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Representations of scientific culture among future teachers of science

Introduction

Setting the issue

The issue studied in this paper focuses on the evolution of representations: Does an art initiation modify the teachers' view on scientific culture? Such investigation presumes a reflexion about the fundamental notions that it entails. Because if, concerning scientific culture, a large consensus is established around declarations of principle, things are less clear once one goes into detail with the definitions. Yet, as we will see, there is no consensus on how to understand scientific culture. Thus, this paper is divided in two parts: first, a definition of the notion of scientific culture is suggested, then the report of an experiment conducted within the university setting is presented.

Clarifying the notion of scientific culture seems ambitious as the word "culture" is hazardous because of its conceptual fragility. Moreover, if the adjective "scientific" is added to it, confusion increases. In order not to give an arbitrary or *ad hoc* definition, an overview of different representations is needed. In the present case, the nature of the link between science and arts (or, if preferred, science and culture) is at the heart of the matter. That is why our review will deal with the relations' angle (unproven or refused) between science on one hand and the arts on the other hand (literature, visual arts, cinema, etc.). Scientific culture will thus be approached in terms of separation, mutual influence and pooling rather than in terms of diffusion. Our goal is not to set a definition capable of reaching a consensus but to revise the most common meanings and to consider their implications. This will be done with the intention to legitimize a conception that opens up science to arts, a theoretic founding necessary to the experimentation that will follow. Thus, secondly, we will relate the first results of an action led on future teachers who intend to teach sciences in secondary schools. By means of questionnaires we measured the evolution of representations' before and after an initiation to the writing of poetry and plays.

Let us remember that studying the representations is a relevant topic within the didactic questions as they guide (mostly not consciously) the teaching or learning methods.

I

Attempt at definition of scientific culture

It is easily noticeable, when literature on scientific culture is consulted, that the authors do not have the same definitions. Let us see a first draft of propositions. They all adopt the principle of separation science from culture: science must be separated from non-science, which means that the scientific culture is to be distinguished (even shunned) from culture. The scientific culture can only construct itself regardless of culture. It is gnosiological, i.e. constituted of knowledge. This defines a first school of thinking. The general tone is pessimistic.

Scientific culture as a “minimal scientific luggage”

One of the most commonly heard meaning is – not suprisingly – a gathering of fundamental knowledge that a person simply cultured (and not an expert) “must” possess. For example, a “mathematics culture” consists of knowing what a prime number is, resolving a second degree equation, and so on and so forth.

Scientific culture as knowledge on sciences

It is however a general belief that scientific culture cannot limit itself to knowledge *in* sciences (plural form). It must rely as well on knowledge *on* sciences. There are three:

- *historical knowledge*: for instance, scientists’ biographies, knowing that the parthenogenesis was discovered by Bataillon, and other information based on the same topics,
- *methodological knowledge*: how researchers work, reason, set a problematic, formulate or validate a hypothesis,
- *social knowledge*: on the men of sciences, which cannot be distinguished from the category above: the models developed in science sociology (Merton, 1942; Bourdieu, 2001; Latour, Wodgar, 1979) approach the scientific culture as a scientists’ culture.

Scientific culture thought through the literary culture’s model

This separation between science and culture was favoured by the division set by Dilthey (1942) in the knowledge field between two schools of discipline, each of them having its methods and autonomous ends:

- the “sciences of spirit” (i.e. the science of men, the human sciences, formerly the “humanities”),
- and the “sciences of nature” that separate themselves from the knowledge field and are formed in a specific field.

The result is an analogy between literary field and scientific field. Each of them gives rise to a specific culture. Hence the parallel between what “must” be known of Shakespeare and what must be known of the 2nd law of thermodynamics or the mass notions or acceleration. But is this parallel not misleading?

