



European Journal of Educational Research


Volume 11, Issue 1, 381 - 391.

ISSN: 2165-8714

<https://www.eu-jer.com/>

Scientific Culture and Education Sector: Literacy, Understanding, or Engagement?

Marianella Maxera* 
University of Oviedo, SPAIN

Lucía Álvarez-Blanco 
University of Oviedo, SPAIN

Received: September 6, 2021 • Revised: November 3, 2021 • Accepted: December 6, 2021

Abstract: Scientific culture has been a concern for decades in the developed world, giving rise to conceptual changes known as paradigms. The first one is the longstanding literacy paradigm, defined by the skills and knowledge acquired at the education institution. It has been followed by the public understanding of science paradigm, related to the scientific understanding and an allegedly subsequent positive attitude towards science. Lastly, the engagement with science paradigm or science and society paradigm involves people's implications about the science-technology controversies with significant social impact. This article reflects how science teaching has evolved along the years in line with the scientific culture's conceptual shifts. It is concluded that this triad of paradigms is thus of a school nature, given that educational fields have suffered from transformation processes under the same vision of the world (world view), which has also changed the concept of scientific culture. Individuals in a research community learn ways of thinking, feeling and acting and therefore cannot help feeling a liking for what is short-lived and has not taken roots, both inside and outside the school in our postmodern age.

Keywords: *Literacy, paradigm, science teaching models, scientific culture, world view.*

To cite this article: Maxera, M., & Álvarez-Blanco, L. (2022). Scientific culture and education sector: literacy, understanding, or engagement? *European Journal of Educational Research*, 11(1), 381-391. <https://doi.org/10.12973/eu-jer.11.1.381>

Introduction

In the Western world, the concept of scientific culture has been addressed from critical, academic spaces such as the Social Studies of Science and Public Understanding of Science, interdisciplinary fields of knowledge where Philosophy, History of Science and Sociology, among others, meet (Kreimer, 2015; Kumar, 2016; Smallman, 2014).

Since these governments try to evaluate what citizens know about science and how it is perceived, the urge to study and try to clearly define what scientific culture arises. This evaluation was intended to adjust students' training so that they could get the scientific culture by exploring the most important scientific and technological developments, especially in the field of nuclear energy and the 50s space race. A different approach was pursued in the underdeveloped Western world, as in the case of Latin America, where it arises like a study space that responds to interests from scenarios such as the United States of America (USA), the United Kingdom (UK), and Europe, instead of standing as a region that creates original knowledge in these fields (Kreimer & Vessuri, 2018; Orozco, 2018).

Accordingly, the need to detect or assess the training in sciences of an average citizen has made the conception of scientific culture to be adjusted, so the way it is evaluated suffered a process of redefinition (Singh & Singh, 2016). These definitions were reflected in the creation of questionnaires, traditionally used as tools to show the citizens' conditions. The different approaches are known in the field of Social Studies of Science as paradigms, being identified three since the mid-twentieth century (Cortassa, 2016). The study of these paradigms focused on the different aspects around scientific culture and the moments where the necessity to evaluate it arises, the reasons triggering its evaluation, and the institutions and actors involved in its assessment. This leads to the so-called *literacy paradigm*, *public understanding of science paradigm*, and *science and society paradigm*.

In this broader perspective, this article aims to reflect on whether these scientific culture paradigms are actually three, how exclusive they are, and how the transition from one paradigm to another has been built upon the changes of schools at the same time that has promoted a different way to teach sciences. With that in mind, the authors will try to

* **Corresponding author:**

Marianella Maxera, University of Oviedo, Oviedo, Spain. ✉ maxera@adinet.com.uy

defend that the three paradigms suggested by the Social Studies of Science have a school nature, on the basis that the concept of scientific culture supported by the field as mentioned above has suffered from several changes along an ideological background reflected on the reductions, perspective, and interpretation of the social reality. Therefore, the use of the term 'school paradigm' to identify the scientific culture related to the course contents does not consider the curriculum changes at school produced in line with the reconceptualization of the idea of scientific culture that led to a transition from one paradigm to another. Conversely, the school and its changes in fields such as Science Didactics or Psychology of Learning delimit the aspirations for the ideal of a scientifically educated person, which is also reflected among the outreach and informal environments. Understanding this ineludible junction will make it possible to synergize these fields and enhance the interfaces in and out of school (Sverdlick, 2019).

Paradigm of Scientific Culture: A Conceptual Approach

This section will provide a short description of each paradigm mentioned above, delving into them with a more in-depth analysis of the changes that occurred within the formal education of sciences simultaneously as one paradigm was replaced by another one.

Literacy Paradigm

As previously suggested, there is a tendency to address the concept of scientific culture by evoking three paradigms, placing the concept according to the moment in recent history and social space for each one. Then, the literacy paradigm, acknowledged within the 50s, is related to the necessity to assess the course contents of already graduated people, mainly from the U.S. and Europe. Therefore, scientific culture refers to the scientific content taught at school (Cortassa, 2016; Singh & Singh, 2016).

With that in mind, it is crucial to bear in mind that science education for nonprofessionals of specific fields emerges at the same time the education was made mandatory, originally in elementary education at the beginning of the 18th century in what is now Germany, and has continued until the present day. From then on, mandatory education (and science education implemented as well) blossomed swiftly throughout the Western world, reaching such a strength that led it to be linked to Human Rights, particularly with the second generation of Human Rights (Tomasevski, 2004).

The science teaching approach was widely characterized until the 1950s by its encyclopedism, the use of text exclusively, the approach of learning by repetition, and the unidirectionality of the education (Von Korff, 2016). Although it is observed the coexistence of different educational models, these ones did not prevail over the traditional model in spite of the disagreements concerning the effectiveness of the traditional one (Southerland & Settlege, 2019).

The discontent with this model, mainly related to the poor understanding of the scientific events by citizens but also to the evident and stated indifference of the people towards sciences, alarmed those who led the science policies, hoping to get the citizens to accept these policies to carry out scientific projects without resistance and objection (Martins, 2020).

