The contribution of Rómulo de Carvalho to Portuguese science education (1934-1974): a humanistic project?

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This thesis is dedicated to Marina.

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Abstract

This thesis examines the contribution of Rómulo de Carvalho to science education in Portugal during the period he taught in the secondary school 'Liceu' (1934-1974). In his home country, Carvalho is a well-known educator, historian and poet, a voracious writer who left a great number of works in these three areas.

The scope of Carvalho's activities in pedagogy is wide. He contributed to curriculum development, wrote textbooks, books on popularization of science, and trained teachers. The thesis seeks to pull these activities together and provides an account on the characteristics and impact of Carvalho's contribution to science education within a professional and political context.

The main argument of the thesis is that Carvalho's work on science education can be described as 'humanistic', since he worked for the change of the nature and quality of science education in Portugal in a distinctively 'humanistic' way. Carvalho contributed to the democratization of scientific knowledge in a fascist regime, and gave particular attention to the adequate content and methods of teaching according to pupils' age, interests, and learning condition.

The thesis sets out the political and educational context in which Carvalho's work took place and examines the rationale and impact of some of his key pedagogical activities. An account on Carvalho's contribution to the 1947/1948 liceal reform is provided. The thesis then examines the characteristic and the professional context in which his textbooks were produced. It moves on to scrutinize Carvalho's views on the pedagogy of laboratory classes with a particular concern with his preferred teaching method. Afterwards, accounts on Carvalho's work as a teacher trainer, on his broader support in the practice of teaching, and his own performance in the classroom are provided. In the final part, the thesis examines Carvalho's work on the popularization of science, providing an account of his aims and writing style as well as the significance of this work within the Salazarist regime.

Table of Contents

Acknowledgements **4**
Abstract **6**
Table of Contents **7**
Lists of Tables and Illustrative Material **10**
Abbreviations **11**

Chapter 1
Object and Arguments of the Thesis **12**

1. A Portrait of a Kaleidoscopic Man *14*
2. The scope of Carvalho's pedagogical work *25*
3. The aim and argument of the Thesis *30*
4. A note on sources and methodology *38*

Chapter 2
Aspects of the political and educational context before 1948 **42**

1. Introduction *42*
2. An overview of the political context *45*
3. The pedagogical discourse during Salazarism *48*
4. The historical role of the Portuguese Liceu *50*
5. The role of the Liceu during Salazarism *55*
6. Chemistry teaching content and methodology before 1948 *58*
7. Laboratory classes *61*
8. Heurism in the liceal science teaching *63*
9. IPW in the General Course 1936-1947 *67*
10. Conclusion *73*

Chapter 3
Carvalho's 1948 Chemistry Programme **75**

1. Introduction *75*
2. Carvalho's nomination as the author of the chemistry programme *78*
3. The Innovations in Carvalho's Chemistry Programme to the General Course *81*
4. Context and Meaningfulness in Carvalho's Rationale for the General Course Chemistry Programme *86*
5. Carvalho's Chemistry Programme for the 3rd cycle (Complementary Course) *97*
6. Reactions and Effectiveness of Carvalho's Chemistry Programme *104*
7. The Changes in the chemistry programme in 1954 *111*
8. Conclusion *114*

Chapter 4
A "compendium" writer in a changing political environment **117**

1. Introduction *117*
2. The Sole Book contest *119*

3. Carvalho's 2^{nd} and 3^{rd} cycles chemistry compendia in the Sole Book contest *125*
4. Carvalho's Sciences of Nature for the Preparatory Cycle: humanistic science education realized? *138*
5. Conclusion *147*

Chapter 5
Carvalho and the pedagogy of laboratory classes **150**

1. Introduction *150*
2. Carvalho's view on the "behavioural adjustments" of IPW classes *154*
3. The relationship between the "heuristic method", the "inductive process", and the "inductive method" *156*
4. Carvalho's use of the Socratic method in the beginning of his career *162*
5. A rationale for the use of the Socratic method? *164*
6. A shift from the Socratic method to "discovery learning"? *170*
7. Conclusion *174*

Chapter 6
Carvalho and the training of teachers **178**

1. Introduction *178*
2. The context: Portuguese teacher training during Salazarism *181*
3. Involvement with the journals Gazeta de Física and Palestra *184*
4. Carvalho's articles on the use of experiments *189*
5. Carvalho's views on the qualities and preparation of a science teacher *193*
6. Carvalho as a teacher *202*
7. Taking teaching training seriously: Carvalho as a Metodólogo Teacher *206*
8. The end of an era in Portuguese science teacher training? *211*
9. Conclusion *216*

Chapter 7
Carvalho and the popularization of science **220**

1. Introduction *220*
2. Bento de Jesus Caraça: Liberal education for the people *223*
3. Forgotten works: Carvalho's Journal and Magazine articles. *227*
4. Contributions to the Cosmos Library *234*
5. Science for Young People *237*
6. Physics for the People *243*
7. Philosophy of Science *246*
8. The A Treasure of Science for Young Minds *252*
9. A subtle activist? *257*
10. Conclusion *266*

Chapter 8
Final Remarks and Conclusion **268**

A humanistic project? *283*

Appendix 1 **289**
Appendix 2 **290**
Appendix 3 **293**
Appendix 4 **296**

Bibliography **300**

Unpublished sources *300*
Governmental Decrees *302*
Rómulo de Carvalho's books and articles *302*
António Gedeão's books *307*
Contemporary Publications *308*
Modern Publications *312*

Lists of Tables and Illustrative Material

Table 1, p. 53: The 1917 Liceal curriculum framework.

Table 2, p. 58: The 1947 Liceal curriculum framework.

Table 3, pp. 290-292: Sketch of 1936 and 1948 Chemistry programmes' contents in the 2nd cycle (General Course).

Table 4, p. 293: Sketch of the 1936 3rd cycle Chemistry programme.

Table 5, pp. 294-295: Sketch of the 3rd cycle 1948 Chemistry programme.

Table 6, p. 284: Humanistic approaches in science education.

Figure 1, p. 296
Page 204 of Rómulo de Carvalho's Sciences of Nature (Ciencias da Natureza) (1968)

Figure 2, p. 297
Page 205 of Rómulo de Carvalho's Sciences of Nature (Ciencias da Natureza) (1968)

Figure 3, p. 298
Page 206 of Rómulo de Carvalho's Sciences of Nature (Ciencias da Natureza) (1968)

Figure 4, p. 299
Page 207 of Rómulo de Carvalho's Sciences of Nature (Ciencias da Natureza) (1968)

Abbreviations

AHME – Arquivo Histórico do Ministério da Educação (Historical Archive of the Ministry of Education)

BNP – Biblioteca Nacional de Portugal (Portuguese National Library)

DGEL – Direcção Geral do Ensino Liceal (General Direction of the Liceal teaching)

IEL – Inspeção do Ensino Liceal (Liceal Teaching Inspection)

MEN – Ministério da Educação Nacional, Lisboa (Minister of National Education, Lisbon)

Chapter 1

Object and Arguments of the Thesis

For long, biographical studies have been an important channel for the understanding of the life and the social context of important figures in the history of human civilization. However, for some historians, until recently this historical approach has been seen as an "old-fashion" resource, partially for its tendency to bypass important philosophical and social issues, and to offer cheap accounts of heroes, altruistic people devoted to duty (Shortland & Yeo, 1996). Within the past two decades, biographical studies have resurged with appreciation, since it is believed it can yield, perhaps more than any other historical approach, "the integration of intellectual and institutional narrative, of cultural and economic life" (ibid, p. 6).

In the literature it is not difficult to realize that much attention has been given from the nineteenth century onwards to the significant efforts of science educators, mainly in the US and the UK, to develop science teaching in secondary school. What has been little acknowledged is that also in less visible countries[1] important contributions to science education have been made. Regardless of their location, distinct contributions to science education enjoys, potentially, a wide audience, since science teaching faces few boundaries in terms of content and methodology and its examination always provide an opportunity for more comprehensive understanding of its practice. In this study, I will examine the pedagogical work of Rómulo de Carvalho, an important figure within Portuguese cultural life, who dedicated more than four decades of his life for a change both in quality and in nature of science education in his home country.

This introduction will provide an overview of Carvalho's life, as well as point out the main aspects of his pedagogical work and how each chapter will address them. The aim and the main arguments of the thesis will also be discussed here.

[1] Regarding history of science ,countries like Portugal, Spain, Finland, Hungary, Greece etc have more recently been referred to as the "European Periphery" (e.g. see Simões, 2012)

1. A Portrait of a Kaleidoscopic Man

> He was everything: a teacher, a populariser, a historian, and a poet. And, furthermore, did everything very well, he was exemplary in everything he did (...) He was a multifaceted, Enlightenment-like man" (Fiolhais, 2006, pp. 35-37 - physicist and educator)

> ... in the process of communicating to his students, he highlighted the fascinating impact of science and technology upon the everyday life of us all, and made us feel how the relationship between science and society are so important (A. M. d. Costa, 1996, p. 20 - formerly Carvalho's student and science teacher)

> He was a historian who believed, in his texts and his practice, that teaching could help changing society, improve human condition, alter the government system and, above all, teaching could change the views and the condition of citizens (M. d. F. Nunes, 2006, p. 33 - historian)

> It is education (…) which leads António Gedeão/Rómulo de Carvalho to bridge the two cultures – the scientific and humanistic. Rómulo de Carvalho on one hand, and António Gedeão on the other, worked to construct a firm web capable to unite these two poles of the human knowledge (G. d. O. Martins, 2001, p. 52 - former Carvalho student).

The quotations above amount to a small sample of a number of testimonies addressed to Rómulo de Carvalho in Portugal, which suggest diversity as well as quality in his work. But in spite of the constant praise in his home country, Carvalho is hardly known elsewhere: an isolation imposed by the limited reach of the Portuguese language, it has been suggested (Fiolhais, 1997a). In the light of what is said in the quotations above, it can be asked: should Carvalho be best characterized as a science teacher, as a historian or as a poet (the pseudonymous António Gedeão)? This question, in Carvalho's own view does not make sense: "Is there really any dichotomy?", he questioned in an interview. "There isn't!", he firmly responded. He also responded that

> A person should look at a poem just as he looks at science, or at art, or at anything. There are no incompatibilities. (…) There is absolutely no reason for us to say, 'So, you're a scientist, yet you write poetry? But they don't have anything to do with each other!' 'Yes,' I reply, 'I do, and I also make furniture!' (Gedeão, 1992, p. 174).

It was because of this symbiosis of 'different beings' into one, that on the 14th of December 1994, then 88 years old, Rómulo de Carvalho was unanimously indicated for the title of PhD "Honoris Causa" by the Scientific Council and Senate of the University of Évora, having the title been awarded on the 8th of June 1995 (*Doutoramento "Honoris Causa" do Dr. Rómulo de Carvalho*, 1995). The document justifies the title for his contributions as teacher trainer, author of textbooks, divulger of science, historian of eighteenth-century Portuguese culture, dramaturgist, fictionist, and poet. Chiefly after his death, many articles, books, and even a TV special were produced which intended to celebrate the work of this 'kaleidoscopic' man, which together attest his popularity in Portugal. A number of celebrations convey the scale of his work. For instance, in Portugal, the date of Carvalho's birthday, 24th of November, was chosen to celebrate the National Day of Scientific Culture, promulgated in 1996 by the Minister of Science and technology Mariano Gago. When he was 81 years old, he was awarded with the Medal of the Highest Merit of the Order of the Public Education granted by the Portuguese Government

(Santos, 1991). In 1996, he was awarded with the Grã-cruz da Ordem Militar de Sant'Iago e Espada, given by the then President of Republic Jorge Sampaio. In 1997, the journal *Gazeta de Física* dedicated an issue to him, with articles by Carvalho and other authors. In 2006, year of the centenary of his birth, dozens of celebrations took place[2]. To cite some, the Portuguese National Library published a work (Rêgo & Lopes, 2006) comprising texts recalling Carvalho's trajectory as poet as well as an educator, and Nuno Crato (Crato, 2006c) published a book with nine articles written by Carvalho on the teaching of physics originally published decades ago. Also in 2006, Araújo published a book about the period Carvalho spent in the city of Oporto, comprising some of his articles published in local journals and some of his manuscripts (J. M. d. Araújo, 2006). In 2007, the Calouste Gulbenkian Foundation brought to the public a book for children (R. d. Carvalho, 2007) that Carvalho had written to his son fifty years ago but never intended to publish, and more recently published Carvalho's book *Memórias* (R. d. Carvalho, 2010): a memoir of his personal and professional life. The University of Évora published two books with a lengthy collection of Carvalho's articles on the History of science (R. d. Carvalho, 1996, 1997), which together amounts to more than a thousand pages. Frederico Carvalho, his son, has been systematically providing information about Carvalho's personal life and some analysis concerning his poetry (F. Carvalho, 1998, 2004, 2006a, 2006b, 2008), and more recently his daughter Cristina Carvalho published a book with her memories about Carvalho (C. Carvalho, 2012). There are also some more articles published elsewhere (Cabanas, 2008; J. Caraça, 1997; Costa, 1997b; Couto, 2006; R. Fernandes, 2006; Fiolhais, 1997a; R. N. Rosa, 2002; Santos, 1997; L. D. Soares, 2006), to cite some, apart from lectures, and expositions.

[2] For a list of celebrations: http://www.100anos-romulogedeao.info/index.html, accessed on 20/06/2013.

Carvalho/Gedeão was not just 'an interesting' character of the Portuguese culture whose image has been remembered and praised without actual influence in contemporary educational initiatives. It is difficult to assess the extension to which Carvalho's thought still has (or ever had) on teachers practice, but it is undeniable that the attention given to Carvalho chiefly in the last twenty years has motivated Ministers of Education and educators to invest in science education in various ways. To give some examples, the University of Evora created the "Rómulo de Carvalho Award"[3], to acknowledge authors of the Lusophonic world who have produced distinct works in the realm of history of science, science teaching, and popularization of scientific culture. The Ministry of Education created in Portugal the "Live Science Centres", which comprise a number of "interactive spaces" spread out throughout the country to promote popularization of science and technology[4]. The Live Science Centre *Pavilhão do Conhecimento* in Lisbon produced an itinerant hands-on exposition "Physics in Everyday" (*Física no Dia-a-Dia*) drawn on one of Carvalho's book. Also, the Live Science Centre of the University of Coimbra, called "O Rómulo", justifies the name of the centre saying Carvalho is "a symbol of the scientific culture in Portugal", and adds that "Carvalho's name is very inspiring for us and we will continue to follow his example"[5]. Arguably, these initiatives should have built up Carvalho's image in the identity of science education in Portugal and certainly in some science teachers, as we shall see later. One of the greatest supporters of science education today in Portugal, the physicist Carlos Fiolhais, said: "Science has to continue alive, it will continue alive, more and more alive, and it will

[3] See http://www.100anos-romulogedeao.info, accessed on 16/06/2013
[4] See www.cienciaviva.pt, accessed on 16/06/2013
[5] See http://nautilus.fis.uc.pt/rc/ and www.mocho.pt, accessed on 16/06/2013

only be very alive, among us, if we always keep the memory of Rómulo de Carvalho" (Fiolhais, 2006, p. 42).

Today, it is not difficult to find general information about Carvalho, either by talking to students and academics, or even by a quick visit on Internet search engines[6]. Any person who, in any way, has some interest in science teaching in Portugal will certainly come across at least one of the document tributes. In the light of what was said in the paragraphs above, one can see that Carvalho already belongs to the history of Portuguese science education. He is a well-known figure which composes the identity of science education in Portugal. However, as Nuno Crato - who was Carvalho's student in the Liceu, and currently Minister of Education in Portugal - has pointed out, among the three main activities that Carvalho dedicated in his life, pedagogy, history, and poetry, it is the first which is less studied and comprehended (Crato, 2006c). It is influenced by this fact that this thesis is almost entirely dedicated to Carvalho's pedagogical work for the Liceu, his work as a science teacher.

***

When Rómulo Vasco da Gama de Carvalho was born in Lisbon, on the 24th of November 1906, Portugal was still a Monarchy. That was a time of great political changes, instability, and financial crises in Portugal, which came to proclaim its First Republic in 1910 – which lasted only 16 years. He witnessed the dawn and fall of the

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[6] See for instance see the website "António é o meu nome" http://www.romulodecarvalho.net/biografia.html; and the "Instituto Camões" webpage http://cvc.instituto-camoes.pt/, accessed on 16/03/2013.

forty-year Salazarism, a fascist regime, and died in 1997 under a democratic regime at the age of ninety.

Carvalho was a middle-class boy, with outstanding school attainments, and very interested in literature since childhood (R. d. Carvalho, 2010). His first contact and interest for sciences only appeared at the end of secondary school (ibid), and when the time came to choose which university course he was going to pursue, he hesitated:

> At the time I was not at all sure what I wanted to do because I was equally interested in both science and literature. I eventually chose science because I realized fairly quickly that I would be able to make a living more easily in science than in literature. (…) In fact, though, I felt that I was equally prepared for both a scientific and literary career (Gedeão, 1992).

He left secondary school in 1925 and became a student of the University of Lisbon in the preparatory course of Military Engineering in that year (J. M. d. Araújo, 2006). There, all of his lecturers at the university were Generals or Colonels and such environment did not stimulate the young student, who was expected to become a military officer (F. Carvalho, 2006b). Consequently, Carvalho did not demonstrate any enthusiasm for the course (Carvalho, 2010). He decided to move to the city of Oporto, in the north of Portugal, in order to live with his sister and carry on with his studies in a different environment. In 1928, he started studying the course of Physics-Chemistry at the Science College of the University of Porto. There he revealed great interest in laboratory classes, was happier and more dedicated to his studies, achieving outstanding scores of 19/20 (F. Carvalho, 2006b). He completed the course in 1931 and then returned to Lisbon, the city in which he always preferred to live (R. d. Carvalho, 2010), and started attending pedagogical lectures at the *Faculdade de Letras*[7] and a placement at the Liceu Normal Pedro Nunes (J. M. d. Araújo, 2006).

Carvalho taught physics and chemistry from 1934 to 1974 in the governmental institution *Liceu* (the secondary school for the Portuguese middle class or the "elite")[8]. A collection of the recent secondary sources portrays Carvalho as an outstanding, skilful, witty (Costa, 1997b), revered (F. Carvalho, 2006b) science teacher, an innovative writer (Santos, 1997), and a benchmark for science teachers (Crato, 2006a). Many who worked with Carvalho described him as "a distant and almost mythic character (...) because [of his] competence, wisdom, poetic aura and immense serenity" (Louro, 2001, p. 57)[9].

As it is written in a book with Carvalho's personal information at Liceu Camões[10], in 1934 he completed his placement at the "Liceu Normal de Lisboa" with grade 13 (out of 20) and started his activities as a physics-chemistry teacher at Liceu Camões - the biggest and one of the most important liceus in Lisbon (Nóvoa & Santa-Clara, 2003). The low mark obtained in his placement is claimed by Carvalho to be the consequence of his bad relationship with his supervisor (R. d. Carvalho, 2010). As a vindication for his claim, in the following years, very rapidly he took over important position in his professional activity and his name gained prominence.

[7] This is a kind of 'Faculty of Humanities' in which languages, literature, philosophy etc are studied.
[8] Carvalho taught in three liceus: Liceus Camões (1934-1948) in Lisbon; Pedro Nunes (1948-1950) also in Lisbon; D. João III (1950-1958) in Coimbra; and again in the Pedro Nunes (1958-1974).
[9] Maria Lucília Louro was Carvalho's colleague at Liceu Pedro Nunes in the sixties
[10] Available at the Historical Archive of Liceu Camões. "Livro de cadastro Pessoal de Rómulo de Carvalho", (1934-1947). Number 3, pages 8, 8/verso e 9.

As early as 1935 he was appointed to be part of the examination board for admission at the University of Coimbra[11], and in 1938 he was nominated director of the chemistry laboratory of the Liceu Camões[12], a position of status and responsibility within the liceal teaching environment. Only eight years after starting teaching, Carvalho was invited to participate in the elaboration of the new liceal science programmes, and in 1948 he became sole author of the national chemistry programme. Also in 1947 and 1948, he was nominated to be part of the commission to elaborate written examinations to the School of Engineering of the University of Oporto and the Superior Technical Institute (Instituto Superior Técnico – IST) of the Technical University of Lisbon[13]. From 1950 to 1958, he worked in Coimbra in the Liceu D. João III, when finally he moved back to Lisbon to work as a Metodólogo teacher (teacher trainer) at the Liceu Pedro Nunes and retired in 1974. A summary of key dates in Carvalho's career in relation to the different political regimes which ruled Portugal over the twentieth century is shown in Appendix 1.

Despite his decision to pursue a scientific career, it has been said that Carvalho lived all his life immersed in the worlds of both science and poetry (Couto, 2006). He wrote his first poetry when he was only five (Gedeão, 1992) and during his youth wrote scripts for theatre plays (J. M. d. Araújo, 2006). From the fifties

[11] Rómulo de Carvalho's Personal Registration at Liceu Camões, N° 3 leafs 8 - 8/verso and 9, published in the Official Daily Bulletin of the Portuguese Government on the 10/07/1935, n° 158.

[12] Ibid, published in the Official Daily Bulletin of the Portuguese Government on the 24/01/1938, n° 19.

[13] Official Daily Bulletin of the Portuguese Government, II série, on 23/05/1947 and 18/03/1958

onwards, the poet António Gedeão[14] started publishing poems which were very well accepted by the public as the media of that time indicates:

> António Gedeão - the poet and playwright; Rómulo de Carvalho - the teacher, scientist, author of many works on the popularization of science. Two facets of a man dedicated to culture and to the scientific progress of our time (A. Martins, 1965, p. 1)

From 1956, Gedeão published a number of books (Gedeão, 1956, 1958, 1961, 1967, 1968, 1983, 1990, 1997). It is very likely that his work as a poet gained a much wider audience than any other activity. He often inserted social issues and scientific vocabulary into his poetry, and explained in an interview that in his view science and poetry shared many similarities, as the former investigates nature and the later investigates human nature (Naves, 1996). Because of this amalgamation between Carvalho and Gedeão, he has been characterized as "a Renaissance man in the twentieth century" (Santos, 1996, p. 17). The unusual poetry awoke curiosity and some of his poems were used as song lyrics (probably his most famous poem is Pedra Filosofal, which the musician Manuel Freire used as song lyrics), something that contributed to the popularization of Gedeão in Portugal (Niza, 1996, p. 18). To a large extent this pseudonym gained a separate and distinct life, leading newspapers to interview "António Gedeão", some of them without even mentioning the actual name behind it (Guimarães, 1996).

[14] Given the repressive aspect of the Salazarist regime and the libertarian aspect of Carvalho's poetry, one might think that this pseudonym was deliberately to conceal his real name. I do not rule out this possibility, but Carvalho says in his book *Memórias* that he simply did not like to see his real name in a list of poets: "it did not sound well for the purpose" (Carvalho, 2010, P. 403).

Regarding his writings, Carvalho wrote several articles and books addressed to students and the general public in which he discussed the history and philosophy of science, as well as published several historical works on the Sciences Academy of Lisbon, of which he became one of its members in 1985 (J. Araújo, 1996). Carvalho started working on the history of science as early as 1953, by reconstructing the work of a Portuguese chemist (R. d. Carvalho, 1953b), and since then dedicated to study the works of Portuguese scientists, and the dialogue between Portugal and the rest of Europe in the scientific realm (F. Nunes, 1997). According to the historian of science Augusto Fitas, Carvalho managed to historically reconstruct the Portuguese effort to follow and contribute to the revolutionary ideas of the Enlightenment during the eighteenth century (Fitas, 1996). His work in the history of science, he adds, has "an innovative and precursor character, acknowledged by historians and scientists" (ibid, p. XIV).

Furthermore, Carvalho - who said in an interview "I never was in a hurry for anything" (Vasconcelos, 1989, p. 10) - also produced seminal works on the history of Portuguese education. From his retirement as a science teacher in 1974 until the end of his life, Carvalho wrote a number of books and articles which expressed his keenness to comprehend and convey the historical moment people were living in. As early as 1959 he published a book about the "History of the Royal School of Nobles of Lisbon" (*História da Fundação do Colégio Real dos Nobres de Lisboa*) (R. d. Carvalho, 1959), and later a history of the physics laboratory of the University of Coimbra (R. d. Carvalho, 1987a), both also belonging to the eighteenth century. His historical works were to a great extent a personal need:

> I felt the need to learn about the history of our teaching, which nobody taught me (...) I studied in all possible details and I wrote, already at the end of the twentieth century, the first history of our teaching (Rocha, 1994, p. 104)

The excerpt below was taken from the referred to book, which is indeed a landmark in his career, entitled "History of Education in Portugal" (*História do Ensino em Portugal*) (R. d. Carvalho, 1986). In its introduction, Carvalho explains why it is important to study history.

> …it situates us on a continuum, coming from far and passing us by, justifying our presence there in the occupied place, our actions, our vision of the pedagogical problems, allowing us a professional awareness that only alone and with difficulty one manages to build for oneself. (R. d. Carvalho, 1986, p. 7)

His last writing called *Memórias*, already mentioned above, handwritten for his "great-great-great-grandchildren" in order to "offer them news from a very distant time" (R. d. Carvalho, 2010, p. 20), was posthumously published and also conveys much of the same keenness in understanding our lives with the support of a historical context. Carvalho died still active, working in one more historical work. Almost ninety years old, he said in perhaps his last interview: "I am working on an eighteenth century Portuguese man [the ethnologist Alexandre Rodrigues Ferreira], who was sent to Brazil in order to study the customs of Brazilian indigenous people…" (Naves, 1996, p. 25).

Given what has been said in the foregone pages, it is difficult to contest Carvalho's son's opinion that the work of his father "stood out for having left a broad and multifaceted work, in correspondence to the universality of the interests of his life" (F. Carvalho, 2011, p. 2). Indeed the brief account above on Carvalho's different activities confirms the complexity and richness in Carvalho's thought which has been pointed out by many secondary sources. It is likely that Carvalho's inclination to the 'humanities' (mainly his natural inclination to history) played an important role in his pedagogical work, and I will return to this at the end of this thesis.