A lamentation speech

This concept of culture fears above all the falsification of knowledge (e.g.: before Galileo, people thought that the Earth was flat, cloning allows to reproduce identically the same person etc.). What is more, the inquiries show that the scientific culture is not shared enough despite tremendous and expensive efforts. As a result, pessimism is often linked to that school of thought. Most of the time, the tone of the speech is based on lamentation.

In this first school of thought, a divorce between science and culture is wished. The second school of thought, on the contrary, sees that separation as a tragedy. It regrets that science and culture are separated that much. Once again, pessimism is used, though for other reasons.

Another difference is that the scientific culture is not characterised by knowledge but by a state of mind, an attitude towards the world, the society and life.

Science is unfortunately separated from culture

There are two leading authors. The first one is Charles Snow who declared at a conference in 1959 that there is no common culture (Snow, 1959), but two cultures which cannot communicate anymore. According to Snow, this “*schism of culture*” is specific of the Western world and got worse while spreading.

The other one is Jean-Marc Lévy-Leblond. He traced back the process of separation. Until the 17th century, there was no separation (Lévy-Leblond, 2004), science was integrated with cultural world. In the 18th century, a progressive autonomisation of science began. It was highlighted by the creation of the academy of sciences and the academies of the belles-lettres and fine arts. The separation was consecrated with the *Encyclopédie* by Diderot and D’Alembert (supervising literature/philosophy and sciences respectively). In the 19th century, science increased in power. Big universities – built on the model of Berlin’s university (founded by Humboldt) – became a place of knowledge production with its own laboratories. Science was coupled with technology and industry and was financed by the state. Nowadays, the divorce between science and culture is consummated.

This situation is disastrous for culture and science

According to Snow, the lack of communication between both cultures leads to a general creativity crisis (Snow, 1959). Thus, the intellectual life and life itself are put in jeopardy: we misinterpret the past, misjudge the present and lose faith in the future.

As for Jean-Marc Lévy-Leblond, he supports the iconoclast thesis of the disappearance of a scientific culture among scientists: there is no culture to share or to diffuse anymore. Scientists forget too much about the history of their field because in sciences, there is a tendency to forget the mistakes of the past and the expired knowledge (Lévy-Leblond, 2004). However, science is like other branches of culture dependent on its past. And, in order to assume it, it must know it.

The call for a change of direction

It is urgent to reconcile science and culture and make them “talk” together. Snow thinks this call is addressed to the intellectual elite: for a mutual enrichment, scientists should read literature and the literati need knowledge in sciences.

Jean-Marc Lévy-Leblond aims for a larger change: we need to “put science back into culture” which means bring science and culture closer. The matter is urgent: Jean-Marc Lévy-Leblond wondered whether it was too late or not (Lévy-Leblond, 2008). Pessimism is here at its height.

Our positioning will be based on this second school of thought. It is unfortunate to observe this wide separation. As a reminder, science has known its development inside a cultural context that has been favourable. It was Alexandre Koyré’s conviction (Koyré, 1973), the great historian of sciences. It is thus prejudicial to separate science from its cultural roots.

However, this separation does not appear so radical neither so hopeless. Mutual influences survive provided that the scientific culture is looked at through the cultural productions inspired by science. Nothing forbids us to speak about a scientific culture just as we would speak about a religious culture: an intellectual elaboration that produced over the centuries a certain sensibility, literature, architecture, painting, statuary etc. Yet, the influence that science has on culture takes no doubt. Two examples come to our minds. The first one is from literature – science helped with the birth of new genres: the “scientific novel”, science fiction, cyberpunk. The other example is futurism. It is an artistic movement (and not scientific) directly inspired by sciences. Initiated by a poet and developed by painters, it breaks off with academicism (the former aesthetic cannons) in order to echo the contribution of science in the society.

If previously science was separated from what it is not, we are now naturally linking science to arts, literature, and cinema. In this sense, science is a part of culture and there are no distinguishable cultures (as Charles Snow thought). If you still go along with our point of view, it is difficult to understand the meaning of “putting

science into culture” as it is constituent to culture (without of course, being reduced to it).