Thereon, it should be kept in mind that, in the middle of the 20th century, an important acceleration in the production and consumption of goods and services took place, boosted by the scientific and technological changes occurring during these years in the USA and also by the development and use of nuclear weapons in World War II. It created the need for society to have more and better scientists able to stand out in fields such as nuclear physics and the space race, particularly important during the Cold War. On the other hand, there was thus a crucial need for trained workers concerned with the specialized knowledge of the world they lived in, able to carry on their daily lives with scientific and technological systems and socially adapted to be part of the society and community with a positive attitude towards these fields of knowledge (Cortassa, 2016).

The term "literacy", inherent to the school environment, is linked to cognitive and/or encyclopedic aspects: an individual is literate when they possess certain knowledge that enables them to read and write. This concept of general literacy has been extended to include the ability to do specific things such as reading a bus timetable, map directions, or writing a letter, which has led to the term "functional literacy". There is theoretical and practical knowledge and, similarly, the idea of scientific literacy relates to an individual's ability to read and write texts on science and technology, to read food labels and nutritional information, to repair the fault of a simple household appliance, to write a letter of complaint or suggestion about an issue using scientific and technological foundations.

Moreover, it can be added that the individual can read texts on relevant current scientific facts as a way of broadening his or her general culture. Scientific and technological literacy was seen in an analogous way to the literacy promoted at the end of the 19th century, which aimed at integrating individuals into a new society, the industrialized society. The idea of finding out whether people were close to that ideal came from outside the classroom. To this end, the first survey conducted in the USA in 1957 by the National Association of Scientific Writers included not only questions about knowledge, but also about attitude and interest in science (Albe, 2015).

It is understood that the first instruments that intended to measure citizens' scientific culture appeared in response to the alarm that in the USA by the placement in orbit of the Russian satellite Sputnik. These instruments were

questionnaires that assessed the course contents allegedly acquired by the students at the end of their schooling period. Understanding scientific culture as a cluster of scientific school concepts is, consequently, what has been named as the *literacy paradigm of scientific culture*.

Although this paradigm has been transcended by those presented in the following sections, the idea of measuring both knowledge and attitudes related to the literacy paradigm continues to guide much research work. For example, a recent joint UK-China study of a sample of almost three thousand university students aimed to assess awareness of the need for clean energy (Cotton et al., 2021). Using the terms "energy literacy" and based on the paradigm described above, the research focused on a topic of current relevance, climate change and its link to energy expenditure, which is currently addressed in depth in formal education. Some of the most salient results point to the need for a crossover between science literacy and attitudes towards science. It was found that while UK students perceived themselves to be more knowledgeable than Chinese students, Chinese students nevertheless gave more often correct answers to knowledge questions. UK students had more positive attitudes towards energy care and conservation than Chinese students, while Chinese students were somewhat oblivious to the problem, relying on their trust in their governments and businesses. The authors recognized the importance of these results in guiding policies to address a global issue such as climate change and the need for cultural appropriateness, implications that show that the literacy paradigm is still relevant.

Public Understanding of Science Paradigm

In the 1970s, the USA faced another challenge that also had an impact on the promotion of scientific culture, such as the arising of Japan as an economic power, a fact that cracked the American economic competitiveness and its industrial leadership. Also, the international reputation of the USA concerning scientific research suffered a notable decline. It was again assumed that scientific education caused these weakenings, which raised once more the social relevance of scientific culture (Pestre & Bonneuil, 2015).

The Bodmer Report from 1985, endorsed by the Royal Society of London (Great Britain), detected in those days deficiencies during the parliamentary debates about scientific and technological issues and shortcomings in the institutions' strategies to make people interested in science to promote the understanding of science. Scientists were then encouraged to work as well on the study of the sociological aspects of Natural Sciences and get involved in the analysis of scientific activities with methods from Social Sciences (Nielsen, 2018).

They also encouraged scientists to fulfill the scientific dissemination activity, a request that persists to this day; paying particular attention to the fact that scientists themselves must be part of the process to recognize the reliability of a source of information (Bauer, 2017; Cortassa, 2016; Seethaler et al., 2019; Simis et al., 2016).

By these means, the Public Understanding of Science (PUS) studies were born with a prevailing thought: the more you know about science, the more you love it. The term *Understanding* may be perceived as communication but also as comprehension. This concept has been the most used because it transcends the idea of communicating or disseminating, as was established at the beginning of this field, nearing the idea of making people understand. This approach extends the scientific education responsibility to more expansive spaces than a traditional school, adding conventional newspapers and institutions such as museums, science and information centers, planetariums, T.V. shows, etc., with a leading role by the scientists (Larkin, 2019).

Although this approach was taken as the principal one from the abovementioned Bodmer Report until 2000, some groups that began to question a unidirectional approach coexisted during this period, where people were depicted just like receivers of scientific knowledge (Seakins & Hobson, 2017).

Scientists played a leading role in this new approach at the time, but with drawbacks. On the one hand, the assumption of dissemination tasks by a scientist was, during those years, viewed with rejection by a large part of the scientific community. The professional prestige of those who, in addition to doing science, popularized science, was strongly questioned by those who did not: it was argued that the function of a scientist was to do science, not to talk about science, distinguishing between a first class mind, that of scientists, and a second class mind, that of 'popularisers' (Hardy, 2005).

This view was highly influential after the Second World War and still has an impact on those who popularize science today. The task of popularizing science by a scientist was understood to be assumed in old age as part of intellectual decadence. The activity of popularisation was even viewed with disgust: "there is no scorn more profound, or on the whole more justifiable, than that of the men who make for the men who explain. Exposition, criticism, appreciation, is work for second-rate minds" (Hardy, 2005, p.1). Today, this is to some extent legitimized by the universities themselves, which give minor merits to the outreach activities of the researchers working there when they are accredited. Despite the fact that scientists declare the value and importance they give to the dissemination of science, the actions they take in this regard are scarce; for example, studies on this problem in Mexico point to the lack of time and the absence of academic recognition for dissemination tasks as obstacles encountered by scientists (Sanz-Merino & Tarhuni-Navarro, 2019).