2. The scope of Carvalho's pedagogical work

As we can see above, the multifaceted aspect of Carvalho's work has received substantial attention in his home country. However, there seems not to exist any thorough or lengthy study (e.g. a book or a thesis) about Carvalho's pedagogical thought, his activities in this field, and the short or long-term impact of his work in science education in Portugal.

A survey of a number of small studies and testimonies indicate that his work in pedagogy presents a wide scope. Over the forty-year period that he worked as a liceal teacher, Carvalho's activities in pedagogy can be roughly divided into: curriculum development, writings for students, writings on experiments in school science, and teacher support. Naturally these activities are much interwoven but this classification serves to convey the width of his contribution, and these represent the main types of activity with which the thesis will be concerned. A summary of

Carvalho's activities and how secondary sources have addressed them is offered below.

Carvalho participated in 1948 in the science curriculum development for the liceal course by writing its chemistry programme. It belongs to a liceal reform which occurred one year earlier, in 1947. This programme is a landmark in his career for various reasons. This was the first time that Carvalho's name gained some prominence in the national panorama, and the educational ideas present there speak very closely to many other pedagogical works he carried out in the following decades. There is no thorough account on Carvalho's participation in this reform, but the few studies (Beato, 2005; M. C. Silva, 2008) indicate that the new chemistry programme was "revolutionary", rather different to what was being carried out before 1948. This is in part because Carvalho withdrew chemistry formulae and equations from part of the programme and gave substantial more attention to the study of 'everyday substances'. As another controversial issue relative to the 1947 Reform, the laboratory classes were withdrawn from the General Course of the Liceus. This was criticised by the science teaching community, chiefly by José Teixeira, another science teacher. It is not known who decided to withdraw the laboratory classes from the General Course in 1947, but suggestions of Carvalho's participation in this event can be inferred (J. A. Teixeira, 1951b, p. 229). Possibly related to this change, it has been claimed that the 1947 liceal Reform faced a problem of 'identity', as the liceal teaching was at that time trying to find its place within the Portuguese educational system (Adão & Remédios, 2008).

As another activity, his son, Frederico Carvalho, has pointed out that Carvalho developed in his professional life a "wide and useful activity in the elaboration of textbooks and other writings for the youth" (F. Carvalho, 2011, p. 4). Indeed Carvalho wrote textbooks for the chemistry and physics programmes for the secondary school published in 1948, and also wrote in 1968 a textbook for students between ten and twelve years old. Regarding the former, in another study, Beato (2004) has indicated that Carvalho participated in the "Sole Book contest", a contest created by the Salazarist regime, which forced teachers to use the same textbook in each discipline in all liceus of Portugal. Beato says that Carvalho had problems in the fifties to have some of his textbooks approved for use in the liceal course. He pointed out that one of the 'referees' (teachers appointed by the Government to assess textbooks) said that Carvalho, then author of the chemistry programme, "did not interpret the programme well" (Beato, 2004, p. 60), a somewhat puzzling statement. Other sources indicate that the textbook published in 1968, entitled *Sciences of Nature* (*Ciências da Natureza*), seems to have been more successful, as in a conversation between Carvalho and two scholars, he seemed pleased with its achievements. He said this textbook was "absolutely ground-breaking here in Portugal" for it was written in a "completely innovative way" (Gedeão, 1992, p. 171).

From late forties Carvalho started writing articles and books on the popularization of science, which might be classified as a kind of 'informal education', beyond the boundaries of the liceu. Nevertheless it is considered here as part of Carvalho's contribution to science education, and part of his pedagogical thought. A recent article published in the journal *Gazeta de Física*, of which Carvalho was co-founder and member of the executive committee and of editorial board, points out that Carvalho published in this journal 22 articles concerning popularization and other issues, "an immense work to take to a broader public a knowledge traditionally kept by 'guardians of knowledge'" (Pessoa, 2001, p. 19). Carvalho's work on the popularization has been receiving much attention in Portugal, which attests the significance of his work in this field. Recently, Carvalho had a book (R. d. Carvalho, 1995a) and also a collection of small booklets to science (R. d. Carvalho, 2004) republished. In the introduction of the latter, Frederico Carvalho points out that these booklets were just a small part of an extensive work, having many of them given great attention to the "historical evolution of ideas, and to remarkable realizations of science and technology" (F. Carvalho, 2004, p. 9). Carvalho also wrote books addressed to people who did not have the chance to study sciences in school (ibid). Other examples can be added to this list. Anyone who browses the shelves of many second-hand bookshops in Lisbon will probably find some of Carvalho's books written in the famous book collection *Cosmos Library* (*Biblioteca Cosmos*). This was directed by the mathematician and communist Bento de Jesus Caraça, an important figure in the history of education in Portugal who boldly fought against the Salazarist dictatorship.

As another prominent aspect in his pedagogical work, Carvalho has been claimed to be a great promoter for the use of experiments in school science, for his great passion for 'manual activities'. For instance, it has been pointed out that experiments were one of the reasons why Carvalho became a science teacher, and also the reason why he chose physics and chemistry instead of any other science (F. Carvalho, 2006b). It was also for the experimental aspect of physics and chemistry that he chose studying sciences, as he said: "I've always enjoyed working with my hands. I've often said that if things had been otherwise I would have liked to have been a metalworker or cabinet-maker" (Gedeão, 1992, p. 170). Carvalho added that he tried to foster in his students this manual work, insisting them to work with experiments (ibid). The physicist Rui Namorado Rosa, who worked with him for the *Gazeta de Física*, said that whenever there was a missing instrument in his laboratory, he used to build one himself (R. N. Rosa, 2002). It has been pointed out that, in all his lessons, including those commonly referred to as 'theoretical lessons', there was some sort of experiment (ibid), which should be carefully carried out in advance, tested it in detail, in order to avoid any fault which could put in risk the conclusion it was intended to be drawn (Crato, 2006b).

Regarding Carvalho's support to science teachers, there is little information in secondary sources about Carvalho's work as a Metodólogo teacher (teacher trainer), or as a theoretical pedagogue, but the existing information indicates another dense working field awaiting scrutiny. This activity was also sharply marked by his support with the use of experiments. In a catalogue published few years ago by the Portuguese National Library in Lisbon, its then Director General Jorge Couto points out that Carvalho had a particular concern in "developing methodologies" for the teaching of physics and chemistry, which led Carvalho to write a number of "texts on teaching" and worked on "the collaboration of several scientific and pedagogical journals, such as *Gazeta de Física*, *Liceus de Portugal* or *Palestra*" (Couto, 2006, p. 3). Carvalho used these journals extensively, in which, according to his former trainees Alcinda do Aido and Maria Gertrudes Bastos, Carvalho discussed experiments demonstration, etymology of new scientific words, and History of science education (Aida & Bastos, 2001). As an important event in the history of science teaching in the liceus, the physicist Fernando Bragança Gil (1994) has pointed out that in the 1960s the liceus received a significant investment in the acquisition of new experiments which, in his opinion, science teachers were not prepared to deal with. He suggests that Carvalho's work was remarkable in supplying those teachers with the information necessary to deal with that situation.

These and other small accounts on Carvalho's pedagogical work are certainly useful to learn about Carvalho's contribution to science education, but they form a patchwork sometimes difficult to bring together the magnitude of his work. They do not offer an extensive examination of Carvalho's understanding of science education and how this might have been influenced by professional and political contexts. They also lack of a characterization of his pedagogical thought and how this speaks to other international trends in history. The section below explains how this thesis intends to contribute to the existing body of knowledge about Carvalho.

3. The aim and argument of the Thesis

The aim of this thesis is to provide a historical account on the **characteristics and impact of Carvalho's pedagogical thought and work within a professional and political context**. This is not meant to be an exhaustive study of Carvalho's work. However it intends to bring together for the first time Carvalho's different activities in education. The thesis seeks to provide an analysis of the rationale of Carvalho's various activities in science education. It also seeks to point out his motivations, his objectives, the reach of his work, and the significance of these in the context of science education in mid-twentieth century, both in Portugal and in a wider scale.

In different chapters, the thesis will try to present different arguments, which are set out in detail in the next section. The main argument of the thesis, however, which runs through the chapters, is the notion that Carvalho's vision for the reform and improvement of science education can be described as 'humanist'. In fact some testimonies about Carvalho referred to him as a 'humanist educator'. It was these sources which inspired me to examine and elaborate this view. To give some examples, in the year of Carvalho's ninetieth anniversary and therefore in a celebratory occasion, a newspaper article tried to describe him as "A Humanist in Science" (J. S. d. Costa, 1996), whilst a recent study refers to the "Humanistic character" of his poetry (N. Nunes, 2001).

The word 'humanist' is of course problematic, or at least it carries with it a wide range of meanings, and has a history which arguably runs back over 2000 years. Indeed, one can easily find references to 'humanism' to classify a variety of historical contexts - such as the Greek and Roman classical humanism, as well as in the Renaissance and Enlightenment movements (Aloni, 2007). It is also referred to as a 'system of thought' in which, for instance, "human values, interests, and dignity are particularly important" (Law, 2011, p. 1), commonly opposed to religious-centred worldviews. I will not attempt to offer a unifying meaning at this point, which is in any case probably an impossible task. Instead I will discuss the senses in which I think Carvalho's vision was 'humanist' at appropriate points in the thesis. The reader should note that the idea of a 'humanistic education' will appear in a range of forms throughout the thesis. In short, I will claim as humanistic: Carvalho's deep concerning with contextualized and meaningful learning; his understanding of the central role of the teacher in the learning process; and his intention to democratize scientific knowledge. I will seek to draw these together in my closing chapter, when I will finally relate Carvalho's pedagogical views with some contemporary understanding for humanistic education. However, in order to provide a flavour of what humanizing science education might mean, it is appropriate to say a little about the broad modern understanding of a ‘humanistic science education’ here.

Scholars have tried to describe humanistic (also sometimes referred to as “liberal”[15]) approaches in education in different ways. Some of them value the teaching of the ‘canonical’ knowledge, that is, the most refined knowledge that humankind has managed to produce to date. For instance, the influential American educator Joseph Schwab has claimed that curriculum must be drawn on “the best statement of our present knowledge of the human make, of the various means” (Schwab, 1978, p. 125). The English philosopher Michael Oakeshott (1989) has criticized the ‘narrow utilitarian’ learning for the “here and now”, and claims that liberal education should focus on the “most substantial expressions we have of human self-understanding” (p. 29). Advocates of this understanding of a humanistic/liberal education oppose early specialisation such as vocational teaching in primary and secondary schools.

As another way to describe a humanistic education, some scholars have defended that the teaching of sciences needs to foster inclusiveness, contextualization and meaningfulness, with some attention to utilitarian knowledge (with more immediate use in people’s everyday lives), nevertheless also emphatically avoiding vocational and ‘narrow utilitarian’ education (Aikenhead, 2003, 2006). In this perspective, the teaching solely of the canonical and abstract scientific knowledge is

[15] This is debatable. However, liberal education, understood as “the education appropriate to a free human being” (Donnelly, 2004, p. 763), is commonly used in the literature interchangeably with the term humanistic education. This is probably because both terms oppose to ‘narrow utilitarian’ views in educational, and advocate the development human abilities and human values in ways which develop human autonomy.

seen with scepticism. In addition, some educators have been trying to point out the educational benefits to widen the use of history and philosophy of science (HPS) in school science, also as a way to humanize science education. They argue that learning philosophy of science fosters, perhaps more than any other discipline, critical reasoning, logical and independent thought, which might have practical use when political and ethical issues are debated (Matthews, 1994, p. 87-89).

Carvalho's contribution to science education cannot be perfectly framed in any of the views above. From chapters 3 to 7, I will seek to identify the 'humanistic' aspects of his pedagogical work. The last chapter will try to provide an account of the distinctive quality of Carvalho's work which, I will claim, can be characterized as 'humanist'. Below a synopsis of each chapter of the thesis is offered.

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The examination of Carvalho's pedagogical work will start with the exploration of his involvement with the 1947/1948 liceal reform. Because of the "revolutionary" aspect of his programme, **Chapter 2** aims to gain clearer understanding of the educational context where Carvalho worked. In particular, it intends to understand how science [mainly chemistry] was taught in the liceus before Carvalho's intervention and what caused the changes implemented by the 1947/1948 Reform.

This chapter will revisit both the historical humanistic aims of the liceal education within the Portuguese education system, as well as the characteristics of science education in the liceus in the first half of the twentieth century. It will argue that science education was mainly organized around the transmission of the scientific canonical knowledge, giving little attention to students' everyday lives and interests. It will be claimed that by 1947 science teachers were living an exciting moment centred on the teaching method known as 'heurism', commonly used in laboratory classes. The chapter will also seek to shed light on the political motivations for the withdrawal of laboratory classes and will examine whether Carvalho had any participation on this decision or not. Given the drastic political change occurred in Portugal from the thirties with the dawn of the Salazarist regime and the consequent change in the educational policy, this chapter will also provide an overview of the main aspects of this regime, and provide an account of the possible conditions that it might have imposed on pedagogic issues within the liceal teaching community. In subsequent chapters I will refer back to chapter 2, as this is intended to serve as a backdrop for the whole thesis.

Also relative to the "revolutionary" aspect of Carvalho's 1948 programme, **chapter 3** will address the content, the teaching methodology and the rationale that Carvalho used in the designing of his chemistry programme, which explains the radical suppressions of chemical formulae and equations. This chapter will address these issues chiefly by examining the Official Decree which contains the programme and Carvalho's orientations on how teachers were supposed to interpret it. It will be argued that Carvalho's programme was organized around two distinctive stages (or 'cycles'). In a first stage, his programmes aimed at a contextual, meaningful, utilitarian, and ultimately inclusive chemistry education. In a second moment, in the last two years of the liceal course, the programme was selective, demanding, for few students, only for those more apt to deal with the canonical knowledge of science. Also this chapter will seek to provide an account of the short-term impact of Carvalho's intervention in this reform, the reaction of science teachers and the long-term impact in science teaching. As we shall see, the reaction of the ‘conservative’ forces against Carvalho’s intervention altered his aims.

Chapter 4 will address the contexts and the conditions in which Carvalho wrote his textbooks. His involvement with what is called the ‘Sole Book’ contest in the 1950s had very different outcomes from his textbook written in the 1960s. The chapter will assess the extent to which the Sole Book contest affected Carvalho’s work, in particular, and the science teaching community as a whole. It will also examine the characteristics of his textbooks, and the source of an apparent misunderstanding between Carvalho and his textbooks’ referees. It will be argued that the Sole Book contest was very harmful for Carvalho in particular and for the science education community, as it provoked animosity and proved to be inefficient for choosing good quality textbooks. Also this chapter will examine the content and the approach used in his 1968 textbook *Sciences of Nature.* It will seek to point out the reasons why Carvalho had such positive opinion about it, arguing that it gave great attention to context, to everyday issues, as well as guiding students to enquire and draw conclusions.

Chapter 5 will address Carvalho’s use of experiments in school science. In spite of the wide acknowledgment for his passion for this teaching tool, little is known about whether Carvalho had any preferred teaching method either in the classroom or in the school laboratory. In addition, there is no detailed account on his views on the pedagogical use of experiments in school science. The chapter will analyse Carvalho’s rationale for the pedagogical usefulness in the use of experiments in school science, and analyse the impact of his ideas. It will seek to demonstrate that, for Carvalho, laboratory classes presented an important opportunity to educate pupils with organizational skills, foster thoughtful persons with positive attitudes, as well as influence them to pursue scientific careers. This chapter will also argue that different from many of his contemporaries, Carvalho did not use the heuristic method. He preferred a different approach: the use of the Socratic method. Ultimately, Carvalho drew a clear distinction between pedagogical and scientific methods, perhaps not perceived by others. However, it will be suggested that in spite of his dedication in use experiments in science classes, Carvalho did not leave any extensive theoretical account on the use of experiments, and partly as a result the impact of his ideas on this matter was small.

Chapter 6 will address Carvalho's work on the supporting of science teachers. It will examine Carvalho's views on what makes a 'good' science teacher. As we saw before from some secondary sources, it seems that journal articles were an important instructive tool that Carvalho used to support teachers. An account of the content of these articles and how they speak to Carvalho's general views on education will be provided. Carvalho's work as a Metodólogo teacher will also be analysed, including his personal relationship with his trainees. This chapter will analyse two documents on teacher training that he wrote to the Ministry of Education in different moments of his life, as well as his own performance in the classroom. It will be claimed that his performance reflected very well his ideas, and consequently his work as a Metodólogo teacher. In order to gain a more realistic understanding of Carvalho's practice as a teacher and his work as a Metodólogo, the teaching/learning atmosphere inside the liceus will be examined. The chapter will argue that the controlling and disciplinary setting maintained by the Government suited Carvalho and helped him to carry his work out more efficiently.

Chapter 7 explores Carvalho's work on the popularization of science. The chapter will examine the literary context in Portugal during Salazarism and point out the 'uniqueness' of Carvalho's writing style. The chapter will scrutinize the characteristics and the impact of a number of Carvalho's books and articles. I will argue that Carvalho stood out for his ability to communicate clearly and suitably to a range of audiences, as well as that he influenced a number of students to pursue scientific careers, thus having done an important civic work in a repressive environment.

Although Carvalho's articles and books on popularization were written in a repressive regime, they were intended to disseminate knowledge which might have reached all spheres of society, including those people who did not study science in school, as his son Frederico Carvalho suggested. For this reason, this chapter will examine whether Carvalho's work on popularization intended to communicate any ideology, and whether his work differed, if at all, from other works with the same aim. It will provide some examples of educational endeavour with libertarian/humanist ideologies carried out in Portugal during Salazarism. The chapter will argue that Carvalho's work on popularization carried the same libertarian/humanist connotation, and will suggest some reasons which might explain why Carvalho was not targeted by the fascist regime as were some other 'liberal' educators.

Chapter 8 will summarize the preceding chapters' main arguments and provide further comments and conclusions. It will provide an account of how Carvalho's educational project can be characterized as humanist, indicate some limitations in this study and present possible future research themes related to Carvalho's pedagogical work.

4. A note on sources and methodology

Naturally, Carvalho's pedagogical thought was examined in a specific educational context. Given the fact that Carvalho worked during a fascist regime, the political and educational context gained special attention, although they are not the main object of this thesis. My methodology consisted chiefly on document analysis. By document analysis I mean not simply the understanding of the content of the consulted documents, but a more indepth process through which I tried to comprehend the context, the rationale, the aims, possible motivations, suggest limitations, indentify the relationship among texts produced at different times etc. In short, analysing is in this thesis is a hermeneutic practice. No pre-defined routine, or 'method', was used here to analyse documents. In this sense, this was a process in which the questions of 'how'and 'why' were constantly raised when key texts were scrutinized. Ultimately, this aimed at gaining the sense of a meaningful historical narrative.

In practice, my task initially consisted of understanding as wide as possible this context and then move on for a scrutiny of Carvalho's pedagogical thought as it can be understood in this context. Thus, most of secondary sources used in this thesis are on the political and educational context in Portugal during Salazarism, and I will refer to them in chapter 2.

Carvalho's pedagogical work has been addressed by a number of articles or small-scale studies, in their overwhelming majority by people who met Carvalho, worked or studied with him, or were his relatives. In spite of the relevant information they provide and their usefulness in pointing out potential research resources, with few exceptions (J. M. d. Araújo, 2006; Beato, 2004, 2005; F. Silva, 2008), they do not provide an integrated account across the wide range of his work, many of them limited to paying him some kind of homage. However, because many of these authors lived or worked with Carvalho, these sources will be very often used in this thesis as *primary sources*, as a testimony of Carvalho's thought and attitude towards his teaching community. The critical examination of these small texts was useful to the extent that they served to create a broad picture of Carvalho's many activities and as a starting point in terms of mapping out a research strategy. Not less important, given the testimonial aspect of many of them, they also served as evidences for some of the arguments set out further above.

The arguments and conclusions presented in this thesis are naturally dependent on the availability of sources. Public homage praised the name of Rómulo de Carvalho, but criticisms on his work are scarce not to say non-existent. Particularly in chapter 6 and 7, the testimonies were used extensively, but the hagiographic message conveyed in some of them will be treated with scepticism, or at least admitting the possibility of bias. The testimonies' voices might be used as evidences for certain arguments, but the limits of the claim will be indicated in the due course.

I had access to virtually all published Carvalho's pedagogical articles and books. I also accessed the *Archives of the Ministry of Education* in Lisbon, where are kept several unpublished works, such as textbooks, as well as official decrees and internal documents relative to Carvalho and his contemporaries. In the *Hemeroteca library* (a newspaper archive) in Lisbon, several newspaper articles with a number of testimonies and interviews with Carvalho were consulted. I was also conceded access to Carvalho's personal documents, archived at the *National Library in Lisbon*, which keeps a massive number of letters, manuscripts, official documents, and pictures. Among these documents, Carvalho left a kind of auto-biography with more than a thousand handwritten pages which runs from his childhood to his professional activities. This text, as indicated before, was recently published in a book format with the title *Memórias* (R. d. Carvalho, 2010) and will be used extensively as it sheds light in a number of his educational activities. However, Carvalho's personal documents, particularly his *Memórias*, were analysed and used cautiously because of the possibility of their being 'self-serving'. More detailed information about sources will be provided in the due course.

Many primary sources used in this thesis were never published and therefore are not freely open in the public domain. They can be internal official documents, personal letters, reports etc, and are set out in the bibliography under the heading 'Unpublished sources'. However, because they do not follow a standard referencing style, the documents would not be easily identified in the bibliography. For this reason they will be also referenced in footnotes with details of their location in archives and libraries.

Finally, translating from Portuguese into English caused interpretative issues, mainly to strike a reasonable balance between the original meaning and readability in the English language. The philosophy used in this matter was, whenever feasible, to try to be as faithful to the original construction as possible, although sometimes I needed to adopt freer translations in order to make the text more intelligible. Related to this issue, some words or terminologies in Portuguese do not have a straightforward translation in English. In the main body of this thesis translational or interpretative problems will be signalled whenever they come up.

Chapter 2
Aspects of the political and educational context before 1948

1. Introduction

The role of this chapter in the thesis is to provide a broad political and educational context chiefly during Salazarism for the subsequent chapters. It will give particular attention to chemistry education in the liceus before the publication of Carvalho's 1948 chemistry programme.

This chapter will first provide an overview of the ideological mainstream which underpinned the Portuguese first Republic and the Salazarist regime. By this, it is intended to draw attention to the contrast between the liberal aspect of the former and the fascist aspect of the latter. Next, the role and the framework of the Liceu within the Portuguese educational system will be addressed, pointing out its elitist and humanistic aspects.

Afterwards, the chapter will provide an account of chemistry teaching before 1948, arguing that content and methodology *in the classroom* focused on canonical[16] scientific knowledge with extensive use of abstract concepts and of numerical problems. This study will give support to my argument in the next chapter, that Carvalho's 1948 programme provoked a 'shift' towards a more humanistic approach in science teaching in Portugal. Finally, it will be pointed out that many Portuguese science educators were committed to a teaching method for laboratory classes called 'heurism' (understood as a teaching method where the student should work as independently as possible at empirical investigation). This study will be relevant to the analysis I will carry out later of Carvalho's understanding on the use of experiments in school science.

This chapter uses both primary and secondary sources. The account of the historical role of the liceu mainly draws on secondary sources. That of the teaching of sciences draws on official documents of the Minister of Education (available in the Archives of the Minister of Education in Lisbon), and educational journals of that time. A class of documents, which sheds light in teachers' teaching practice was

[16] By 'canonical' I mean the 'official' knowledge as it is communicated within the scientific community, with all its official terminology, naming, and meaning, commonly detached from other 'mundane' affairs.

teachers' Official Reports. Until the fifties it was compulsory for some teachers[17] to write up a report with details of their professional activities. The content is diverse, and constitutes a rich historical source.

There are a number of studies of Portuguese science education which focuses on aspects of the 1947 liceal reform and its consequences. Some of these studies addressed the teaching of physics (F. Silva, 2008), the teaching of geology (Mota, 2001), the teaching of physics-chemistry sciences (Beato, 2003, 2004, 2005), teachers' views on the use of school laboratory (M. E. d. C. Martins, 2009), objectives of science education (A. M. Freire, 1993), and science liceal exams (M. C. Silva, 2008). Other accounts address more general political aspects of this reform (Adão & Remédios, 2008), or the textbooks contest in that reform (Beato, 2004), to cite only a sample.

The studies that I have accessed, which address science education in the Liceu in the first half of the twentieth century, explore the teaching of electromagnetism in the textbooks (Saraiva, Malaquias, & Valente, 2007), and the teaching of physics in laboratory classes (Amador, 2007; Chaves, 2008). Among these, the most relevant for the purposes of this thesis was Chaves' study on the methodology in laboratory classes during Salazarism, which describes the evolution of practical classes in the laboratory under the influence of several decrees from the beginning of the century. Chaves observes that the inductive method (which, as we shall see later, was extensively used by Carvalho and his contemporaries) was

[17] Liceal teachers used to be qualified as "Agregados" (those who did not have a place granted in any liceu, nor paid holidays), "Auxiliaries" (those who had a place granted and paid holidays, although he/she could be placed in any liceu) and "Efectivos", those who had a place granted in a specific liceu ("Decree 27084," 1936). "Efectivos" were not obliged to write reports (Ó, 2002).

recommended in some official decrees whereas the verification method was discouraged for laboratory classes. Chaves nevertheless does not scrutinize the actual practice in schools, and how teachers interpreted such recommendations. Another account on the history of science education, from the foundation of the Liceu in 1836 until 1926[18], is provided by Vasco Pulido Vatente (1973). The focus of his study, however, was the debate between the 'classics' and the 'moderns' upon the purpose of the liceal teaching. None of the studies referred to above provide information about *chemistry teaching* in the liceus before 1947/1948 to the extent it could shed light in the controversies caused by Carvalho's chemistry programme in 1948. These accounts also lack in depth empirical research about the contents and methods used by teachers in classroom and school laboratory.