Our conviction is that there is much to gain by considering the scientific culture as a mix of science and non-science, just like the fertilization of cultural fields by science. This speaks in favour of an anthropological approach (i.e. cultural, historical, social, artistic) of the scientific culture.

We started from a purist conception of the scientific culture (principle of separation of science and non-science) to get to a mixed and open conception: a mix of science and humanist culture, places of influence and mutual improvements between two fields of activity of the human intellect.

II

Experimental approach

This anthropological approach of the scientific culture justifies the experimentation which is to follow.

Representation of science culture

While some authors see the scientific culture as a vector helping the rise of a new knowledge relation (Jacobi, Schiele, 1988), Jean-Marc Lévy-Leblond (2010) also cast light on the role of scientific culture such as the art as a vector questioning our knowledge relation. This scientific knowledge relation is described as a state of mind, a deep reflexion related to the origin of knowledge, its role in the society, as well as a critical vision of its own limits and its real status in the society (Canguilhem, 1961; Giordan & Pellaud, 2009).

We thus decided to interrogate the representations of teachers – to be thanks to two precise cultural scientific actions: scientific poem and play. The aim is to identify, through a study case and a research-action, if the actions on scientific culture influence the future teachers’ representations of their approach on scientific culture.

Methodology

Surveyed sample

Our study focuses on two groups: group A of 20 teachers-to-be (with a first initiation to scientific culture) and group B of 28 future teachers (without a scientific culture) in their Masters preparing for their teacher’s biology exam or young teachers of biology. Data were gathered, thanks to a diagnosis evaluation, by collecting initial representations before the activities and training on scientific

culture. Initial representations (Q1) were collected from open questions on scientific poem and scientific play such as “According to you, what is the purpose of studying and writing a scientific poem? Would you like to study and write a scientific poem with your pupils? According to you, what is the purpose of studying and performing a scientific play? Would you like to study and perform a scientific play with your pupils?”

A second collection of representations (Q2) on these topics were realised after an initiation and production of scientific poem and scientific play a few months later on group A.

Data processing

The results are gathered in four charts indicating the results for students with a first initiation (Q1-A) in Chart 1, for those without an initiation in Chart 2 (Q1-B), for students with an initiation at the scientific poem and play a few months later in Chart 3 (Q2-A), and then a comparison between promotion A-Q1 and A-Q2. For all of them, the number of future teachers is mentioned and indicates in each case whether they found an interest (yes or not) in studying and writing a scientific poem or play. Also, the percent of students indicates whether they would like to write and study a scientific poem and play with their pupils.

Results

Students who have been initiated at scientific culture but never at scientific poem or scientific play: group A (Q1)

Chart 1: Students with a first initiation at scientific culture (A-Q1), in % of students, n = 20

Poem				Play			
Interest		To write with pupils		Interest		To write with pupils	
yes	no	yes	no	yes	no	yes	no
80	20	48	52	95	5	59	41

Purpose of the scientific poem and scientific play according to prospective teachers

Most of the students with an initiation at scientific culture found, an interest for scientific poem (80%) and scientific play (95%).

A scientific poem could, according to them, match science under another view, could develop creativity, could change the approach on sciences and could help to associate words and concepts. A scientific play brings, according to them, another point of view, allows the learning of science history and finally systematizes knowledge.

For the students, who think that the scientific poem is not interesting, the arguments are different: it seems very difficult to organize because the educational system does not give time for that, poems are very difficult to write and it is a linguistic exercise more than a scientific exercise. Few students think they do not have the abilities to write a scientific poem. As for the students who think that a play is not interesting, they seem to believe that a lot of work is produced only for little knowledge and the interest is only, according to them, cultural and not scientific. Moreover, the lack of time during training sequence does not allow for this type of work to be done.

