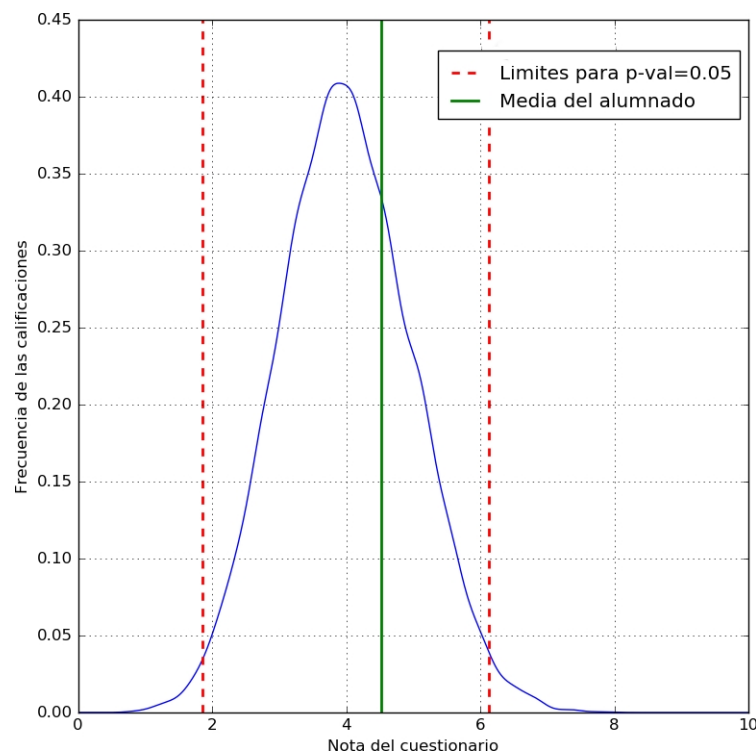


FIGURE 2.5: Result of the t-test statistic performed to test hypothesis A: There are no significant differences between students' scores in the initial test and the values obtained by chance. The blue band corresponds to the probability distribution of the randomised model. The green band is the mean obtained by the class in the initial questionnaire. The red band indicates the maximum and minimum values necessary to falsify the hypothesis, for a  $p$ -value of 0.05.

The result obtained in *Welch's test* for two unpaired samples indicated that there were no significant differences in the results obtained in the initial questionnaire between groups A and B ( $p$ -value = 0.4396).

Table 2.2 shows the results of the *paired-sample Student's t-tests* applied to groups A and B. In the case of group A, no significant differences were found between the initial and final questionnaires, while in the case of group B, such differences were statistically significant (p-value <0.05).

TABLE 2.2: Result of *Student's t-test* statistic implemented to falsify hypothesis B

	Group A	Group B
Degree of freedom	6	7
Statistic $t$	1.3653	2.3691
p-value	0.2211	0.04967

The boxplot in figure 2.6 shows the distribution of data obtained by groups A and B in both the initial and the final questionnaire. As can be seen, in the case of group B there was a significant improvement in the ratings. In the case of group A, the variance was reduced, but no statistically significant differences were observed.

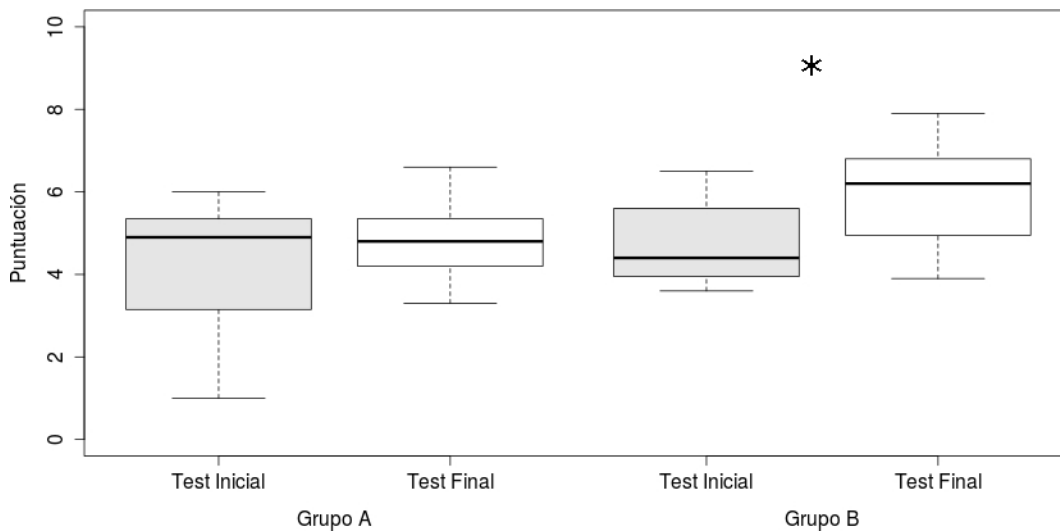


FIGURE 2.6: Boxplots showing details of the results obtained by groups A and B in the questionnaires.

\* indicates that there are significant differences.

Two conclusions can be drawn from the results obtained, derived from the initial hypotheses:

- Second-year Baccalaureate students in the science track are unable to distinguish between scientific publications and pseudo-scientific publications.
- The implemented methodology allows for the improvement of competences linked to the identification of reliable scientific publications.

### **2.2.5. Proposals for Improvement**

Based on the results, the impressions derived from the work plan developed, and with the aim of promoting critical thinking from the paradigm of the hidden curriculum, the main recommendations for improvement are set out below. Most of them aim to reduce the role of the teacher during the teaching-learning process, and to encourage a greater role for the students.

- **Contents.**
  - **Conceptual content.** The initial work plan included two alternative itineraries of complementary conceptual content, with the aim of neutralising the effect of cultural homogenisation typical of the traditional curriculum. As a proposal for improvement, and as a means of increasing motivation, students could be allowed the possibility of proposing an additional set of conceptual contents, depending on their personal interests.
  - **Procedural content.** With regard to procedural content, and in order to encourage students to participate actively in their own teaching and learning process, as a proposal for improvement, they should be encouraged to propose additional procedural content according to their interests.
- **Proposed activities.**

- 
- **Pre-assessment questionnaire.** One of the difficulties encountered when designing the teaching-learning situations was the lack of data on the students' level. This is why, as a recommendation for improvement, an initial knowledge assessment questionnaire should be included in the *Moodle* platform.
  - **Face-to-face sessions.** The original planning envisaged 50-minute lecture sessions; however, in practice these proved to be inconvenient. For this reason, as an improvement plan, it is suggested that each face-to-face session should consist of two parts: a 20-minute lecture explanation, in which the main contents are presented, and a second part, in which students critically analyse a text related to the block being developed.
  - **Size of the working groups.** The initial proposal established two working groups, which proved to be difficult because the groupings were not very functional due to their excessive size. Therefore, in a new working proposal, the groups would be limited to a maximum of 4 members.
- **Assessment procedures and grading criteria.**
- **Evaluation of the cooperative writing workshop.** The initial work plan included the use of a rubric as an instrument to facilitate self-assessment of the students' work, but the final grade was assigned by the teacher. As a proposal for improvement, the rubric should be used not only as a guide for the elaboration of the work, but should also be used to carry out peer marking among the different work groups, so that they themselves are responsible for assessing the work of their peers.
  - **Format of the final exam.** One of the difficulties encountered during the development of the didactic unit was the time constraints. For this reason, as a recommendation for improvement, and taking into account the resources offered by the Internet, the final exam should be taken online, during non-teaching hours, so that an additional face-to-face session could be available for the development of the work plan. This would also enhance the

responsibility of the learner in directing his or her own learning process.

- **Grading criteria.** With the aim of redistributing power relations in the classroom and giving students a greater degree of autonomy in the learning process, as a proposal for improvement, greater importance should be given to the cooperative writing activity, in which, as previously mentioned, students should be given the leading role in terms of assessment. Thus, the proposed percentages would be: online questionnaires (25 %), cooperative writing workshop (50 %) and final exam (25 %).

## **2.3. New Intervention Proposal**

### **2.3.1. Objectives**

We can distinguish between general stage objectives, area objectives and subject objectives.

#### **General Stage Objectives**

The work plan comprises the following objectives:

- To encourage cooperative and collaborative work in order to assume their duties responsibly, to know and exercise their rights with respect for others, to practice tolerance, cooperation and solidarity among individuals and groups, to practice dialogue, strengthening human rights and equal treatment and opportunities between women and men, as common values of a plural society and to prepare for the exercise of citizenship.
- Encourage self-learning and research to develop and support habits of discipline, study and individual and team work.



as a necessary condition for the effective accomplishment of learning tasks and as a means of personal development.

- Encourage work in heterogeneous groups, attending to diversity and non-discriminatory inclusiveness in order to value and respect the difference between the sexes and equal rights and opportunities between them. Reject discrimination against people on the basis of sex or any other personal or social condition or circumstance. Reject stereotypes that involve discrimination, as well as any manifestation of violence.
- To put into practice didactic strategies and methodologies to strengthen their affective capacities in all areas of their personality and in their relations with others, as well as to reject violence, prejudice of any kind, sexist behaviour and to resolve conflicts peacefully.
- Encourage self-learning and research to develop basic skills in the use of information sources in order to acquire new knowledge with critical awareness. To acquire a basic preparation in the field of technologies, especially information and communication technologies.
- Work on scientific competences in a transversal way in order to conceive scientific knowledge as an integrated knowledge, which is structured in different disciplines, as well as to know and apply the methods to identify the problems in the different fields of knowledge and experience.
- Encourage the production of reports/essays and oral presentations in order to understand and express oneself correctly, orally and in writing, in the Spanish language.

### **General Area Objectives**

In the case of the general objectives of the area, the didactic unit includes the following:

- Strengthen reading, study and discipline habits, proposing to students the reading of simple scientific texts or articles that complement the information obtained in the classroom and put them in contact with the voluntary *open curriculum*, which is so important for advancing personal scientific knowledge.
- Use information and communication technologies with competence and responsibility, necessary not only for searching the Internet for the information we need, but also for the preparation of presentations, papers and presentations in the subject.
- Access to fundamental scientific and technological knowledge and master the basic skills of Biology, inherent to the development of the subject itself.
- Understand the fundamental elements and procedures of research and scientific methods.
- Knowing and critically assessing the contribution of science and technology in changing living conditions, as well as strengthening sensitivity and respect for the environment, also included in the teaching-learning process of the subject itself.

### **General Subject Objectives**

Among the points covered by the legislation to be addressed are the following, which belong to block 3 of the content:

- Define the concept of mutation by distinguishing the main types and mutagenic agents.
- To contrast the relationship between mutation and cancer. Differentiate different evidences of the evolutionary process.
- Recognise, differentiate and distinguish the principles of Darwinian and neo-Darwinian theory.
- Relate genotype and gene frequencies to population genetics and their influence on evolution.

- Recognise the importance of mutation and recombination.
- Analyse the factors that increase biodiversity and their influence on the speciation process.

### **2.3.2. Contents of the Didactic Unit**

#### **Conceptual Content**

The conceptual contents addressed in this didactic unit are part of the contents proposed by the official curriculum, included in Royal Decree 1105/2014, of 26 December, which establishes the basic curriculum for compulsory secondary education and the Baccalaureate. These include:

- Mutation and types of mutations
- Tumour cells and cancer
- Protooncogenes and tumour suppressor genes
- Mutagen and types of mutagens
- Species and population
- Implication of mutations in evolution Evidence of the evolutionary process
- Speciation
- Natural Selection and Gene Drift
- Darwinism and Neo-Darwinism
- Neutralism and Punctuated
- Equilibrium Epigenetics

Together with these, and in accordance with what is established in section 2.1, two alternative itineraries of additional complementary contents are established, with the possibility of free choice on the part of the students depending on their affinity and degree of motivation. It is also possible for students to propose their own itinerary of complementary contents.

TABLE 2.3: Alternative content pathways.

Itinerary A	Itinerary B
Altruism	Science
Black Queen Hypothesis	Truth
Social immunity	Scientific method
Superorganism	Objectivity
Mutualism	Postmodernism

### Procedural Contents

As far as procedural content is concerned, among those proposed are the following:

- Scientific essay writing
- Reading and understanding popular science articles
- Using online cooperative writing tools ■ Identifying reliable sources of information
- Viewing of informative documentaries
- Use of computer simulation tools

In this way, students will be offered the possibility of proposing, according to their interests, alternative procedural contents to those included in the present work plan, in order to encourage their active participation in the teaching-learning process.