Another problem has been the loss of rigorousness in dissemination. When scientists undertake the task of popularizing science to the general public, they place themselves in a zone of tension, which is also shared by educators: in order to bring a scientific concept closer to people, one can be strictly rigorous and present the content without compromise, despite the difficulty in understanding it, or, on the other hand, sacrifice the content, distort it and obtain the public's understanding, but of a concept that is no longer the same. Albert Einstein is credited with the phrase: "the popularisation of science should be done in the simplest possible way..., but no more" (Schwinger, 2002).

This idea raises the problem of modifying the concepts that we are trying to disseminate, a question that has been called "didactic transposition" in science teaching. It is accepted that there is a knowledge that belongs to scientists and is strictly rigorous, as opposed to the knowledge that is taught, which is the result of a modification of the knowledge in order to be understood. The theory of didactic transposition, put forward by Chevallard in the 1990s, has given rise to other approaches that explore the concept in greater depth and propose rules on how scientific knowledge should be transposed to the classroom, which shows the effectiveness and validity of the concept (Chevallard, 1991).

Engagement Paradigm

The criticism aimed at the previous paradigm resulted in a new change that started to grow in strength from the 1990s. On one side, scientific culture is now located in its context. This paradigm suggests an alternative option that, instead of emphasizing what people lack, focuses on those contexts where someone comes in contact with science. From this point of view, people are considered as able to give an opinion and argue over their own fields of expertise, presenting the arguments about their decisions to choose between their beliefs and scientific understanding (Alcibar, 2015).

Furthermore, the idea of a uniform and homogeneous audience with similar perceptions is no longer valid since contexts and situations vary from one individual to another. It is noticed hence the need to link scientific culture with the role played by each person. Scientific culture has no longer the single objective to accept what the scientists provide us with because people, from their own reality and conflicts, enhance alliances, break them, and fight against them, deploying a wide range of actions far from representing a static condition with a genuine commitment with science. Those who defend this paradigm strongly criticize the previous paradigms for blurring or disregarding people's potential in their interaction with science and society and for not accepting its local culture, history, and knowledge, focusing above all on isolated scientific knowledge (Goldenberg, 2016).

Regarding the concept of *empowerment*, it must be noted that it represents the main idea of this paradigm of public engagement with science (PES). This term, even though spreading nowadays towards minority social groups, and regarding scientific culture, is usually related to non scientific people whose voices are not heard in scientific and technological issues may minimize this vulnerability, strengthening their capabilities, their confidence, and, above all, their relevance from their particular situations (Kreimer, 2015).

This is a brief summary to approach the concept of scientific culture, and the three historical paradigms that embody it that depicted as in the previous paragraphs may not look inclusive nor complementary.

Evolution of the School Models and Their Relationship with the Paradigms

The switch from one paradigm to another has not been an arbitrary condition, but is based on the social, political, scientific, and technological changes attained by a society. These changes are also reflected in the educational field, and therefore it is not surprising that there are relationships and overlapping areas among them.

The Interface Literacy/Understanding

The literacy of scientific culture paradigm, related to the encyclopedic course contents with emphasis on cognitive aspects, and simply thought to be useful to continue university studies, is linked with the traditional school and lasted predominantly from the mandatory education's origins. Nowadays, its hegemony has decreased enough to give rise to its coexistence with other pedagogical perspectives (Sjöström & Eilks, 2018).

In the middle of the past century, when the USA school curriculum shortages were noticed, more than fifty committees were created, made up of scientists who helped to redraft the course contents of, mainly, Physics and Chemistry. Two of the most outstanding statements were, on the one hand, the creation of the Physical Science Study Committee (PSSC) in 1956, which caused a significant shift in the education of Physics at secondary schools in the USA. This committee, made up of teachers and physicists, worked out a worldwide-impact proposal that was given concrete expression with the elaboration and use of specific equipment like new coursebooks, films, and laboratory materials. That same year, the United Nations Educational, Scientific and Cultural Organization (UNESCO) Conference (Hamburg) recognized the demand for updating science education, particularly Physics education, regarding the emergence of the atomic age. This culminated with the Nuffield Science Teaching Project in Great Britain in 1957 (Nielsen, 2018). The reasons behind these teaching experiences were manifested in the document *Scientific Literacy: Its meaning for American schools*, where the term *scientific literacy* was firstly used in a print version (Bybee, 2015).

The involvement of scientists in the promotion of scientific culture begins before the moment the public understanding of science paradigm is usually located, and this promotion used to take place at school. At this moment, the traditional model of science education evolves into another one by rediscovery, characteristic of the proposals suggested by the aforementioned scientific committees. The conventional teaching, explanatory, by word of mouth, leads to a teaching model that simulates the researcher workflow, making the students inductively walk along the same path that the scientists followed previously. As stated before, it is impossible to separate the literacy paradigm from the public understanding of science paradigm given that the school was clearly permeable to the scientists' proposals but, also, it assumed what scientists did out of the school as its own: the guided museum visits, reading newspapers about current, scientific topics in class, scientists' talks in class, the visits to scientific institutions (laboratories, technological enterprises), etc. (Orozco, 2018). Likewise, it is interesting and noteworthy the turn experienced by museums, ideal spaces for scientific dissemination, during the twentieth century: the concept of the museum as simple storage of treasures to be seen and admired has evolved to a place with teaching potential. This latter statement is demonstrated by creating education departments and cabinets managed by educators at the museums (Dorfman, 2019; Janes & Sandell, 2019; Pedretti & Iannini, 2021).