2. An overview of the political context

The Portuguese First Republic (1910-1926) was a short but, at least regarding education, progressive period, when the improvement and democratization of the educational system was intended. However, according to many historians, politically and socially, the Portuguese First Republic was a very unstable period when the working class was not willing to accommodate to the patronage demands and rebellions and strikes were common (Mónica, 1978). There were no political means capable to absorb those conflicts which "broke the modernization process" (Pais, 2003, p. 141). Although there were "wonderful individuals, democrats, liberals!", it

[18] Year of the military coup that lead Portugal to the Salazarist Dictatorship (1934-1974).

has also been claimed that during the period of the First Republic, Portugal endured "a terrible time" (Teodoro, 1999b, pp. 23-24). On the 28th of May 1926 a revolution overthrew the First Republic Government through a military coup and established a dictatorship, which was, in the first place, very well accepted by all (R. d. Carvalho, 1986; Teodoro, 1999a). It aimed to bring back order and make the former liberal doctrine disappear (Mónica, 1978). The military Government led to what is known as the Salazarist regime, established in 1933.

The Salazarist regime ruled Portugal from 1933 to 1974. Some similarities between Salazarism and Fascism have been identified: they are both "anti-liberal, anti-communist, authoritarian, and nationalists" regimes (Mónica, 1978, p. 95). In the view of Rómulo de Carvalho (1986) and other historians, Salazar was, ultimately, a reactionary who fought against the democratic and liberal ideology of the First Republic (Baiôa, Fernandes, & Meneses, 2003). It was thus Salazar's aim to destroy liberal institutions and any working class organizations (Rosas, 1986). He intended to stratify the society, giving little room for social mobility with high social control, so very little was done by Salazar to instruct the working class (Manso, 2009). The role of primary education for the working class was limited to ratifying this rigid society, halting the circulation of ideas, insulating people from any revolutionary ideas, such as communist or anarchist influences, and encouraging pupils to accept existing conditions (R. d. Carvalho, 1986, pp. 726-757). Salazar's educational policy affected science studies in higher levels with outdated university science courses (Gibert, 1946) and overlooked the importance of the presence of outstanding refugee scientists[19] in the country (Fitas & Videira, 2007). The regime targeted democratic

[19] E.g. the Austrian theoretical physicist Guido Beck (1903–1988) and the Romanian-French theoretical physicist Alexandre Proca.

educators who had supported the liberal ideology of the First Republic. In particular, the regime targeted those who developed humanist initiatives during Salazarism in order to democratize knowledge and allow the working class to have access to humanist education with a libertarian connotation (Pintassilgo, 2006, Nóvoa, 1994). Salazarism tackled educational endeavour which would aim at intellectual emancipation, critical understanding and active participation in the construction of society.

The overall ideological aspects of both the First Republican regime and the Salazarist regime, briefly discussed above, will appear in different moments of this thesis. Of course there is much more to be said about these regimes, but, purposively, I am trying to be concise, as this is not the object of my thesis and I intend to use it as a backdrop. I will provide more in depth information about specific aspects of these regimes as needed.

Another important contextual aspect for this thesis is how secondary science teachers discussed pedagogical issues, and to what extent this discussion was affected by the Salazarist regime. Given the repressive aspect of the regime, one can query whether the regime controlled the pedagogical debate in educational journals. The section below will turn to this matter.

3. The pedagogical discourse during Salazarism

Probably the most important journal during the period before the 1947 Reform was the *Labor* (1926-1940 and 1951-1973), with wide contributions by liceal teachers. During a certain period *Labor* temporarily ceased publication (1940-1946) and the journal *Liceus de Portugal* rather took over its place. The articles found in those journals did not bear clear research in 'academic style'. Mainly, they were part of a big *internal* debate which teachers expounded their personal opinions, presented teaching experiences, suggested methodologies, made analyses about the science teaching scenario etc.

In spite of the dictatorship's repression on people's lives, in these journals all teachers enjoyed large freedom to suggest and criticize pedagogical issues. The extensive control of the educational system indicated by many Portuguese historians (Barros & Henriques, 1987; R. d. Carvalho, 1986; R. Fernandes, 1967; Mónica, 1978; Nóvoa, 2001, 2005, 2003; Nóvoa, Barroso, & Ó, 2003; Nóvoa & Santa-Clara, 2003; Ó, 1990, 2002) either in primary education or in the general structural organization of the Liceal teaching was not strong within the 'internal' debate upon liceal education. Teachers, Rectors, Ministries, or anyone who wished to make any input relative to education made wide use of these educational journals and others such as *Seara Nova* (1921-) and *Palestra* (1958-1974), to express their thoughts, to make suggestions, to criticise programmes, to criticize Government educational policy, to exalt either national or foreign values, to propose foreign teaching methods, etc. References to foreign educational practices and their educators, references to good measures taken during the time of the First Republic, positions against the nationalist and patriotic feeling, or even criticism on the Portuguese student's mental capability can be found in the pages of those journals. *Nearly* anything could be treated in that ongoing *internal* debate. Indeed, except from political ideology and its relation to the extreme catholic principles, anything related to liceal pedagogy could be and was openly discussed at any time during either the Military dictatorship or the New State.

One who explores the volumes of these journals will likely conclude that there was an active small group of teachers who contributed systematically, whereas some other teachers did it sporadically. The degree of involvement of a teacher with science education matters reflected not only in the amount they published in the journals, but also in directing those journals, writing textbooks, and writing science programmes. So, commonly, those main contributors of the journals were, to some extent, those who would come to interfere in the science educational curriculum. According to the tone of the articles, it seems these journals were also the means to pressure the Ministry of Education for changes. Indeed, at least in science education, the content of the texts presented, frequently, a kind of prelude to the changes in the science curriculum that were attempted.

4. The historical role of the Portuguese Liceu

The secondary school institution 'Liceu' was founded in 1836 in Portugal. Its role over the decades gained different interpretations by politicians, educators, and thinkers, which were to some extent echoed in some of the many liceal reforms, spread out in the nineteenth and twentieth centuries (Valente, 1973).

From their foundation to their end in 1974, all the liceus in the country shared the same curriculum and served boys and girls, whenever possible in separate schools. According to the analysis of Vasco Pulido Valente (1973), in different periods the liceus were supposed to provide either a) an *aristocratic (Nobre) education*: appropriated to gentlemen; or b) preparation for *practical life*: a comprehensive education to help students to deal with the modern industrial and scientific society, and to prepare them to productive social functions such as technical careers; or c) to make them able to follow up their studies in *university*. João Barroso (1995), addressing the different views of the role of the Liceu only from the thirties onwards, makes a similar analysis, while excluding the "aristocratic education", characteristic of the early years of the liceu.

Part of this change over time is due to the Liceu facing a peculiar situation within the Portuguese educational system. For its intermediate place, between primary school and University, it was supposed to provide both the necessary knowledge to deal with more mechanical jobs to those who would have the liceal course as their last studying stage, and also as a means to provide students the preparation to move on to a higher education. A liceal student would become a doctor, an engineer, a lawyer, a teacher, but could also work in, for example, public administration, clerical jobs, or as traders. Regardless their future, as it is commonly found in the many Governmental Decrees in the twentieth century, the liceu course should foster the development of students' faculties, their general culture, and the development of their "spirit"[20].

At least until late sixties, providing mass education was not part of the objective of the Liceu. Up to 1926, Lisbon and Porto have experimented with some modernization in the industrial and commercial sectors, closing the gap between them and other main European cities. However, Portuguese industrialization was centred in a static monarchical government without fertile soil for entrepreneurships, which triggered a slow and weak development (Mónica, 1978). Thus, as late as 1930, 80% of the seven million Portuguese people still lived in the countryside, where it was still possible to identify similarities with the feudal system (ibid). The Liceu was not designed to either educate or instruct that public. Due to the small amount of students who studied in the Liceu, being a liceu student meant being a part of the social elite, regardless of the content or methodology conducted in it. Indeed, in 1930, less than one third of the school population attended primary school. Millions were illiterate. Only 3,7% of those students who attended primary school followed up their studies in the Liceu (R. d. Carvalho, 1986), which meant a population of about seventeen thousand students (Alves, 2009). Roughly 80% of those students who attended the liceal course ended up in the university courses (R. d. Carvalho,

[20] Decrees did not spell out what the development of students' spirit meant. Drawn on secondary sources (Ó, 2009), it seems this meant a thoughtful youth, with physical and intellectual competences, disciplined, responsible, autonomous, and, ultimately, an active and entrepreneur citizens.

1986). During the twentieth century that picture improved significantly, but the status associated to the social class who could attend the Liceu remained always high.

Leaving aspects of social class behind, from 1894 was the period that, according to António Nóvoa (2005), the "modern Liceu" was created (p. 29), when the liceal teaching framework gained a well-defined double purpose. Since then, students who entered the Liceu when they were about ten years old and left it when were about seventeen, should attend the "General Course" and the "Complementary Course"[21]. These courses were also divided into "cycles"[22] as the table below displays. This framework remained virtually unchanged until the end of Salazarism[23]. The Table 1 below draws on the information provided by the 1917 liceal reform decree (Decree 3091, 1917).

This twofold organization would shape the structure of Carvalho's programme as we will see later. As a preparation for university courses and exams, the 3rd cycle (Complementary Course) was supposed to be concise, more abstract, focused on providing a solid knowledge base to those who wanted to pursue a university courses.

On the other hand, the General Course was intended to be more inclusive. The indication above that students should learn some "knowledge, usually useful as knowing" can be interpreted as an education capable of providing wide-range

[21] Not all liceus provided the Complementary Course, but only in the most important ones - called "Central Liceus" (R. d. Carvalho, 1986).
[22] Similar to the concept of 'stages' in the contemporary UK school system.
[23] The period from 1936 to 1947 was the only time this structure changed. During that period the 1st cycle comprised three years, the 2nd cycle also three years, and the third cycle only one year.

knowledge, exploring the different aspects of our culture; a preparation to understand and deal with the surrounding world, without any specialization, with no vocational ends.

Table 1 – The 1917 Liceal curriculum framework			
Course	**Students' age**	**cycles**	**Purpose**[24]
General Course[25]	From 10 to 12 years old	1st	Should provide the students a set of knowledge, usually useful as knowing and advantageous as a means to the regular and harmonic development of theirs faculties.
	From 13 to 15 years old	2nd	
Complementary Course	From 15 to 17 years old	3rd	Should enlarge students' education, and simultaneously prepare them to enter into the university courses.

A concrete example may best convey the purpose of education in a Liceu. Some of the liceus, located in the cities of Lisbon, Coimbra, and Porto, gained a prominent position due to their location and the work of their rectors. The Liceu Pedro Nunes, located in Lisbon, where Carvalho taught from 1958 to 1974, was one of them. Rectors were school principals who directed and organized their liceus and reported directly to the Ministry of Education. During the First Republic they were elected by the school council (a group of teachers) of each school, but during

[24] The purpose of the General and Complementary courses are translated from a Liceal Reform happened in 1917, and was used here for it is clearer than the 1894's, and it is more similar to the organization found in 1947.

[25] Regardless the period, in the twentieth century both physics and chemistry were taught from the 2nd cycle onwards together with the discipline of Natural History, and separately in the 3rd cycle.

Salazarism they were directly chosen by the Government, which rather transformed the pedagogical role of the rectors into a more bureaucratic one (Nóvoa, Barroso & Ó, 2003).

Founded in 1906[26] the Liceu Pedro Nunes was known to be concerned with pupils' *active* education, "a teaching with practical and experimental characteristics which was addressed to pupils' body and mind" (Nóvoa, et al., 2003, p. 65). Thus, since the beginning of the twentieth century, it took care with its facilities, providing laboratories, artistic drawing classrooms, and sporting activities. It was intended to work out "student's full faculties" in order to provide a comprehensive education. The outstanding position of this Liceu is largely due to the work of its founder, António Sá Oliveira, who ruled it from 1906 to 1919, and again from 1930 to 1941. According to Ó (2002), since its beginning, Sá Oliveira tried to implement in his Liceu the ideals of the *New School*: students were encouraged to work on their own, to organize expositions, to promote educative parties, and to develop Science Museums. Although it might not sound like the education for the elite, Sá Oliveira fought against the book-geared teaching and encouraged practical knowledge, like gardening, breeding and selling animals, like silkworms and birds, also encourage them to write reports, and to make data analyses. The Liceu Pedro Nunes was praised by educators for its organization and functionality - a school which served as an example to the others. The Pedro Nunes defended an education where the students educated themselves by personal conviction (Ó, 2002).

[26] Then still called *Liceu Central de Lisboa* (Central Liceu of Lisbon), changed its name to Pedro Nunes only in 1911.

5. The role of the Liceu during Salazarism

There were two main liceal Reforms during Salazarism, the first in 1936 and the second in 1947. As Marques (2003) has suggested, the Salazarist regime tried to condition liceal education to fit in the new society model Salazarism intended to establish, which aimed to subordinate people. As he claims, the liceal system expected that students were to "surrender to the motherland, and to passively adhere to the moral principles of the national education", students were to learn to be "subjected to the homogeneity of the totalitarism" (Marques, 2003, p. 136).

Arguably, these educational aims would place the humanistic/liberal aspects of the liceal teaching in an awkward situation. And in fact disciplines such as History seem to have been more controlled. According to Carvalho (1986), a Decree of April 1932 explains the History taught until then had been negativist and "defeat-geared"; and established that History teaching from then on should offer "the truth which interests the Nation" (p. 744). However, in spite of these ideological controlling mechanisms, as we will see in the following pages, in the 1947 Reform Decree there were clear orientations to avoid premature specialization.

In spite of the claim of promoting an anti-liberal education, Marques (2003) on the other hand also claims that since the thirties the Liceu gained an even more elitist aspect, with great investment in new buildings and facilities. He says that the Salazarist New State tried to draw a distinct line between the liceal and the technical teachings, as the former were supposed to provide a non-professional teaching, and focus on culture and morality. Confirmed by other sources, as Salazarism pursued social segregation, there was a deliberate intension to halt students' flow into the liceus and an encouragement to youngsters to follow the technical teaching (Barroso, 1995; Grácio, 1986).

There was an economical reason for this segregation. It happens that during the first half of the twentieth century Portugal urgently needed a qualified workforce but "in the thirties the technical teaching was visibly forsaken" (Grácio, 1986, p. 41). A technical teaching reform only started being organized in 1941 and was finally published in 1948. By this reform the Government intended to encourage students to enrol in the technical school, in order to diminish the pursuit for the liceal teaching and to foster the necessary workforce (Alves, 2009). The institution of a new technical teaching was immersed in the creation of a different educational system, with the coordination between the two educational branches, the liceal and the technical. Since a new concerted technical programme was instituted to provide the kind of teaching which would interest *industry and commerce*, the purpose of *Liceal* teaching was reinforced as the provider of a humanistic education, which would at the same time provide the utilitarian knowledge to deal and understand everyday phenomena and technology in the surrounding world, and a preparation for university courses. According to Alves (2009), with this measure

> the New State would maintain distinct functions for the liceal and the technical teaching, taking advantage of their different objectives to keep reproducing the separate social classes (…) with a broader role given to the technical school, once the Liceu is devoted to the education of the elite (Alves 2009, p. 34)

The coordination between the liceal and the technical branches is explicit in the Decree which established the new liceal reform in 1947, and was used to justify the needed changes:

> The Government recognized the urgency of a reform in the liceal teaching, not only because it formulated numerous repairs during the current regime, but for the need of coordinated measures between this teaching branch and the parallel branch of the technical teaching (Decree 36507, 1947, p. 879)

Addressing more specifically the programmes of the disciplines of the General Course (2nd cycle), the document ratifies its concerns with no early specialization, neither would there be a pre-professional aspects to its teaching:

> Programmes organization will aim to awake in the students the spirit of observation, foster the habits of reasoning and enjoyment of personal effort, it will encourage active exercise of reflection and criticism, to develop ethic and aesthetical sense and a creative imagination, *avoiding* the disordered accumulation of knowledge, *a premature specialization*, and excessive systematization (Decree 36507, 1947, p. 885, my italics)

The 3rd cycle (Complementary course), on the other hand, maintained the clear propaedeutic characteristic for the university courses: "After the General Course follows, therefore, specialized courses, constituted in harmony with the career to which the student bounds" (ibid, p. 883). As we can see in the table below, drawn from the 1947 Decree 36507, the aims of the General and Complementary courses are very similar to those in 1917, shown in Table 1 above.

Table 2 – the 1947 curriculum framework			
	Cycle	**Number of years**	**Purposes**
General Course	1st	2 (1st, and 2nd years)	Provide a more adequate culture to satisfy the common needs of social life, improvement of the intellectual faculties, and also physical invigorate, character formation, professional value, and to strength moral and civil virtues. (p.884)
	2nd	3 (3th, 4th, and 5th years)	
Complementary Course	3rd	2 (6th, and 7th year)	Besides the same objectives of the General Course, provide students' preparation to be admitted into superior courses. (p.884)

It was under these guidelines and under this new general organization between liceal and technical teachings that Carvalho wrote his 1948 chemistry programme. As we could see above, the liceal teaching had, in its history, aimed to prepare the Portuguese elite youth for 'life' (in its broadest sense) but with no early specialization. Since its foundation, its organization has been marked by broad knowledge, active teaching, but without a technical nor vocational aspects, which may be seen as a humanistic approach in education. I will seek to demonstrate in the next chapter that, although controversial, Carvalho's programme suited very well the humanistic aspects of the General Course, and the preparation for exams aspect of the Complementary one.

6. Chemistry teaching content and methodology before 1948

The source of the controversy in Carvalho's programme seems to be in its contrast with the previous programmes. An examination on the content and the teaching method of the 1936 chemistry programme (the last before 1948) will shed light in the controversies. There are two characteristics in the 1936 programme which are relevant to what will be discussed in the next chapter: its abstract content and the high use of numerical problems, as I explain below.

Possibly uncomfortable with the idea of inclusive education, the 1936 chemistry programme presented non-contextualized content, and aspects of technical teaching; also, references to everyday phenomena and the application of chemistry in technological artefacts gained only very marginal attention in chemistry programmes. The chemistry programmes of the 1905 (Decree 3) and 1936 (Decree 27084) were very clear to limit teaching to the canonical knowledge of chemistry such as chemical naming (representing elements by means of formulae and reactions by means of equations), the study of the characteristics of some elements (e.g. oxygen, hydrogen, nitrogen) mixtures (e.g. air and water) and notions of chemical concepts (e.g. atomic and molecular weight, valence, weight laws, atomic hypothesis).

To be more specific, the 1936 chemistry programme indicated that the liceal chemistry teacher was supposed to teach 14 to 16 years-old students[27] things like "Volume of gas state represented by chemical formulae"; "practical rule to the approximate calculus of gas or vapour density, when its molecular formulae is known"; "Practical meaning of the symbols of elements and of the formulae of compounds"; and "volumetric composition of a gas compound" (Decree 27084, 1936, p. 1269). The whole programme is concerned with chemical abstract concepts.

[27] At that time the 2nd cycle encompassed years 4, 5, and 6 of the liceal course. The 3rd cycle comprised only the 7th year.

These quotations above are only a small fraction of a number of properties and chemical naming that students were supposed to study. Students' knowledge about chemistry also encompassed notions of concepts such as body, mixture, composition, decomposition, metalloids, valence, oxygenate acids, salts, chloride, hydroxides, ethyl ether etc (ibid). As it is clear, chemical naming, formulae, equations, and abstract concepts were extensively taught in the 2nd cycle (General Course) of the liceus.

Following the orientation above, the questions used in liceal 'theoretical exams' were drawn on the prescription of abstract knowledge. In addition, the programme recommended that the mastering of all this chemical knowledge was supposed to be worked out by a number of 'numerical problems': "all elementary chemical calculus will be subjected to numerous and repetitive exercises, and students should learn to solve them promptly" (Decree 27084, 1936, p. 1270).

To give some examples, the questions in chemistry exams were structured along these lines:

> To neutralize an aqueous solute with 1/40 gram molecule of a certain organic acid, 50 cc of an alkaline solute were used. 0,44 grams of this acid, composed of carbon, oxygen… (…) Calculate: a) The acid acidity; b) The empirical formulae; c) The molecular formulae…[28]

[28] Physics-chemistry exame, 1946, in the Liceu Maria Amália de Carvalho. MEN, AHME. Fundo DGEL, "Exames", box 16/1963.

In another liceu, this traditional question was reproduced:

> A sodium soap is made of 50% of palmitate, 35% of stearate, and the rest of oleate. What mass of sodium hydroxide is used to make 10 kilograms of this soap?[29]

In different liceus the same 'kind' of questions were used to assess students' knowledge in the 2nd cycle with the same numerical-solving aspect, and with the constant use of chemical naming. The lack of questions with references to everyday phenomena or chemical experiments is another characteristic in these examinations. Given the influence that exams have on teaching, it is likely that the numerical nature of these questions with large use of chemical naming was one of the strongest characteristics of chemistry teaching before Carvalho's intervention.

7. Laboratory classes

Laboratory classes, where students could have the opportunity to work with laboratory apparatus on their own, were called *Trabalhos*[30] *Prácticos Individuais* (Individual Practical Works – henceforth *IPW*). They were formally introduced in the Liceu's curriculum in 1917 (Decree 3091, 1917), to be compulsory *only* in the 3rd cycle (Complementary course). The Decree emphasized that "the work should be individual" (p. 270) in order to foster "manual ability" and the "habits of investigation and criticism"; practical works should not be "mere recipe execution",

[29] Physics-chemistry exame, 1946, in the Liceu Manuel de Arraiaga na Horta. MEN, AHME, Lisbon. Fundo DGEL, "Exames", box 16/1963.

[30] "Trabalho" in Portuguese means "Work" in English. In the context of laboratory classes, maybe a better free translation would be "Activities". I still prefer the word "Work" as a way to preserve the faithfulness with the original title.

but rather “investigation of problems of interest to the students and which allow them, on their own, to enunciate conclusions”; and it should stress “measurement activities” in order to foster the “habit of scientific discipline”. In spite of the stress in the ‘scientific’ aspect of this activity, the aim of the IPW was, supposedly, to educate students’ faculties “regardless the destiny of their career” (p. 271).

The quotations above represent the pedagogical thinking of many influential science educators of the first half of the last century in Portugal, probably influenced by educational trends elsewhere. Álvaro Sampaio (1927), a science teacher of the Liceu de Aveiro has remarked that, amongst other purposes, “the teaching carried out in the liceus are supposed to try to create and develop in the students the habit of working, of method, of order, in a word, of mental discipline” (p. 180). Álvaro Machado, a physics teacher very respected within the scientific community, and author of some secondary physics textbooks (Sarmento, 1947), also believed that the ‘scientific method’ could help pupils in their everyday activities, and should provide the useful knowledge to cope with the world of that time (Machado, 1927).

The excitement around the educational and scientific benefits for the use of IPW echoed in several official documents. In 1929, in the Decree in which the new discipline programmes were published acknowledged that “the actual trend is indeed to make laboratory’s influence bigger and bigger” (Decree 16362, 1929). The Decree suggested that IPW contributed to the development of students’ a) *general culture,* for it improved their “direct observation capacity” and their “working method”; and because it fostered “prudence and mental honesty”, “cleaning habits”, and “manual ability”; and b) *scientific knowledge,* once it furnished “first-hand knowledge”, it awaked “students’ interest”, it promoted “clear questions comprehension”, and the improvement in the capacity to make "adequate expression". The educational and scientific usefulness of IPW classes seemed consensual within teaching community and were often reinforced by other educators, including Carvalho as we shall see later.

At that time, the 'teaching method' in IPW classes became a big issue, as this was intensely referred to either in educational journals as in teachers' Official Reports. Teachers used experiments to demonstrate, to prove, to help with concepts' visualisation, and also to generalize ideas. Amongst a variety of possibilities, one method gained prominence: the heuristic – a method also used in the UK and Germany at that time (Brock, 1973), which came to influence other educational ideas over the twentieth century such as teaching methods referred to as 'discovery learning'. The section below will address what this method entailed, and the extension to which it was used in the liceus.

8. Heurism in the liceal science teaching

In 1929, the physics programme orientates teachers in the following manner:

> The high pedagogical value of physics is in its experimental and mathematic feature. The great easiness in which experiments can be arranged, and the degree of certainty which physical generalization and inferences embodies, are perfectly adequate to the employment of the so called *heuristic methods* (Decree 16362, 1929, p. 101, italics in the original)

The passage above referred to physics IPW in the 3rd cycle (Complementary Course) *only*, and the same method was recommended for the teaching of chemistry years later. Before 1936, in the 2nd cycle (General Course), teachers were still supposed to perform experiments in the classroom, using as much as possible simple materials which could also be reproduced at home by the pupils.

The reference above to *heuristic methods* demands explanation for the recurrent reference to it by teachers and discipline programmes, and, more importantly for this thesis, because Carvalho tried to use it at least in the beginning of his career, as we will see in chapter 5. Such method is closely related to the name of the English chemist Henry Armstrong, who disseminated it throughout England. As Brock (1973) has pointed out, Armstrong studied in Leipzig, Germany, and brought from there, in 1870, a new view about the teaching of experimental sciences. When in Leipzig, Armstrong had the opportunity to study on his own, with much freedom, which made him an advocate of self-education through laboratory research. Armstrong believed that teachers should avoid simply giving the answers to pupils, and students should be the ones responsible for their own learning. The biggest educational aim, in Armstrong opinion, was not the gaining of knowledge, but the development of the power of students' self-initiative (Armstrong, 1898). In Armstrong's own words,

> Heuristic methods of teaching are methods which involve our placing students as far as possible in the attitude of the discoverer – methods which involve their *finding out*, instead of being merely told about things (ibid, p. 111, italics in the original).