### **2.3.3. Methodological Principles and Strategies**

Within the framework of the socio-cultural constructivist paradigm, the desirable features of educational design in the information society include the promotion of self-directed learning, the promotion of cooperative teamwork, the organisation of open learning environments in which divergent reasoning is encouraged, and the promotion of complex and socially relevant cognitive tasks (Díaz Barriga, 2005). Thus, in accordance with these characteristics, the basic methodology implemented in the present project was cooperative learning. According to Coll, quoted by Ferreiro (2007), in the last years of the last century the constructivist conception, more specifically speaking, social constructivism, had among its most innovative educational proposals cooperative learning.

Cooperative learning emphasises the need for the participation of the subject in his or her own learning process, his or her external activity, but also his or her internal activity, i.e. that which refers to the higher psychological processes provoked by external activity; furthermore, the emphasis lies on the need to take into account the communication processes inherent in all human activity (Ferreiro Gravié, 2007).

Citing Ferreiro (2007), cooperative learning takes from Piaget the entire theoretical foundation of the organisation of learning situations in which the learner is confronted with the object of knowledge. In order to learn, this confrontation with the object of learning is necessary, that is, with the content of the teaching; cooperative learning takes from Vigotsky the need of the other, of other people, in order to understand what is being learned (Ferreiro Gravié, 2007).

Cooperative learning requires moments of both individual and collective effort (Ferreiro Gravié, 2007). Another particularity is that, in addition to encouraging participation, it is essential to diversify the ways of doing so, in such a way as to stimulate the different neuropsychological areas involved, and to provoke learning with the whole brain and, therefore, the full development of the human person (Ferreiro Gravié, 2007).

The choice of writing as a pedagogical tool in the context of cooperative learning is determined by the essential role of writing in the cooperative learning process.

language plays a role in the construction of ideas. In a way, scientific activity is also a linguistic activity: language helps to construct more elaborate scientific models and these help to configure a more precise language (Bargalló, 2005).

As Bargallo (2005) points out, what is important in reading is not the comprehension of the text itself, but the students' ability to establish relationships between the concepts expressed in this text and knowledge acquired in other situations. Group goals were set with two objectives: to minimise individualism within the group, and to motivate students to collaborate in the learning of their peers, as well as to help them overcome their reluctance to ask for help or to lend support to another (Slavein, 1989).

#### 2.3.4. Activities

Given the pressure imposed on second-year baccalaureate students as a result of the entrance exams and the limited time available for classroom activities, the option chosen was to use the virtual platform (Fig. 2.7) as a vehicle for the development of training activities, facilitating access to educational and current material as a meeting and discussion space.

In accordance with the constructivist model of teaching, the activities proposed to students are characterised by the fact that they aim to create cognitive conflicts. They can be classified into initiation, development and synthesis activities.

##### Start-up Activities

- **Pre-assessment questionnaire.** In order to obtain the necessary data to optimise the didactic transposition process, students will be asked a series of questions related to basic concepts of evolutionary genetics through the *Moodle* platform.

Navigation

- Home
  - Dashboard
  - Site pages
  - My courses
    - Microbiologia
      - GenEvo
        - Participants
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        - Competencies
          - Genética y Evolución
          - Bloque A: Mutaciones
          - Bloque B: Mutantes, Mutágenos y Cáncer
          - Bloque C: Genética Evolutiva (I)
          - Bloque D: Genética Evolutiva (II)
          - Recursos Adicionales
        - UDMM
        - PI

Administration

- Course administration
  - Question bank
- Site administration

Search

### Genética y Evolución

Bloque de contenidos desarrollado por Cristóbal Gallardo en torno a la Unidad Didáctica: Genética y Evolución, correspondiente a la asignatura de Biología de 2º de Bachillerato.

- Cuestionario Inicial**
- Taller de Escritura Cooperativa**

Aquí se detallan los aspectos principales del proyecto de escritura cooperativa.
- Escritura Científica y la Cooperación Online**

Artículo publicado en Nature el 1 de Octubre de 2014 sobre cómo las plataformas de escritura cooperativa están revolucionando la forma de construir la Ciencia.
- Entrega de la Tarea Cooperativa**
- Foro de Cuestiones Generales**

Foro habilitado para plantear todas las dudas/cuestiones relacionadas por la presente unidad didáctica.

---

### Bloque A: Mutaciones

Una mutación se define como cualquier cambio en la secuencia de un nucleótido o en la organización del ADN (genotipo) de un ser vivo, que produce una variación en las características de este y que no necesariamente se transmite a la descendencia.

- Diapositivas Bloque A**

Si piensas que la diapositiva requiere editar alguna parte, eres libre de ello.
- Actividades del Bloque A**

Actividades propuestas en relación a los contenidos del bloque A: Mutaciones.

**Material suplementario:**

- Anotaciones de Clase Bloque A**

Contenidos tratados en la clase correspondiente al bloque A.
- Documental: Epigenética, la nueva revolución biológica**

La epigenética es el estudio de modificaciones en la expresión de genes que no obedecen a una alteración de la secuencia del ADN y que son heredables.
- Artículo científico: Evolución por duplicación génica**

---

### Bloque B: Mutantes, Mutágenos y Cáncer

En biología, un mutágeno (latín, "origen del cambio") es un agente físico, químico o biológico que altera o cambia la información genética (usualmente ADN) de un organismo y ello incrementa la frecuencia de mutaciones por encima del nivel natural.

- Diapositivas Bloque B**

Si piensas que la diapositiva requiere editar alguna parte, eres libre de ello.
- Actividades Bloque B**

Actividades propuestas en relación a los contenidos del bloque B: mutantes, mutágenos y cáncer.

**Material suplementario:**

- Documental - Mutaciones**

Documental emitido en la 2 de RTVE sobre las mutaciones y su papel en la evolución.

---

### Bloque C: Genética Evolutiva (I)

La genética evolutiva o genética de poblaciones, es la ciencia que estudia cómo se distribuyen los alelos en las poblaciones de organismos y de una generación a otra.

- Diapositivas Bloque C**

Si piensas que la diapositiva requiere editar alguna parte, eres libre de ello.
- Documental: Los Orígenes de las Especies**

Si la ciencia tuviera templos, la casa de Darwin sería posiblemente una catedral. En este lugar, Darwin concibió su teoría de la evolución por selección natural y escribió su obra fundacional *El origen de las especies*.

En este ámbito histórico, Eduard Punset entrevistó a uno de los mayores expertos mundiales en biología evolutiva, Mark Pagel, de la Universidad de Reading y charlaron sobre cómo surgen las especies, sobre el significado del altruismo y sobre la evolución de las lenguas.

**Artículo de Wikipedia: Presión Evolutiva**

**Teoría científica**

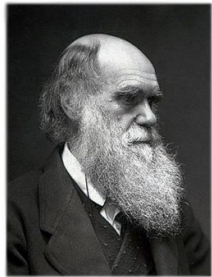
**Material suplementario:**

- Artículo de Wikipedia: Explosión Cámbrica**
- Documental - La Peligrosa Idea de Darwin**

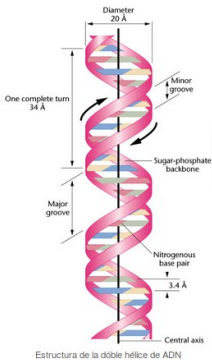
La peligrosa idea de Darwin un largometraje documental que combina entrevistas y hechos científicos con dramatizaciones de la vida de Darwin.
- ¿Qué son y cómo se forma los fósiles?**
- Now You Know: Which Came First, the Chicken or the Egg?**

Artículo entorno a la controversia sobre si primero el huevo o la gallina, publicado en la revista Time el 21 de septiembre de 2016.
- Script de la Simulación de la Presión de Selección**

Éste es programa de ordenador, con el que se generó la simulación de la presión de selección de la población de conejos/as.



Charles Darwin (1809-1882)



Diámetro 20 Å

One complete turn 34 Å

Minor groove

Sugar-phosphate backbone

Major groove

Nitrogenous base pair 3.4 Å

Central axis

Estructura de la doble hélice de ADN

---

RSS Sobre Ciencia

**Taller de identificación de noticias falsas**

Este proyecto se ha desarrollado en el marco del Máster de Educación Secundaria, especialidad Biología. Púlsala en la imagen para iniciar.

**Evolución: la supervivencia del más sociable**

"La violencia ha sido la progenitora de todos los valores del mundo", escribió el poeta Robinson Jeffers en 1940. ¿Qué sino los dientes del lobo blanquearon tan finamente el conjunto de extremidades del antlope? ¿Qué sino el miedo alado de los pájaros, y el hámbre en los ojos de la cabeza del gran azor? ". Hemos [..]

**Los registros del Ártico no sobreviven a Trump**

Traducción de I am an Arctic researcher. Donald Trump is deleting my citations, publicado en The Guardian el 28 de Marzo de 2017. Como investigador del Ártico, estoy acostumbrado a que existan lagunas en los registros de datos. Solo entorno al 1% de las aguas del Ártico pertenecientes a EEUU han sido analizadas de acuerdo [..]

**El dilema de Goodhart**

El profesor Goodhart ironizó hace años sobre la pretensión monetarista de garantizar la estabilidad económica con tan sólo controlar el crecimiento de una magnitud monetaria determinada (M1, M3... ). "Cualquier relación estadística estable tenderá a desvanecerse tan pronto se intente utilizar como mecanismo de control", señaló entonces el distinguido economista británico, hoy miembro del comité de [..]

**El negacionismo es un fenómeno que emplea algunas o todas de estas cinco estrategias:**

- La primera es la identificación de conspiraciones.
- La segunda es el uso de expertos falsos.
- La tercera característica es la selectividad, basándose en informaciones aisladas que desafían el consenso dominante o destacando las falas en los argumentos más débiles entre aquellos que lo apoyan como un medio de desacreditar todo el campo.
- La cuarta es la creación de expectativas imposibles de lo que la investigación puede ofrecer.
- El quinto es el uso de la tergiversación y las falacias lógicas.

Martin McKee - Denialism: what is it and how should scientists respond?




FIGURE 2.7: Virtual platform enabled for the teaching unit.

**Development Activities**

- **Lectures.** The lectures will last a maximum of 25 minutes and will clarify the basic concepts of the subject. Students will be provided with a concept map at the beginning of the lecture. Student participation should be encouraged.
- **Critical analysis of texts.** This activity is designed to be carried out in the classroom sessions, after the lectures. Each student must analyse, in pairs, a scientific text related to the topic developed during the first part of the class; the aim is to assess the veracity of the text as a means of encouraging critical thinking.
- **Cooperative writing workshop.** This activity aims to deploy, with the greatest possible degree of depth, the objectives set out in section 2.3.1. Two themes were proposed for the development of the activity, in accordance with the conceptual content itineraries set out in section 2.3.2.
  - Option A: Cooperation as an evolutionary mechanism.
  - Option B: The nature of science and its relation to truth.

A few minutes will be set aside at the beginning of the second face-to-face session to clarify organisational issues. In addition, in order to facilitate coordination between students, a forum should be set up on the virtual platform to establish the basic lines of the work proposal:

- The aim is to cooperatively produce a scientific article/essay.
- If the topics proposed are not to the group's liking, the group can propose one to the teacher, as long as it is related to the contents of the didactic unit.
- The maximum size per working group is four members.
- Only one document should be produced per group.
- The internal organisation of the group is a matter of free choice.
- The final text should be coherent in content (i.e. clear and well-structured) and original.



- The assessment criteria and standards are listed in the ad hoc rubric.
- Arguments should be supported by bibliographical citations.
- It is recommended to use a talky.io channel for remote coordination of the work.
- At the end of the task period, each group should use the rubric to evaluate another group. In this way, the students themselves will be responsible for grading each other's work.

The proposed bibliography for the cooperative elaboration of the texts is included in Appendix B. Finally, together with the basic rules, students will be provided with a concept map on the basic characteristics of an essay and four guides for writing popular scientific articles:

- **What is an essay, characteristics, types and examples.**
  - **How to write a popular science text?**
  - **How to write a popular article.**
  - **Example of a scientific essay.**
- **Informative documentaries.** In each of the blocks in which the didactic unit is structured, audiovisual material will be provided through the virtual platform, with the aim of consolidating the conceptual contents transmitted in the classroom, complementing the training and stimulating self-learning. The proposed videos are:
- Mutations - **Epigenetics, the new biological revolution**
  - Mutagens and cancer - **Mutations**
  - Evolutionary Genetics (I) - **The Origin of Species**
  - Evolutionary Genetics (II) - **Evolution, the big transformation**
- **Computer simulations.** In the context of the contents linked to biological evolution (blocks C and D of the didactic unit), two computer simulations are proposed, with the aim of inducing cognitive conflicts in the students as a result of possible

The gap between intuition and computational models.