The Interface Literacy/Engagement

Accordingly with the previous paragraph, it is also noteworthy that the scientific engagement paradigm is connected to the concept of empowerment, a concept that Paulo Freire —a Brazilian educator who developed the critical pedagogy theory— presents without making an explicit reference to the term. The main idea is for a school to empower their students as a way to transform the people and the society, where all the educative agents and the community itself get involved (Shih, 2018).

Translated to scientific culture, the lack of the public's voice on the scientific and technological decision-making process raises hence a power asymmetry where the weakest elements are the poorly trained citizens. The democratic component plays an important role in the scientific engagement paradigm, and it is presented as a participation model where the public and scientists benefit from each other and learn commonly by possessing the valuable knowledge and perspectives that could contribute to the development of science and its application in society (Kreimer, 2017). The legitimacy of the scientific results lies in the shared responsibility before and after the decision-making process, through civic practices and habits from scientists and people, giving rise to the so-called 'Governance of Science,' which is still subject to extensive discussion (Lyll & Tait, 2019).

Another relevant aspect regarding this paradigm is the fact that the daily life problems that awaken people's interest in taking part in this decision-making process are usually solved from different and interdisciplinary fields. Given this situation, the school also plays a relevant role and notices how important it is to work in an interdisciplinary way. Many current school curricula created curricular proposals based on the work on an issue across multiple perspectives and disciplines after recognizing the need to go beyond the traditional education based on disciplines. This approach is characterized by the projects Science-Technology-Society and the renowned SALTERS, APQUA, SATIS, or SAE (Martins, 2020).

Nowadays, this proposal has evolved towards the integration not only of Natural Sciences and Technology but also Mathematics and Arts, fields comprised under the acronym STEAM. Even though it is considered a controversial model, there have been many endeavors to implement it (Colucci-Gray et al., 2019; Sjöström & Eilks, 2018).

Therefore, it is clear the school's connection with the way society conceives the scientific workflow and the participation of the citizens. This issue appears in the curriculums of the fields of sciences, and it is produced by the inclusion of the scientific and technological conflicts, appointed in the school setting as Science, Technology, and Society controversies, or Socially Acute Questions (SAQ), among many other terms (Díaz-Moreno & Jiménez-Liso, 2014).

The idea of engagement, participation, and transformation of the society, the feature of this third paradigm, is also found in the Latin-American popular schools that emerged during the 1950s promoted by authors such as Freire, in order to create organizations able to change the reality through methodological proposals whose ultimate purpose was to evolve towards more socially fair situations (Freire, 2010). Accordingly, the term *emancipation*, mainly used by Paulo Freire, refers to the citizens' necessity of detaching themselves from an imposed reality thanks to a critical vision of the world (Sverdlick, 2019).

At present, this approach where the students' contributions are taken into account is promoted by recommending a critical and activist education, with which students achieve an individual, logical decision-making process for scientific and technological socially acute questions, and also they are prepared to make political and social decisions thanks to constant, critical thinking (Alsop & Bencze, 2014; Bencze et al., 2019; Simonneaux, 2014).

World View

Having reached this recognition of the relationships between the paradigms of scientific culture described from the Social Studies of Science and school models in the Western world, the question must be asked: What gives rise to these relationships? An approach to its elucidation could be achieved by resorting to the world view idea.

We could begin by remembering, as a way of illustration, the explanation given to a natural phenomenon which has attracted attention since ancient times; the movement of a body. Five centuries before Christ, two coexisting civilisations, the Greek and the Chinese, defended opposing postures with respect to the causes that keep a body moving at a constant speed. Therefore, while Aristotle attributed this behaviour to the existence of a constant external force, in China the thinkers proposed the idea that force was only necessary if the body needed to be stopped and that forces were not necessary unless its state of movement was to be changed. This Chinese proposal is what was known 2000 years later as the principle of inertia, one of the principles established by Isaac Newton in his *Mechanics*. So the causes of these opposing postures faced with the same problem can be explained by the relationship between science and ideology. These differences respond to the fact that a given society, on developing its science, is conditioned through an ideology based on certain epistemological assumptions (Piaget & García, 1982). These authors refer to this conditioning of ideology as an epistemic framework and explain that in Aristotle's time the world was static and therefore the natural state of objects was rest. Movement meant "violence" applied to an object and therefore required a force. For the Chinese society, in the same era, the world was in constant movement and therefore movement did not need to be explained. Now a force is needed to break this natural state of movement. To conceive that the natural state of the world is rest or movement leads to different explanatory systems and therefore to different physical theories. This conception of the world permeates the way of perceiving individuals in different areas such as Religion, Art, Philosophy or Science.

The expression world view has been used to describe the particular way of observing the world in a certain society or historical moment. In this regard, and effecting a conceptual approach, the expression "world view" has a long history. Some point out that it was coined by Immanuel Kant who, starting out from the German term "Weltanschauung", transformed it into an essential term for German Idealism and Romanticism, trying to use it to express the idea of a global view of the world and life, on occasions from religious viewpoints (Naugle, 2002). Around 1830 this expression began to be used more extensively in the rest of the Western world, resembling the Spanish concept of "cosmovisión".

Other scholars associate the first use of this expression to the end of the XVIII and beginning of the XIX centuries, with the linguist Wilhelm Von Humboldt, who, in one of his studies on the purpose of linguistic research, points out that the difference between languages is not that referred to sounds in themselves but the discrepancy in the visions of the world that they transmit. In this way, the peoples that have different cultures and languages segment reality in different ways, forming special ideas of the world in which they live (Underhill, 2009).

Wilhelm Dilthey is also recognised as having delved into this subject. According to this thinker, neither thought nor will gives rise to conceptions of the world; it is the vital experience through determinants linked to the limitations of the era that define a conception of the world. Therefore, world views are subjected to changes in history and culture according to a diversity of factors. On occasions, the effectiveness and relevance of a specialised knowledge can produce a strange interpretation which then spreads out to include everything (Makkreel, 2021; Maleki & Davari, 2020).