Moreover, Armstrong believed that

> It is in no sense mere opinion on my part but a conviction gradually forced upon me and established beyond all doubt by actual trial and observation during many years past, that the beginner not only may but must be put absolutely in the position of an original discoverer (Armstrong, 1903, p. 253)

Armstrong, in many of his articles on science teaching, stressed active teaching centred on the student along with *laboratory techniques*. Indeed, if the idea was placing students to work as scientists, it would be expected that laboratory techniques would be part of their activities. Armstrong, in his writings to promote the heuristic method suggested, to quote some examples, activities such as “determine the composition of water” (Armstrong, 1884, p. 80), or how “to prepare hydrogen by the ordinary method of dissolving” (ibid, p. 81), or “lessons in measurement” (Armstrong, 1889, p. 93), where is found indications to teach the use of scales, to compare different kinds of measuring methods, to tabulate results, and to determine the heat capacities of some metals.

Speaking in the end of the nineteenth century, Armstrong said “technical requirements have been too long overlooked” (Armstrong, 1897, p. 104) in English schools. Maybe it was the case that Armstrong’s note on technical requirements was misinterpreted. Armstrong was indeed advocating a more practical science school, but he was cautious enough to warn about the danger in transforming the heuristic method to merely teach laboratory techniques: “Architects knowing nothing of the requirements have too frequently built (…) school laboratories which are mere slavish copies of those provided in colleges where technical education is given” (Armstrong, 1898, p. 118). In spite of Armstrong’s warning, as will be discussed in more detail further below, science books, such as Perkin & Lean's *An Introduction to Chemistry and Physics* (1913) with direct reference to Armstrong's method were full of references to laboratory techniques.

It is not clear when the use of heurism arrived in Portugal, but as it was indicated in the foregone paragraphs, there were already some indications of its influences in the 1917 Official Decree, with indications such as 'habits of investigation'. The physics programme did not prohibit the use of other methods, such as a 'verification method', as long pupils did not know beforehand the result of their measurements. However, heuristic method seemed to be the most appropriate or sophisticated method to be pursued as, quoting Hall[31], the verification method had a non-scientific attitude "carrying out an experiment which results are known beforehand" (Decree 16362, 1929, p. 104).

It is difficult to gauge the percentage of teachers who actually tried to use the heuristic method in IPW classes, as its actual use was a challenge for the lack of well prepared teachers and for the lack of proper material, chiefly in the smallest liceus (Pereira, 1928; Prieto, 1928). However, some teachers tried to share their experiences with this method on the pages of *Labor*. To give some examples, drawn from teachers' commentaries on their work, a revealing course set up was carried out by António Nicodemos Pereira, teacher of the Liceu de Vila Real (Pereira, 1928). In Pereira's view, the IPW should aim to determine constants, enunciate scientific laws, and to learn measuring with precision. In his course each student used to work

[31] Probably the American Edwin Hall who wrote a book with Alexander Smith, "The teaching of chemistry and physics in the secondary school" (Smith & Hall, 1902, p. 276). A comparison between Smith and Hall's book and science programme's orientation in the 1929 Decree indicates that the latter was, to a large extent, drawn on the former.

individually with a different experiment from his classmates. They were given questions/indications in "telegram language", such as "What is the calliper nature?"[32] or "Set the calliper to 28° 40'" (p. 296-297). Meanwhile, in laboratory classes with no more than eight students, the teacher could spread out his/her attention to all the students, and help with their doubts and difficulties. In the end of the activity, they were supposed to write a report about the work they have carried out with the problems. If not identical, such methodology is at least very close to the heurism. As another example, in Figueiredo's science programme proposal (Figueiredo, 1927), apart from the many references to experimental verification, everyday life, technological applications, industrial machines, there are also extensively references to laboratory measures and "rediscovery of physics laws" (p. 304). Paulo José de Cantos, a science teacher of the Liceu Póvoa do Varzim, used to make his students rediscover the pendulum's laws in his lessons (Cantos, 1928).

The use of heurism as a teaching method in the IPW classes gained great prominence in the chemistry programme of 1936 Reform, as laboratory classes were transferred from the 3rd cycle (Complementary Course) to the 2nd cycle (General Course), as will be discussed below.

9. IPW in the General Course 1936-1947

From the end of twenties, it was argued in Official Decrees that the IPW should be extended to the General course, since all children were able to employ "all mental

[32] In Portuguese: "Qual é a natureza do nónio?"

activities which are intended to cultivated by the study of sciences"(Decree 16362, 1929, p. 95).

This was probably the result of António Augusto Riley da Motta's[33] work. Riley da Motta (1893-1967) was one of the greatest advocates of the use of experiments in science classes in the liceus, both in the laboratory and in the classroom. One could see Riley da Motta defending that laboratory programmes were now "trying to touch the main disciplines' branches and to exemplify the kinds of the most essential *laboratory techniques*" (Motta, 1930, p. 248, my italics). He was a science teacher of the Liceu de Antero de Quental, in Ponta Delgada, became rector of that Liceu in 1936, and in 1940 became Director-General of Liceal Education ("Dr. António Augusto Riley da Motta," 1940). He was very involved with every sort of issue related to science education, and constantly used the pages of the educational journal *Labor* to express his thoughts. Riley da Motta was a trusted man for the Salazarist Regime (as his promotion to become a rector indicates) and his influence upon political decisions was clear. As was stated on the pages of the *Labor*, the Government Bulletin "Diário do Governo" (Official Daily Bulletin of the Portuguese Government) "frequently heard him" ("António Augusto Riley da Motta," 1937, p. 338).

In 1930, Riley da Motta argued that if it was necessary to choose, it would be preferable to offer laboratory classes in the General Course than in the Complementary one. In that case, in his opinion, an "active teaching (…) with small paper instructions about very simple experiments to be carried out *by them*" (Motta,

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[33] As later on we are going discuss in more detail, in 1950 Riley da Motta and Rómulo de Carvalho submitted a chemistry book (Motta & Carvalho, 1950) to the 2nd cycle of the liceal teaching.

1930, p. 247, emphasis in the original). The emphasis on "*by them*" is a criticism about the then prevailing methodology, in the General Course, in which demonstrations were performed solely by the teachers in the classroom. Riley da Motta supported the first-hand, self-governed, and experiment-geared ideal of heurism, as he recommended two books[34] with similarities to Armstrong's heurism (Motta, 1930).

In 1934, Riley da Motta made a claim in the pages of the *Labor* to bring the IPW to the General Course and expounded, in his opinion, how science curriculum and methodology should be set up in the upcoming years. It is noteworthy that Riley da Motta's description of IPW classes had many aspects of heurism, such as pupils working independently and drawing conclusion by themselves.

> Students, soon in their first school day, will not go to the classroom but to the laboratory, in turns. The book will be a practical handbook (…) Each student will work in his place with simple things. The teacher will walk among them teaching as less as possible (…) [and] will leave them draw conclusions, even wrong ones. After some days of this work, the teacher will take the class to the lecture theatre (…), will draw conclusions with the class (…) will carry out some more delicate experiments and will make, with the class, generalizations (…) Summing up (…) from concrete to abstract, from particular to general (Motta, 1934, p. 530)

The 1936 liceal Reform (Decree 27084, 1936) complied with Riley da Motta's recommendations. The IPW that used to be carried out *only* in the 3rd cycle was basically moved to the 2nd cycle (General Course). Addressing the authors of the

[34] Motta quoted: Smith & Hall's The teaching of chemistry and physics in the secondary school (Longmans) and Perkin & Lean's Introduction to the study of chemistry (Macmillan)

textbooks which were supposed to be written in accordance to it, the new 1936 chemistry programme makes reference to an English chemistry textbook (Perkin & Lean, 1913). In the English book's preface, the authors advocated that "gaining knowledge" (p. vii) is more important than "knowledge itself" (ibid), that is, students were supposed to "learn how to learn" (ibid). In their textbook, Perkin & Lean refer to Henry Armstrong as the leader of that movement and were amused to note the curriculum proposed by the Incorporated Association of Headmasters "dealt with [their] manuscript" (ibid). They had in common "the cultivation of a spirit of inquiry" (ibid).

Contrary to some traditional humanistic approaches in education which avoids early specialization, the programme also presented strong technical aspects. The chemistry laboratory classes stressed "laboratory operations" such as: "triturating", "dissolution", "filtering", "distillation", "precipitation", and "exercises of current technique": "glass working", "cork working", "flask cleaning", "considerations on laboratory accidents" etc. (Decree 27084, pp. 1269–1270).

Heurism and its technical features did not have a long life in the Liceus. As discussed before, probably because of the reinforcement of the elitist aspect of the Liceu in comparison to technical teaching, the 1947 Reform moved 'laboratory classes' back from the 2nd cycle (General course) to the 3rd cycle (Complementary course). This change caused revolt in the science teaching community (Beato, 2005), and in Carvalho (1947) as well. From the perspective of some science educators, the loss of IPW in the 2nd cycle should have been the most negative alterations in the new liceal curriculum in 1947 (Teixeira, 1951a). Statements made in the teachers' Official Reports, as the following one, were not rare: "Doubtlessly the absence of

IPW was a great difficulty, mainly in the initiation of physics, which obliged me to a great waste of time and effort, not always with the desired result"[35].

In the next chapter, we will see that Carvalho was criticized by some of his contemporaries because of the alterations he introduced in the chemistry programme in 1948. I wish to advance here that this criticism might have been amplified by the supposition of his involvement in the withdrawal of IPW from the General Course. Actually, I do not have clear evidences of whether he participated or not in the decision to withdraw IPW from the General Course, however, this possibility was ventilated a few years after the 1947 Reform, in a public debate involving five articles published on the pages of the educational journal *Labor*, between Carvalho and another influential contemporary science teacher, José Augusto Teixeira. José Teixeira (1914-1991) was a prominent science educator in Portugal, the editor of the renown journal *Labor* of which Carvalho was one of its contributors. He became a very respected teacher, having taught in the Liceu de Aveiro and Liceu Camões, in Lisbon, and participated in commissions to study new laboratory material to secondary and university courses (Nóvoa, 2003). He also wrote physics and chemistry textbooks for the liceal teaching, and was a great advocate of practical activity in the liceal course, having written a number of articles for its use.

In the above referred to debate, Teixeira and Carvalho discussed the alterations in the chemistry programme of the General Course. This debate is a useful source of evidence on Carvalho's view of reform and I will return to it in the next chapter. The following excerpt, stated by Teixeira, belongs to the referred to debate

[35] MEN, AHME, Fundo 13 "Relatório dos professores", box 2, Historical Archive nº 114 (academic year 1947-1948). Helena Paulo Vital, teacher of the Liceu da Infanta D. Maria.

in March 1951, and refers to the lack of experimental practice of students in the new chemistry programme:

> [Students] in chemistry classes see [demonstrations] or simply listen. And in this aspect we register regression. As we pointed out in a previous article, in the 2nd cycle students carried out [experiments] by themselves, one and half hour per week. (…) The greatest interest in chemistry relays on experiment – all of us agree with that. There is lack of interest whenever the experimental conditions fail. We therefore need to think carefully and calmly assess if there were drawbacks where the alterations in the programme were deeper (J. A. Teixeira, 1951a, p. 117-118)

Indeed, Teixeira (and perhaps others) suspected Carvalho's involvement in the withdrawal of IPW from the General Course. In Carvalho's personal documents[36], there are some letters from Teixeira to Carvalho during the time these articles were published. In one of these letters, written in April 1951 (after Teixeira's first article), Teixeira said the following:

> I would like to thank you for your considerations about the IPW. (…) I am glad to know that you did not have any responsibilities about the classes' time span – a hypothesis that I, by the way, posed on you[37]

Unfortunately, I did not have access to Carvalho's 'considerations about the IPW' which Teixeira refers to above (this should have been done in a letter from Carvalho to Teixeira). Only in November 1951, in the last article of the debate, Teixeira finally reveals that nobody really knew who had decided to withdraw IPW from the General course.

[36] BNP, section "Reservados", "Archive 40".
[37] Letter from Teixeira to Carvalho in April 1951, at BNP, section "Reservados", "Archive 40", box 3, folder "Labor".

> The new [physics and chemistry] programmes invested against symbology. But worsen than the attack on the symbology was the retreat to active chemical experimentation of students. The responsible for such regression we do not know (J. A. Teixeira, 1951b, p. 229)

The withdrawal of IPW from General Course should have been related to the new educational system the government was implementing with the investment in the new technical school. Such alteration affected science education at least until the end of Salazarism in 1974, and of course also affected Carvalho's work as a science teacher. With this alteration, from 1947 onwards teachers could only use experiment 'demonstrations' in *the classroom* in the General Course. Probably for this reason, the 'movement' for the use of experiments from the twenties on the pages of *Labor* lost momentum, and the use of experiments in the General Course became a marginal issue. As we shall see in chapter 5, Carvalho had a different understanding for the use of IPW classes, but because practical teaching in the liceu considerably lost terrain, Carvalho's work to promote the use of experiments turned out to be of great value from the fifties to the seventies. Carvalho's performance with experiment demonstrations was very admired by many of his students and trainees, which, by the way, became one of Carvalho's strongest characteristics.

10. Conclusion

As a conclusion for this chapter it can be said that, historically, the Liceu has served the Portuguese middle-class both as a preparation for everyday life and as a preparation for university courses. Before 1948 science disciplines tried to provide these two preparations by teaching the 'canonical' knowledge and laboratory techniques. Content chemistry was mainly non-contextualized and in IPW classes the teaching method heurism gained prominence. The repressive aspect of the Salazarist regime did not seem to affect directly the pedagogical discuss in science education. However, in the forties, it tried to improve the quality of the working class and instituted a reform of the technical teaching. This affected the 1947 Liceal reform, which intended to avoid early specialization and promote even more the elitist aspect of the liceal education. This reform set out very sharply the distinction of aims between the General and Complementary Courses, which should have influenced the decision to move IPW classes from the former back to the latter.

When Carvalho wrote his chemistry programme one year later in 1948, he tried to comply (biased by his own understanding) with the framework set out in Table 2 above (which emphasized the different purposes for the General and Complementary Courses), and this provoked another substantial alteration in the content and method of chemistry teaching in the classroom, as we will see next.

Chapter 3

Carvalho's 1948 Chemistry Programme

1. Introduction

After instituting the 1947 liceal reform, which set out a new coordinated organization between the liceal and the technical branches, the Government published in 1948 the disciplines' programmes. The programmes prescribed classroom and laboratory content. They also presented a section called 'Observations', which orientated teachers and textbook writers about teaching methods and disciplines' aims.

Carvalho was the author of the chemistry programme, and in its 'Observations' section he explained teachers the following:

> The new chemistry programme to the 2^{nd} cycle now presented, although comprising much information already taken part in the previous programmes, is radically opposite to what has been instituted. (…) In many points and, in particular, in the 2^{nd} cycle the programme makes its way towards new paths, newer, by the way, in the disposition than in the subject. (Decree 37112, 1948, p. 1161)

Carvalho added that the framework of his programme was in accordance with the sharp distinction between the objectives of the two cycles. These objectives were, in his opinion (perhaps with some irony), "present in the spirit of everybody" (Decree 37112, 1948, p. 1161). It has been claimed that Carvalho's programme aroused a "controversy in the midst of [his] pedagogical group" (Beato, 2005, p. 14).

My aim in this chapter is to examine the aspects and the rationale of Carvalho's 1948 chemistry programme for the General Course, compare it with the previous one, and try to shed light on the source of the controversy. I will also describe Carvalho's programme for the 3^{rd} cycle (Complementary Course), as this will furnish a more thorough account of how Carvalho envisaged the overall chemistry teaching framework in the liceus.

This programme is one of the central examples within the thesis of Carvalho's 'humanizing agenda'. It is made the more significant because in it is found the first major opportunity that Carvalho had to influence practice on a wide scale. I will argue that his approach was very much geared by the need for context and meaningfulness in science education as a way to comprehend the world. His objective, in contrast with the previous programme, was to make the process of learning more joyful and meaningful to the students in the 2nd cycle. Concomitantly, through the new teaching orientations, he aimed to enable students to gain effective understanding of what, in his view, they so commonly verbalized meaninglessly. Some probable influences Carvalho might have received from other educators will be pointed out.

This chapter also argues that Carvalho's chemistry programme for the 3rd cycle (Complementary Course) was based on the canonical knowledge, demanding, selective, as it was devised to provide a full preparation to those who wished to pursuit science university courses. It is in this cycle that Carvalho introduced the learning of chemical symbols by means of its history. The final part of this chapter assesses the likely impact in teaching practice by analysing teachers' reaction. It also examines the effectiveness of Carvalho's programme in the sense of actual use as originally proposed.

Primary and secondary sources have been used in this study. Document analysis was carried out substantially drawing on official documents and Carvalho's writings which encompassed his articles, Official Reports, decrees, and guidelines of his 1948 chemistry programme.

The section below briefly explains how Carvalho was nominated the author of a national liceal programme. This will contextualize the intervention, shed some light on the important issue of how Carvalho rose in the national educational panorama, and will help to understand later how Carvalho was able to make such a radical reform virtually on his own.

2. Carvalho's nomination as the author of the chemistry programme

As discussed before, Riley da Motta, a very engaged and influential science educator became in 1940 Director-General of Liceal Education.

If as an ordinary science teacher and as a rector Riley da Motta used to be frequently heard by the Ministry of Education ("Dr. António Augusto Riley da Motta," 1940), now as Director-General he was even more powerful and, very likely, more influential to the Ministry. Directed by Riley da Motta, the "Commission for liceal curriculum reform" (*Comissão de reforma dos estudos liceais*)[38] was set up in 1944[39] to review and reorganize the disciplines' programmes, in order to simplify and increase their efficiency, and also to devise a better way to prepare students for superior courses[40]. He started organizing this commission as early as August 1941, as Carvalho received a letter from Riley da Motta indicating he was chosen to participate in the organization of the new physics and chemistry programmes. Another teacher, Carlos Cerdeira Guerra, was also appointed to work alongside Carvalho [41].

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[38] MEN, AHME, Fundo DGEL, box 13/1790

[39] Official Daily Bulletin of the Portuguese Government, 11/11/1944, Portaria of "Pedagogical Section"

[40] In 1936, the three cycles of the liceal course where divided into 3+3+1 years. This means that the 3rd cycle (Preparatory Course) encompassed only one year, as it was the intention of this reform to focus on pupils' general culture, and to overlook preparation for university.

[41] See Carvalho's personal documents at BNP, Archive 40, box 4, folder "vida professional".

However, in spite of his dedication and acknowledged work for science education, Riley da Motta was dismissed from his function in 1946, only one year before the 1947 Reform was instituted, for his “levity” in consulting liceal teachers about co-education in the liceus, an unacceptable issue within the catholic-driven Salazarist ideology (R. d. Carvalho, 1986). It is very likely that his absence from the General Direction of the Liceal Teaching weakened his influence in the upcoming reform. After this event, Riley da Motta indeed disappeared from the educational journals where he frequently shared his pedagogical views.

The Reform was published on the 17th of September 1947 in the Official Daily Bulletin of the Portuguese Government (Decree 36507, 1947), and only one month later a document was sent to all liceal rectors with the programmes of the disciplines to the 1947/1948 academic year (it contained roughly the *same content* found in the previous programmes), and also saying:

> It was not possible yet to proceed with a thorough reorganization of the existing programmes in order to simplify them to the new study plan, but hopefully this will happen by the first half of the academic year which initiates now[42]

Intriguingly, after five years with a commission working on the revision of the programmes, the Ministry of Education issued roughly the same programmes of the previous 1936 reform. It is not known in which direction the Commission was heading to, but the excerpt above is an indication that its work was, at least temporarily, disposed. Now without Riley da Motta as the leader in science

[42] MEN, AHME, fundo DGEL, Série “Diversos”, Box 13/2270. Also published in the Official Daily Bulletin of the Portuguese Government, I Série, N. 231, in 4/10/1947.

education, the Ministry needed to nominate new authors for the discipline programmes.

There is very little information about the transition from Riley da Motta's dismissal to the process of choice of the new authors of the physics and chemistry programmes. In fact, official documents do not posses this information, and it is still not known who the authors of the physics programme of the 1948 reform were. The only information about Carvalho's nomination as the author of the chemistry programme is given by Carvalho himself. He explained in his book *Memórias*, his auto-biography, that in August 1948 he was contacted during his holidays by the then Minister of Education to write a new chemistry programme for the new academic year, which was about to start. Without planning, without sharing ideas to anyone else, Carvalho wrote his programme. In his words: "Thus I did it, alone on the beach, sitting on the sand, without any consulting source nor anyone with whom I could exchange impressions"[43] (R. d. Carvalho, 2010, p. 290).

Carvalho indeed wrote his programme without any wide discussion with other science teachers, which triggered dissatisfaction from some of his contemporaries, as we shall see later. Nevertheless, it is likely that this autonomy enabled him to "radicalize" chemistry teaching in the liceus.

[43] This may be true, but considering Carvalho's knowledge about foreign educational publications, it is likely Carvalho wrote his chemistry programme with their virtual support.

3. The Innovations in Carvalho's Chemistry Programme to the General Course

On the 22nd of October 1948, only two months after Carvalho was contacted by the Minister, his chemistry programme was issued in the Official Daily Bulletin of the Portuguese Government along with all other disciplines (Decree 37112). As was discussed in the last chapter (see Table 2), the new liceal curriculum set out very clearly the different purposes of the 2nd and 3rd cycles: the former more concerned with everyday life, whereas the latter a preparation to university courses. It is not known what the Minister told Carvalho when he was contacted, but it is clear that Carvalho agreed with the new cycles' purposes as he defended it few years later by means of two articles (R. d. Carvalho, 1951b, 1951e).

There are two important aspects to be compared and analysed between the 1936 and 1948 chemistry programmes: their *contents* and *teaching methodologies*. Carvalho divided the 2nd cycle's chemistry content through the three-year programme as follows: "in the 3rd year the air and the water are studied; in the 4th, home substances where the carbon is introduced; in the 5th, the metal and metalloids" (Decree 37112, 1948, p. 1161). The Table 3 in Appendix 2 provides a sketch of the 1936 and 1948 programmes relative to the 2nd cycle (General Course).

As we can see from Appendix 2, in 1936, the focus was on the learning of the canonical scientific concept, the chemical elements, the chemical formulae, and chemical naming. For example, part of the 4th year 1936 programme is the notion of

"Body and substance", and "Practical meaning of symbols of the elements and of formulae of compounds". In the 5th year we can see "General idea of the chemical naming: anhydrides, oxides, hydroxides, acids, bases, and salts; and in the 6th year something like "Elementary study of some of the most important aromatic hydrocarbon: benzene, naphthalene. Turpentine and camphor. Phenic acid and aniline". There were no explicit references to everyday phenomena or application of the scientific concept in technological artifacts, with only few exceptions in the 6th year.

On the other hand, Carvalho's 2nd cycle's chemistry programme gave substantial more attention to the link between chemical knowledge and its applicability (in everyday life or industry) than the previous one, concomitantly avoiding abstract chemical concepts. Carvalho divided the whole programme into themes or 'home substances', such as air, water, coal, wine, wood, metals, metalloids etc. That was an innovative approach in the teaching of chemistry in the liceus, which José Teixeira usefully came to name them, few years late in 1951, as "Study Centres" (J. A. Teixeira, 1951a). There are a number of examples spread out throughout the programme, which are potentially more meaningful approach to science education such as "careful observation of the most important minerals in Portugal", or "animals' and plants' breathing" (Decree 37112, 1948, pp. 1157-1158). Following this idea, the "Observation" section of the 1948 chemistry programme stresses that, differently from the previous one, the study of, for instance, "volumetric composition of certain combinations, [and] the occupied volume by a molecule-gram" (ibid, p. 1161) are not part of the new programme.

Carvalho's programme also gave substantial more attention to history of science. It indicates the study of "Lavoisier's experiment", "history of the discovery of the oxygen and nitrogen", "Cavendish, Nicholson", and the "history of hydrogen and water composition discoveries" (Decree 37112, 1948, p. 1157). In Carvalho's view, these historical accounts were not supposed to be just factual historical ones. Indeed, Carvalho's chemistry textbook, written to his own programme some years later, provides an account of the difficulties faced by scientists, such as explaining the development of experiments and of ideas carried out by Lavoisier, Scheele, Priestley, and Daniel Rutherford in their endeavour to interpret chemical phenomena involving oxygen and nitrogen [44].

When we turn to *teaching methodology*, differently from the 1936 programme which stressed the use of chemical naming, chemical formulae, and 'repetitive numerical problems', in 1948 it was Carvalho's aim to change the view that chemistry is a science "bristled of formulae" and that learning chemistry did not mean "writing a memorized equation" (p. 1161). So, again in the 'Observations' section, the orientations to the use of chemical symbols and formulae were:

> There will be indicated symbols and their numerical value and, every so often, a formula will be presented so that the student always comprehends what it means. The fundamental interest of the knowledge of formulae is concentrated in this meaning, in the 2nd cycle, and in no way is it desired for students to know them by heart. Chemical phenomena will be introduced by equals sign, corresponding to chemical phenomena where the compounds are represented by their names and not by their formulae. (…) Formulae will be

[44] MEN, AHME, Fundo DGEL, "Manuais Escolares", box 15/1931. Carvalho's 1952 chemistry textbook "Compêndio de Química para o 2° ciclo (texto)", pp. 8-11.

> a detail and not the unbearable terror that they constitute many times (Decree 37112, 1948, p. 1162)

Furthemore,

> Evidently, numerical applications will not be excluded. Their utility is not denied, but only the domination they have enjoyed (ibid, p. 1162)

The 'Observation' section also indicated that most appropriate teaching methodology under his new proposal was what is known as *Lesson on Common Things*, which also demanded a sense of contextualization from the student. In the literature, the goal of *Lesson on Common Things* has been described as the "intellectual development of children, the acquisition of scientific knowledge, and the provision of experiences for the exercise of the reason, speculation and imagination" (Hodson & Prophet, 1983, p. 172) and also "to quickening the powers of observation and increase skills in the arrangement and classification of objects" (Layton, 1973, p. 24). It is described as oral lessons, illustrated by apparatus, models and experiments. Although scientific knowledge was communicated, their objective was not to foster scientists. Lessons on Common Things were also seen as those which could provide useful knowledge that could help pupils to understand the surrounding world, to help them in performing their professional activities (Layton, 1973, pp. 24-27), and should constitute elementary science in so far as they helped pupils "to observe some of the facts of nature upon which natural science in founded" (Jenkins, 1979, pp. 38-39).