- **Gene drift simulator.**
- **Natural selection simulator.**

### Synthesis Activities

- **Presentation of the cooperative writing assignments.** In the last face-to-face session, the fifth, the working groups must present a synthesis of their work to the rest of the class.

### 2.3.5. Contribution to Core Competences

- **Linguistic Communication:** the very structure of cooperative learning groups contributes to the development of communicative skills and abilities (Sagredo and Ana, 2006).
- **Mathematical Competence and Basic Competences in Science and Technology:** throughout the teaching intervention, active work must be done on the promotion of ethical criteria associated with science, interest in science, support for scientific research and the valuation of scientific knowledge.
- **Digital competence:** in order to contribute to this competence, two digital tools will be made available to the students to facilitate the remote coordination of the groups: **Talky** and **MeetingWords**. Likewise, the source code of the computer simulations generated *ad hoc* for the development of the didactic unit (see appendix **A**, code A) will be provided in order to introduce students to the field of computer programming.
- **Learning to learn competence:** within the framework of this competence, the use of concept maps should be promoted as a cognitive strategy to transform and reconstruct information, giving it a different structure in order to understand and remember it better (Elosúa and García, 1993). In addition, at the beginning of each intervention, the following will be provided

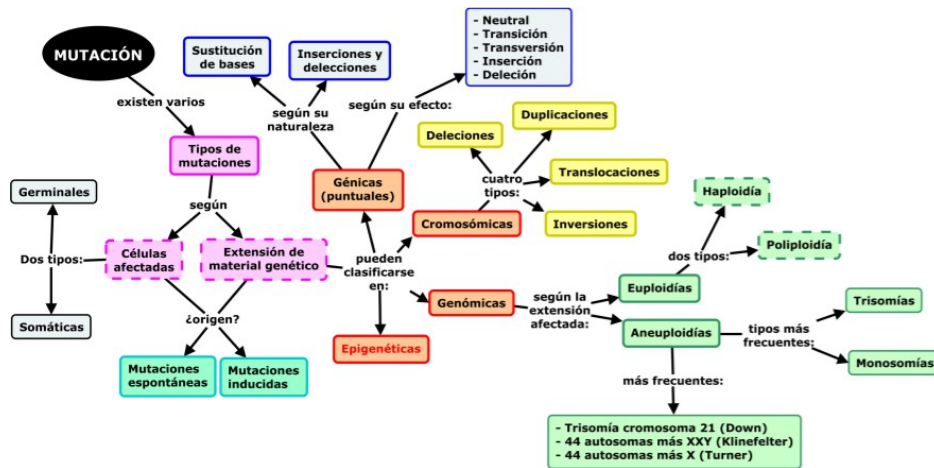


FIGURE 2.8: Example of a concept map provided to students during the teaching intervention.

The concept map of the content to be covered, similar to the one shown in figure 2.8, will be given to each student.

- **Social and civic competences:** the contribution to this competence is determined by the strategies implemented within the framework of the hidden curriculum, which include the stipulation of feelings of sociability, the development of cooperation as a means to achieve common goals. According to Marina (2006) these are some of the goals to be achieved in order to make personal and social well-being possible.

### 2.3.6. Evaluation and Qualification Criteria

#### Evaluation Instruments and Data Analysis

In order to obtain updated information on the teaching-learning process, with the aim of assessing the progression of the students' learning in relation to the basic contents of the unit, the use of questionnaires implemented in the Moodle 2.9 platform will be used.

This information in turn made it possible to identify those students with the greatest difficulties.

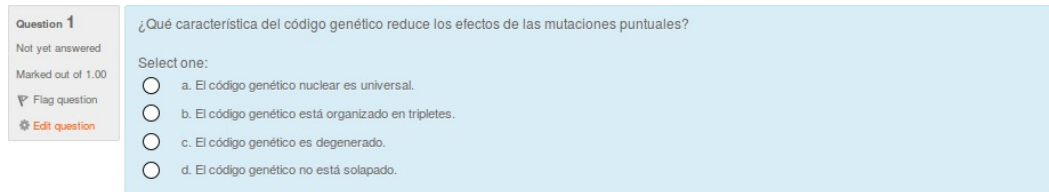


FIGURE 2.9: Example of a question from the continuous assessment questionnaires.

The assessment of the cooperative writing activity will be done in pairs, using the rubric provided, which reflects the criteria and standards related to the learning objectives (Appendix C). Thus, each working group will evaluate and grade each other's work. This assessment tool should be provided to the learners at the beginning of the task, so that they can also self-assess their work. Among the elements to be assessed are the sources of information, the organisation of the text, the cohesion, the contents and the personal contribution.

In addition to this, once the cooperative writing project has been handed in, a final test will be carried out through the *Moodle* platform, in order to assess the acquisition of the basic conceptual content.

### Qualification Criteria

The specific weighting of each of the activities in the grade assigned to the teaching unit developed was as follows:

- Online questionnaires - 25
- Cooperative writing workshop - 50 %
- Final exam - 25 %

Final exam - 25

### **2.3.7. Organisation of Time and Space**

The work plan includes five face-to-face classroom sessions. The first four will consist of two parts: a lecture on the most important concepts and a critical analysis of texts. The fifth session will be reserved for the presentation of the results of the cooperative reading workshop. Likewise, after each session, a questionnaire on the contents developed in the classroom will be made available on the virtual platform. The period for the elaboration of the texts will be three weeks. At the end of this period, the final exam will be available on the Moodle platform.

### **2.3.8. Attention to Diversity**

Measures to be implemented include the use of inclusive language and possible support measures for students with Asperger Syndrome characteristics.

### **2.3.9. Hidden Curriculum**

The aim of the hidden curriculum is to stimulate critical thinking by using the following strategies:

- To undermine the authoritarian effects of the traditional hidden curriculum by reconfiguring power relations in the classroom.
- Convey the idea that there are no absolute truths; to this end, special emphasis should be placed on the fact that in science, theory is the most rigorous, reliable and complete form of knowledge possible.
- Encourage the active participation of students in the design of teaching-learning situations, for which they will be encouraged to edit the slides prior to the lectures.
- Cultivate self-criticism, for which self-evaluation rubrics will be used to assess the work carried out.

- To dilute the effect of cultural homogenisation, for which two alternative pathways of conceptual content are established.
- To build a sense of community; to this end and in harmony with the socio-cultural paradigm, the present intervention plan opts for cooperative working groups.
- To critically analyse hegemonic scientific theories in relation to alternative theories; this can be done by drawing on Pyotr Kropotkin's idea-force of *mutual support*, as opposed to Darwin's *survival of the fittest*.

## Chapter 3

# Critical Reflection

*What if all this that we are living is nothing more than a hoax and everything in reality is radically different from what we think it is?*

René Descartes, *Metaphysical Meditations*

The considerations presented below are framed within the tradition of critical-radical educational theory. The text includes, implicitly and explicitly, the conclusions derived from the Master's Degree in Teaching (...) at the University of Malaga, both from the theoretical part, developed in the classroom, and from the practical part. Some may consider these reflections to be nothing more than a hyperbole of reality, but as Ortega y Gasset points out in *La Rebelión de las Masas* (1943), to think is, whether one likes it or not, to exaggerate; those who prefer not to exaggerate must paralyse their intellect and find a way to become idiotic.

One of the questions arising from the conclusions of the research project carried out during the intervention plan (see 2.2.4) is: is the cognitive inability of pupils to identify reliable knowledge a direct consequence of the current school structure, rather than a circumstantial one? As a first approximation we can turn to the objectives for the baccalaureate set out in the LOMCE:

*Article 25.b: To consolidate personal and social maturity that enables them to act responsibly and autonomously and to develop their critical spirit. To anticipate and resolve personal, family and social conflicts peacefully.*

As can be seen, the development of critical thinking is among the main objectives. Why, then, is there a failure to implement it in the classroom? As a strategy to answer this question we can try to deconstruct <sup>it</sup><sup>1</sup>, i.e., what is the meaning of the signifier *critical thinking*?

As Giroux (2001) notes, the most common definition appeals to the function of teaching students to analyse and develop reading and writing tasks from the perspective of formal logical patterns of coherence. However, this approach to the concept of critical thinking is clearly insufficient, since pseudo-scientific knowledge is not incompatible with logical coherence. This situation is illustrated in the article in figure 3.1, published in the online *Journal of Microbial & Biochemical Technology*.

In this case, the consideration of this text as <sup>pseudo-scientific</sup><sup>2</sup> is not determined by its lack of logical coherence. Its unreliability is due to the fact that it has not passed the necessary filters; it belongs to the *predatory journals*<sup>3</sup>.

<sup>1</sup> The idea of deconstruction is used in philosophy and literary theory to refer to the act and result of deconstructing. This verb, which comes from the French word *déconstruire*, refers to dismantling, through intellectual analysis, a certain conceptual structure.

<sup>2</sup>Pseudoscience is a statement, belief or practice that is incorrectly presented - or scientific, but which does not follow a valid scientific method, cannot be reliably verified, or lacks scientific status.

<sup>3</sup>*Predatory journals* refers to a business model for scientific publications, which involves charging fees to authors without providing the editorial services associated with legitimate journals, such as peer review.



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J Microb Biochem Technol 2016, 8(6)(Suppl)  
http://dx.doi.org/10.4172/1948-5948.C1.0263<sup>rd</sup> World Congress and Expo on**Applied Microbiology**

November 07-09, 2016 Dubai, UAE

**Mutagenesis and protoplast fusion of *Arthrobacter* sp. for improved glucose isomerase production**Heba Sayed Mostafa  
Cairo University, Egypt

In attempts to construct superior glucose isomerase-producing strains, four bacterial strains (i.e., *Arthrobacter* sp. B-3728, *Actinoplanes missouriensis* B-3342, *Streptomyces phaeochromogenes* B-1131 and B-1517) were screened for their glucose isomerase (GI) synthesis. Both *Arthrobacter* sp. and *A. missouriensis* were proved as the highest producers (16.8 and 15.6 U.ml<sup>-1</sup>, respectively). Ultra Violet (UV) and Ethyl Methane Sulfonate (EMS) were used for mutagenesis. Induced mutants having antimicrobial resistance markers generated from *Arthrobacter* sp. and *A. missouriensis* (wild types) were screened for their GI production and compared with wild types. About 8 mutants from each treatment and each strain were examined. The mutant EMS 60-28 D generated from *Actinoplanes missouriensis* exhibited the highest activity (33.6 U.ml<sup>-1</sup>) amongst the isolated mutants from this strain with 1.99-folds. While, the mutant EMS 60-25 D generated from *Arthrobacter* sp. exhibited the highest GI production in this study (49.7 U.ml<sup>-1</sup>) with 3.2 folds improvement than its wild type. Protoplast fusion technology was successfully applied using hyper-producing GI mutants generated from *Arthrobacter* sp. according to their antimicrobial responses, 4 mutants were selected to perform 6 crosses. Eight fusants were obtained from each cross and their GI activities were determined. The fusant (C 3-2) exhibited the highest GI synthesis (2.75 folds the wild type). For optimal GI synthesis by the mutant EMS 60-25 D and fusant C 3-2, batch fermentation system was optimized. Optimization of production fermentation resulted in an additional 10% improvement in enzyme synthesis by mutant EMS 60-25 D. On the other side, GI of fusant C 3-2 was increased after optimization from 42.4 to 60.1 U.ml<sup>-1</sup> with 3.85 times the activity of the wild type. Enhanced glucose conversion ratio (48 and 48.8%), respectively was also noted by the studied strains compared to 35.3% for the wild type. Glucose isomerase of fusant C 3-2 was extracted, then purified by ammonium sulfate fractionation followed by gel filtration on Sepharose 4-B. The total yield was 17.8%. SDS-PAGE of the purified GI showed one band with a molecular weight of 47 kDa. Optimum temperature; pH; substrate and Mg<sup>2+</sup> concentration of the purified enzyme were 75 °C, 8500 mM and 0.05 M, respectively. Km value as calculated from Lineweaver-Burk plot was 285 mM. The enzyme was stable for 1 hour at 80-90 °C and pH 5. The highest GI producing fusant C 3-2 was successfully immobilized within K-carrageenan gel, hardened with glutaraldehyde, for the continuous production of HFCS. The immobilized preparation exhibited a maximal glucose conversion of 36% after 12 hours of isomerization at 60 °C and the half life of such beads was 408 hours of continuous operation.