Going back to the example of the explanations given about the movement of bodies with which this section began, the *Weltanschauung* or world view is at the root of its differences. At every historical moment and in every society there is a predominant *Weltanschauung* that is a product of social and epistemic paradigms which, once it has been set up, makes it difficult to distinguish between the social and cognitive contributions to a problem. The knowledge produced by each society is the conscious or unconscious expression of structures, values and projects of that society which reveal a style (Thuillier, 1990).

In turn, in the field of education, the discussion about the idea of a world view has been a clear focus of research. Education Science recognises its influence on defending the existence of certain non postulated nor named hypotheses about what the world is like. Themes such as that society is a strongly united reality or that individuals are rational or non-rational are deeply rooted in the personal reality of the researchers and take on the category of "facts" which organise their perceptions and shape their subsequent theorising attaching themselves to the research (Ferreira, 2020; Nery, 2020; Popkewitz, 1994).

The trilogy of culture, language and mind, the raw material of school settings, has worldview as its anchor point (Rahmawati, 2016). From this perspective, then, any possibility of circumventing the imposed worldviews would seem utopian. But a revision of what is understood to be critical stances in education is seen as a path towards infrastructures and models of educational research and towards schools where disempowerment is enhanced and the absorption of differences is put into practice. The essence of these new positions lies in making unstable what it appears natural, or that which transforms us into unconsciously obedient observers (Popkewitz & Huang, 2021).

However, on addressing the study of this subject, not only is the focus set on the researchers but the idea of a world view is also discussed regarding its impact on teachers, syllabuses and on the way of tackling the students' curricular

subjects, highlighting today, for example, the situation of Asian countries which apply Western-European educational frameworks, with the resulting discordance between theory and practice (Cairns, 2020; Gupta, 2020; Jooste & Heleta, 2017; Jung, 2018; Kim & Kim, 2019; Kumar, 2019; Nikolaeva et al., 2019; Park, 2017; Sharma, 2018; UNESCO, 2015; Wang & Hoffman, 2016; Zeng et al., 2020).

Conclusion

As was mentioned in previous sections, both schools and the consecutive changes in the concept of scientific culture have tended, over the last few decades, to accept as part of scientific culture ubiquitous, emerging and transitory knowledge which appears aside from a deliberate plan. It would then seem to be that if school scientific culture is thought to be a characteristic of the literacy paradigm, it should be understood that there is only one paradigm, the literacy one, since those cultural elements have been adapting and evolving, integrating new discourses and generating new practices, and scientific culture itself being the driving force of general culture in society.

What has been described is not sequential, that is, it is not a question of general culture in a society existing first and school scientific culture emerging a posteriori, nor viceversa. The same as with the lithographs by Maurits Cornelis Escher of drawing hands, each one gives rise to the other and both complement each other. At this point it must be emphasised that it is not the intention of this proposal to search for the guiding lines which bring about this parallel between the science teaching models and the conceptualisations about scientific culture, a thread of discussion which, without a doubt, could be extremely interesting.

However, certain characteristics of our times, of the view of the Western world, can be recognised and these can be related to that overview which is focused on scientific culture to try to study it. That new overview has been revealing and relocating scientific culture in such a way that it has spread from the school to the fields of divulgation or to people's daily lives. At the same time, the informational nature of the teaching of sciences and daily life itself through the inclusion of technical-scientific controversies has made its way into the school.

In accordance with this line of argument, the Social Studies of Science raises to the status of scientific culture cultural objects acquired as clichés, disconnected from a body of knowledge and used temporarily over a short period of time (Seakins & Hobson, 2017). These studies recognise as being scientific culture not only those scientific, cultural objects associated with wise, solid, unified, long-lasting knowledge attainable through time and effort, which are characteristic of a type of schooling and necessary to continue with higher education. Additionally, from this curricular field both those scientific cultural objects acquired through museums, newspapers and other mass media and those obtained in daily life by reading the directions for use on a medical product or debating the suitability of placing a telecommunications antenna on the rooftop of a building which has a residents association are also recognised as scientific culture. The ubiquity of their place of acquisition includes areas which are not specifically set aside for this. In the latter cases, these scientific cultural objects, because they stem from the citizen's free will or respond to an isolated personal matter, have a sporadic, fortuitous and momentary character and are disconnected one from the other. Lacking in space and long-term intention, this new knowledge does not settle in and it is handled with a low commitment to lasting in time (Bauman, 2015).

However, it is worthy of note that the above-mentioned knowledge is now encompassed under the construct of "scientific culture". It is almost as if a long-term, less committed, more provisional and disposable scientific culture, ready to be substituted were what was wanted to be relied on. Paradoxically, the school itself extols this style of acquiring culture through science education by adding to its educational projects dissemination activities and debates about technical scientific controversies with social repercussions, which change as quickly as society itself.

As can be seen, both inside and outside the school, that host of scientific knowledge, loose, dissolute and licentious, is accepted as scientific culture, and what is more, on being given the status of scientific culture, this level of acquiring scientific culture is promoted from institutions. It is important to point out therefore that these means of acquiring scientific culture and this type of cultural object acquired as clichés have always existed and will always exist; however, their recognition or endorsement as scientific culture is a new phenomenon. It would seem that our current minds "enjoy" elusive and temporary knowledge that fulfils a sporadic and casual purpose to immediately prepare the way for others which will have the same fleeting destiny (Bauman, 2013).

In this regard, both the school and the Social Studies of Science extend what is thought to be scientific culture, hence it appears scattered throughout society recalling David Harvey's words in the work entitled "The Condition of Postmodernity" (Harvey, 1990); this author reflects:

I begin with what appears to be the most startling fact about postmodernism: its total acceptance of the ephemerality, fragmentation, discontinuity, and the chaotic that formed the one half of Baudelaire's conception of modernity. But postmodernism responds to the fact of that in a very particular way. It does not try to transcend it, counteract it, or even to define the 'eternal and immutable' elements that might lie within it. Postmodernism swims, even wallows, in the fragmentary and the chaotic currents of change as if that is all there is. (p. 44)

This document concludes by accepting as its own the thesis defended by Popkewitz (1994) and it can be applied both to the field of Social Studies of Science and to the field of education, that is to say: the individual in a research community learns ways of thinking, seeing, feeling and acting and therefore cannot help feeling a liking for what is short-lived and has not taken roots, both inside and outside the school in our postmodern age.