As Carvalho suggested, chemistry lessons should be joyful, the teacher should illustrate abundantly, practice, interest, kindle, and students “should be pleased to what they see and listen, as they do with their improvised play” (p.1162). This method was another innovation in the 2nd cycle chemistry programme. The innovation was on the fact that *Lesson on Common Things* was normally used in the first years of pupils’ contact with sciences, as it was referred to for some times by other science educators in Portugal in previous decades on the pages of educational journals, but always proposing it to the 1st cycle. Its major advocate in Portugal was Alvaro Machado, already mentioned here in Chapter 2.

These are indications that Carvalho’s chemistry programme in the 2nd cycle focused on the teaching of what might have immediate use in students’ life, and that could help them to appreciate their surrounding world. There was very little attention to the canonical knowledge, which was left, as will be discussed later, to the 3rd cycle, to those students who wanted to pursue a university course in sciences. All of this does not explain, however, what Carvalho’s rationale was. The next section will scrutinize this matter.

4. Context and Meaningfulness in Carvalho's Rationale for the General Course Chemistry Programme

> At that time [in the liceu] there were exercise books to train students to solve many problems, even without awareness of what they were doing. Many times I saw students complaining about their low attainment in exams, saying 'but I solved 600 problems!'. They were right, but the truth is that they did not know the subject matter, neither know how to resolve the problems unless by following a predefined scheme ("O Polémico Livro Único," 1988, p. 8)

The excerpt above was taken from an interview with Carvalho in 1988, forty years after he wrote his chemistry programme. In spite of the distance in time, this excerpt still seems to convey the same feeling that drove Carvalho's rationale, as this section will argue.

Examining Carvalho's rationale for his 1948 programme is essential for the aims in this thesis, as it intends to explore Carvalho's pedagogical thought. This task is somewhat challenging because he did not write many texts concerning, specifically, the teaching of chemistry. In fact, only his 'Observations' in the programme and two more articles written in 1951 focused solely on chemistry teaching. These two articles (R. d. Carvalho, 1951b, 1951e) were part of a public debate[45] which occurred on the pages of *Labor,* already mentioned in Chapter 2. They were responses to José Teixeira's criticism about the new chemistry programme, which will be analysed in more detail in the next section along with

[45] Starting with a José Teixeira's article, the whole debate took place in five articles (R. d. Carvalho, 1951b, 1951e; J. A. Teixeira, 1951a, 1951b, 1951c).

other teachers' reaction to the new chemistry programme. All other Carvalho's writings dealt with the teaching of physics. Nonetheless they can still be useful to the understanding of Carvalho's rationale in 1948 due to proximity of general guidelines in the programme of these two disciplines: both avoided canonical knowledge and emphasised contextualized content in the 2nd cycle (General Course).

The analysis of these materials indicates that, as far as the General Course is concerned, Carvalho wrote his programme taking into account two main 'principles' which are very much in tune with some views of a humanistic education: suitable knowledge for pupil's age, all-round education, and contextualization. The principles focus on utilitarism and true learning. I named them as *educative* and *cognitive* principles, explained in more detail below.

Regarding the *educative principle*, in Carvalho's opinion, studying sciences in the General Course should mirror real life and thus contribute, along with other disciplines, to the education of citizens conscious about their surrounding world, with very clear *utilitarian ends*. To fulfil this aim, content should be more concrete and related to the everyday world, whilst problems should be more chemical and less arithmetical, and also related to the real world. These concerns are found in the programme's Observations:

> The student who leaves school after having completing the 2nd cycle [General Course] needs to carry with him a small amount of knowledge which is advantageous, understandable and simple (…) it values what is useful, what can serve immediately to the elementary appreciation of the surrounding world (…) the programme should be structurally simple and of immediate interest. (Decree 37112, 1948, p. 1161)

In 1951, in the debate with Teixeira to be discussed later, Carvalho widened the account of his rationale to the General Course. Teixeira's criticism was based on the unfeasibility in teaching that content (i.e. coal, wine, milk, cotton etc) by means of experiments, and also that the use of formulae simplifies the study of chemistry, so that teaching without them was more difficult.

Carvalho explained that his rationale was based on two questions that he himself raised: "what is the purpose of the General Course?" and "how can that purpose be achieved?" (R. d. Carvalho, 1951e, p. 199).

As far as the first question is concerned, taking the quotations below, Carvalho believed the General Course was not a place to teach chemistry or any other discipline in a strict sense, but it should provide as much of a wide and comprehensive education as possible to help students cope with everyday situations. That is, the study of physics and chemistry in the first years was important as a simple part of an interwoven utilitarian whole. In a bold revelation (perhaps for the heat of the debate), Carvalho said he believed the subjects studied in the 2nd cycle were neither chemistry, nor mathematics, nor Portuguese, nor any specific discipline and said that

> I only consider myself a chemistry teacher when I teach in the 3rd cycle [Complementary course]. There, students are, for me, chemistry students. I would feel, however, rather dislocated if I looked at students in the General Course as a chemistry teacher (R. d. Carvalho, 1951e, p. 199).

Now to turn to the second question (on how to reach the intended purpose of the General Course), he said that regardless of the discipline, "teachers (…), in a joint effort, [should] try to make them [students] citizens aware of their surrounding realities" (ibid, p. 199). Whereas some teachers of other disciplines should teach, for example, how to express ideas and feelings in the right way, or teach to respect the work of those who came before us to the construction of the world we live in today, the science teacher could contribute to students' general development, teaching them "to appreciate physical and chemical phenomena that nature or experiment put easily within our reach, making them realize the human effort to take advantage of them" (ibid). In other words, Carvalho was advocating an inclusive chemistry teaching, which should teach a content that could be meaningful and useful to all students regardless their future careers, with no specialization, and appreciating the wealth of science in the history of our civilization.

Turning now to the question of numerical problems and chemical symbols, Carvalho advised teachers in the Observations that "Problems must be simple, must have chemical interest, and not numerical, and must correspond, as much as possible, to realities" (p. 1162). According to some of his articles, by "realities" he meant problems we might encounter in our everyday lives. Different writings have revealed that same concern. For example, in 1947 Carvalho published an article in the *Gazeta de Matemática*[46] where he revealed his concerns upon the relation between physics and mathematics in the early years of physics teaching. He believed that the frequent use of carefully chosen equation with whole roots of equation was "truly counter-educative because it completely sets apart school from life" (R. d. Carvalho, 1947g,

[46] A journal founded in 1939 which aimed (and still aims) maths teachers and students of all teaching levels.

p. 13). Solving repetitive numerical problems, he believed, addicted students to relay the correctness of their results solely on the numerical answer (i.e. whole number or not, implies correctness or not) of their calculations (R. d. Carvalho, 1952a). Carvalho maintained that mindset until the end of his career. Nuno Crato, who was Carvalho's student in the Liceu Pedro Normal Nunes in the sixties, has recently pointed out (Crato, 2006b) that Carvalho always tried to use real data in the exams. Crato mentioned a case where a student asked Carvalho about the "weird" value for the volume capacity of a bottle (something around 1.08 litre), as the student thought it was just to make it more complicated; Carvalho replied saying he had measured its volume beforehand in order to introduce it in the question, because he liked to work with real data.

Now regarding the *cognitive principle*[47], there were different aspects of teaching that contributed to cognition in Carvalho's view. A lasting learning, which frees students from repeating meaningless words and move towards understanding an inter-related world, is central to some contemporary humanistic approach in science education as we saw in the introduction.

First of all, enjoyment played a central role in learning for Carvalho. Thus, as we could see, Carvalho orientated teachers to make the study of chemistry "joyful". The study of chemistry in the General Course should not be boring but enthusiastic.

[47] Certainly cognition is an overloaded concept. Nonetheless, I used this term for I believe everyone agrees it is somehow generally linked with people's learning process, which encompasses motivation, teaching settings, content, etc.

So it is stipulated that it should be avoided the use of the chalk and should illustrate abundantly[48], to make students interested and keen (Decree 37112, 1948, p. 1162).

As another aspect, Carvalho was obsessed that students must *meaningfully* apprehend what they studied. This was indeed one of his boldest characteristics since his first year as a liceal science teacher. The excerpt below was taken from Carvalho's first Official Report, which refers to the teaching methodology he used in the 3rd cycle of the 1934-1935 academic year, that is, in his very first year as science teacher of the liceu Camões, in Lisbon. The fact it referred to the 3rd cycle is not really relevant here, for it only aims to convey that that concern was already present in him for at least a decade.

> I always had a constant concern: convince them [the students] that science, in particular physics, should not be crammed, but comprehended. (…) A student does not know a formula by heart? I do not care. Derive it. (...) What interests me is that he knows how to derive it when he needs it[49].

Following up the same concern, in his 1947-1948 Official Report Carvalho complained about the lack of comprehension in the General Course for very commonly when students got into the Complementary Course, "they do not know, and when they know, do not comprehend what they know"[50]. The following lines found in his report, written a few months before the programmes were published, convey Carvalho's mindset during the period he wrote his programme:

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[48] It can be inferred by the programme, this should mean displaying objects, and performing experiment demonstrations.

[49] MEN, AHME, Fundo 13 "Relatório dos professores", box 49, Historical Archive nº 2322 (academic year 1934-1935).

[50] MEN, AHME, Fundo 13 "Relatório dos professores", box 2, Historical Archive N° 107 (academic year 1947-1948), p. 6

> I am regarded as very demanding and the circumstances force me to recognize that I am. (...) My demand simply consists in not forgiving students when they neglect what they "know". Is it too much to demand the comprehension of their statements? I do not think so, and I even think that without it all students' schoolwork is useless. As far as I am concerned, one of the most serious drawbacks of our teaching is to allow the utterance without the respective comprehension [51]

According to comments in the programme's 'Observations', making content more concrete was aimed at furnishing the sort of knowledge *suitable* to students' age in the General Course.

> So far, chemistry programmes have started with the notions of matter, of body, and of substance. Notions that adults, even those well informed, understand precariously (…) [the new programme] sets aside everything that is not of interest to the general mass of children of the General Course, everything they cannot really learn (…) Let us save 13 year-old students from the obligation of memorising metaphysical notions. Let us avoid having them parrot phrases that are not comprehended (Decree 37112, 1948, p. 1161).

Thus, the new chemistry content avoided abstract chemical concepts, and stressed the study of concrete, everyday substances. As we could see in Appendix 2, the new approach entailed a different focus on what should be communicated about the subject matter to students, such as substances' properties, kinds, characteristics, applicability, preparation, obtainment, industrial and nutrition value, their history, and their relation to Portugal. This seems to be one of the most important difference in the rationale of the 1948 chemistry programme from the previous ones, i.e.,

[51] MEN, AHME, Fundo 13 "Relatório dos professores", box 2, Historical Archive N° 107 (academic year 1947-1948), p. 6

ultimately the new programme was communicating a different 'kind' of knowledge: *a more material and less theoretical knowledge*.

Certainly, to Carvalho, concrete content was relevant to cognition. However, it was probably more important for him to make students solve problems by *thinking* and thus constructing meaning. Carvalho explained that numerical problems should not fall in the trap of the systematic substitutions of numbers by letters. In the 2nd cycle, questions such as "what is the weight of 20 litres of oxygen at some degree and at some pressure?" was certainly accepted, as long as, for example, it is solved using "the oxygen density in that conditions" (p. 1162). That is, he aimed to enable students to solve numerical problems by means of intrinsic characteristics of the substances.

Also relative to meaningful learning, Carvalho suggested that chemical formulae should only be *eventually* presented in order to make students understand what they represent. It was for the lack of distinctions between proportions on the one hand and chemistry on the other, that students used to say "'in a portion of oxygen there is a portion of iron sesquioxide [Fe_2O_3]', etc" explaining that "Whereas it is of no importance as far as proportion is concerned, it is very serious as far as the chemical phenomena are concerned (...) the established proportions are one thing, and chemistry is another very different" (Decree 37112, 1948, p. 1162). This was one of the drawbacks in the use of chemical formulae as students did not see the "chemistry" behind the synthesis provided by the formulae nor even see 'what contains what' in a chemical compound, but rather focused solely upon the proportions of the elements.

It is not clear whether Carvalho drew his teaching proposal from other educators' ideas or if he simply looked for opinions elsewhere which could give greater intellectual weight to his claims within his teaching community. Before 1951, he had never pointed out any sort of external source which underpinned his rationale. Actually, in the 'Observations' he indicated he relied on his "own experience" to propose a new teaching methodology (p.1161). However, in order to replay José Teixeira's criticism in 1951, he needed to strengthen his argument. Thus, Carvalho referred to the English journal *School Science Review* and said that "Anyone who consults its 117 issues already published (…) will find (…) valuable works about secondary English teaching and will be able to follow its evolution along the last decades" (R. d. Carvalho, 1951e, p. 200). He moved on to offer different examples of articles where the teaching of chemistry used to be made, at least since 1942[52], without numerical applications and chemical equations. He quoted part of an examination question proposed by the author of one of those articles[53], to depict what he meant:

> I. Describe the preparation of hydrogen chloride and sketch the apparatus you would use. (a) Label your sketch to show: the chemical used in the preparation; whether they are used in the pure state or diluted with water, and why; whether heat is applied or not; how spray from the reaction is kept back. (b) What happens when you try to collect the gas over water? (c) Write an equation for the reaction. (d) What happens if the gas is: mixed with ammonia gas; dissolved in water and treated with sodium carbonate; dissolved in water

[52] He referred to S.S.R. Jun/1942 and Feb/1943

[53] In 1943, that sort of evaluation was far from hegemonic in England at that time. As Hood explained (Hood, 1943), because the outbreak of the war had impeded the exams in the end of December, pupils were assessed by means of only one exam in July. This forced him to use that "revolutionary" (p.156) form of evaluation, which should be at the same time comprehensive and not time consuming. In that opportunity, Hood claimed for the inclusion of that sort of examination (in opposition to factual type and multiple type tests) in the School Certificate exams.

and treated with silver nitrate solution; passed over red-hot zinc? (If you know how to write the equations, do it; otherwise state actions in words.) (Hood, 1943, pp. 156-157, quoted by Carvalho 1952, p. 201)

Carvalho was certainly aware that that was only a proposal made by the author to introduce that kind of question into the English School Certificate examinations, as it is clearly indicated in the original article, but obviously omitted it. His comments remained on the predominance of the practical knowledge, to the variety of the details demanded by the question, and all of this "without any numerical application!" (p. 201).

He provided another example from the same journal *School Science Review*[54] with the sort of methodology he proposed and the sort of "chemistry" he wanted pupils to learn. Quoting the author of the article, he explains:

> … in the beginning of the study of chemistry, the equations that translate reactions, chosen from the simplest ones, should be represented by means of words. They are called 'word-equations'[55]. (…) This familiarizes the child with the idea of representing the reactions by means of equations and of expressing, most concisely, the essential process which occurs during a reaction (Tilston, 1949, quoted by R. d. Carvalho, 1951e, p. 202)

That method was to be used for two or three years, which in Carvalho's own words, should be used as a propaedeutic to accumulate "a great store of practical knowledge about the production and properties of substances" (R. d. Carvalho, 1951e, p. 202).

[54] This text, found in the section "Notes and Correspondence", is not an academic article but a personal opinion of the referred to teacher on how chemical equations should be taught in the *general science course* which precedes the teaching of symbol equations.

[55] He exemplified: mercury oxide $\rightarrow^{\text{heat}}$ mercury + oxygen and potassium chlorate $\rightarrow^{\text{heat}}$ potassium chloride + oxygen

Carvalho also referred to the same journal to explain that the use of this methodology during the General Course was because students in the early stages were supposed to *analyse, not synthesize*:

> Formulae summarise, condense, synthesise; the novices of chemistry undo, separate, analyse. It is not meant to initiate synthesising. Furthermore, formulae are symbolic. (…) One thing is the symbol; the other is what the symbol represents. 'Manipulating symbols in chemistry – says Professor Philbrick in the *Chemical Semantics* (S.S.R., Feb. 1943) – does not mean dominating things that the symbols represent' (R. d. Carvalho, 1951e, p. 203)

In the same article, Carvalho also made reference to the "modern chemistry programmes" of the October 1950 UNESCO reports, which did not make any references to the use of formulae or equations during the first three years of the study of chemistry. Its introduction, according to the report, "is the most followed science course in the public teaching in the US" (ibid, p. 204). Only after "acquired a great amount of practical knowledge", he insisted, "it gets into systematization, a long programme similar to our 3rd cycle" (ibid). In the next section we will see that the study of chemical abstract concepts or models, such as atoms, equations by means of formulae, weight and volumetric meaning of formulae, valence, and the ionic theory etc, was left to the 3rd cycle (also proposed by the UNESCO report in 1950).

The previous paragraphs indicate that Carvalho was advocating a kind of humanistic, inclusive, chemistry teaching. He supported teaching content and method that could be significant and useful to all students regardless of their future careers; liberal in the sense of no early-specialization; and appreciating the wealth of science in the history of our civilization. He tried to humanize science in the General Course (students aged 13 to 15) regarding the way it should be taught in context, with utilitarian ends, meaningful to students' lives, just as part of a whole alongside other disciplines. This brought the study of chemistry closer to students via everyday phenomena, everyday objects, and technological artefacts, (e.g. their origin, how they were produced, how it may be part of the Portuguese environment and economy, etc). At the same time, humanizing science education in the General Course meant avoiding the mechanical repetition of meaningless (to some students) chemical concepts, chemical equations, and numerical problems while encouraging reasoning and comprehension by means of chemical reactions as they would unfold before students' eyes, and the study of elements and substances in contextualized and meaningful settings.

5. Carvalho's Chemistry Programme for the 3rd cycle (Complementary Course)

> [with the new programme], the student enters the 6th year [1st year of 3rd cycle] without chemical theoretical knowledge, neither right nor wrong, neither well nor ill secure. Until today, the contrary has happened. Students entre the 3rd cycle full of theoretical information that is repeated, in general, without comprehending it, because it was acquired at the wrong age.
> (…)[students] so far have received Lesson on Common Things. Now [in the 3rd cycle], with a certain number of facts, they will follow the thought of those who have investigated the natural laws and penetrated in the structure of matter (Decree 37112, 1948, p. 1162)

The excerpt above is from the 'Observations' for the 3rd cycle of the 1948 chemistry programme, and as we can see it again emphasized the difference of purposes between the 2nd and 3rd cycles. Carvalho followed this overall orientation, however, as I will seek to show, he went beyond this aim. It will be argued that, in his view, more than demanding, the 3rd cycle must be *selective* and must *leave outside* those students who did not fit to it. The analysis in this section will encompass the rationale, the content and the methodology that Carvalho proposed to be used in the 3rd cycle. This analysis is important since it will embrace more thoroughly Carvalho's rationale in his 1948 programme.

During the prevailing period of the 1936 liceal reform, the 3rd cycle encompassed only one year, which was supposed to make a "philosophical synthesis of the acquired knowledge" (Decree 27084, 1936, p. 1235) of the previous years (i.e. the years correspondent to the 2nd cycle). Consequently, as the Table 4 of Appendix 3 indicates, the content of the 1936 chemistry programme of the 3rd cycle was very small. It was the 1936 liceal reform's philosophy to see the liceal course as an end in itself, so it purposively neglected preparation for university courses (Decree 27084, 1936).

Neglecting preparation for university courses proved problematic, so that the 1947 reform reallocated two years for the 3rd cycle (Decree 36507, 1947). The Table 5 in Appendix 3 contains a sketch of Carvalho's 1948 chemistry programme for the 3rd cycle. According to Carvalho, it was written "in a more traditional way in comparison to the 2nd cycle one" (Decree 37112, 1948, p. 1162).

As we can see from Table 5, all the canonical knowledge, with the abstract concepts, formulae and naming were left to be taught in the 3rd cycle. Therefore the 3rd cycle taught a different 'kind' of knowledge from that taught in the 2nd one. If in the 2nd cycle Carvalho proposed a *Lesson on Common Things*, which stressed more material knowledge, the 3rd cycle intended to make students understand the 'theoretical knowledge of chemistry'[56], since students had finally reached "the appropriate age" to comprehend it (Decree 37112, 1948, p. 1162).

Carvalho's rationale for the 3rd cycle seems to have been underpinned by two main ideas. The first idea simply followed the orientation of the 1947 Reform to make a demanding preparation for university courses. Indeed, in the end of the 1947-1948 academic year, thus few months before the new programmes have been published in the Official Daily Bulletin of the Portuguese Government, Carvalho wrote his Official Report[57] where he said that the then current programme for the 3rd cycle "demands little".

The second underpinning idea (which goes beyond the 1947 reform's orientation) was the 'selection of the fittest ones' (as I can best describe it). In his Official Report relative to the 1948-1949 academic year, Carvalho explained that one of the aims of the 3rd cycle was to make a demanding selection of those few students who are *able* to go on to university. In his view, the normal, the average student, could not take over certain positions such as a teacher, a doctor, or an engineer. The

[56] In more recent literature, Matthews (1994) makes this distinction between the two 'kinds' of knowledge by calling the former the "material object of knowledge" and the latter the "theoretical object of knowledge" (p. 26).
[57] MEN, AHME, Fundo 13 "Relatório dos professores", box 02, Historical Archive nº 107 (academic year 1947-1948). Rómulo de Carvalho, Aggregate teacher of the Liceu de Camões

3rd cycle was to instruct the more able students and rule out others. Consequently, whereas in the 2nd cycle he proposed an accessible and joyful teaching *for all*, he understood the 3rd cycle should be *for few*:

> [the 3rd cycle] is a preparation to the university which, because of its own intention, cannot have that easy condition of accessibility the 2nd cycle has. Whereas in this, rare should be the student who does not succeed, in the 3rd cycle the same cannot be said. To make the 2nd cycle, for learning difficulty, accessible to few, would be misplace the purpose of a general course (…). This should be accessible to all. To say, however, the same to the 3rd cycle would be admitting that the normal teenager should have the qualities to get into a university course. It seems that students of this course are, or should be, products of selection, since it is amongst them that the Nation will get the men it needs for its multiple activities in the intellectual field: teachers, doctors, engineers, lawyers, etc. So, it seems little likely – and to me incomprehensible - that the normal teenager is that one with aptness to be a teacher, a doctor, a engineer or a lawyer. In my understanding the 3rd cycle should be highly selective. The sooner the student acknowledges his incapacity for a given occupation that he has chosen, many times without reasonable criteria, more beneficial. (…)
> I had the satisfaction to initiate the 3rd cycle programme in two classes of the 6th year (physics-chemistry sciences). I recognized what I beforehand expected: that many students should not be in that place (…). The programme is wide, is serious, and cannot be comprehended by means of summaries. It demands a lot of study, a lot of attention, a lot of interest and inclination to the subject matter it addresses.[58]

The excerpt above could not be clearer. The inclusive chemistry course Carvalho had so enthusiastically advocated had its place: the 2nd cycle, not the 3rd one. Carvalho's

[58] MEN, AHME, Fundo 13 "Relatório dos professores", box 05, Historical Archive nº 292 (academic year 1948-1949). Rómulo de Carvalho, Auxiliary teacher of the Liceu Pedro Nunes, Lisbon

rationale for the 3rd cycle was twofold: rule out the unsuitable ones and provide strong preparation to the fittest ones, those who were able to pursuit university courses.

In teaching *methodology*, despite the "traditional" aspect of the 3rd cycle programme as Carvalho mentioned further above, the 3rd cycle introduced a very innovative approach with the use of history of chemistry in order to make students understand chemical symbology[59]. The 1936 programme had fairly neglected this important aspect of the sciences, with only a minor reference in the 3rd cycle programme (Decree 27084, 1936). Chemistry compendiums before 1947 echoed the lack of attention to this matter (see J. N. Prudente & Esteves, 1938b).

In the 1948 chemistry programme, history of chemistry was supposed to be used in the beginning of the 6th year as Table 5 in Appendix 3 shows. In spite of its demanding and selective aspect, it is also in tune with his concern in providing meaningful and contextualized knowledge, which was so carefully taken into account in the 2nd cycle. Indeed more than factual historical information, Carvalho organized the programme according to the "historical order of development of that science", from the alchemists to Dalton, without forgetting the "philosophical reasoning that always follows man in his investigation" (Decree 37112, 1948, p. 1162). He advised teachers in the 'Observations' of the programme to focus on its "exceptional philosophical[60] value, and to the extraordinary contribution they [chemists] furnished

[59] In this aspect, Matthews (1994) suggests "this is a full-fledged liberal approach to the teaching of science, and can be seen in programs like Harvard Project Physics, or Harvard Case Studies in Experimental Sciences." (p.11)
[60] Carvalho, by the way, was passionate about philosophy, and tried in different occasions to address to it in some of his didactic writings. This theme, however, will be treated in a more appropriated time.

to a more detailed knowledge about the structure of matter" (ibid). Quite unusually, he explained that by following the historical evolution of chemistry the students should see how formulae appeared as a result "almost spontaneously from fruitful hypothesis, to which the progress of our century is much indebted". In his view, that was a prerequisite to the correct interpretation of formulae: "Having studied these elements of chemical philosophy, the student is found with the complete information he needed to interpret formulae quantitatively, in weight and in volume" (ibid, p. 1162). From then on, he continues, the study should insist on the chemical equations which translate phenomena.