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FIGURE 3.1: Example of logically coherent pseudoscience.

In contrast to this superficial and clearly insufficient conception, Gould-ner, quoted by Giroux (2001), points out that critical thinking must be capable of questioning even the logic of reasoning itself, that is, it must be capable of problematising what has hitherto been treated as self-evident, of turning into an object of reflection what had previously been simply a tool. To quote Marcuse (1968), critical thinking aims to define the irrational character of established rationality.

From the assumption of this conception of critical thinking a new question arises: is it really in the interest of the current Education System to encourage critical thinking, or, to put it another way, is it in the interest of the students to be able to question the validity of the Education System itself? One element that can help to answer these questions is the hidden curriculum, since, as Giroux (2001) points out, *any pedagogy that is interested in critical thinking must consider the content of the hidden curriculum.*

One of the obvious manifestations of the hidden curriculum that showed itself in all its intensity during the internship period was the hegemonic discourse mode, i.e. the expository discursive mode. In this

discursive mode, the sender acts repeatedly on the receiver but gives him/her a passive role (Castejón, España and Ganzarain, 2004). It is necessary to point out that this was the dominant discursive mode during the master classes developed during the present work plan, which is one of the main criticisms that can be attributed to it. However, the choice of this discursive mode was not accidental, but responded to the need imposed by the selectivity exams, which is another evident manifestation of the hidden curriculum, which affects the teaching-learning process in all its dimensions.

If there were really an interest in fostering critical thinking, the discursive mode that should dominate in the classroom should be the interrogative one. As Sztajnrajber (2013) states, questioning is an exercise in dismantling those certainties that are installed as layers of truths imposing the tyranny of the obvious. Questioning is a way of thinking, and that is why thinking is not only deriving conclusions, but often consists of the opposite: starting from the accepted conclusions of a community and turning them upside down (Sztajnrajber, 2013). There is nothing that contradicts and compromises popular improvement more than an education that does not allow the learner to experience debate and analysis of problems and that does not provide the conditions for true participation (Freire, 1978).

As Giroux (2001) notes, no matter how progressive an approach to critical thinking may be, it will squander its own potential if it operates on the basis of a web of social relations in the classroom that are authoritarianly hierarchical and promote passivity, docility and silence.

A second manifestation of the hidden curriculum perceived during the internship that contributes negatively to the promotion of critical thinking in the classroom is the way knowledge is approached, i.e. the memorisation of content. As Fromm (1978) points out, the current organisation of the educational system promotes *the mode of having*, which consists of possessing more knowledge; in the mode of having, happiness depends on superiority over others, on power, and ultimately on the ability to conquer, steal and kill (Fromm, 1978).

Against this, schools should promote the *way of being*, which aspires to know more deeply. In the way of being, which has independence, freedom and critical reasoning as its requisites, well-being depends on loving, sharing and giving (Fromm, 1978). The having mode would, according to Fromm (1978), be a clear attack on the aspiration of fostering critical thinking, since individuals, faced with thoughts that make them doubt the information they retain, tend to feel disturbed and show rejection. In fact, the students considered to be the brightest were the ones who showed the greatest resistance to the implementation of novel methodologies.

In the words of Paulo Freire, we could call the dominant pedagogy, in its relation to the promotion of critical thinking, *the culture of silence*.

Another manifestation of the hidden curriculum perceived during the internship period, closely linked to the dominant mode of discourse, was the imposition of meanings. According to Giroux (2001), the imposition is intimately linked to its aspiration to depoliticisation. Faced with this, we could ask ourselves: does this aspiration impact in any way on the objectives of the LOMCE? To answer this question, we take the first objective for the Baccalaureate from Organic Law 8/2013, of 9 December:

*Article 25.a: To exercise democratic citizenship, from a global perspective, and to acquire a responsible civic conscience, inspired by the values of the Spanish Constitution as well as by human rights, which fosters co-responsibility in the construction of a fair and just society.*

As Žižek (2007) argues, the main goal of anti-democratic politics is and always has been depoliticisation, i.e. the non-negotiable demand that things *return to normal*, that everyone takes his or her place. The struggle for ideological-political hegemony is always a struggle for the appropriation of those concepts that are *spontaneously experienced as apolitical*, because they transcend the confines of politics (Žižek, 2007). This is a clear example of the contradictions between the explicit objectives of the LOMCE and the implicit objectives linked to the practices of the hidden curriculum.

As Bakunin (1869) points out, there is an axiomatic incompatibility between the claim of depoliticisation of schools and their aspiration to create just, free and moral citizens, for if schools were to be founded in today's society which gave their pupils as perfect an instruction and education as we could imagine, would men become just, free and moral? No, for when they leave school they would find themselves in the midst of a society which is run on contrary principles.

The education system is political, so aspiring to its politicisation does not imply an inference in its functions (Marcuse, 2013); as Žižek points out, it is impossible not to be biased, because even neutrality implies taking sides.

Another practice, cited above, which is a frontal attack on the claim of creating an active and democratic citizenship is the expository mode of discourse, since, according to Giroux (2001) this approach teaches students more about the legitimacy of passivity than about the need to critically examine the lives inspired by it. According to Foucault (1992) the control strategies derived from the hidden curriculum are a clear attack on the sovereignty of the people themselves.

Some may argue that despite its shortcomings, the current hidden curriculum produces positive effects at the level of knowledge. However, we should ask ourselves what kind of knowledge we want to produce in schools. In the words of Giroux (2001), when students have little room left to generate their own meanings, learning degenerates into a euphemism for a strategy of control.

The final conclusion that can be drawn is: the prescribed curriculum is the sublimation of the hidden curriculum, and not an independent element of the latter.

### **3.1. Final Question**

Briefly reason: should schools train young people to adapt to today's society as it actually is, or, on the contrary, does the school have a revolutionary mission to train young people who will try to improve that same society?



## Appendix A

### Programming code

The programming codes corresponding to various scripts developed during the didactic unit are included below.

- Code A: Natural selection simulator. Code C:
- t-test to test hypothesis A. Code D: t-test to
- test hypothesis B.

## Code A: Natural selection simulator.

```
1#!/usr/bin/python
2
3"""
4NATURAL SELECTION SIMULATOR
5Author: Cristobal Gallardo
6Date: 04.04.17
7"""
8
9import random
10from sys import argv
11import matplotlib.pyplot as plt
12from time import sleep
13from matplotlib.animation import ArtistAnimation
14import os, sys
15from matplotlib.offsetbox import AnchoredText
16
17n = 100
18birth = 0.5 #int(argv[1])/100.0
19kill = 0.1 #int(argv[2])/100.0 #0.2
20generations = 200
21fps = 5
22
23population = {"AA": n, "Aa": n, "aa": n}
24colours = ["black", "grey", "white"]
25
26def processing(val, population):
27    while True:
28        if val % 5 and poblacion["AA"]: return "AA": return "AA": return "AA": return "AA": return "AA": return "AA"
29        elif (val % 2 or val % 3) and population["Aa"]: return "Aa".
30        # elif val % 5 and poblacion["grises"]: return "grises"
31        else: return "aa"
32
33def dice():
34    return random.choice(range(1, 13))
35
36def survivors(population):
37    return len([x for x in population.values() if x != 0])
38
39def cycle(population, k):
40    population[k] = population[k] - population[k] * kill
41    for p in population.keys():
42        if population[p] < 2:
43            population[p] = 0
44        else:
45            population[p] = population[p] + population[p] * birth
46
47def plotting(D, colours, g):
48    f, ax = plt.subplots(1, 1)
49    plt.bar(range(len(D)), D.values(), align='center', color=colours)
50    plt.xticks(range(len(D)), D.keys())
51    x1, x2, y1, y2 = plt.axis()
52    plt.axis((x1, x2, 0, 100))
53    plt.xlabel('Genotypes')
54    plt.ylabel('Frequency relative')
```



```

55 plt.title('Generalsevelopmentofgeneralsover
56 time')
width red xt = AnchoredText ("Generacion %s" % (g * 5), pad = 0.7,
57 borderpad = 1, lorc = 2)
58 ax.addartist(anchored xt)
59
60 plt.legend()
61 plt.tightlayout(
62 ) #plt.show()
63
64 def normalize (D):
65     total = sum([x for x in D.values()]) fo
66     r i in D.keys():
67         D[i] = round((D[i] / total) * 100, 2)
68
69 def main():
70     #while survivors(population) > 1:
71
72     for i in range(generations):
73         k = processing(dice(),
74 population) cycle(population, k)
75     if survivors(population) == 1: break
76     normalize(population)
77     print population
78     plotting(population, colours, i / 5)
79
80     #plt.show()
81     fname = 'tmp%05d.png' % i
82     plt.savefig(fname)
83     plt.clf()
84     os.system("rm movie.mp4")
85     os.system("ffmpeg -r %s -i %s -c:v libx264 -r %s -c:a aac -y %s" % (fps, fname, fps, "movie.mp4"))
86     os.system("rm %s" % fname)
87
88 if __name__ == "__main__":
    main()

```

**Code C: Code corresponding to the actual t-test. The results of the study were used to test hypothesis A: there are no differences between student outcomes and a randomised model.**

```
1 #!/usr/bin/python
2
3 import random
4 import numpy as np
5 from matplotlib import pyplot as plt
6 import numpy as np
7 import pandas as pd
8 import scipy.stats as stats
9 import math
10 import matplotlib.mlab as mlab
11 random.seed(12)
12
13
14 # configuration
15 n = 10000 # number of repetitions for the Central Limit
16 # Theorem
17 resfile = "/home/nouser/Desktop/master/memory/results/te
18 # auxiliary functions
19 def custionary():
20     """
21     Randomised randomised custions simulations in situat ion.
22     """
23     whichstion = [1, 0.2, 0]
24     result = []
25     for i in range(20):
26         result.append(random.choice(que stion))
27     return round(sum(result)/2.0, 1)
28
29 def ramres(n):
30     """
31     Function for the simulation of the Limit Theorem.
32     """
33     result = []
34     for i in range(n):
35         result.append(custionary())
36     return result
37
38 def alumres(path):
39     """
40     Reading of the students' reports.
41     """
42     results = [float(x.strip("\n")) for x in open(path).r
43     eadlines() if x != "\n"]
44     print len(results)
45     mean, devest = np.mean(results), np.std(results)
46     return (resultados, media, devest)
```

```

47
48 def main():
49     # Repetition of alleational process
50     .repetitions = ramres (n)
51
52     # Check that they are still in a normal state. """"
53     fig, ax = plt.subplots (nrows=1, ncols=1) pd.
54     DataFrame (repetitions).plot(kind='density',
55                               figsize=(9,9),
56                               xlim=(1,10))
57     plt.savefig('histogram random')
58     """"
59     # critical value of Z for a p-value of 0.05. reps = np
60     .array (repetitions)
61     reps mean = reps . mean ()
62     z critical = stats . norm . ppf (q=0.975)
63     # Note : q = 0.975 because it has two colles.
64
65     # Calculation of the confidence intervals.
66     reps s dev = reps . std () # Standard deviation .
67     margin of error = z critical * (reps s dev / math . sqrt (
68     n)) confidence interval = (reps mean - margin of error
69     ,
70     reps mean + margin of error)
71
72     # Average number of pupils
73     result , alumean , al us td = alumres (res file)
74
75     # Sample of the resultateds.
76     # print 'Valor critico z:', z critical
77     # print 'Intervalo de confianza:', confidence inter
78     val print 'Aleatorized sample mean:', reps mean print
79     'Aleatorized sample tipical deviation:', reps s dev
80     print 'Average of pupils:', alumean
81     print "Tipical development of the publics:", allowi
82     ng the us td
83
84     # differences significantes significantes with respect ion to t
85     herespection ally
86     ts tat , pval = stats . ttest 1 samp (are sult , reps mean) pri
87     nt "The stadistic otis:", ts tat
88     print "The p-value of flest is:",
89     pval # plot
90
91     # norm = np . random . normal (loc=reps mean , scale=reps s dev , size
92     =10000)
93     uplim = (ts tat * al us td) + reps mean
94     downlim = reps mean - (ts tat * al us td) f
95     ig, ax = plt.subplots (nrows=1, ncols
96     =1)
97     pd . DataFrame (repetitions).plot(kind='density', label='Label',
98     figsize=(9,9),
99     xlim=(0,10), legend=False
100
101     ) plt.xlabel("Questionary Note")
102     plt.ylabel("Frequency of halifications")
103     plt.axvline (uplim, color='r', linestyle='--', lw=2, label="Limits
104     for p-val=0.05")
105     plt.axvline (downlim, color='r', linestyle='--', lw=2)