Perhaps the key lies in the role assigned to the school in society: an uncritical and reproductive school will be inclined to propagate what the rest of society, particularly the most dominant sector, imposes; a school that generates consensus and promotes a plurality of discourses and their critical discussion for the purpose of transforming society will be a focus of change. Between these two extremes we will find the influences between the meaning given to scientific culture promoted at school and that conferred by the academic spheres that study what is understood to be scientific culture.

Recommendations

According to the previous section, and in order to provide some suggestions for future researches and practitioners, it is essential both to involve and facilitate the understanding of the educational community, and citizens in general, of the curricular and methodological changes that arise from these interrelationships and which, occasionally, could appear arbitrary. Challenging the idea of current scientific culture, that is, that which includes superficial and clichéd knowledge, would be a way of making what appears to be natural unstable.

Limitations

The above selected literature mostly concerns the Western world. This work could be enriched with more contributions from Asian researchers on the subject, as it is from outside perspectives that both the idea of worldview and the predominance of foreign worldviews that permeate educational settings are evident. This is not intended to replace one worldview with another, but to recognise and appreciate the existence of difference.

Declarations of interest

None

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authorship Contribution Statement

Maxera: concept and design, data acquisition, data analysis / interpretation, final approval. Álvarez-Blanco: drafting manuscript, critical revision of manuscript, technical or material support, supervision

References

- Albe, V. (2015). Science for citizenship. In R. Gunstone (Ed.), *Encyclopedia of Science Education* (pp. 904–905). Springer. <https://doi.org/10.1007/978-94-007-2150-0>
- Alcíbar, M. (2015). Comunicación pública de la ciencia y la tecnología: una aproximación crítica a su historia conceptual [Public communication of science and technology: a critical approach to its conceptual history]. *Arbor*, 191(773), 1-13. <https://doi.org/10.3989/arbor.2015.773n3012>
- Alsop, S., & Bencze, L. (2014). Activism! Toward a more radical science and technology education. In J. Bencze & S. Alsop (Eds.), *Activist science and technology education* (pp. 1-19). Springer. https://doi.org/10.1007/978-94-007-4360-1_1
- Bauer, M. W. (2017). No time for experts? Trust in science after the BREXIT vote of 23 June 2016. In B. Schiele & J. LeMarec (Eds.), *Cultures of Science* (pp. 91-99). Acfas.
- Bauman, Z. (2013). *Culture in a liquid modern world*. John Wiley & Sons.
- Bauman, Z. (2015). *Los retos de la educación en la modernidad líquida* [The challenges of education in liquid modernity]. Editorial Gedisa.
- Bencze, L., Carter, L., Groleau, A., Krstovic, M., Levinson, R., Martin, J., Martins, E., Pouliot, C., & Weinstein, M. (2019). Promoting students' critical and active engagement in socio-scientific problems: inter-trans-national perspectives. In E. McLoughlin, O. Finlayson, S. Erduran & P. Childs. (Eds.). *Bridging research and practice in science education. Contributions from science education research* (pp. 171-188). Springer. https://doi.org/10.1007/978-3-030-17219-0_11