A few years later Carvalho published a chemistry textbook for the 3rd cycle[61] (R. d. Carvalho, 1953a), which provides a concrete idea of how he intended to show how 'formulae appeared as a result of fruitful hypothesis'. His book dedicates eighteen pages to the history of chemistry, discussing the history of elements and compounds, Aristotle's elements, the alchemists, the transition to the modern chemistry by Boyle's work, the phlogistic theory, Cavendish, Scheele, Priestley, Proust, Dalton, Richter, and finally reached the idea of chemical symbols and formula. In more detail of this historical quest, Carvalho explains the idea, and emphasizes the importance, of the 'proportional numbers' in chemical reaction, notably discovered by Proust in 1797. Carvalho then explains that Berzelius suggested the use of letters or symbols, which would have qualitative and quantitative information of each element, in a compact and simple way. The formulae provide a concise way to inform the elements involved in a compound and also, based on the 'proportional numbers', in what ratio they combine. That is, it was Carvalho's intention to make students realize that "formulae are symbolic

[61] I will return to this textbook in the next chapter.

expressions, which represents a compound both qualitatively, for they say which elements form it, and quantitavely, for they say in which proportion they are combined" (R. d. Carvalho, 1953a, p. 24).

This approach in Carvalho's textbook reminds us of his concern with meaningful understanding when studying sciences. This was addressed in the last section as a 'cognitive principle' used in the rationale of his programme. As discussed before, he believed that "one of the most serious drawbacks of our teaching is to allow the utterance without the respective comprehension"[62].

Carvalho's 3rd cycle chemistry programme was clearly not inclusive, but selective, and reflected his understanding that it should not suit all students. If we think of some of the characteristics pointed out in the introductory chapter, which associated humanistic approach in science education with contextual and utilitarian knowledge, relevant to students' everyday lives, Carvalho's 3rd cycle programme might not suit very well in this concept. However, there are other ways to see it. Different understanding of liberal or humanistic approaches in education claim that students should learn the best and most sophisticated knowledge of human culture (e.g. see my brief reference to Schwab and Oakshott in the introductory chapter). As students were older in the 3rd cycle and Carvalho intended this course to aim only students who would pursue scientific careers, the canonical knowledge might be seen as appropriate for their future careers.

[62] MEN, AHME, Fundo 13 "Relatório dos professores", box 2, Historical Archive N° 107 (academic year 1947-1948), p. 6

It should be noted, however, that Carvalho's 3rd cycle chemistry programme is not the best representative of his pedagogical work. Indeed, as we shall see in the next chapters, Carvalho's work as a pedagogue is not mainly focused on the preparation for university courses, but on the facilitation of learning science, regardless of learners' inclination or background. In fact, we will see later that some of his textbooks and his writings on the popularization of science seem to share the same rationale of his 2nd cycle (General Course) chemistry programme. Therefore, unlike the view that we should teach pupils the 'best statement of our present knowledge', Carvalho's pedagogical thought is more easily identified with the idea of inclusive education, meaningful for students' everyday life.

The next section will analyse the impact of Carvalho's 1948 chemistry programme both by teacher's reaction and the effectiveness of the new chemistry programme for the 2nd and 3rd cycles.

6. Reactions and Effectiveness of Carvalho's Chemistry Programme

It is very difficult to gauge the extent to which Carvalho's innovations in chemistry teaching affected students' learning. Probably a study on students' opinion about the new programme, and on detailed attainment database before and after intervention could give us a more precise understanding of the impact of Carvalho's work, but I did not have access to these information. Nevertheless, I accessed Official Reports of several teachers written from 1948 to 1952, which should offer an insight of teaching activity during the studied period and which shed light on this matter. In total the following commentary is derived from 44 Official Reports[63] which were analysed. As we will see below, together with José Teixeira's campaign to undermine Carvalho's programme, teachers' opinion played an important role in the modifications suffered by Carvalho's programme in 1954.

We should bear in mind that the great controversy in Carvalho's programme was limited to the 2nd cycle, as the changes implemented in the 3rd cycle did not arouse much comments from teachers, probably because it was less innovative. Indeed the necessity of a new 3rd cycle programme which should be in tune with the demands of university courses seemed consensual at least since 1941. Neither its selective aspect, nor its historical approach were significantly addressed to draw any general conclusion. The main difficulty faced by teachers in the 3rd cycle was to fulfil the whole Physical-Chemistry programme due to its length, not to the difficulty in understanding an abstract subject matter or solving numerical problems. Although not displayed here, it should be said that the physics programme in the 3rd cycle was also astonishing lengthy[64]. Both physics and chemistry programmes were supposed to share the number of classes allocated to the physical-chemistry discipline.

[63] As explained before, these were written compulsorily by some teachers in the end of each academic year in which they should describe their teaching activities, indicate problems, make suggestions, make requests etc. These reports did not follow any template so that the points analyzed and described by the teachers varied significantly. Each teacher gave the information he/she thought seemed more important. Some Reports were pure bureaucratic documents, a reflex of lack of interest about pedagogical matters in some of them. Some others focused students' success rate, others the methodology used in either classroom or laboratory, suggestions and complaints about the programmes, conditions of infrastructure, some Reports were lengthy whereas others were very summarized etc.

[64] This problem with accomplishing the programme was also due to the lack of an official textbook to the 3rd cycle, which only came to be approved in 1950. The next chapter will provide an account for this disruption.

According to a teacher, teachers “consider the physical-chemistry sciences programme excessive, mainly the physics’ which absolves the first two terms and, possibly, part of the 3rd yet”[65]. Another teacher said “I confess I saw myself in serious trouble to accomplish the programme of this year. Not for its difficulty… but for its length”[66]. José Teixeira agreed they were too lengthy (J. A. Teixeira, 1953).

Now turning to the 2nd cycle, teachers’ Official Reports provide a range of approving and disapproving comments. They indicate that, in general, teachers and students accepted the new programme very well. For the majority of teachers, the students performed well with the overwhelming majority presenting success rates ranging from 70% to 100%. This might indicate that the programme was fulfilling Carvalho’s intention in making the study of chemistry in the General Course suitable for the majority of students, an inclusive chemistry education, which aimed at students’ immediate interest. Some teachers provided some information about this matter. One of them, whose students reached an 84.2% success rate in that year, opined that “almost everybody likes it for it is simple and beautiful” (M. A. Carvalho, 1952, p. 7). That same teacher said that “the students learn the lesson easily with the experiments that can be performed in the classroom, since almost everything can be shown. They have more to observe than to memorize”[67]. “We have worked out some very simple problems without using formulae”[68]. Another teacher

[65] MEN, AHME, Fundo IEL “Relatório dos professores”, box 12, Historical Archive 626, Isabel Afonso Madeira, Aggregated teacher of the Liceu Pedro Nunes, academic year 1950-1951.
[66] MEN, AHME, Fundo IEL “Relatório dos professores”., box 5, Historical Archive 305, Alice Bravo Torres Maia Magalhães, teacher of the Liceu Amália Vaz de Carvalho, 1948-1949.
[67] MEN, AHME, Fundo IEL “Relatório dos professores”, box 12, Historical archive 621, Maria Augusta Carvalho’s Official Report, academic year 1950-1951.
[68] MEN, AHME, Fundo IEL “Relatório dos professores”, box 9, Historical Archive 512. Francisco Manuel Meira da Costa, Auxiliary teacher, academic year.

who, as we can see below, did not seem to like the innovations, yet seemed compelled to acknowledge the following:

> As far as chemistry treated in this year [4th year] is concerned, which I continue to think is of very little use, I must acknowledge students' sympathy towards it and that, either for the simplicity it should be taught or for the interest it awakes, or, more probably, for both reasons, it is noticeable that marks often increase from the moment it is included in those subject matters[69]

However, despites the apparent students' interest in the new programme, Carvalho's chemistry programme did not escape public criticism altogether. One of the problems pointed out by several teachers in their Official Reports were relative to the unfeasibility of carrying out experiment demonstrations in the classroom[70]. For instance, a teacher pointed that "teaching was made with experiments whenever the liceu offered material to perform experiments"[71], which indicates that experiments could in theory be performed but not always in practice. According to another teacher[72], part of the programme went smoother than others. In her opinion, the teaching of coal, soup, and sugar did not present problems and students appreciated them, whereas the study of wine, wood, grease, milk, flour, and cotton (the majority) was affected for the difficulty in performing experiments. That was roughly the same

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[69] MEN, AHME, Fundo IEL "Relatório dos professores", box 14. Carmen de Lourdes Faria Goinhas, academic year 1951-1952.

[70] The implementation of his programme also faced other vicissitudes of organizational nature. For instance, the new programmes of the disciplines (2nd and 3rd cycles) were only published in *October* 1948, that is, when the 1948-1949 academic year had already started (with the old programmes). Teachers needed to make its accommodation in the middle of the academic year. Some difficulties in the first academic year are related to this inconvenience.

[71] MEN, AHME, Fundo IEL "Relatório dos professores", box 9, Historical Archive 515. Bartolomeu Dias de Gouveia Rocha, Auxiliary teacher of the Liceu Nacional de Bragança, academic year 1949-1950.

[72] MEN, AHME, Fundo IEL "Relatório dos professores", box 12, Historical Archive 621. Maria Augusta Carvalho, teacher of the Liceu Castelo Branco, academic year 1950-1951.

opinion of another teacher[73], who said that normally the experiments were too complicated, demanded too many steps, or took too long. The lack of students' interest was inevitable, she said. Even with all problems, her students in three different classes reached a good attainment in the 4th year: 89,1%, 97,4%, 70%. More or less with the same opinion, another teacher pointed to difficulties with experiments, and did not approve the methodology suggested by the programme. This teacher opined that *Lesson on Common Things* had "bigger informative value than educational and tend to overload students' memory" for it was not possible to undertake "experimental teaching in a great number of headings" [74].

Very important for the changes that would come to be made in Carvalho's programme in 1954, following up these comments, José Teixeira decided in early 1951 to attack and undermine, now publicly (J. A. Teixeira, 1951a), Carvalho's programme. This triggered the heated debate between Carvalho and Teixeira already mentioned in the last chapter. In Carvalho's view, Teixeira was the representative of a group of teachers (according to Carvalho, the majority) who advocated the traditional style of teaching chemistry (R. d. Carvalho, 1951e, p. 198), whereas Carvalho was the one who was bringing the "modern aspect of didactics and of chemistry" (p. 200).

Regarding programmatic content, amplifying teachers' comments above, Teixeira pointed out that the 4th year's content (Table 3 in Appendix 2) would lead chemistry teaching to an inevitable book-geared teaching approach, because of the

[73] MEN, AHME, Fundo IEL "Relatório dos professores", box 12. Maria Valentina de Carvalho Barreiros Saraiva, teacher of the Liceu Maria Amália Vaz de Carvalho, academic year 1950-1951.
[74] MEN, AHME, Fundo 13 "Relatório dos professores", box 5, Historical Archive 309. Isabel Afonso Madeira, academic year 1948-1949.

difficulty in performing experiment demonstrations in the classroom about those innovative content, and reminded that it was the programme's intention to avoid 'chalk and talk'. Furthermore, Teixeira was furious with the new chemistry programme and Carvalho's radicalism for totally suppressing the compulsory teaching of formulae and equations. Teixeira's main complaint with the programme's recommendation was with its radicalism. As opposed to Carvalho, he claimed chemistry's language was its symbols so that the use of formulae simplifies, summarizes, and condenses. He rejected the idea that students are horrified by the use of formulae, if used moderately (J. A. Teixeira, 1951a, 1951b, 1951c).

What Teixeira did not know is that actually the scandal provoked by Carvalho could have been even bigger, as it seems that his 1948 programme does not reflect precisely the extent to which Carvalho wanted to change chemistry teaching. Carvalho had a great friend, also science teacher called Túlio Lopes Tomás[75], with whom he exchanged many letters on educational matters. In June 1951, he wrote to Carvalho and said: "I don't know if you remember that Cerdeira Guerra and I made you alter the 'Observations' of your programme, foreseeing the scandal it would provoke in such a conservative class"[76]. It is not clear the relation of power between Carvalho and Tomás at that time (i.e it is not known whether there was a different hierarchy between Tomás and Carvalho to which the latter was supposed to comply). So that it is not clear what Tomás meant when he said "I made you alter the Observations", whether this was just a friendly advice or a superior order.

[75] It is likely that Tomás participated to some extent in the elaboration of the physics programme. In the same letter quoted above he tells Carvalho that he was "meditating" and considering making some changes in the physics programme.
[76] See Carvalho's personal documents, Archive 40, box 4, folder 6.

Nevertheless, this suggests that had Carvalho not heard Tomás, he probably would have published an even more radical programme.

Returning to Teixeira, although the content of his first article (J. A. Teixeira, 1951a) was to a certain extent a repetition of what other teachers had opined before in their reports, his 'communication' was 'in nature' different from those reports. The publication of that article had a much greater political intention. Indeed Teixeira seemed to have an agenda to modify the chemistry programme back into the 'old modes'. In 1951, right after publishing the first critics on Carvalho's programme, a text written in the name of *Labor*'s steering board indicated that there were rumours that some amendments to the then prevailing programmes would be considered in the near future (J. A. Teixeira & Tavares, 1951). It seems likely that this was opportunity Teixeira was waiting for to launch a campaign towards modifications in the science programmes. *Labor* then called for science teachers to share their experiences and to provide suggestions for modifications (ibid).

In the aftermath of the debate some teachers made comments on *Labor* about the two opposite views (Carmo, 1959, 1960a, 1960b; Magalhães, 1952; J. A. Teixeira, 1953; Tomás, 1952). But as we will see below, influenced by teachers' opinions and also very likely by his debate with Teixeira, as early as 1951 Carvalho seemed already convinced that he needed to modify some lines of his programme.

7. The Changes in the chemistry programme in 1954

At the end of the 1948-1949 academic year Carvalho gave his own impression about his chemistry programme in his Official Report. In his understanding, many teachers did not grasp the underlying spirit of the programme. Carvalho already expected difficulties since "every initiation is full of difficulties"[77].

> such deep refashion demands (...) a mental adaptation that is not always easy (...) for the inevitable revolt in accepting a point of view with which the teacher may not agree (…) not all teachers adapted conveniently the spirit of the programme (…) I have received letters and oral requests asking for information about what interpretation should be given to certain paragraphs so that I noticed not all opinions matched and many went astray to what I intended[78]

Drawning on his own experience by using his programme, Carvalho claimed in this report that the programme enjoyed students' great acceptance, and the programme suited them very much. Convinced of his ideas, Carvalho never recognized any drawback in his programme. In his reports, regardless the problem, he always blamed outer vicissitudes, excusing the programme itself. He finalized his comments on 2nd cycle saying:

[77] MEN, AHME, fundo IEL, Box 5, Historical Archive 292. Rómulo de Carvalho's Official Report 10/08/1949.
[78] ibid

> Students' splendid acceptance of the subject matters deserves especial reference. The simplification to which the programmes were subjected (I always refer to the physics and chemistry) made its assimilation much easier, perfectly accessible to average students. This is the fact although many ignorant appreciations say otherwise. In physics and chemistry nearly all students' work is on the observing eyes. The observed things are attractive and the comprehension very easy. Everything depends on fulfilling or not the programme's spirit of these disciplines[79]

In spite of Carvalho's fierce response (a characteristic whenever he was criticized), Teixeira campaign to change it was, to some extent, successful. Indeed in 1954 Carvalho proceeded to some amendments (Decree 39807, 1954). The general lines were kept, such as the study of "substances that everybody knows" and the orientation to make the study of chemistry of immediate use with simple numerical problems, but he partially retreated from his radicalism regarding formulae, equations, and abstract knowledge. Carvalho suppressed all references to *Lesson on Common Things* and, contrary to the spirit of the 1948 programme, re-introduced the abstract notions that he thought were very difficult to be grasped by the students:

> Notion of atom. Notion of molecule of a compound. Notion of atomic weight (given from the symbols of the elements). Notion of molecular weight (given from the formulae used to the compounds) (Decree 39807, 1954, p. 1050)

In the 'Observations' of the new programme it is said:

> The teaching of chemical formulae will be initiated with Water, which is studied in the end of the 3rd year [1st year of the 2nd cycle]. These formulae

[79] MEN, AHME, fundo IEL, box 5, Historical Archive 292, Rómulo de Carvalho's Official Report 10/08/1949.

should serve as a first example to the qualitative and quantitative meaning of those symbolic expressions, meaning that the teacher will strive to keep it always alive in students' spirit. (p. 1054)

By including abstract concepts, which Carvalho argued were not suitable to pupils' age in the General Course, the 1954 chemistry programme deviated from its initial 'humanistic approach' to make science education more meaningful to students.

These changes should not be understood as a shift in Carvalho's pedagogical ideal. As early as 1951, immediately after the debate was published in *Labor,* Carvalho seemed convinced that he needed to change his programme in order to comply with Teixeira's criticism. Carvalho and Teixeira exchanged many letters in that year during the time their articles about the chemistry programme were being published in the journal. In contrast to their articles, their letters bore an amicable tone, and served each other as means to explain, justify, and excuse any tension arouse by the articles. In perhaps his last letter to Teixeira, Carvalho wrote in order to inform him that he had made some recommendations to the Ministry of Education taking into account teachers' and Teixeira's opinions about the programme, but emphasized the following:

> My attitude does not represent a shift of opinion, but indicates that I recognized (…) that the majority of teachers of our group are favourable to the compulsory teaching of formulae in the 2nd cycle [General Course][80].

As the author of the chemistry programme, Carvalho seemed to have on his hands the power to decide whether or not the chemistry programme should be

[80] Draft of a letter from Carvalho to Teixeira on the 22nd of October 1951. See Carvalho's personal documents at BNP in Lisbon, Archive 40, box 3, folder "Labor".

changed. It is not clear by that time what influence Teixeira had over the Ministry of Education in order to force an alteration in the programme's content and orientation. I have not found any document or letter from the Ministry which would orientate Carvalho to change his programme in any direction. The alterations were located in the 2nd cycle, as the 3rd cycle was hardly touched. Although Carvalho's intervention did change the way chemistry was taught, it was not carried out from 1954 onwards in the exact way Carvalho would have desired.

8. Conclusion

This chapter explored the characteristics of Carvalho's first nationally significant work on curriculum development. The analysis contained here was drawn on official decrees (i.e. the intended curriculum), but also addressed the actual teaching practice (i.e. implemented curriculum). The analysis of these documents indicates that Carvalho's rationale presented a humanistic perspective in the sense that it sought to foster meaningful learning by adapting content and method according to pupils' age and interests. In the next chapters I will analyse Carvalho's involvement with other pedagogical activities and I will seek to show that the same search for meaningful learning was revealed in different ways, both in his textbooks, and his actual performance in the classroom.

The alterations in the chemistry programmes for the 2nd and 3rd cycles in the 1947/1948 liceal Reform established a new science teaching in the Portuguese liceus which partially survived at least until 1974. Before his programme, chemistry education was seized by abstract and non-contextualized subjects. Carvalho promoted a considerable shift in science education in 1948 which, at that time in Portugal, few would have dared to propose. Both the educative and the cognitive principles identified earlier seem to focus upon Carvalho's humanistic aims. Maybe in the educative principle the idea of context and meaningfulness with the study of "substances that everybody knows" is clearer than in the cognitive one. However, it seems that these aims also underpinned his proposal in withdrawing formulae and equations to promote better understanding of the chemical process and the characteristics of substances. Although there was considerable positive feedback from some of his contemporaries, the conservative forces in science education (in the present case represented by the name of José Teixeira) argued for the return of the old tradition in science education.

Perhaps the most intriguing part of Carvalho's work in 1948 is the selective aspect of the 3rd cycle programme, which intended to suit only the most able students for university courses and discard the less able ones. This understanding contrasts very sharply with his aims in the 2nd cycle. One possible explanation for this would be that Carvalho was just trying to comply with the 1947 Reform regulation, which set out very clearly the differences between the two cycles. However, recalling what Carvalho said further above, it was from the 3rd cycle that "the Nation will get the man it needs for its multiple activities in the intellectual field", and added that he did not believe that "normal teenager has the capacity to be a teacher, a doctor, an engineer or a lawyer"[81]. It seems a more plausible conclusion that he believed that for those people who would not pursue more 'intellectual' jobs as the ones he mentioned, it would be unnecessary learning more abstract and theoretical

[81] MEN, AHME, fundo 13 "Relatório dos professores", box 05, Historical Archive nº 292, academic year 1948-1949. Rómulo de Carvalho, Auxiliary teacher of the Liceu Pedro Nunes, Lisbon

knowledge: the more ‘material’ knowledge of the General Course would suffice. This conclusion is not without problems, since many of Carvalho’s books written for the youth also tried to teach more abstract notions in science, chiefly in physics, as we shall see in chapter 7.

Carvalho’s involvement with the 1947/1948 liceal Reform was not restricted to the elaboration of his programme. The Government had instituted the “Sole Book” in the 1947 Reform. Carvalho had an intense participation in the contest to choose the Sole Book. In sciences, this was a source of problems. The consequences of the introduction of the Sole Book to the teaching of sciences and how it affected Carvalho’s work in particular will be discussed in detail in the next chapter.

Chapter 4
A “compendium” writer
in a changing political environment

1. Introduction

Carvalho wrote several textbooks (or ‘compendiums’, as they were commonly referred to at that time) for the liceal course, the majority were written in the fifties in accordance to the orientation of his 1948 chemistry programme. They are important elements in his work heritage, as they belong to Carvalho’s effort to change science teaching in Portugal.

There are two very distinct moments when Carvalho wrote his compendiums. In a first moment, right after 1948, Carvalho participated in the 'Sole Book' contest, which would force all science teachers to use the same physics and chemistry textbooks. The previous chapter and the next ones in this thesis give great attention to Carvalho's 'pedagogical thought' and 'pedagogical works', using the political setting more like a backdrop. In this sense, the first part of current chapter is an exception. It will bring to the foreground aspects of how the political and professional contexts affected Carvalho's work and the science education community as a whole.

In a second moment, twenty years later, in the late sixties, without the competitive environment created by the Sole Book contest, Carvalho managed to write a truly innovative textbook for the then recently created "Preparatory Cycle": this was a common cycle for liceal and technical students between 10 and 12 years old. The schoolbook was entitled *Sciences of Nature* (Ciências da Natureza) (R. d. Carvalho, 1968a). It will be argued that this book enabled Carvalho to address his humanistic views in a way which had not been possible in the environment of twenty years earlier.

The chapter will initially provide an account of the framework of the Sole Book contest, as well as the role and intentions of the referees. This will lead us to my analysis in which I point out the possible reasons why two of his chemistry compendiums, written to the 2nd and 3rd cycles of his chemistry programme, were at some point rejected as Sole Books by the referees. The last section of the chapter will turn to Carvalho's *Science of Nature*.

In this chapter, I used as consulting sources official Governmental Decrees which instituted the Sole Book, Carvalho's and his contemporaries' compendiums, personal letters from Carvalho's friends and acquaintances, referees' compendium Reports[82], some newspaper interviews with Carvalho in the eighties and nineties, and his book *Memórias* (R. d. Carvalho, 2010). These sources had different uses. The personal letters and the compendiums provide more nuanced information of the event, however they form a patchwork sometimes difficult to integrate. Available in the National Library in Lisbon are only the letters Carvalho received, not the ones he sent. In very few occasions, there are drafts of Carvalho's letters, but his handwriting is often almost intelligible. Carvalho's *Memórias*, interviews and newspaper articles, although more distant in time, and perhaps more self-serving, provide a more intelligible account of the event and help to link together other historical documents.

2. The Sole Book contest

> The Sole Book system was, relatively to certain disciplines, a premeditated violence of the Dictatorial regime that was established among us. (...) It aimed, with the choice of the sole book, to impose the doctrines which were convenient for the State by means of the compendiums of certain disciplines, particularly History, Philosophy, Portuguese and Political Organization (...) The creation of the sole books' referees was a very deleterious fact for the teachers' class, which revealed a focus of animosity among colleagues, truly deplorable (R. d. Carvalho, 2010, p. 216-218)

[82] These Reports were internal documents, by which the referees provided to the ministry of Education their long and detailed analysis about the contestant compendiums.

These are Carvalho's words in his book *Memórias*. Even though they were written decades after Carvalho's involvement in the Sole Book contest, they still convey a strong feeling of anger and disappointment. Apart from the historical significance of this event, it is also because of its significance in Carvalho's life that this theme should be examined in this thesis.

In 1947, the document implementing the Liceal Reform instituted the Sole Book under the following terms:

> The school compendiums must circumscribe rigorously to the discipline programmes and can only be adopted after approval in contest held by the Ministry of National Education. For the teaching of each discipline in the different years of a cycle will be adopted in all liceus the same book, which can be divided in volumes, one to each year. (Decree 36507, 1947 p. 885)
>
> Books approval will be made under public contest and will be valid for five years (Decree 36508, 1947, p. 917)

The Sole Book for *all* disciplines marked the liceal science teaching from 1950 to 1974 with a "normative teaching culture" (Nóvoa, 2005, p. 91). Its implementation meant the compulsory use of the same schoolbook for each discipline in both primary and secondary Portuguese school. Before that date, liceal science teachers' choice of schoolbooks was fairly democratic. Any author could have their science books available in the market for adoption and, in practice, any science teacher could choose the physics and chemistry compendiums they wished to adopt from a list of compendiums, pre-approved by the Government. For this reason, the implementation of the Sole Book was probably Salazarism's most harmful measure for science education in general. I say it was harmful because even during

Salazarism the science education community enjoyed a fairly open arena for discussing pedagogical ideas, for teaching practice, for proposals etc (as the content of many journal articles during Salazarism attest), and the Sole Book policy curtailed that freedom.

The actual use of the new compendiums only started a few years later. In 1948, the Decree 37112 established that the first of the five-year-periods referred to above was supposed to start in the 1st of October 1950. This means that teachers had to use the new programmes published in 1948 without new 'official compendiums' at least until 1950. The same Decree said that in the meantime School Councils[83] could choose the most suitable compendium already available in the market (Decree 37112, 1948).

Authors would have only two years to study the programme, devise a new approach in order to comply with the new programmes' orientation, and to write a brand new compendium. All the work of planning, writing, editing, correcting, and illustrating the new book was of course very tiring and time-consuming, and all expenses were supplied by the teacher without any governmental support[84]. The Government had set up a convenient cost-free scheme for itself, whereas all the work and risk was left over the teachers.