```

```

101 plt.axvline (alumean, color='g', lw=2, label=" Average of the student
    body".
102 )
103 plt.legend (loc='upper right')
104 plt.savefig ('plottedlegend')
105 #mu = reps mean
106 #sigma = reps stdev
107 #x = repetitions
108 #plt.plot (x, mlab.normpdf (x, mu, sigma)
109 )
110
111 #plt.show ()
112 if __name__ == "__main__":
113     main ()
114
115
116
117 """
118 # Use scipy.stats.ttestindfromstats.
119 t2, p2 = ttestindfromstats (abar, np.sqrt (avar), na,
120                             bbar, np.sqrt (bvar), nb,
121                             equalvar=False)
122 print ("ttestindfromstats: t = %g    p = %g" % (t2, p2))
123
124 # Use the formulas directly.
125 tf = (abar - bbar) / np.sqrt (avar / na + bvar / nb)
126 dof = (avar / na + bvar / nb) ** 2 / (avar ** 2 / (na ** 2 * adof) + bvar ** 2 / (
nb
    ** 2 * bdof))
127 pf = 2 * stdtr (dof, -np.abs (tf))
128
129 print ("formula :                t = %g    p = %g" % (tf, pf))
130 """

```

## Code D: Code corresponding to the t-test carried out to test hypothesis B.

```
1 #!/usr/bin/Rscript
2
3 # Author: Cristobal Gallardo
4 # Date: 3.05.17
5
6 # ficherooffichersroute
7 fichero A = "~/Desktop/master/memory/resultated/groupA.csv"
8 fichero B = "~/Desktop/master/memory/resultated/groupB.csv"
9
10 # data processed
11 dataA <- read.csv(file=file A,
12                  header=TRUE,
13                  sep=",",
14                  stringsAsFactors = F,
15                  row.names = 1)
16 dataB <- read.csv(file=file B,
17                  header=TRUE,
18                  sep=",",
19                  stringsAsFactors = F,
20                  row.names = 1)
21
22 # column renaming
23 header = c("Apellido", "Block A",
24           "Initial", "Block B", "Block CD", "Final", "Course"), "Final", "Course")
25
26 names(dataA) = header
27 names(dataB) = header
28
29 # extraction of testinical and final data
30 groupA <- dataA[, c("Initial", "Final")]
31 groupB <- dataB[, c("Initial", "Final")]
32
33 # elimination of nil value entries
34 groupA = groupA[-c(1, 4, 9, 10), ]
35 groupB = groupB[-c(3, 8, 11), ]
36
37 # data preparation for the t-test
38 groupA[, 1] <- as.numeric(groupA[, 1])
39 groupA[, 2] <- as.numeric(groupA[, 2])
40
41 groupB[, 1] <- as.numeric(groupB[, 1])
42 groupB[, 2] <- as.numeric(groupB[, 2])
43
44 AI <- groupA[, 1]
45 FA <- groupA[, 2]
46
47 IB <- groupB[, 1]
48 FB <- groupB[, 2]
49
50 # l-t-e s t parameters
51 diffNull = 0
52 confide n c e = 0.95
53
```

```

54 # Welch's test for two unpaired samples
55 res IN I = t.test(x=IB, y=IA, paired=FALSE, conf.level=confidence, mu=diffNull)
56
57 # t-test of group A
58 resA = t.test(x=FA, y=IA, paired=TRUE, conf.level=confidence, mu=diffNull)
59 # t-test of group B
60 res B = t.test(x=FB, y=IB, paired=TRUE, conf.level=confidence, mu=diffNull)
61
62 # boxplots
63 clase <- rbind(groupA, groupB)
64 png('rplotA.png')
65 boxplot(groupA, ylim=c(0, 10),
66         xlab="Group A",
67         ylab="Score",
68         col=c("grey 90", "grey 100"),
69         names=c("Test Inicial", "Final Test"))
70 dev.off()
71
72 png('rplotB.png')
73 boxplot(groupB, ylim=c(0, 10),
74         xlab="Group B",
75         col=c("grey 90", "grey 100"),
76         names=c("Test Inicial", "Final Test"))
77 dev.off()

```

## Appendix B

# Bibliographical references on cooperative working groups

The bibliographical references proposed to each of the working groups for the cooperative elaboration of the scientific essays were as follows:

Group A:

- The Survival of the Most Sociable \*
- Altruism as a Factor in Evolution \* Mutual
- Support (chapter II) \* Altruism as a Factor in Evolution \* Mutual Support (chapter II) \* Altruism as a Factor in Evolution \* Altruism as a Factor in Evolution
- Social Immunity \* Black
- Queen Hypothesis
- Social Immunity and Insect Societies
- Sharing, the Basis of Human Hunter-Gatherer Societies The Role of
- Cooperation and Altruism in Evolution
- Fungal Insects, an Example of Mutualism

- *A Gene Associated with Social Immunity in Nicrophorus vespilloides*



Group B:

- *The World and its Demons (Chapter 12) \**
- *Denialism: What is it and How Should Scientists Respond? \** ■

About the Truth

- *A Finder's Guide to Facts \**
- *Sokal's Limits of Criticism \** ■ *How Do you Know a Paper is Legit? ■ Case Study - 99.9% Caffeine-Free*
- *A Peek Inside the Strange World of Fake Academia*
- *Why Fake Data When you can Fake a Scientist?*
- *School Children 'Should be Taught to Recognise Fake News' ■ Before 'Fake News' came False Prophecy*

\* Recommended basic bibliography.



## **Appendix C**

### **Evaluation rubric**

The rubric used to evaluate the results of the cooperative writing workshop is attached below. This instrument was given to the students at the beginning of the activity.

**Instructions:** The essay will be assessed on the basis of this rubric. Consequently, it is recommended that this rubric be used as a guide for writing and to check that the required points have been adequately developed.

Element	Excellent	Good	Satisfactory	Deficient
<b>Introduction</b>	The introduction includes the purpose, general statement of the topic, clear objectives and main subdivisions.	The introduction includes a n overview of the topic and main subdivisions. The objectives are a bit unclear.	The general statement of the topic or the main subdivisions are not presented. Purpose, topic and objectives require clarification or are not presented objectively.	The introduction is incomplete, ineffective, confusing or absent. It does not include an overview of the topic, its main subdivisions or is not relevant. The purpose, subject and objectives are unclear.
<b>Sources of information</b>	<p>The sources of information are varied and multiple and the way of citing is in accordance with APA standards. The information gathered is related to the topic, relevant and up to date.</p> <p>The sources are reliable, contribute to the development of the topic and are followed by inferences or comments that contribute to a better understanding of the text.</p>	<p>The sources of information are varied and the way of citing is in accordance with APA standards.</p> <p>The information collected is up to date but includes some data that are not relevant or not related to the topic.</p> <p>The sources are reliable and contribute to the development of the topic, the comments are very brief.</p>	<p>The sources of information are limited or not very varied. There are several errors in citing according to APA standards</p> <p>The information collected is relevant to the topic but some of it is not up to date or relevant.</p> <p>Some sources are unreliable and therefore do not contribute to the development of the topic, comments or inferences are a repetition of the quotation.</p>	<p>There are few or no sources of information. Citation forms do not conform to APA standards.</p> <p>If you use sources, they are unreliable and do not contribute to the topic. The information has little or no relation to the main topic, and you did not comment after the citation.</p>
<b>Organisation (paragraphs and transitions)</b>	Ideas are presented in a logical order. There is coherence and fluidity in the transition of ideas. The order of the paragraphs reinforces the content. Each paragraph presents a different idea.	<p>Ideas with some errors in logical order. Some errors in coherence and fluidity in the transition of ideas.</p> <p>The order of the paragraphs reinforces the content. There are some paragraphs with repeated ideas</p>	<p>There are many logical errors in the ideas.</p> <p>There are several errors in coherence and the transition of ideas between paragraphs is not smooth. The order and ideas in the paragraphs only reinforce the content to a limited extent.</p>	<p>The ideas are not presented in a logical order.</p> <p>It lacks coherence, transitions between paragraphs are poor or non-existent and the order of paragraphs does not reinforce the content.</p>
<b>Cohesion</b>	The structure or word order (syntax) in sentences is logical. Uses different cohesion mechanisms such as: markers, substitutions, pronouns, etc. to give clarity to the text.	The structure or order of words (syntax) in sentences is logical. It makes use of two cohesion mechanisms	It has errors in sentence structure, and makes repeated use of only one cohesive mechanism.	Sentence structure is disorganised and does not use cohesive mechanisms.

<b>Spelling</b>	It has no spelling, literal, accentual or punctuation errors.	It has some accentual spelling errors.	It has some literal and accentual spelling errors.	It has many spelling errors that are considerably or totally distracting to the reader.
<b>Content</b>	All ideas presented are directly related to the topic. Ideas are presented clearly and objectively.  These are not repeated and there are no gaps. He did not use copy and paste.	Almost all the ideas presented are directly related to the topic and are presented quite clearly and objectively.  These are not repeated and there are no gaps. Copying and pasting was used on only one occasion.	A good number of the ideas presented are related to the theme.  These need to be presented more clearly or objectively. Some ideas are repeated. There is very little originality in the document.	The ideas presented have little or no relation to the topic, are poorly defined, unclear and not presented objectively.  Many ideas are repeated. The text is practically a copy and paste.
<b>Conclusion</b>	You end your essay by making use of a concluding strategy such as topic synthesis, thesis reiteration or recommendation and this is sufficient and clear.  The transition between the body of the presentation and the conclusion is smooth.	He ends his essay with a synthesis, a reiteration of the thesis or a very brief recommendation.  The transition between the development and the conclusion presents a few flow problems.	It makes use of a completion strategy but this is confusing.  The transition between development and conclusion is not very smooth.	When reading the last part of the text, it is perceived as an incomplete text because it does not reach any kind of conclusion.  The transition between development, presentation and conclusion is very poor or non-existent.
<b>Personal Contribution</b>	Coherent, serious and convincing personal contributions to the topic of the essay are presented.  At least two original and applicable contributions are presented.	Coherent, serious and convincing personal contributions to the topic of the essay are presented. At least one original and applicable contribution to the topic is presented.	An inconsistent and unserious personal contribution to the topic of the essay is presented.	No original contribution applicable to the topic is presented.

Important complements:

Presence of copy-paste: If there are more than 2 paragraphs with copy-paste the essay will get 10% of the total grade.



## Appendix D

# Original Memory

### D.0.1. About the Subject Matter

The work plan was developed mainly around the subject of Biology in the 2nd year of Bachillerato; the focus of this subject is molecular biology. The textbook used as a reference is *Biology 2*, by José Alcamí and collaborators, published by SM. The main block of conceptual content developed corresponds to topic 17: genetics and evolution, belonging to block 3. According to Iñiguez (2013), genetics is one of the most difficult sections of biology for students to understand and one of the most conceptually difficult.

Likewise, activities were also carried out in the subject of Biology in 1st ESO and in the subject of Biology and Geology in 4th ESO, which will be described in the section of

### D.0.2. About the Alumni

The 2nd year Baccalaureate class consisted of 22 students with very different profiles; it should be noted that this group was considered by the rest of the teachers linked to some of the subjects to be *extraordinarily competitive and hard-working*. Among the students, there was one student with Asperger's syndrome and one with a very different profile.

one pupil diagnosed as highly able, although at her own request she did not receive any type of special attention. Likewise, in terms of geographical origin, the group was made up of two pupils of South American origin, one pupil of Moroccan origin and one pupil of Romanian origin.

## **D.1. Objectives**

Making educational results profitable requires the need to explain the scientific and didactic objectives we set ourselves (Ayuso and Ba- net, 2002). This is why, at all times, the students were informed of the objectives to be achieved through the sequence of activities implemented during the development of the didactic unit. Thus, we can distinguish between general stage objectives, area objectives and subject objectives.