Staging a scientific poem and scientific play with pupils according to future teachers

About half of the students (48%) would suggest to write a scientific poem with their pupils and a little more than half of them (59%) would suggest to write a scientific play with their pupils. The scientific poem seems easier to tackle during a lesson because of its short duration. Moreover, imagination is developed. The scientific play takes up more time so it could be interesting to work on it as an interdisciplinary project. Future teachers who do not prefer to write a poem or a play, explained that a poem requires too much precisions and a play is too long to write during a lesson.

Students who have not been initiated at scientific culture: group B (Q1)

Chart 2: Students without an initiation at scientific culture (B-Q1), in % of students, n = 28

Poem				Play			
Interest		To write with pupils		Interest		To write with pupils	
yes	no	yes	no	yes	no	yes	no
25	75	11	89	82	18	36	64

Purpose of scientific poem and scientific play according to students

Students without an initiation at scientific culture naturally have an interest for scientific plays (82%) but not for scientific poems (25%).

The scientific poem is unknown for most of them. It seems too difficult to understand. They think they do not have the abilities to write a poem. Some of them have a bad representation of poetry from their scholar curriculum. Most of them think that poetry is only a literary exercise. Only a few who are interested in scientific poems think it could bring another point of view to understand sciences.

Students who are not interested in scientific plays (just a few of them, 18%) point to the lack of time and the lack of efficiency to understand scientific concepts. Most of them think that theatre is a good way to wind down. Theatre can introduce scientific historic facts and could bring another point of view on sciences.

Staging a scientific poem and scientific play with pupils according to prospective teachers

89% of students without an initiation at scientific culture would not suggest to write a scientific poem and 64% would not suggest to write and perform a scientific play. In these two cases, the students explained that these exercises are too long during a training sequence. Moreover, poems are too difficult to write with pupils and the latter would be destabilised by this work so it would not even be efficient.

Students who have been initiated at scientific poem and play: group A (Q2)

Chart 3: Students with an initiation at scientific poem and play (A-Q2), in % of students

Poem				Play			
Interest		To write with pupils		Interest		To write with pupils	
yes	no	yes	no	yes	no	yes	no
89	11	68	32	95	5	77	23

Chart 4: Comparison between group A-Q1 and A-Q2, in % of increase or decrease in function of A-Q1

Poem				Play			
Interest		To write with pupils		Interest		To write with pupils	
yes	no	yes	no	yes	no	yes	no
+9	-9	+20	-20	0	0	+18	-18

Purpose of scientific poem and scientific play according to students

Those students who had already been initiated to the scientific culture and confronted with the writing of a scientific poem or play clearly exhibit an interest (Chart 3) in the study of a scientific poem (89%) and the writing of a scientific play (95%). The main arguments did not change compared with the Q1 phase. However, it appeared that the main arguments developed by the students who positively changed their mind about working on a scientific poem (+9%, Chart 4) are that it brings creativity and allows another approach to sciences. No students (0%, Chart 4) have changed their minds about the positive interest of writing and staging a scientific play for they are still 95% to have a positive image of theatre.

Staging a scientific poem and play with pupils according to future teachers

The main modifications of the students' representations towards scientific culture seem to be the consequence of their will to write scientific poems and plays with their pupils (Chart 3). Indeed, 68% of the students are ready to write a scientific poem and 77% are willing to write and stage a scientific play with their pupils. 20% of the students (Chart 4) have clearly and positively changed their view

on writing a scientific poem and 18% of them (Chart 4) also have positively changed their approach to their pupils' writing a play.

It also appeared that it is the same students who changed their representations on scientific poems and plays.

The main argument developed concerning the writing of a scientific poem and a play is that it is possible to find links and organize an interdisciplinary project.

Discussion

This study case put into light an obvious difference of the prospective teachers' representations according to their initiation or not to the scientific culture in general. Indeed, it revealed that initiated students see a personal cultural interest in the analysis and the writing of a scientific poem and play.