What did the Ministry of Education intend by implementing the Sole Book to science disciplines? Unfortunately there is no recorded explanation from the

[83] The School Council was formed by a group of teachers chosen by the rector of each Liceu ("Decree 36508 ", 1947).
[84] See introductory note in Álvaro Machado's 1950 chemistry textbook at MEN, AHME, "Elementos de Química para o 2.° ciclo". Fundo DGEL, "Manuais Escolares", box 15/2031.

Government concerning specifically physics, chemistry, or biology and mathematics. According to Carvalho, the Government's justification for the compulsory use of the Sole Book *for all disciplines* was economic, saying the Sole Books would be cheaper for the families, because of the number of books published at once (R. d. Carvalho, 2010, p. 216-217). In the ideological realm, according to Mónica, the answer is that it aimed at undermining liceal teachers' pedagogical freedom in order to extent control (Mónica, 1978), as the "official ideology" (p. 345) – i.e. its political ideology - meant the spread of the values of "obedience, resignation, charity, persistent work, and patriotism" (Monica, 1978, p. 345). The totalitarian regime pursued homogeneity. Regarding science disciplines, Filipa Silva (2008) has suggested that the use of the Sole Book seemed to be caused by a sheer attempt to reinforce the power of the Dictatorship.

Within this same ideological purpose, in a more recent newspaper interview with Carvalho, it has been suggested that its institutionalization was justified for "certain disciplines in which free choice would pose a threat to the [regime's] ideological foundation" ("O Polémico Livro Único," 1988, p. 8). In the liceal course, the Ministry of Education made explicit orientation for 'certain disciplines', such as History, to change its approach. It argued that its teaching had been negativist and "defeat-orientated"; and established that the History teaching from then on must offer "the truth which suits the Nation's interest"; i.e. it should be taught the History that interests the Nation in order to strength the feeling of Family, Faith, Principle of authority (Decreto 21103, 1932, p. 625).

In 1936, the Government had instituted the "National Education Board" (*Junta Nacional de Educação*) (Decreto 26611, 1936). Overall, that was a technical and consulting agency of the Ministry of Education, which aimed at studying problems concerning the character, the teaching, the culture and the physical capacity of the Portuguese citizen. Among many other competences, from 1947 it was due to the National Education Board to choose the Sole Book for each of the disciplines. In order to assess the suitability of the compendiums, that Board appointed ‘referees’, normally two liceal teachers. For each contestant book, the referees were supposed to provide a detailed and well-grounded report through which he/she must expose the “relative and absolute pedagogical and scientific merit of each work” (Decree 36508 , 1947, p. 917). These reports were internal documents, and inevitably presented a number of diverse personal opinions – a source of problems as we will see later.

From what is said in some of the referees’ reports, it is clear that they tried to comply with the specification of their job. But, in practice, their job went beyond that specification. It happens that the implementation of the Sole Book in sciences along with the new programmes also created an atmosphere which demanded ‘innovation and quality’. Because only one could be chosen, the assessment of the books in contest gained a special care. Indeed, Túlio Lopes Tomás, an influential science teacher already referred to in previous chapters, who assessed many compendiums, explained in one of his reports[85] that because of the great importance the Sole Book would have, it could not just be reasonable, but “really good”. By ‘really good’ he meant: “given the new conditions, the [chosen] compendium will be alone, which demands being superior in quality than the previous ones”[86]. He added that it would be preferable not having any official compendium approved than submit students and

[85]MEN, AHME, fundo DGEL, box 15/2011. Report of Túlio Lopes Tomás upon Seixas&Soeiro’s“Physics Compendium”, 1949.
[86] MEN, AHME, fundo DGEL, box 15/2011. Report of Túlio Lopes Tomás upon Xavier de Brito’s “Experimental Physics Lessons” 1949, p. 1.

teachers to use, for five years, a book without pedagogical value. At least in sciences, the referees did not seem concerned with the Dictatorship's doctrine (e.g. its anti-liberal ideology of resignation, and patriotism, as might have been the case with History), but limited their comments to pedagogical and scientific issues.

Very important on the controversy of referees' work, as we will see below, possibly influenced by the spirit of 'innovation', in Tomás' view, the Sole Book needed to be "integrated in a modern and practical view", otherwise it would fall in a "repetition, in a different tone, of the old French books of sixty years ago"[87], thus, as he added, ignoring systematically schoolbooks in countries like Germany, the UK and the USA. Given the general aspect of many liceal textbooks up to 1948, it is likely that by 'old French books' they meant the following presentation of content: assertion of a scientific principle/law, followed by the carrying out of an experiment in order to "prove" or "verify" what had been asserted. Carlos Cerdeira Guerra, a veteran teacher who also assessed many physics and chemistry compendiums, had the same concern with innovation. In one of his assessment reports, for instance, he condemned the author of a compendium for his deliberate attempt to adapt books that used to be adopted "forty years ago" into the new programmes, which are "totally different from the programmes of that time"[88].

In sum, it seems that the referees had a 'model' of book in their minds to assess the Sole Book contestants. Whatever this model was, it needed to be different from the "old French" ones. From the start, this was one of the many problems

[87] MEN, AHME, fundo DGEL, box 15/2011. Report of Túlio Lopes Tomás upon Soeiro & Seixas's physics compendium, 1949, p. 2.
[88] MEN, AHME, fundo DGEL, box 15/2011. Report of Carlos Cerdeira Guerra upon Seixas & Soeiro's physics compendium, 1950, p. 1.

aroused from the work of the referees, because neither the 1947 nor 1948 official decrees quoted before, nor the referees themselves, specified, publicly and officially, what the model should be. The consequences of this setting we will see below.

3. Carvalho's 2nd and 3rd cycles chemistry compendia in the Sole Book contest

Carvalho wrote three chemistry schoolbooks for the Sole Book contest. One compendium to the 2nd cycle (General Course), written in partnership with Riley da Motta, one compendium to the 3rd cycle written on his own, and a practical guide to chemistry. The practical guide was approved for the period 1951-1956, and had thirteen re-editions thereafter until 1974, which should have associated Carvalho's image to the teaching of experimental chemistry in Portugal. As a traditional laboratory practical guide, its approach was very similar to previous ones (J. N. Prudente & Esteves, 1938a). The compendia for the 2nd and 3rd cycles were written to fulfil the innovations of his 1948 programme. The former was never approved as a Sole Book and the latter was approved in the first contest but rejected in the next one. The aim of this section is to examine the possible reasons for this unsuccessful project.

Carvalho chemistry compendium for the 2nd cycle (General Course) was assessed in 1950 by Carlos Cerdeira Guerra and Carvalho's friend Túlio Lopes Tomás. This compendium was not approved by the referees and the reasons why are not difficult to perceive. As some quotations in the previous section show, both were very convinced about the need for compendiums with ‘modern’ approaches, such as American or British ones (they did not provide examples). Cerdeira Guerra wrote in his report that the authors of the compendium “have not understood well the programme, neither its observations”[89]. In other words, he suggested that Carvalho did not understand what he intended by his own chemistry programme. At first glance this is a puzzling statement, but it makes sense. In the pages devoted to the fifth and last year of the 2nd cycle, Riley da Motta and Carvalho’s compendium (Motta & Carvalho, 1952) presents a great number of formulae and symbol equations, contrary to what Carvalho had clearly orientated in the Observations of his programme. Cerdeira Guerra also pointed out that the compendium presented a “language which reminds us the old compendiums”[90]. This was ratified by Tomás, who provided a summary of the book. While acknowledging the great effort in the chemistry programme to transform the teaching of chemistry, Tomás said:

> Against what we expected, however, the presented book does not impose itself either by innovation or by merit. In general, it correctly develops the programme’s orientation, but the authors did not appear to successfully have - I would not say comprehend, because I do not believe it - managed to fulfil the spirit that the programme intends to introduce in chemistry teaching. (…)
>
> Where I expected to find a live chemistry, fashioned in a completely new manner, I see something similar to what for many years has been educating generations and generations in the sacred horror of chemistry. The

[89] MEN, AHME, fundo DGEL “Manuais Escolares”, box 15/2011. Carlos Cerdeira Guerra’s Report on Riley da Motta’s and Carvalho’s compendium, 1950, p. 2.
[90] Ibid, p.4

> programme's orientation is very clear to leave any doubt about what is intended to innovate in the teaching of this science[91]

Riley da Motta's and Carvalho's compendium indeed communicated the knowledge in a non-contextualized way, and therefore their book's organization and approach were very like "the old French books of sixty years ago", as I quoted Tomás before. A comparison between their compendium with chemistry compendiums of the previous programme (N. Prudente & Esteves, 1940, 1946), published before 1948, indicate great similarities in approach. The main characteristics of these books were their wide tendency to explain chemical phenomena, concepts, characteristics etc with the support of illustrative experiments[92], in a straightforward approach: systematically, they provided a statement followed by an experiment in order to "prove" what was stated. Presumably as a result of this criticism their compendium was not accepted in 1950 (nevertheless none was).

It is difficult to explain why Carvalho, who had written a programme which had "ruthlessly" withdrawn formulae and equations from the General Course, wrote a compendium full of them. One possible explanation is the name of Riley da Motta as his co-author, actually the first author of the book. Another possible explanation was lack of time. As we could see further above, the Ministry of Education had left less than two years until the first Sole Book contest took place in 1950. Thus teachers would have a short period to devise and write new compendiums. Many liceal

[91] MEN, AHME, fundo DGEL, "Manuais Escolares", box 15/2011. Túlio Lopes Tomás's Report on Riley da Motta's and Carvalho's compendium, 1950, pp. 1 and 8.
[92] Few other authors wrote books with less attention to experiments for verification (Almeida, 1950; Barroso, 1995; R. d. Carvalho, 1986; M. L. Sampaio, 1950), nevertheless they also did not succeed to be approved as a Sole Book.

teachers participated in this risky ‘race’, where only one book would be chosen, whereas all the others would be wasted effort. For Carvalho, writing school textbooks in accordance to his own chemistry programme probably was a challenging task because he had never written a compendium before and because , as he confessed, the organization of his new programme “had never been tried before”[93]. Even so, he decided to write not one, but three at a time, and did it in the impressive span of only one year (Carvalho, 2010). As he says in his book *Memórias* he started working on them in 1949 and they were published by April 1950, six months before the first period of five years for the use of the Sole Book (R. d. Carvalho, 2010, pp. 215-216). Authors could publish textbooks before the Sole Book was chosen. It is possible to infer from some letters he received at that time that such a rush to publish three compendia before the contest was in order to assess teachers’ feedback about the compendia, consolidate them in the market, and thus, possibly, influence referees’ final decision[94].

In 1952[95] a new contest was held with Carvalho’s participation, but this time on his own, without Riley da Motta[96]. The compendium submitted in 1952[97] was

[93] Official Daily Bulletin of the Portuguese Government. Decree 37112, I Série, nº 247, 22nd of October 1948. Observations in the chemistry programme, p. 1161

[94]The many letters in Carvalho’s personal documents suggest that authors used to send their compendiums to teachers throughout the country in order to influence them to adopt their books.

[95] Official Daily Bulletin of the Portuguese Government on 10/01/1952, III Série, No 8

[96] The reason why Riley da Motta did not participate in this new contest is not clear. Perhaps, considered Riley da Motta’s dismissal for his “levity” in sending to liceal teachers an enquiry about co-education in the liceus (see chapter 3) was making its approval more difficult. Nonetheless, because of the possibility of using books available in the market whilst the Sole Book was still not chosen, Riley da Motta and Carvalho’s compendium was used in the classrooms of many liceus(J. A. Teixeira, 1951b) until the academic year 1954-1955, when the chemistry Sole Book for the 2nd cycle was finally chosen in May 1955.

modified in order to comply with the referees' orientation in the previous contest, although there was no guarantee they would be the same in the next one. This time there were no more formulae in the whole book, but the same approach of 'old' French compendia was kept. Possibly for this reason his compendium was rejected once again. Nevertheless, again, no 2nd cycle chemistry compendium was chosen in this year and a new contest would be held[98].

A new Sole Book contest was held on the 18th of September 1954[99]. This was only eleven days after Carvalho's programme had been modified in order to comply with all the criticism, mainly carried out by José Teixeira (see chapter 3). Carvalho submitted his compendium without Riley da Motta once again. But in the list of compendiums participating in the contest, published in the Official Daily Bulletin of the Portuguese Government[100], there was something new: the name of José Teixeira as one of the contestants, who had never participated before in the contest; and he could not, for since 1950 he was being one of the referees of chemistry compendium in the Sole Book contest[101]. José Teixeira's chemistry compendium for the 2nd cycle was the one approved in 1955[102] as a Sole Book (J. A. Teixeira, 1955).

Intriguingly, Teixeira's compendium for the 2nd cycle (J. A. Teixeira, 1954) also presented the approach presented by Carvalho's and all those identified by

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[97] This is the only not-approved Carvalho's compendium available for study at the AHME in Lisbon.
[98] The list of books in the contest was published in the Official Daily Bulletin of the Portuguese Government on 19/08/1952, III Série, No 195.
[99] Official Daily Bulletin of the Portuguese Government of 18/09/1954, III Série, No 221.
[100] Official Daily Bulletin of the Portuguese Government of 29/12/1954, III Série, No 303.
[101] MEN, AHME, fundo DGEL, "Manuais Escolares", box nº 15/2846.
[102] Official Daily Bulletin of the Portuguese Government on 18/05/1955, II Série, No 118.

Tomás as the “old French Books” e.g., full of experiments in order to “prove” what was stated. Moreover, Teixeira’s compendium gave much less attention to the History of science than Carvalho’s. It is indeed possible to perceive in Carvalho’s 1952 chemistry compendium[103] that he tried to bring to the foreground how chemists managed to solve scientific challenges in the history of chemistry, whereas Teixeira’s provided only few factual information, i.e., dates, names, and great discoveries. Teixeira was, as Tomás has described[104], much influenced by another science teacher, Fernando Zamith, also a textbook author, an old respected liceal science teacher, who defended the old teaching methods of previous reforms.

I do not have further elements to explain why the referees chose Teixeira’s compendium as the chemistry Sole Book for the General Course. This is a complex issue, which might have involved sensitive egos or personal interests. As one possible explanation, Carvalho said in his book *Memórias* that “the approved contestant would receive money, it was not known how much, but the amount would not be little because the volume of books used by the system would surpass any normal publication” (R. d. Carvalho, 2010, p. 218). Earlier in an interview he said that this financial help would be “enough to save something – since what was earned as a teacher was the strict minimum for the livelihood” ("O Polémico Livro Único," 1988, p. 8). He expressed the possibility that one of the referees could have rejected the compendiums in previous contests for the possibility of having his/her own compendium approved in the next one, and therefore earn a great amount of money.

[103] MEN, AHME, Fundo DGEL, “Manuais Escolares”, box 15/1931. Carvalho’s 1952 chemistry textbook “Compêndio de Química para o 2° ciclo (texto)”.
[104]Letter from Túlio Lopes Tomás to Carvalho in the 2nd of July 1976, Carvalho’s personal documents, BNP, Archive 40.

“His interest [of any referee] would be himself to write a compendium, which would be propitiated by the rejection of his contestant” (R. d. Carvalho, 2010, p. 218).

Attention turns now to Carvalho’s 3rd cycle (Complementary Course) compendium. Different from his 2nd cycle compendium, this one was approved right in the first contest in 1950 (R. d. Carvalho, 1953a). We should recall from the last chapter that Carvalho’s 3rd cycle chemistry programme organized the content according to the historical development of chemistry. As one science teacher[105] described it, Carvalho’s 3rd cycle chemistry compendium was a “serious, attractive, and clear work, which, besides its ‘scientific scrupulous’, had an ‘originality that should look provoking for many short-sighted teachers’”. This letter was addressed to Carvalho himself and therefore the assessment was possibly biased. However, regarding the reference to ‘originality’, in the last chapter I explained that this compendium dedicated eighteen pages to the history of science in order to provide a concrete idea of how ‘formulae appeared as a result of fruitful hypothesis’. Although this compendium has not received much attention from historians, because of its innovative approach, this book can be seen as a milestone in the Portuguese history of science education.

In 1950 this compendium was assessed and approved as a Sole Book by the same referees who rejected his 2nd cycle chemistry compendium: Túlio Lopes Tomás, his great friend, “a highly regarded and correct person”, and Cerdeira Guerra, a “tempestuous creature, irregular (…) an notorious alcoholic, who could present in public without the control of his legs and of his words” (R. d. Carvalho, 2010, p.

[105] Letter from A. Jorge to Carvalho on the 13th of May 1951. Carvalho’s personal documents, BNP, box 4, folder 6.

217-218). The contrast in Carvalho's characterization between Tomás and Cerdeira Guerra is because he believed the book was approved because of the presence of the former, whereas the latter wanted to reject it (R. d. Carvalho, 2010, p. 218). Cerdeira Guerra in fact came to reject the same book in 1955 and 1956. In 1957 Cerdeira Guerra chose another compendium as the new Sole Book for the period from 1957 to 1962[106].

It was not possible to find Cerdeira Guerra's report on Carvalho's 3rd cycle compendium, but Carvalho had in the beginning of 1957, and left a summary of it with a letter to the Director-General commenting on the assessment[107]. Carvalho's letter to the Director-General presented a long list of comments in which he points out, in his understanding, the inappropriateness of referee's behaviour and comments. According to this document, the referees' reports did not indicate any mismatch between the textbook and the programme's orientation. The reason for its rejection was presented by a number problems characterized by terms such as "regrettable", "condemnable", "serious", "not excused" etc, which, in Carvalho's opinion, revealed the "hostile disposition of the person who wrote it". Carvalho understood this as "an abuse of accidental authority that the referee acquired over the

[106] The authors this time were Alice Maia Magalhães and his friend Túlio Lopes Tomás.
[107] See Carvalho's personal documents at BNP, box 4, folder 6.

author", as an example of "hypercriticism"[108]. He seemed upset with referees' vocabulary and disdain[109].

Carvalho was subjected as any other author to the pedagogical opinions of the referees, and it might have been the case that this was just one more case of disagreement between author's and referees' views. However, the reasons why this compendium was approved in the first place and rejected later are rather intriguing. Intriguing because Cerdeira Guerra had already approved his compendium in 1950. Moreover, three years later, in 1953 (when Carvalho's compendium was sold out and in the new edition he fixed some deficiencies), the alterations attracted Cerdeira Guerra's compliments, pointing out "an extraordinary improvement in its aspect"[110].

One who reads Carvalho's *Memórias* will likely conclude that Carvalho had an issue with Cerdeira Guerra. He believed that his 3rd cycle compendium was rejected for personal reasons. This is of course an assertion very difficult to gauge, notably because the material cited belongs to Carvalho's views only. Letters that Carvalho exchanged with Tomás and Cerdeira Guerra at that time do not explain whether there was a specific problem between Carvalho and Cerdeira Guerra, but

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[108] Not surprisingly, referees' reports were a list of "discordances", as Tomás had explained earlier, "between my view and the authors'". The reports can be indeed characterized as a very long "list" of, in the view of the referee, inappropriate explanation of scientific knowledge, inappropriate approach, along with long suggestions about how the book was supposed to be written. MEN, AHME, fundo DGEL, box 15/2011.

[109] Apparently this was an usual approach. For instance, in another case, Álvaro D'Athayde, then liceal teacher for forty one years, said the following about the comments he received on his compendium: "It is possible that in one or two equations a coefficient may be absent. But for God! Do not suggest this fault is for ignorance!" MEN, AHMEN, fundo DGEL "Manuais Escolares", box 15/2031.

[110] Letter from Carlos Cerdeira Guerra to Rómulo de Carvalho on the 2nd of April 1954. BNP, Archive 40, box 4, folder 6.

reveal that at some point during this process their relationship might have gone under strain.

Moreover, they also indicate that for some reason in the fifties Carvalho experienced a kind of personal problem with his colleagues. From 1950 to 1958 Carvalho lived in Coimbra, so that Tomás used to send him letters from Lisbon to inform him everything he knew about science education in the Capital. In October 1950, right after Carvalho's compendium was approved, Tomás warned Carvalho that teachers were pointing out problems in his compendium. He wrote to Carvalho saying that the "Aristarchus of criticism were preparing to thrash [his] book, as well as all other Sole Books"[111]. In Carvalho's understanding the Sole Book authors were attacked by the teaching class because of "envy and anger", for some teachers had "books approved and others not, for some have written and others not, for the economic benefit one would gain" (R. d. Carvalho, 2010, p. 221). Tomás wrote the two letters below in 1951, through which he tried to explain the reasons why Carvalho's 3rd cycle compendium was attacked by the teaching community after it had been chosen as a Sole Book in 1950.

> Now I tell you that you should have annoyed many people because the attacks on [your 3rd cycle] book have, in many cases, personal aspect.[112]
>
> You know you are considered, in general, a non-welcome person, maybe because you do not go after everyone indistinctively and do not go to the Café Portugal[113].

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[111]Letter from Túlio Lopes Tomás to Rómulo de Carvalho on the 12th of October 1950**.** BNP, Archive 40, box 4, folder 6.
[112]Letter from Túlio Lopes Tomás to Rómulo de Carvalho in August 1951.Carvalho's personal documents, BNP, box 4, folder 6.

> (…) In your personal case, you outraged the class for having put yourself aside.[114]

It is not clear what this "personal aspect" in the first excerpt might be. Perhaps, as the second excerpt seems to imply, this is related to Carvalho's reserved behaviour, or as a consequence of the implementation of his radical programme. The key point is that the criticism was not only addressed to Carvalho, but also to the referees who approved the compendium in 1950: "in our case", added Tomás in the same letter, "the drubbing is shared by three [i.e., Carvalho, Tomás, and Cerdeira Guerra]". Perhaps, these attacks explain the source of problems between Carvalho and Cerdeira Guerra. Indeed, Cerdeira Guerra seemed bothered about the criticism on the book he had approved. This can be perceived in the following letter that Cerdeira Guerra wrote to Carvalho in 1951:

> What happens is that I am attacked again for having fulfilled my duty and acting justly. These things are like that, unfortunately, among us: I am attacked for making justice by choosing a good work [Carvalho's book], (…) Imagine that I came to know that Dr. Rómulo [de Carvalho] was convinced that I tried to torpedo your book! (…) Evidently that the esteem I have [for him] would never allow me to do such a thing. [115]

In 1955, the period of five years for the use of his chemistry compendium for the 3rd cycle would finish, so that a new contest would be held. In 1954, nobody else submitted a chemistry book for the 3rd cycle. As he says in his *Memórias,* he

[113] Letter from Tomás in October 1951. Café Portugal probably was a meeting point of teachers in Coimbra, where Carvalho lived from 1950 to 1958.
[114] Another letter from Túlio Lopes Tomás to Rómulo de Carvalho now in October 1951.Carvalho's personal documents, BNP, box 4, folder 6**.**
[115]Letter from Carlos Cerdeira Guerra to Rómulo de Carvalho on the 15th of February 1951. BNP, Archive 40, box. 4, folder 6.

submitted exactly the same book that was being in use as a Sole Book since its last edition. “It was ready” (R. d. Carvalho, 2010, p. 224). This time, Tomás did not evaluate the book. The referees were Cerdeira Guerra, again, and José Ascenso, a science teacher of the Liceu do Faro. In May 1955 it is said the book was not approved[116]. In 1956, a new contest was held and again, coincidently, the same referees examined his compendium[117]. They rejected the book for the second time. According to Carvalho’s friend Tomás, writing in 1957, Cerdeira Guerra had been the nemesis for his books: a “personal enemy from behind and an attentive, venerator, and thankful person from front”[118].

Whether this was the case or not, Carvalho felt he was victimized in this evaluation. Carvalho also seemed victimized by the Sole Book contest framework. He did not accept having his work being evaluated by another liceal teacher, who, presumably, in his understanding, was not in the intellectual position to judge his work. Indeed, in 1957, after having his compendium rejected, he wrote to the Director-General saying

> Just by accident one of them, the referee, is in the position to appreciate the work of the contestant, a situation which, by similar accident, could be inverted (…) The books’ approval keeps depending on a contingent parallelism between the referee’s taste and the exposition of the author[119]

[116] Official Daily Bulletin of the Portuguese Government on 18/09/1954, III Série, No 221.
[117] MEN, AHME, fundo DGEL “Diversos”, box 13/1514.
[118] Letter from Tomás to Carvalho in the 29th of February 1957. Carvalho’s personal documents, BNP, box 4, folder “Correspondencia de professores”.
[119] Carvalho’s letter to the Director-General of Liceal Education on the 21st of February 1957 available in Carvalho’s personal documents at BNP. In the occasion he was complaining about the work of one of his referees about his 3rd cycle chemistry compendium.

The problems Carvalho had during the Sole Book contest with his two compendiums for the 2nd and 3rd cycles explain his bitter memories of this time, as I quoted him before: “The creation of the sole books’ referees was a very deleterious fact for the teachers’ class, which revealed a focus of animosity among colleagues, truly deplorable” (R. d. Carvalho, 2010, p. 216-218).

There is one last important point about the creation of the Sole Book contest. As discussed before, Sole Books were expected by the referees to be of excellent quality - “really good”, to use Tomás words. Regarding quality, decades after the institution of the Sole Book, this is the conclusion of Carvalho and Américo Palma, a geography teacher and also author of a Sole Book: In Palma’s opinion, “amongst many books that I wrote and with which I participated in the contest, the chosen one was the worst I had.” ("O Polémico Livro Único," 1988, p. 8). Even Tomás, who in the first place advocated its implementation, evaluated many books, and ended up being an author of a Sole Book, wrote to Carvalho in 1957 saying that “now I am even more anti-Sole Book. The choice of one implies the exclusion of the others, and it is not scientifically proven, aprioristically, which one is the best”[120].

A very different story happened in the end of the sixties, when Carvalho, more experienced, more financially and logistically supported, and with more time to work, finally wrote an outstanding and successful book. The next section will turn to it.