### **D.1.1. General Stage Objectives**

Among the points in the legislation that have been dealt with during the traineeship are the following:

- Encourage cooperative and collaborative work in order to responsibly assume their duties, to know and exercise their rights with respect for others, to practise tolerance, cooperation and solidarity among individuals and groups, to exercise dialogue by strengthening human rights and equal treatment and opportunities between women and men, as common values of a plural society and to prepare for the exercise of citizenship.
- To encourage self-learning and research in order to develop and support habits of discipline, study and individual and team work as a necessary condition for the effective performance of learning tasks and as a means of personal development.



- Encourage work in heterogeneous groups, paying attention to diversity and non-discriminatory inclusiveness in order to value and respect the difference between the sexes and equal rights and opportunities between them. Reject discrimination against people on the basis of sex or any other personal or social condition or circumstance. Reject stereotypes that imply discrimination, as well as any manifestation of violence.
- To put into practice didactic strategies and methodologies to strengthen their affective capacities in all areas of their personality and in their relations with others, as well as to reject violence, prejudice of any kind, sexist behaviour and to resolve conflicts peacefully.
- Encourage self-learning and research to develop basic skills in the use of information sources in order to acquire new knowledge with critical awareness. To acquire a basic preparation in the field of technologies, especially information and communication technologies.
- Work on scientific competences in a transversal way in order to conceive scientific knowledge as an integrated knowledge, which is structured in different disciplines, as well as to know and apply the methods to identify the problems in the different fields of knowledge and experience.
- Encourage the production of reports/essays and oral presentations in order to understand and express oneself correctly, orally and in writing, in the Spanish language.

### **D.1.2. General Area Objectives**

In the case of the general objectives of the area, those implemented during the didactic unit developed are the following:

- To reinforce reading, study and discipline habits, encouraging students to read simple scientific texts or articles that complement the information obtained in the classroom and bring them into contact with the scientific literature.

with this voluntary "open curriculum" which is so important for the advancement of personal scientific knowledge.

- Use information and communication technologies with competence and responsibility, necessary not only for searching the Internet for the information we need, but also for the preparation of presentations, papers and presentations in the subject.
- Access to fundamental scientific and technological knowledge and master the basic skills of Biology, inherent to the development of the subject itself.
- Understand the fundamental elements and procedures of research and scientific methods.
- Knowing and critically assessing the contribution of science and technology in changing living conditions, as well as strengthening sensitivity and respect for the environment, also included in the teaching-learning process of the subject itself.

### **D.1.3. General Subject Objectives**

Among the points included in the legislation to be worked on during the traineeship are the following, which belong to content block 3:

- Define the concept of mutation by distinguishing the main types and mutagenic agents.
- To contrast the relationship between mutation and cancer. Differentiate different evidences of the evolutionary process.
- Recognise, differentiate and distinguish the principles of Darwinian and neo-Darwinian theory.
- Relate genotype and gene frequencies to population genetics and their influence on evolution.
- Recognise the importance of mutation and recombination.

- Analyse the factors that increase biodiversity and their influence on the speciation process.

## **D.2. Contents of the Didactic Unit**

### **D.2.1. Conceptual Content**

The conceptual contents addressed in this didactic unit are part of the contents proposed by the official curriculum, included in Royal Decree 1105/2014, of 26 December, which establishes the basic curriculum for compulsory secondary education and the Baccalaureate. These include:

- Mutation and types of mutations
- Tumour cells and cancer
- Protooncogenes and tumour suppressor genes
- Mutagens and types of mutagens
- Species and population
- Implication of mutations in evolution ■ Evidence of the evolutionary process
- Speciation
- Natural Selection and Gene Drift
- Darwinism and Neo-Darwinism
- Neutralism and Punctuated Equilibrium ■ Epigenetics

Together with these, and in accordance with the provisions of section ??, two alternative itineraries of complementary contents were established.

additional courses, with the possibility of free choice by the students **a c c o r d i n g t o** their affinity and degree of motivation.

TABLE D.1: Alternative content pathways.

Alternative routes	
Group A	Group B
Altruism	Science
Black Queen Hypothesis	Truth
Social immunity	Scientific method
Superorganism	Objectivity
Mutualism	Postmodernism

### **D.2.2. Procedural Contents**

As far as procedural content is concerned, we can cite the following as the main ones:

- Scientific essay writing
- Reading and understanding popular science articles
- Use of on-line cooperative writing tools ■ Identification of reliable information sources
- Viewing of informative documentaries
- Use of computer simulation tools

### **D.3. Methodological Principles and Strategies**

Within the framework of the socio-cultural constructivist paradigm, desirable features of educational design in the information society include the promotion of self-directed learning, the encouragement of cooperative teamwork, the organisation of open learning environments, and the development of a more open learning environment.

in which divergent reasoning is encouraged, and the promotion of complex and socially relevant cognitive tasks (Díaz Barriga, 2005). Thus, in accordance with these characteristics, the basic methodology implemented in this project was cooperative learning; specifically cooperative writing (Gallardo, 2017).

Group goals were set with the aim of motivating students to collaborate in the learning of their peers and to help them overcome their reluctance to ask for help or to support others (Slavein, 1989).

The choice of writing as a pedagogical tool in cooperative learning is determined by the essential role that language plays in the construction of ideas. In a way, scientific activity is also a linguistic activity: language helps to construct more elaborate scientific models and these help to configure a more precise language (Bargalló, 2005). According to Márquez Bargalló (2005), one of the fundamental premises that justify the need to promote the development of students' scientific communicative competence is that learning science is like learning another language; in the process of learning science, new words and grammatical structures have to be learned. What is important in reading is not the comprehension of the text itself, but the ability of students to establish relationships between the concepts expressed in this text and knowledge acquired in other situations (Bargalló, 2005).

## D.4. Organisation of Time and Space

In order to facilitate access to the educational material, a virtual platform was set up (Fig. D.2) where students could access the resources at any time. The platform was also intended to serve as a meeting and discussion space. The time distribution is described in figure D.1.

The interventions took place between 3 and 7 April. The fifth intervention was the examination, which took place on 3 May. The time allowed for the preparation of the cooperative essay was extended by



FIGURE D.1: Timing of teaching intervention.

from 4 April to 26 April. Further details on the timing of the activities are given in Figure D.1.

## D.5. Activities

Given the pressure imposed on second-year baccalaureate students as a result of the entrance exams and the limited time available for classroom activities, the option chosen was to use the virtual platform as a vehicle for the development of training activities. In accordance with the constructivist teaching method, the activities proposed to the students were characterised by their aim to create cognitive conflicts. They can be classified into 3 main groups:

- a) Cooperative writing workshop: this activity was designed with the aim of deploying, in as much depth as possible, the objectives set out in section D.1.2.

Navigation

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          - Bloque B: Mutantes, Mutágenos y Cáncer
          - Bloque C: Genética Evolutiva (I)
          - Bloque D: Genética Evolutiva (II)
          - Recursos Adicionales
        - UDMM
        - PI

Administración

- Course administration
  - Question bank
- Site administration

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### Genética y Evolución

Bloque de contenidos desarrollado por Cristóbal Gallardo en torno a la Unidad Didáctica: Genética y Evolución, correspondiente a la asignatura de Biología de 2º de Bachillerato.

- Cuestionario Inicial**
- Taller de Escritura Cooperativa**  
Aquí se detallan los aspectos principales del proyecto de escritura cooperativa.
- Escritura Científica y la Cooperación Online**  
Artículo publicado en Nature el 1 de Octubre de 2014 sobre cómo las plataformas de escritura cooperativa están revolucionando la forma de construir la Ciencia.
- Entrega de la Tarea Cooperativa**
- Foro de Cuestiones Generales**  
Foro habilitado para plantear todas las dudas/cuestiones relacionadas por la presente unidad didáctica.

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### Bloque A: Mutaciones

Una mutación se define como cualquier cambio en la secuencia de un nucleótido o en la organización del ADN (genotipo) de un ser vivo, que produce una variación en las características de este y que no necesariamente se transmite a la descendencia.

- Diapositivas Bloque A**  
Si piensas que la diapositiva requiere editar alguna parte, eres libre de ello.
- Actividades del Bloque A**  
Actividades propuestas en relación a los contenidos del bloque A: Mutaciones.

**Material suplementario:**

- Anotaciones de Clase Bloque A**  
Contenidos tratados en la clase correspondiente al bloque A.
- Documental: Epigenética, la nueva revolución biológica**  
La epigenética es el estudio de modificaciones en la expresión de genes que no obedecen a una alteración de la secuencia del ADN y que son heredables.
- Artículo científico: Evolución por duplicación génica**

---

### Bloque B: Mutantes, Mutágenos y Cáncer

En biología, un mutágeno (latín, "origen del cambio") es un agente físico, químico o biológico que altera o cambia la información genética (usualmente ADN) de un organismo y ello incrementa la frecuencia de mutaciones por encima del nivel natural.

- Diapositivas Bloque B**  
Si piensas que la diapositiva requiere editar alguna parte, eres libre de ello.
- Actividades Bloque B**  
Actividades propuestas en relación a los contenidos del bloque B: mutantes, mutágenos y cáncer.

**Material suplementario:**

- Documental - Mutaciones**  
Documental emitido en 2 de RTVE sobre las mutaciones y su papel en la evolución.

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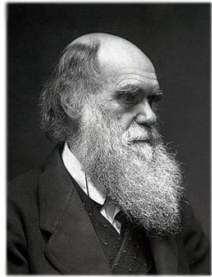
### Bloque C: Genética Evolutiva (I)

La genética evolutiva o genética de poblaciones, es la ciencia que estudia cómo se distribuyen los alelos en las poblaciones de organismos y de una generación a otra.

- Diapositivas Bloque C**  
Si piensas que la diapositiva requiere editar alguna parte, eres libre de ello.
- Documental: Los Orígenes de las Especies**  
Si la ciencia tuviera templos, la casa de Darwin sería posiblemente una catedral. En este lugar, Darwin concibió su teoría de la evolución por selección natural y escribió su obra fundacional *El origen de las especies*.  
En este ámbito histórico, Eduard Punset entrevistó a uno de los mayores expertos mundiales en biología evolutiva, Mark Pagel, de la Universidad de Reading y charlaron sobre cómo surgen las especies, sobre el significado del altruismo y sobre la evolución de las lenguas.

**Material suplementario:**

- Artículo de Wikipedia: Presión Evolutiva**
- Teoría científica**
- Artículo de Wikipedia: Explosión Cámbrica**
- Documental - La Peligrosa Idea de Darwin**  
La peligrosa idea de Darwin un largometraje documental que combina entrevistas y hechos científicos con dramatizaciones de la vida de Darwin.
- ¿Qué son y cómo se forma los fósiles?**
- Now You Know: Which Came First, the Chicken or the Egg?**  
Artículo entorno a la controversia sobre si primero el huevo o la gallina, publicado en la revista Time el 21 de septiembre de 2016.
- Script de la Simulación de la Presión de Selección**  
Este es programa de ordenador, con el que se generó la simulación de la presión de selección de la población de conejos/as.



Charles Darwin (1809-1882)

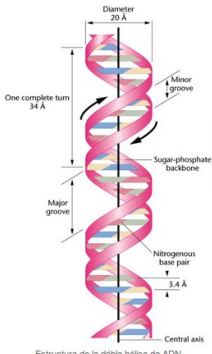


Diagrama de la estructura de la doble hélice de ADN. Muestra un eje central con una distancia de 3.4 Å entre los pares de bases nitrogenadas. El diámetro de la hélice es de 20 Å. Una vuelta completa mide 34 Å. Se indican las fosfatos de azúcar y las fosfatos de azúcar en el esqueleto exterior, y las fosfatos de azúcar en el esqueleto interior.

RSS Sobre Ciencia

**Taller de identificación de noticias falsas**  
Este proyecto se ha desarrollado en el marco del Master de Educación Secundaria, especialidad Biología. Púlsala en la imagen para iniciar.

**Evolución: la supervivencia del más sociable**  
"La violencia ha sido la progenitora de todos los valores del mundo", escribió el poeta Robinson Jeffers en 1940. ¿Qué sino los dientes del lobo blanquearon tan finamente el conjunto de extremidades del antlope? ¿Qué sino el miedo alado de los pájaros, y el hámbre en los ojos de la cabeza del gran azor? Hemos [...]

**Los registros del Ártico no sobreviven a Trump**  
Traducción de I am an Arctic researcher. Donald Trump is deleting my citations, publicado en The Guardian el 28 de Marzo de 2017. Como investigador del Ártico, estoy acostumbrado a que existan lagunas en los registros de datos. Solo entorno al 1% de las aguas del Ártico pertenecientes a EEUU han sido analizadas de acuerdo [...]