Non initiated student exhibit very little interest (25%) in studying and writing poems for they think such an activity is a purely literary exercise that has no link with sciences and is not easy for a person who is not a wordsmith himself. Yet, a scientific play seems more interesting and understandable for them (82%). Thus, the initiation to a scientific culture and most of all, an initiated reflexion on the scientific culture as a space for reflexion on knowledge (Jacobi & Schiele, 1988) modified the students' relation to the interest of scientific cultural activities such as a poem or play. Indeed, for these activities, the initiated students found an obvious interest in studying a scientific poem (80%) or a scientific play (95%). Initiated students found an obvious interest in studying a scientific poem (80%) or a scientific play (95%). The cultural reflexion seems to have enable them to apprehend these cultural activities in a new and different dimension with the task being "an exercise that allows the development of creativity and to look at sciences from a different angle" and with a play "brings a different reflexion and a history of sciences". Indeed, as Giordan and Pellaud indicated in 2009, the scientific culture is most of all a state of mind, a way to question the world, a way of thinking, seeing, analysing. These dimensions seem to be developed throughout a formation of scientific culture.

It is also interesting to see that those same initiated students have developed, thanks to the studying and writing of a scientific poem and play afterwards, a new relation to the scientific knowledge. Indeed, 9% of them now define scientific poems as a source of creativity development while they did not think that after a first initiation to scientific culture. It appeared, as Canguilhem quoted (1961), that in the end, it is the convergence of the different forms of scientific culture that constitutes this new relation dimension to the scientific knowledge, as in fact, for these students, it is the action connected to the initiation to scientific culture and coupled with concrete actions that allowed the develop a new reflexive dimension among prospective teachers.

On the other hand, this study showed that, for the most part, non-initiated students do not plan to initiate and develop these aspects of scientific culture with their pupils, as 89% do not intend to study and write scientific poems and as for

the scientific plays the number is 64% of them. As for the initiated students, they are reserved when it comes to this approach, for 48% plan on studying-writing a poem and 59% intend to study-write a play. It is surprising that initiated or non-initiated students with a positive representation of the theatre do not intend to do it with their own pupils, even though this statement is stronger with non-initiated students. It seems that the real obstacle for such activities are institutional constraints. Indeed, the students do not see when they would be able to organise such activities because of their busy school programs. They do not seem motivated enough to set up measures that would allow their pupils to practice such activities, even though they are aware of their interests.

However, one can notice that the implication of the initiated prospective teachers in the study-writing of a scientific poem or play has modified, for some of them, their representation on the pupils' implication during this kind of activity.

Indeed, 20% of them would eventually be ready to suggest this type of activity to their pupils by organising an interdisciplinary project in order to develop these activities that they found good for the pupils' creativity and allow to put scientific knowledge in perspective.

Conclusion

This study showed that an introduction to the scientific culture changes the scientific culture's representations the future teachers have. It confirmed that the convergence of different forms actually supplies this dimension of knowledge relation. Indeed, an introduction to a scientific culture coupled with concrete cultural actions such as writing of scientific poems and plays, seems to awaken or strengthen the interest to initiate their own pupils to an open and mixed scientific culture.

It appeared that every scientific teaching cannot skip a deep reflexion, as well as knowledge transmission, correlated to the origin of knowledge, their roles in the society, and a critical vision of their own limits and their real place in this society (Canguilhem, 1961). That is why culture (scientific or not) must include knowledge, comprehension and association faculties at the same time, that allow us to think, and allow to the spirit to bear fruit (Raichvarg & Jacques, 1991).

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Abstract

There is no consensus on how to understand scientific culture. Thus this paper is divided in two parts: First, a definition of the notion of scientific culture is suggested, then the report of an experiment conducted within the university setting is presented.

This analysis is concerned with the evolution of representations of scientific culture among future teachers: Does art initiation modify the teachers' view on scientific culture?

This work has highlighted that a training to scientific culture changes the representation on scientific culture that future teachers have especially when underlining its role as a vector of creativity.

Key words: communication, scientific culture, representation

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