- Bybee, R. (2015). Scientific literacy. In R. Gunstone (Ed.), *Encyclopedia of science education*. Springer. https://doi.org/10.1007/978-94-007-2150-0_178
- Cairns, R. (2020). Recognizing, reproducing and resisting West as method discourse: An analysis of senior secondary Asia-related history curriculum enactment. *Journal of Curriculum and Pedagogy*, 18(1), 211-44. <https://doi.org/10.1080/15505170.2020.1764413>
- Chevallard, Y. (1991). *La transposición didáctica. Del saber sabio al saber enseñado* [The didactic transposition. From wise knowledge to taught knowledge]. Aique.
- Colucci-Gray, L., Burnard, P., Gray, D., & Cooke, C. (2019). A critical review of STEAM (Science, Technology, Engineering, Arts, and Mathematics). In P. Thomson (Ed.), *Oxford research encyclopedia of education* (pp. 1-26). Oxford University Press. <https://doi.org/10.1093/acrefore/9780190264093.013.398>
- Cortassa, C. (2016). In science communication, why does the idea of a public deficit always return? The eternal recurrence of the public deficit. *Public Understanding of Science*, 25(4), 447-459. <https://doi.org/10.1177/0963662516629745>
- Cotton, D. R. E., Zhai, J., Miller, W., Dalla-Valle, L., & Winter, J. (2021). Reducing energy demand in China and the United Kingdom: the importance of energy literacy. *Journal of Cleaner Production*, 278(1), 123876. <https://doi.org/10.1016/j.jclepro.2020.123876>
- Díaz-Moreno, N., & Jiménez-Liso, R. (2014). Las controversias sociocientíficas como contexto en la enseñanza de las ciencias [Socio-scientific controversies as a context in science education]. In M. A. de las Heras, A. Lorca, B. Vázquez, A. M. Wamba & R. Jiménez (Eds.), *Actas del XXVI Encuentros Didáctica de las Ciencias Experimentales* (pp. 693-701). Departamento de Educación, Universidad de Almería. <https://bit.ly/3ocLupB>
- Dorfman, E. (2019). Changing epistemologies in the museum: An evolving relationship with nature. *Museum International*, 71(1-2), 30-37. <https://doi.org/10.1080/13500775.2019.1638024>
- Ferreira, A. (2020). Dilemmas, conflicts, and worldview diversity: Exploring the relevance of Clare Grave's legacy for planning practice and education. *Journal of Planning Education and Research*. Advance online publication <https://doi.org/10.1177/0739456X20940797>
- Freire, P. (2010). *Pedagogía del compromiso* [Pedagogy of commitment]. Hipatia.
- Goldenberg, M. (2016). Public misunderstanding of science? Reframing the problem of vaccine hesitancy. *Perspectives on Science*, 24(5), 552-581. https://doi.org/10.1162/POSC_a_00223
- Gupta, A. (2020). Preparing teachers in a pedagogy of third space: A postcolonial approach to contextual and sustainable early childhood teacher education. *Journal of Research in Childhood Education*, 34(1), 43-58. <https://doi.org/10.1080/02568543.2019.1692108>
- Hardy, G. H. (2005). *A mathematician's apology*. University of Alberta Mathematical Sciences Society. <https://binged.it/3qIk1PD>
- Harvey, D. (1990). *The condition of postmodernity*. Blackwell.
- Janes, R. R., & Sandell, R. (Eds.). (2019). *Museum activism*. Routledge. <https://doi.org/10.4324/9781351251044>
- Jooste, N., & Heleta, S. (2017). Global citizenship versus globally competent graduates: A critical view from the South. *Journal of Studies in International Education*, 21(1), 39-51. <https://doi.org/10.1177/1028315316637341>
- Jung, J.-H. (2018). Decolonizing educational/curriculum studies in East Asia: Problematizing shadow education in South Korea. *Inter-Asia Cultural Studies*, 19(2), 269-281. <https://doi.org/10.1080/14649373.2018.1463074>
- Kim, H. K., & Kim, Y. (2019). Risk information seeking and processing about particulate air pollution in South Korea: The roles of cultural worldview. *Risk Analysis*, 39(5), 1071-1087. <https://doi.org/10.1111/risa.13231>
- Kreimer, P. (2015). Public understanding of science and social studies of science: convergence or parallel paths? In B. Schiele, J. Le Marec & P. Baranger (Eds.), *Science Communication Today. Current Strategies and Means of Action* (pp. 83-98). Presses Universitaires.
- Kreimer, P. (2017). Los estudios sociales de la ciencia y la tecnología: ¿son parte de las ciencias sociales? [Social studies of science and technology: are they part of the Social Sciences?]. *Teknokultura*, 14(1), 143-162. <http://doi.org/10.5209/TEKN.55727>
- Kreimer, P., & Vessuri, H. (2018). Latin American science, technology, and society: a historical and reflexive approach. *Tapuya: Latin American Science, Technology and Society*, 1(1), 17-37. <https://doi.org/10.1080/25729861.2017.1368622>

- Kumar, A. (2019). Curriculum as a process of conditioning in Asia: Ideology, politics, and religion. In A. Kumar (Ed.), *Curriculum in International Contexts* (pp. 113-149). Palgrave MacMillan. https://doi.org/10.1007/978-3-030-01983-9_5
- Kumar, P. V. S. (2016). Social Sciences in the public understanding of science. *Journal of Scientific Temper*, 4(3-4), 167-187. <https://binged.it/3bPYj3F>
- Larkin, D.-B. (2019). Attending to the public understanding of science education: A response to Furtak and Penuel. *Science Education*, (103), 1294-1300. <https://doi.org/10.1002/sce.21537>
- Lyall, C., & Tait, J. (2019). Beyond the limits to governance: New rules of engagement for the tentative governance of the life sciences. *Research Policy*, 48(5), 1128-1137. <https://doi.org/10.1016/j.respol.2019.01.009>
- Makkreel, R. A. (2021, June 15). *Wilhelm Dilthey*. The Stanford Encyclopedia of Philosophy. <https://stanford.io/30cUUcX>
- Maleki, F., & Davari, R. (2020). The concept of humanities in the late thought of Wilhelm Dilthey. *Occidental Studies*, 10(2), 219-242. <https://bit.ly/3C0vegg>
- Martins, I. P. (2020). Revisitando orientações CTS|CTSA na educação e no ensino das ciências [Reviewing STS|STSE Guidelines in Education and Science Teaching]. *APEduC Revista - Investigação e Práticas em Educação em Ciências, Matemática e Tecnologia*, 1(1), 13-29. <http://hdl.handle.net/10773/31870>
- Naugle, D. K. (2002). *Worldview: The history of a concept*. Eerdmans Publishing.
- Nery, J. A. (2020). La epistemología social de Thomas Popkewitz [The social epistemology of Thomas Popkewitz]. *Perfiles Educativos*, 42(170), 154-168. <https://doi.org/10.22201/iissue.24486167e.2020.170.59321>
- Nielsen, K. H. (2018). Ideas, politics and practices of integrated science teaching in the global Cold War. *BJHS Themes*, 3, 167-189. <https://doi.org/10.1017/bit.2018.1>
- Nikolaeva, A. D., Filin, S. A., & Davaasurengiyn, D. (2019). Modern teacher's worldview and ethics in the context of technological paradigms (case study of a national region of Russia). In V. Mantulenko (Ed.), *SHS Web of Conferences*, 71 (pp. 05005). <https://doi.org/10.1051/shsconf/20197105005>
- Orozco, C. E. (2018). Diez años de investigación de la comunicación pública de la ciencia en y desde América Latina. Un estudio en tres revistas académicas (2008-2017) [Ten years of research on the public communication of science in and from Latin America. A study in three academic journals (2008-2017)]. *Journal of Science Communication, América Latina*, 1(1), 1-20. <https://doi.org/10.22323/3.01010202>
- Park, J. (2017). Knowledge production with Asia-centric research methodology. *Comparative Education Review*, 61(4), 760-779. <https://doi.org/10.1086/693980>
- Pedretti, E., & Iannini, A. M. N. (2021). Towards fourth-generation science museums: Changing goals, changing roles. *Canadian Journal of Science, Mathematics and Technology Education*, 20(4), 700-714. <https://doi.org/10.1007/s42330-020-00128-0>
- Pestre, D., & Bonneuil, C. (2015). *Histoire des sciences et des savoirs, t. 3: le siècle des technosciences* [History of science and knowledge, vol. 3: the century of Technosciences]. Le Seuil. <https://bit.ly/3qygPGr>
- Piaget, J., & García, R. (1982). *Psicogénesis e historia de la ciencia* [Psychogenesis and history of science]. Siglo XXI.
- Popkewitz, T. (1994). Política, conocimiento y poder: algunas cuestiones para el estudio de las reformas educativas [Politics, knowledge and power: some issues for the study of educational reforms sychogenesis and history of science]. *Revista de Educación*, 305(1), 1-29. <https://binged.it/3BVGfPQ>
- Popkewitz, T. S., & Huang, J. (2021). Rethinking critical theory and the study of education: contributions of the 'Posts/New Materialism'. In R. Tierney, F. Rizvi, K. Ercikan & G. Smith (Eds.), *International Encyclopedia of Education* (pp. 1-24). <https://doi.org/10.13140/RG.2.2.32530.99528>
- Rahmawati, L. (2016). Teaching language and world vision: As a cross-cultural communication. *Educatio: Journal of Education*, 1(2), 171-188. <https://core.ac.uk/reader/229765773>
- Sanz-Merino, N., & Tarhuni-Navarro, D. H. (2019). Attitudes and perceptions of Conacyt researchers towards public communication of science and technology. *Public Understanding of Science*, 28(1), 85-100. <https://doi.org/10.1177/0963662518781466>
- Schwinger, J. S. (2002). *Einstein's legacy: the unity of space and time*. Courier Corporation.
- Seakins, A., & Hobson, M. (2017). Public understanding of science. In K. S. Taber & B. Akpan (Eds.), *Science education. New directions in Mathematics and Science Education* (pp. 443-452). Sense Publishers. https://doi.org/10.1007/978-94-6300-749-8_32