**El dilema de Goodhart**  
El profesor Goodhart ironizó hace años sobre la pretensión monetarista de garantizar la estabilidad económica con tan solo controlar el crecimiento de una magnitud monetaria determinada (M1, M3...). "Cualquier relación estadística estable tenderá a desvanecerse tan pronto se intente utilizar como mecanismo de control", señaló entonces el distinguido economista británico, hoy miembro del comité de [...]

**El negacionismo es un fenómeno que emplea algunas o todas de estas cinco estrategias:**

- La primera es la identificación de conspiraciones.
- La segunda es el uso de expertos falsos.
- La tercera característica es la selectividad, basándose en informaciones aisladas que desafían el consenso dominante o destacando las falas en los argumentos más débiles entre aquellos que lo apoyan como un medio de desacreditar todo el campo.
- La cuarta es la creación de expectativas imposibles de lo que la investigación puede ofrecer.
- El quinto es el uso de la tergiversación y las falacias lógicas.

Martin McKee - Denialism: what is it and how should scientists respond?






El Apoyo Mútuo - Piotr Kropotkin

"[...] aun reconociendo enteramente que la fuerza, la velocidad, la coloración protectora, la astucia, y la resistencia al frío y hambre, mencionadas por Darwin y Wallace realmente constituye cualidades que hacen al individuo o a las especies más aptos en algunas circunstancias, nosotros, junto con esto, afirmamos que la sociabilidad es la ventaja más grande en la lucha por la existencia en todas las circunstancias naturales, sean cuales fueran."

The Evolution Of Man And Woman



"El punto en el que los posmodernos se basan principalmente es justo éste: lo que una persona considera verdadero puede ser simplemente una función de su punto de vista individual o bien está determinado por lo que la persona está obligada a considerar verdadero en virtud de diversas, complejas e ineludibles presiones sociales."

Sobre la Verdad - Harry G. Frankfurt



Lynn Margulis (1938-2011)

Una entidad biológica puede ser definida como un organismo si existe una cooperación intensa y unánime entre las partes constituyentes, aun existiendo verdaderos conflictos entre alguna de las partes integrantes. De acuerdo con este punto de vista, los organismos pueden ser vistos como grupos sociales altamente cooperativos y las sociedades organizadas de individuos podrían ser considerados como organismos.

David Baracchi, doctor en sociobiología

FIGURE D.2: Virtual platform enabled for the teaching unit.

A forum was set up on the virtual platform among the students, in which the basic lines of the work proposal were established:

- The essay must be written through the meeting-words.com platform.
- The aim is to produce, in a cooperative way, a scientific article/essay on the proposed topic.
- Only one document should be produced per group.
- The internal organisation of the group is free to choose. ■ The length of the text should be around 10,000 words.
- The final text should be coherent in content (i.e. clear and well-structured) and original.
- The evaluation criteria and standards are listed in the ad hoc rubric.
- Arguments should be supported by bibliographical citations.
- It is recommended to use a talky.io channel for remote coordination of the work.

Two themes were proposed for the development of the activity, in accordance with the conceptual content itineraries set out in section **D.2.1**.

- Group A: Cooperation as an evolutionary mechanism.
- Group B: The nature of science and its relation to truth.

The bibliography proposed for the cooperative elaboration of the texts is included in Appendix **B**. Finally, together with the basic rules, a concept map on the basic characteristics of an essay and four guides to writing popular scientific articles were made available to the students:

- **What is an essay, characteristics, types and examples.**
- **How to write a popular science text? How to write**
- **a popular science article.**
- **Example of a scientific essay.**



- b) Informative documentaries: in each of the blocks in which the didactic unit was structured, audiovisual material was provided through the virtual platform, with the aim of consolidating the conceptual content transmitted in the classroom, complementing the information and stimulating self-learning. The proposed videos were:
- Block A: Mutations - **Epigenetics, the new biological revolution**■
  - Block B: Mutagens and Cancer - **Mutations**
  - Block C: Evolutionary Genetics (I) - **The origin of species**
  - Block D: Evolutionary Genetics (II) - **Evolution, the Great Transformation**
- c) Computer simulations: in the context of the contents linked to biological evolution (blocks C and D of the didactic unit), two computer simulations were proposed, with the aim of inducing cognitive conflicts in the students as a result of possible disagreements between intuition and computational models.
- **Gene drift simulator.**
  - **Natural selection simulator.**

## **D.6. Contribution to the Acquisition of Basic**

### **Skills**

The main means used to contribute to the development of the basic competences set out in the LOMCE was the cooperative writing activity.

- Linguistic communication: the very structure of cooperative learning groups contributes to the development of communicative skills and abilities (Sagredo and Ana, 2006).

- **Mathematical Competence and Basic Competences in Science and Technology:** throughout the teaching intervention, work was actively carried out on the promotion of ethical criteria associated with science, interest in science, support for scientific research and the valuation of scientific knowledge.
- **Digital competence:** in order to contribute to this competence, two digital tools were made available to the students to facilitate the distance coordination of the groups: talk.io and meeting-words.com. They were also provided with the source code (Appendix D) of the computer simulations generated *ad hoc* for the development of the didactic unit (see Appendix A) with the aim of introducing students to the field of computer programming.
- **Learning to learn competence:** within the framework of this competence, the use of concept maps was promoted as a cognitive strategy to transform and reconstruct information, giving it a different structure in order to understand and remember it better (Elosúa and García, 1993). In addition, at the beginning of each intervention, each student was given a concept map of the contents to be covered, similar to the one shown in figure D.3.
- **Social and Civic Competences:** the contribution to this competence is determined by the stimulation of feelings of sociability and by the development of cooperation as a means to reach common goals. According to Marina (2006) these are some of the objectives to be achieved in order to make personal and social well-being possible.

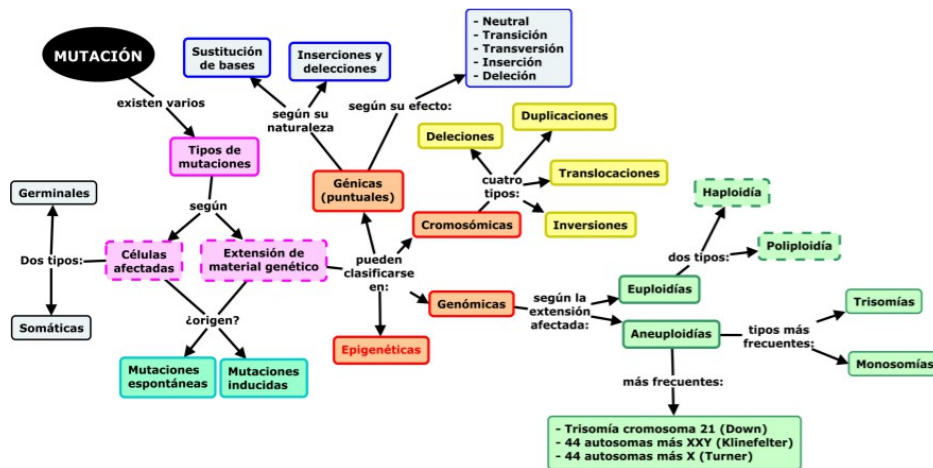


FIGURE D.3: Example of a concept map provided to students during the teaching intervention.

## D.7. Evaluation Procedures and Grading

### Criteria

#### D.7.1. Evaluation Instruments and Data Analysis

In order to obtain updated information on the teaching-learning process, with the aim of assessing the progression of the students' learning in relation to the basic contents of the unit, the following was used. This information, in turn, made it possible to identify those students with the greatest difficulties.

In the case of the cooperative writing activity, assessment was carried out using a rubric reflecting the criteria and standards related to learning objectives (Appendix D). This assessment tool was provided to the students at the beginning of the task, and its main purpose was to encourage self-assessment by the students. Among the elements to be assessed were the sources of information, the organisation of the text, cohesion, content and personal contribution.

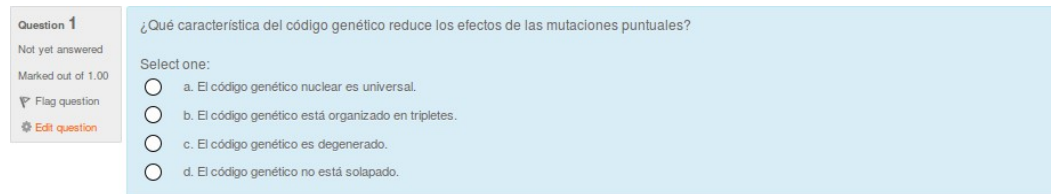


FIGURE D.4: Example of a question from the continuous assessment questionnaires

In addition, a review of the conceptual contents was carried out as an auxiliary instrument for the evaluation of the teaching-learning process.

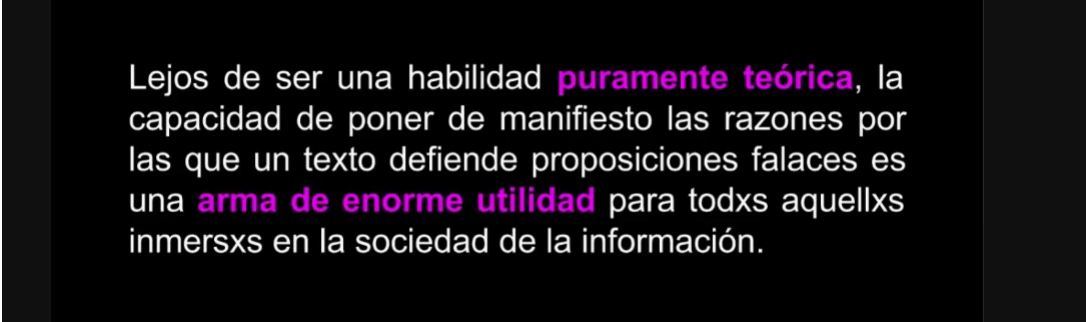
### D.7.2. Qualification Criteria

The specific weighting of each of the activities in the grade assigned to the teaching unit developed was as follows:

- Online questionnaires - 15
- Cooperative writing workshop - 35 %
- Final exam - 50 %

## D.8. Attention to Diversity

Among the measures deployed in relation to the attention to diversity we can highlight, in addition to the use of inclusive language [D.5](#), having provided the student who showed characteristics of Asperger's with extra time to take the exam.



Lejos de ser una habilidad **puramente teórica**, la capacidad de poner de manifiesto las razones por las que un texto defiende proposiciones falaces es una **arma de enorme utilidad** para todxs aquellxs inmersxs en la sociedad de la información.

FIGURE D.5: Example of a measure of attention to diversity: still from one of the materials developed *ad hoc* for the didactic unit in which gender neutrality was used.

## D.9. Hidden Curriculum

The aim of the hidden curriculum deployed was to stimulate critical thinking by using the following strategies:

- To undermine the authoritarian effects of the traditional hidden curriculum by reconfiguring power relations in the classroom.
- To convey the idea that there are no absolute truths; to this end, special emphasis was placed on the fact that in science, theory is the most rigorous, reliable and complete form of knowledge possible.
- To encourage the active participation of students in the design of the teaching-learning situations, for which they were encouraged to edit the slides prior to the lectures.
- Cultivate self-criticism, for which self-evaluation rubrics were used to assess the work carried out.
- To dilute the effect of cultural homogenisation, two alternative pathways of conceptual content were established.
- To build a sense of community; to this end and in harmony with the socio-cultural paradigm, cooperative working groups were chosen.
- To critically analyse hegemonic scientific theories in relation to alternative theories by drawing on Pyotr Kropotkin's idea-force of *mutual support*, as opposed to Darwin's *survival of the fittest*.

## **D.10. Complementary Activities: Research**

As part of the complementary activities, a research project was carried out with the aim of analysing the critical thinking of students in the 2nd year of the baccalaureate.

### **D.10.1. Introduction**

The study group was the class whose characteristics are described in section **D.0.2**. The instrument used to assess the students' level of competence was developed *ad hoc*, and consists of a questionnaire of 80 questions divided into an initial test and a final test. As shown in Figure **D.6**, in each question students had to assign a confidence level to the news items presented. The statistical analysis of the results was implemented and executed using the *Python* programming language.

### **D.10.2. Methodology**

#### **Working hypothesis**

The research carried out during the implementation of the didactic unit aimed to test two hypotheses:

- a) Hypothesis 1: Students on the science track in upper secondary school are, for the most part, unable to distinguish between reliable sources of information and sources of dubious origin.
- b) Hypothesis 2: It is not possible to improve the competence linked to the identification of rigorous scientific news through the implementation of activities aimed at this end.

### Sample Object of Study

The present study was carried out during the month of April 2017, coinciding with the development of the didactic unit and within the framework of the complementary activities, on the working group described in section D.0.2. The class was divided into two groups:

- Group A: Control (n=11; 4 girls and 7 boys)
- Group B: Experimental (n=11; 7 girls and 4 boys)

In the case of group A, in accordance with the complementary conceptual content set out in section D.2.1, the tasks were developed around the importance of cooperation in the evolutionary process, while in the case of group B the guiding thread of the activities was the nature of science and its relationship with truth. Initially, the groups were distributed randomly, being assigned alternatively on the basis of the students' disposition in class, although they were offered the possibility of changing their working group according to their preferences and motivation.

### Phases of the investigation

- a) Design of the methodological sequence. The work proposal was designed taking three fundamental pillars as a starting point:
  - A recent recommendation by Andreas Schleicher, Director of Education at the OECD (Kershaw, 2017), in which he points out that *distinguishing what is true from what is not is a crucial competence today*, with particular emphasis on students learning in schools to think critically about information.
  - The itinerary of the course *Calling Bullshit in the Age of Big Data* (Bergstrom and West, 2017), taught by the University of Washington.
  - An article published in The Guardian under the title *Can you spot the 'real' fake news story?* (Haynes, 2016).

- b) Initial questionnaire. As an initial control, a test was set up on the Moodle platform to assess the students' ability to identify reliable sources of scientific information (Fig. D.6). Likewise, as a way of assessing the acquisition of competences, at the end of the teaching-learning process another questionnaire was made available, in a similar format to the initial control test, although with a different set of questions.

¿Qué grado de confianza le asignarías a este artículo científico publicado en la revista *Nature Reviews Genetics*?

**Functional variomics and network perturbation: connecting genotype to phenotype in cancer**

Song Yi, Shengda Lin, Yongsheng Li, Wei Zhao, Gordon B. Mills & Nidhi Sahni

[Affiliations](#) [Corresponding authors](#)

*Nature Reviews Genetics* (2017) | doi:10.1038/nrg.2017.8  
Published online 27 March 2017

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**Abstract**

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Proteins interact with other macromolecules in complex cellular networks for signal transduction and biological function. In cancer, genetic aberrations have been traditionally thought to disrupt the entire gene function. It has been increasingly appreciated that each mutation of a gene could have a subtle but unique effect on protein function or network rewiring, contributing to diverse phenotypic consequences across cancer patient populations. In this Review, we discuss the current understanding of cancer genetic variants, including the broad spectrum of mutation classes and the wide range of mechanistic effects on gene function in the context of signalling networks. We highlight recent advances in computational and experimental strategies to study the diverse functional and phenotypic consequences of mutations at the base-pair resolution. Such information is crucial to understanding the complex pleiotropic effect of cancer genes and provides a possible link between genotype and phenotype in cancer.

Select one:

a. Absoluta confianza

b. Moderada confianza.

c. Ninguna confianza.

FIGURE D.6: Example of a question used in the initial and final test.

Each test consisted of 20 questions; in each question the student was presented with a screenshot of a scientific news item/publication taken from the web and invited to assign one of the following degrees of confidence: absolute, moderate or none; an example of the question format is shown in Figure D.6. The normative framework proposed for the test, and about which the students were informed beforehand, was as follows:

- There is only one attempt to take the test.



- The time available is 60 minutes.
- There is one correct answer (news can be true or false).
- *Moderate confidence* equals 0.2 points (assuming each question is worth 1 point).
- It is recommended to take the test individually, as each student will have different questions.

In the case of the first test, 40 questions were designed; from this set, the software linked to the Moodle platform randomly selected a group of 20 questions for each student. This measure was carried out in order to guarantee a certain level of independence between each student when taking the test. The questions presented can be classified as follows:

- a) Scientific articles published in leading journals (e.g. *Nature*, *Science*).
- b) Scientific articles published in so-called *predatory journals*<sup>1</sup>.
- c) Well-referenced and well-founded popular scientific texts.
- d) Pseudo-scientific texts or texts linked to unreliable sources of information.
- e) Satirical news with a scientific theme.
- f) Facebook/Twitter posts referring to the types of publication described in the previous points.

A famous example of a *predatory journal* is the *Omicr Group* (Lake, 2017), a business group with a large market presence in the scientific publishing market, which is unreliable due to the absence of internal controls such as peer review of articles prior to publication. A first model of the questionnaire was submitted to the judgement of the head of the institute in order to be able to assess possible recommendations. The final data collection instrument was then designed.

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<sup>1</sup> For-profit publications that publish, with minimal quality controls, scientific articles of dubious credibility.

c) Teaching as such. Taking advantage of the contents deployed in the didactic unit developed, in group A a teaching-learning process was developed centred on the importance of cooperation as an evolutionary mechanism, while in the case of group B the central axis of the teaching was the nature of scientific knowledge and its importance in the information society. The conceptual contents of the teaching-learning process linked to the experimental design are given in section [D.2.1](#). Two activities were proposed through which it was intended to contribute to the central competence of the present study, i.e. the ability to distinguish between science and pseudoscience:

- The preparation of a scientific essay in a cooperative manner, the characteristics of which are detailed in section [D.5](#).
- The viewing of an informative video. In harmony with the two additional content programmes, the proposed material was:
  - Group A: [Darwin and Kropotkin: Competition or Solidarity?](#)
  - Group B: [Workshop on Identifying Fake News](#)

It should be noted that the video *Workshop on Identifying Fake News* was edited *ad hoc* by the author of this paper, in which some of the main strategies to identify credible scientific publications/articles were presented.

- d) Final questionnaire. At the end of the sequence of activities, a final questionnaire was made available, which shared the defining characteristics of the initial test. The aim of this questionnaire was to assess whether students had experienced any progress in the skills linked to the ability to distinguish between scientific and pseudo-scientific publications as a result of the teaching-learning process.
- e) Analysis of the results. The results were analysed using scripts developed in the *Python* programming language. In order to test hypothesis A (students are unable to distinguish between scientific and pseudoscientific publications), we checked whether there were significant differences in the probability distribution corresponding to the results obtained by the students as a whole in the initial questionnaire, with respect to chance, using the theorem of the

central limit; a one-sample Student's t-test was implemented to carry out the test.

To determine whether there were significant differences in the results obtained in the initial questionnaire between groups A and B, a Welch's test was implemented for two unpaired samples. In order to test the second hypothesis (students are not able to improve competences with the proposed activities), we compared whether there were significant differences between the final and initial questionnaires, for which a Student's t-test for related samples was used.

### D.10.3. Results

Figure D.7 shows the result of the contrast statistic implemented with the aim of falsifying hypothesis A, which indicates that there are no significant differences between the mean of the results obtained by the set of students (the sum of groups A and B) and the value of the randomised experiment, obtained using the Central Limit Theorem, giving a p-value of 0.1692 and a t-statistic value of 1.439 (details of the calculation in code D of appendix A).

The result obtained in Welch's test for two unpaired samples indicated that there were no significant differences in the results obtained in the initial questionnaire between groups A and B ( $t = 0.80636$ ,  $p\text{-value} = 0.4396$ ). Table D.2 shows the results of the paired-sample Student's t-tests applied to groups A and B. In the case of group A there were no significant differences between the initial and final questionnaires, while in the case of group B such differences were statistically significant ( $p\text{-value} < 0.05$ ).

TABLE D.2: Student's t-test results for paired samples for groups A and B.

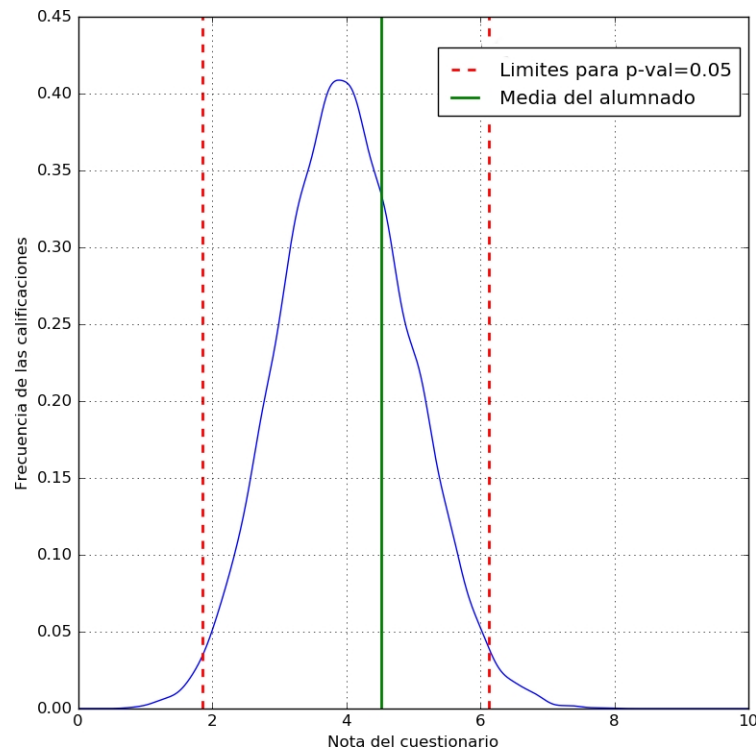


FIGURE D.7: Result of the t-test statistic performed to test hypothesis A: There are no significant differences between students' scores on the initial test and the values obtained by chance. The blue band corresponds to the probability distribution of the randomised model. The green band is the mean value obtained by the class in the initial questionnaire. The red band indicates the maximum and minimum values necessary to falsify the hypothesis, for a p-value of 0.05.

Student's t-test for two paired samples			
Group A		Group B	
t	1.3653	t	2.3691
df	6	df	7
p-value	0.2211	p-value	0.04967

The boxplot in figure D.8 represents the distribution of data obtained by groups A and B in both the initial and final questionnaire.

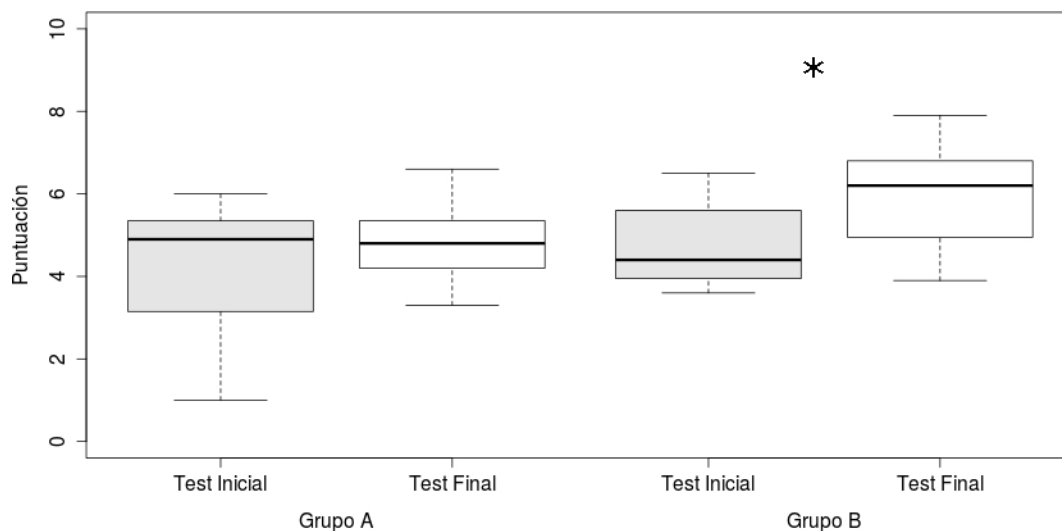


FIGURE D.8: Boxplots showing details of the results obtained by groups A and B in the questionnaires.

#### D.10.4. Discussion and conclusion

The data from the initial questionnaires suggest that the second-year Baccalaureate students, corresponding to the study sample, are unable to identify reliable sources of scientific information. It is possible that this result is conditioned by the fact that most of the information presented was in English; however, this is not a valid justification, considering that this is the hegemonic language in scientific publications.

Two conclusions can therefore be drawn from the results obtained, derived from the initial working hypotheses:

- Second-year Baccalaureate students are unable to distinguish between scientific publications and pseudo-scientific publications.
- The methodology implemented allows for the improvement of skills linked to the identification of reliable scientific publications.



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