- Seethaler, S., Evans, J. H., Gere, C., & Rajagopalan, R. M. (2019). Science, values, and science communication: Competencies for pushing beyond the deficit model. *Science Communication*, 41(3), 378-388. <https://doi.org/10.1177/1075547019847484>
- Sharma, N. (2018). Global citizenship education and Non-Western perspectives. In N. Sharma (Ed.), *Value-creating global citizenship education* (pp. 43-55). Palgrave Pivot. https://doi.org/10.1007/978-3-319-78244-7_3
- Shih, Y.-H. (2018). Some critical thinking on Paulo Freire's critical pedagogy and its educational implications. *International Education Studies*, 11(9), 64-70. <https://doi.org/10.5539/ies.v11n9p64>
- Simis, M. J., Madden, H., Cacciatore, M. A., & Yeo, S. K. (2016). The lure of rationality: Why does the deficit model persist in science communication? *Public Understanding of Science*, 25(4), 400-414. <https://doi.org/10.1177/0963662516629749>
- Simonneaux, L. (2014). From promoting the techno-sciences to activism – a variety of objectives involved in the teaching of SSIs. In L. Bencze & S. Alsop (Eds.), *Activist Science and Technology Education* (pp. 99-111). Springer. https://doi.org/10.1007/978-94-007-4360-1_6
- Singh, S., & Singh, S. (2016). What is scientific literacy: A review paper. *International Journal of Academic Research and Development*, 1(2), 15-20. <https://bit.ly/3ETpgji>
- Sjöström, J., & Eilks, I. (2018). Reconsidering different visions of scientific literacy and science education based on the concept of Bildung. In Y. Dori, Z. Mevarech & D. Baker (Eds.), *Cognition, metacognition, and culture in STEM education. Innovations in science education and technology* (pp. 65-88). Springer. https://doi.org/10.1007/978-3-319-66659-4_4
- Smallman, M. (2014). Public understanding of science in turbulent times III: Deficit to dialogue, champions to critics. *Public Understanding of Science*, 25(2), 186-197. <https://doi.org/10.1177/0963662514549141>
- Southerland, S. A., & Settlage, J. (2019). An invitation into an ongoing conversation: Revealing different perspectives on some of the fundamental assumptions of the work of science educators. *Science Education*, 103(5), 1277-1279. <https://doi.org/10.1002/sce.21539>
- Sverdlick, I. (2019). Inclusión educativa y derecho a la educación: La disputa de los sentidos [Educational inclusion and the right to education: The senses in dispute]. *Archivos Analíticos de Políticas Educativas*, 27(26), 1-24. <https://doi.org/10.14507/epaa.27.3197>
- Thuillier, P. (1990). *De Arquímedes a Einstein: las caras ocultas de la invención científica* [From Archimedes to Einstein: the hidden faces of scientific reasearch]. Alianza Editorial.
- Tomasevski, K. (2004). *El asalto a la educación* [The assault on education]. Intermon Oxfam.
- Underhill, J. (2009). *Humboldt, worldview and language*. Edinburgh University Press. <https://doi.org/10.3366/edinburgh/9780748638420.001.0001>
- United Nations Educational, Scientific and Cultural Organization. (2015). *Global citizenship education: Topics and learning objectives*. UNESCO. <https://binged.it/3wumUnT>
- Von Korff, J. (2016). Secondary analysis of teaching methods in introductory physics: A 50 k-student study. *American Journal of Physics*, 84, 969-974. <https://doi.org/10.1119/1.4964354>
- Wang, C., & Hoffman, D. M. (2016). Are we the world? A critical reflection on selfhood in US global citizenship education. *Education Policy Analysis Archives*, 24(56), 1-22. <https://doi.org/10.14507/epaa.24.2152>
- Zeng, J., Jiang, M., & Yuan, M. (2020). Environmental risk perception, risk culture, and pro-environmental behavior. *International Journal of Environmental Research and Public Health*, 17(5), 1750. <https://doi.org/10.3390/ijerph17051750>