[120] Letter from Tomás to Carvalho on the 31st of May 1957. Carvalho’s personal documents, BNP, box 4, folder “Correspondencia de Professores”.

4. Carvalho's Sciences of Nature for the Preparatory Cycle: humanistic science education realized?

Perhaps as a self-criticism and also as a result of the bad time he had in participating in the Sole Book contest, Carvalho said many years later in an interview that he never enjoyed the traditional approach of the compendiums used in the liceus:

> science was being taught to them through big compendiums which dispensed science as if it could be taught in pill form. Students had to study from these compendiums because they needed to pass from year to year. But they hated what they were studying (Gedeão, 1992, p. 171)

And because of the rough treatment Carvalho received from the referees, which wasted much of his time as a writer, Carvalho had decided not to write a textbook anymore (R. d. Carvalho, 2010). As we will see below, this decision was reversed, and he came to write *Sciences of Nature* (Ciências da Natureza) (R. d. Carvalho, 1968a) in 1968, divided in two volumes. *Sciences of Nature* was an introduction for the learners of sciences, written for the first two years of the study plan of the then recently created Preparatory Cycle of the secondary school.

The Preparatory Cycle was an important (and even democratic) measure of the Salazarist regime, which contrasted with its educational policy to avoid social mobility, identified since its dawn in 1933. In Chapter 2, it was argued that the

Portuguese educational system organization, since the beginning of the twentieth century, had been divided into the liceal teaching, for the "elite", and the technical teaching, for the working class. After World War II, this crystallized system started changing, steadily. Because of social pressures and progressive social policy[121], the Government extended compulsory school to four years during the fifties, and to six years in 1964 (Nóvoa, 2005, p. 117). Nearly twenty years after the Reform of the technical teaching in 1948, the Minister Galvão Teles created in 1967 (Decree 47480, 1967) the "preparatory cycle of the secondary school" which unified the "1st cycle of the liceal teaching" with its correspondent "preparatory cycle of the technical school" (p.1) (in both cases, students' age were from ten to twelve years old). As the Decree explains, it aimed to "provide the proper general education for the continuity of studies" (p.1) and also to identify pupils' natural inclination in order to "orientate" (p.1) them towards either liceal or technical teaching. The creation of the Preparatory Cycle was just one of several different measures to expand education for all, since it was being claimed that there was a relationship between education and economical development (Ferreira, 2003). According to Nóvoa (2005), that was an important turning point in the educational policy for it bifurcated the educational paths, or in other words, it potentially allowed an easier social mobility, since students in the Preparatory Cycle had now two years to decide if they wished to pursue the technical or the liceal course.

With the creation of the Preparatory Cycle for the secondary school, a new opportunity to write a compendium came up, now for an even younger public than those of the 2nd cycle of the liceal course. The idea to write the book *Sciences of Nature* was not Carvalho's, but João Sá da Costa's, the owner of a bookshop and

[121] Namely by the Minister Leite Pinto.

publishing company: the *Sá da Costa Editora*. In a newspaper article, entitled "A Humanist in the Sciences" (Costa, 1996, p. 35), in the occasion of Carvalho's ninetieth anniversary, Sá da Costa explained what happened behind the scenes in order to set up the working plan. Sá da Costa's account is a unique view of what might have influenced Carvalho's work from the sixties onwards.

Sá da Costa said that he went after Carvalho on the eve of the creation of the new cycle with a proposal to develop a "new pedagogical experience". His proposal was to teach pupils "to observe, to develop a critical spirit, to analyse the experiments outcomes, and how it was possible to make a mistake and fix it etc" (ibid, p. 35). Coincidence or not, Sá da Costa's proposal matched to a great extent the content of the Observations of Carvalho's 1948 chemistry programme for the 2nd cycle (General Course), which, we can recall, suggested *Lesson on Common Things* as a teaching method. Now Sá da Costa's proposal had an extra element: an emphasis on the development of pupils' critical spirit.

Carvalho rejected the proposal in the first place. He did not want to be involved in the same rough environment that the Sole Book had created during the fifties. In Sá da Costa's words, "he had decided not to write any other schoolbook given the accentuated negative spirit of the prevailing regime" (ibid, p.35). A combination of facts, however, made Carvalho change his mind. Now, for the Preparatory Cycle, there would be no 'sole book'. For that cycle it was determined by the Government that the School Council of each liceu could choose "compendiums and textbooks amongst those approved by the Ministry of Education" (Decree 47480, 1967, p. 3). Moreover, Sá da Costa guaranteed him full support, such as a photographer, an artist, and a designer who would take care of its disposition, its composition etc. The new condition contrasted with the unsupported condition of nearly twenty years ago, when the authors needed to produce compendiums entirely at their own expense, draw and photograph pictures, edit the book, pay fees etc. Thus, under such a new appealing setting, he accepted. Nevertheless, “the word ‘compendium’ was forbidden, given the negative weight it carried” (p. 35), added Sá da Costa.

In contrast to the time when he wrote for the Sole Book contest, by the late sixties Carvalho was at a better moment of his career. He said in a conversation: “At that time [1968] I was really prepared in my career to undertake such a project. I was sufficiently mature to write the two volumes for the high-school level” (Gedeão, 1992, p. 171). In this same occasion, he explained the motivation to write this book and what impact it had:

> I wrote those books because I felt my students’ sense of having been abandoned. (…) I tried to transmit the same facts, the same knowledge, in a more pleasant and more profound way. I think that I was successful at it, too. As a result, I decided to write the books entitled *Sciences of Nature*, which were highly successful. These volumes were absolutely ground-breaking here in Portugal. They had illustrations, they were organized in a completely innovative way, the language I used was unique (Gedeão, 1992, p. 171)

As we can see, Carvalho was very proud of his book. Proposed by Sá da Costa, *Sciences of Nature* gave substantial attention to experiments, which were encouraged to be performed by the students alone elsewhere other than solely in schools. Two teaching methods marked this new textbook: the *Lesson on Common Things*, which explored the objects of the surrounding world, and a ‘guided dialogue’ with aspects of ‘inquiry-based’ methodology, to which Carvalho attached what is frequently called the '*Socratic method'*. Carvalho described this method as one "where the teacher questions the student in perspicacious terms, of refined subtleness" (R. d. Carvalho, 1959a, p. 46). Carvalho was indeed a believer in this method and I will return to it in the next chapter.

The first volume of the book was closer to disciplines such as physics and chemistry. In general lines, the book introduces the world to the pupil, approaching topics such as "the visible Universe", "The Earth in the Universe", "the physical states of matter" etc. The second volume was closer to disciplines such as botanic, geology, mineralogy.

Sciences of Nature presented a clearly more innovative approach. It returns us to the underlying theme within Carvalho's work which has perhaps become submerged in the personal and professional controversies and disputes which dominated the Sole Book context: his commitment to a humanistic interpretation of science education. Some of these aspects are relevant to his concern in helping pupils to understand the value of science in our culture and in our lifestyle, as the outcome of a collective, human, activity where everyone might contribute. In the introductory message for the pupils, Carvalho wrote the following:

> Whatever your profession will be, for many times you will need to know what are the reasons that certain phenomena you observe happen. In the present world no one should be ignorant about scientific subjects for we are constantly in touch with scientific applications. Furthermore, studying sciences helps you to comprehend the importance of the work that men have been creating with the discoveries they did in all times. (…) Now it is your turn to study sciences and follow up the work of those men who came before

you. In order to take advantage of this study you will need to develop, in your spirit, the own qualities of a man of science. (R. d. Carvalho, 1974a, pp. 5-6)

This excerpt conveys much of the same educational rationale of Carvalho's 1948 chemistry programme discussed before, as it sees science as part of one's general culture, advocates contextualized and therefore meaningful education, and also presents some utilitarian concerns. Carvalho's communication to the reader in order to draw his attention to the meaning of science in our society is recurrent in his books.

Also relative to some understandings of a humanistic science education, in this work Carvalho took special care in proposing experiments suitable to students' age and to visual communication between the book and the student. The book was highly illustrated with pictures of a 10-year-old boy performing the experiments (Appendix 4 provides some examples). As we can see from the excerpt below, by having a child handling the proposed activities, Carvalho could gain an insight into the pitfalls and problems students would face when working with the experiments.

> I imagined to organize a book where everything was acquired through observation and experimentation, using a little boy of the same age of those at which the book was aimed, who was always present on the pages of the textbook, observing and experimenting what I intended to communicate. The little boy would follow my project and I would correct all the difficulties found, adapting thus all of the activities proposed in the text to the students' normal age. The book demanded abundantly illustrative documentation, both drawn and photographic (R. d. Carvalho, 2010, p. 283)

This is the overall aspect of this book: it gives great attention to the surrounding world, to the importance of science in our lives, as part of our culture, and conducts ‘dialogues’ with some provoking questions - a combination of *Lesson on Common Things* and the *Socratic method*. The dialogue seems to intend to constantly engage pupils’ reasoning, as it often makes references to their day-to-day activities, and prompt them all the time to make one more experience. Given pupils’ age (up to twelve years old), the questions are simple and sometimes followed by the answer. Some examples of his dialogue may be useful.

> In your school there will probably be an iron ring through which passes, tightly, a sphere of the same metal. Heating the sphere up it just does not go through; it stands on it. Why so? And if you leave the sphere in this position until it cools down, what do you think it is going to happen? Try it out and explain what you observe. And if you heat up both the sphere and the ring, what should happen? Think about the answer and afterwards verify it, carrying out the experiment (R. d. Carvalho, 1968a, p. 54)

> So now take a glass and cover the lit candle. You will see the flame lasts not for long. It faded away. Don’t you get impressed with the result? So, wasn’t the glass full of air? Wasn’t air what the candle needed to burn? Why did it fade away? (R. d. Carvalho, 1968a, p. 122)

Contrasting his previous textbooks, *Sciences of Nature* became popular and received a positive appraisal of many people. This textbook was, for many students, the first opportunity to study sciences in the school. Sá da Costa said that Carvalho worked for the “introduction of the scientific spirit in the schools, entailing a new teachers’ pedagogical and scientific attitude” (J. S. d. Costa, 1996, p. 35). In comparison to the books approved as Sole Books in previous years for the 2nd and 3rd

cycles, and even in comparison to newer books for the general course (J. Teixeira & Nunes, 1975), *Sciences of Nature* seems to have offered, as Carvalho emphasized before, a "completely innovative way" to teach sciences. Fernando Bragança Gil, Professor of physics of the Faculty of Sciences of the University of Lisbon, wrote to Carvalho in 1969 to say he was delighted with the book's exposition, accessibility, and for the attention to the experimental method. "I am convinced that, once again, my dear friend gave a very positive and original contribution to the teaching of sciences in our land"[122]. Another staff member of the same institution was even more generous with compliments. He said Carvalho had

> fulfilled a work of exceptional value, which contributed with an authentic renovation (...) It has an unique presentation, it is not copied – it is typical of a pedagogue of genius led by a profound humanistic attitude and by an evident love to the transmission of knowledge, and to foster a new mentality[123]

Sciences of Nature was not the only book in which Carvalho used the Socratic method. He used a similar 'guiding' approach in another book, this aimed at the general public, called *Physics for the People*, also published in 1968, which will be examined in chapter 7.

The comments above were made by friends, but *Sciences of Nature* indeed had an impact in Portugal and elsewhere. None of Carvalho's school textbooks had ever gained such a prominence. As Carvalho acknowledged, it achieved "an exceptional success, regarded (…) a magnificent work" (R. d. Carvalho, 2010, p.

[122] Letter from Fernando Bragança Gil to Carvalho in October 1969. Carvalho's documents, BNP, Archive 40, box 3 folder "Ciências da Natureza".
[123] Letter from Germano Sacarrão, in October 1969. Carvalho's documents, BNP, Archive 40, box 3 folder "Ciências da Natureza".

285). Indeed from the first edition of volume 1 in 1968 to 1977 there were twelve editions. The volume 2 had five editions from 1969 to 1972. Combined, an amount of more than five hundred thousand books were sold (p. 288). A Sá da Costa Editor's paperwork[124] indicates that at least one hundred and ten schools throughout Portugal adopted his book. Moreover, *Sciences of Nature* was used in San Diego Schools, California, and received in that State similar compliments to those made above. The schools were searching for a "Portuguese science text as a basis or supplement for their current curriculum of individualized instruction" . This was for a transitional bilingual program (a project called IMPACT[125]). The document entitled "Materiales en Marcha"[126], from the referred to schools, points out that "*Sciences of Nature* 1, 2 by Rómulo de Carvalho were found to be the closest in content level comparable to the current U.S. junior high texts" and carries on to praise it as "superior to his predecessors", "well illustrated", "very well organized fashion", "in all remaining aspects both texts are very thorough, precise, and complete", "Material is presented in a logical sequence", "these books serve as an excellent starting point". Arguably, being similar to the American counterparts did not straightforwardly guarantee quality, but this adoption is a good indication that *Sciences of Nature* had finally reached the approach used by 'American and British' textbooks that Tomás had referred to many years ago.

[124]Carvalho's personal document, BNP, Archive 40. The referred to document presents no date.
[125] This belonged to "The New Bedford Transitional Bilingual Program", which, according to the document "Materiales en Marcha", "was faced with the task of finding a Portuguese science text as a basis or supplement for their current curriculum of individualized instruction"
[126] The document is identified in Carvalho's documents, BNP, Archive 40, Folder "Ciências da Natureza", as follows: "Materiales en Marcha" ESEA Title VII . San Diego City Schools, Portuguese Science Materials: Ciências da Natureza 1, 2" by Arie J. Cote.

5. Conclusion

Education, in any country, in any setting, cannot be dissociated from political affairs. In a fascist dictatorship, where the regime strategically used education as a manipulative tool, such a relationship is even more evident, as other historical studies attest (Monica, 1978; Teodoro, 1991. Ó, 2003).

However, as I pointed out before, science education during Salazarism was not really subject to ideological control, and teachers freely discussed pedagogical issues and modified science curricula as they wished. As an exception, it seems that, during Salazarism, the Sole Book contest caused the greatest harm to science education in general, and to Carvalho in particular. Had the Sole Book contest existed in a democratic regime, the animosity and all other drawbacks aroused by the Sole Book contest between Carvalho and his contemporaries would perhaps have happened in a similar tone. Nevertheless it is impossible to dissociate the image the Sole Book – whose creation did not seem to have any pedagogical purpose, but only ideological – from Salazarism, as a way to affirm its controlling power. For this reason, arguably, the harm provoked by the Sole Book contest stemmed, ultimately, from the fascist ideology.

Moving from wider ideological issues to more personal ones, we should note that with the implementation of the Sole Book, the majority of authors' endeavour became hopeless. The fact that only one could be chosen caused a great frustration for many authors who saw their work not chosen and therefore completely wasted. At least for science, the Government created an unnecessary competition, the value of which was by no means clear and the costs of which were considerable. Carvalho should have had a bitter experience with this contest as some of his works were never used. For instance, the manuscript of one of Carvalho's chemistry compendiums, which was not chosen as Sole Book[127], currently kept in the Ministry of Education in Lisbon, reveals a richness of details, notes, and comments, with hundreds of pages with extremely detailed handmade drawings and photographs. Carvalho also had another textbook not accepted by the referees, a 2nd cycle physics compendium, submitted to the Sole Book contest in 1952[128], in which he worked "stubbornly" for years. This "was an unrewarding, tiring, and useless work" (R. d. Carvalho, 2010, p. 229). Furthermore, although innovation seemed paramount for referees, in practice this seemed to be hardly achieved by many authors. Perhaps at that time Carvalho and others were not entirely prepared to write books which would fulfil the requirements of the new chemistry programme.

Studying Carvalho's compendiums over the period of nearly twenty years also reveals his personal evolution. So far as his schoolbooks are concerned, it can be argued that Carvalho's *Sciences of Nature* was his masterpiece. It represented the spirit of innovation more faithfully than his old Sole Book compendiums. Even though he could not foresee its publication, this book was in fact a long-term project, born at least in the forties, with his radical ideas in the chemistry programme, that I have characterized as adopting a humanistic approach, and an inquiry-based

[127] Carvalho's 2nd cycle chemistry compendium, not chosen as a Sole Book, MEN, AHME, fundo DGEL "Manuais Escolares", box 15/1931.
[128] Official Daily Bulletin of the Portuguese Government of 19/08/1952, III Série, No 195.

methodology. It encapsulated many paramount aspects of Carvalho's pedagogical thought: contextualized and meaningful content, and emphasis on the role of experiments in science learning, care with pupils' age, the promotion of science as an element of culture, and the use of a Socratic teaching method. This last will be examined in more depth in the next chapter.

Chapter 5

Carvalho and the pedagogy of laboratory classes

1. Introduction

In contrast with the last two chapters which explored aspects of Carvalho's involvement with curriculum development (writing an official programme and textbooks), the current and the next chapters will not be concerned with Carvalho's relationship in any well-known historical event, but examine more closely his thought and his own performance in the classroom. Methodological issues on the use of experiments with educational purposes are on the forefront of the pedagogical debate at least since the establishment of mass education in the nineteenth century (Jenkins, 1979; DeBoer, 1991) . My aim in this chapter is to provide a critical and detailed analysis of Carvalho's rationale for the pedagogical usefulness in the use of experiments in school science, and what might have been its impact in science teaching in Portugal.

There are several indications of the importance of experiments in Carvalho's teaching practice which necessitated an examination of this issue in this thesis. See for instance the excerpt below taken from an interview when he explained one of the reasons why at the time he was completing his secondary school he decided to go to sciences courses instead of going to humanities courses in university.

> So, physics and chemistry attracted me because of their experimental, hands-on component. I always encouraged my students to work in the same way, and I always emphasized an experimental approach in my classes. I chose [to study] physics and chemistry because their experimental aspect fascinated me (Gedeão, 1992, p. 170)

Carvalho's passion for the use of experiments in science classes is well known in Portugal. He confirmed this passion many times, and secondary sources reinforce this (Aido & Bastos, 2001; J. Caraça, 1996a, 1996b, 1997; A. M. d. Costa, 1996; Costa, 1997a, 1997b; J. S. d. Costa, 1996; Crato, 2006a, 2006c; Fiolhais, 1996, 1997b; Souza & Fiolhais, 1997). His image in the Liceu Pedro Nunes, where he worked from 1958 to 1974, and to which his name is more commonly associated, is constantly attached to his dedication to teach with experiments. In an educational system which faced material limitations, the physicist Rui Namorado Rosa (R. N. Rosa, 2002) has highlighted his dedication saying that whenever there was a missing experiment in his laboratory, Carvalho used to build one himself. Indeed Carvalho said that he asked the rector of that liceu to provide him with a joinery table in order to construct lacking objects in the school laboratory (M. L. Nunes, 1996, p. 16). The physicist Carlos Fiolhais has the same opinion and said that "The [Pedro Nunes'] physics laboratory is an impressive live document of a time. (...) His spirit is present both in the devices he invented and in the many demonstrations he carried out" (Fiolhais, 1996, p. 21).

In spite of this, very little is known about Carvalho's opinion upon the teaching method and the educational benefits of the use of *school laboratory,* where students could manipulate experiments in the classes called *Individual Practical Works* (IPW)[129]. As we could see in chapter 2, Carvalho's contemporaries were very committed to IPW classes and the use of 'heurism' as a teaching method. So how did IPW and heurism fit within Carvalho's views about the place of the laboratory in the pedagogy of science teaching? Did he use any other teaching method? And how did it affect teaching practice in Portugal if at all? These questions are the central theme of the present chapter. Drawing on Carvalho's Official Reports, books, and articles, it will review some of the key evidence about the use of experiments across the course of his long career.

The chapter presents two overall arguments. The first is that Carvalho saw IPW as a great educational tool, with behavioural benefits. These classes were an important opportunity to educate pupils with organizational skills, foster a positive attitude, a reflective and thoughtful person, and inspire students to pursue scientific careers. However, Carvalho did not expect to see students working as 'scientists'

[129] The title "Individual Practical Work" is associated to the original intention in making students work on their own, in laboratory classes. Although this was not always achieved, laboratory classes kept being called IPW (in Portuguese: TPI – Trabalhos Práticos Individuais, or simply "Trabalhos Práticos").

with sophisticated apparatus - as some forms of educational projects such as PSSC (Rudolph, 2002) are represented as advocating.

The second argument is related to the teaching method in IPW classes. It suggests that Carvalho preferred to use a certain teaching method: the so-called 'Socratic method' (a method where the teacher leads students through an inquisitive and focused dialogue). Although only few times explicitly advocated by Carvalho, examples of this method are scattered in many of his works, including in his textbook *Sciences of Nature*, discussed in the last chapter, and will be used to support the argument here.

The chapter will seek to demonstrate that Carvalho's teaching method contrasted with his contemporaries' most radical views of heurism, who understood that students were supposed to work with little help and draw conclusions on their own. But in spite of his widely acknowledged dedication and ability with the use of experiments in school science, briefly pointed out above, Carvalho did not develop a full and consistent rationale for the use of experiments, but rather used the Socratic method in a 'intuitive manner', and wrote about it because of his duty as a teacher trainer. Furthermore, in spite of his enthusiasm for the use of the Socratic method, by the end of his career Carvalho also seemed to accept alternative teaching methods, perhaps influenced by international educational movements.

2. Carvalho's view on the "behavioural adjustments" of IPW classes

From the time the IPW was instituted in 1917, official decrees and educators' articles reasserted that "the work should be individual" in order to foster "manual ability" and the "habits of investigation and criticism"; practical works should not be "mere recipe execution", but rather "investigation problems of interest to the students and which allow them, on their own, to enunciate conclusions"; and it should stress "measurement activity" in order to foster the "habit of scientific discipline" (Decree 3091, 1917, p. 270).

Carvalho would have agreed with much of this, as he also valued manual ability and measurement. But on different occasions when Carvalho wrote about IPW, he did not stress scientific skills, but rather students' 'behavioural adjustments' (as I can describe it). It seems the first time he addressed this issue was in 1947, in an article entitled "On the Physics Practical Activities in the Liceus" (*Acerca dos trabalhos práticos de Física nos Liceus*). According to the excerpt below, taken from this article, he said:

> The *essential condition* is that the work should be useful, that serves for something under the *educative aspect*. The work *does not need to have high scientific interest* nor demand astonishing equipments. The student needs only to work with simple things, to measure or to weigh, but not as does a

> tailor or a joiner. It must *create the spirit of measurement*, the *physical awareness of what comparing means*. *That seems to be the essential*. The student may, in his real life, never need to measure anything. What he will always need, constantly, day after day, is to *have a thoughtful spirit*[130], *the care of his observation*, the *feeling of equilibrium* that results from the watchful work which the laboratory practice will help him to develop. *Unless all of the educational value of the manual and visual activity is denied* (R. d. Carvalho, 1947a, p. 40, my emphasis)

One can perceive from the excerpt above Carvalho's concern in fostering a thoughtful person, as this opposes to an impulsive and reckless one. Developing the "physical awareness of what compare means" as well as apply "day after day" the "feeling of equilibrium" (apparently this means 'a calm mental state') seemed to Carvalho more important than learning scientific techniques.

Another example of his views on the educational use of IPW can be seen in the preface of Carvalho's *Chemistry Laboratory Guide* for liceal students, first edition in 1950. Following the same lines of the article quoted above, in this book he also says that students' work had the potential to endow pupils with a good attitude, good behaviour, and organizational skills:

> A chemistry laboratory is very useful to appreciate students' qualities. We just need to look at the tables and at the floor after the end of the class in order to recognize the virtues and drawbacks of each one (…) The material untidiness, dirty or ill-washed test tubes, water spilled on the table … (…) are symptoms which helps the teacher to diagnose students' values. (…) [The student] should leave the table tidy and as clean as possible, without feeling diminished or ridiculed for taking a wet cloth and cleaning the table. (R. d. Carvalho, 1974b, p. 8)

[130] In Portuguese: "aplicar a ponderação do seu espírito"

Probably Carvalho did not expect that secondary science teaching should resolve the problem of graduate competent scientists, but to enthuse and foster in all students a more reflective and responsible attitude in their lives. Some of the claims above are not new. As we could see in chapter 2 (section 7), other educators also advocated the use of IPW in order to develop 'mental discipline', or 'cleaning habits'.

Apart from this educational usefulness, Carvalho also believed laboratory classes should provide a strong conceptual basis to the future university students linked to scientific areas, i.e., students should learn scientific concepts, laws, or principles whenever working in the laboratory. Before proceeding to examine more closely Carvalho's thought in these matters, in the section below we will see that Carvalho's contemporaries – many of those who advocated the use of the 'heuristic method' - did not realize the differences between what Carvalho called the "scientific" and "pedagogical" methods in physics and chemistry. I will draw attention to this issue because the distinction was important in Carvalho's view on the pedagogical use of experiments, offering a new understanding for this relationship with potential pedagogical implications, as we shall see later.

3. The relationship between the "heuristic method", the "inductive process", and the "inductive method"

In order to understand the problematic differentiation between the scientific and pedagogical methods, we need first to discuss how Carvalho's contemporaries saw the learning process with the use of experiments, and its significance in the rationale for the use of the heuristic method. Certain terms here play an important role which need some clarification.

"Inductive process" [*processo indutivo*] and "inductive method" [*método indutivo*] were terminologies constantly used by many physics and chemistry educators in Portugal, including Carvalho, whenever they discussed either epistemology in natural sciences, or learning science through the use of experiments. They probably derive from the broad term "inductivism", as I explain below.

In spite of the constant use of these terms, their meanings are not very well spelled out in any of the consulted material, as though they were well understood concepts amongst the teaching community. Even books on science teaching of that time lacked this kind of definitions or general idea. To give an example, chapter 2 indicated the likelihood that the 1929 science programmes were drawn on a book entitled *On Aspects of Chemistry and Physics Teaching* of two American educators, Alexander Smith and Edwin Hall (Smith & Hall, 1902). The authors make constant associations between "method of observation, [and] of induction" (p. 88). But they also do not provide any reflection for the term *inductivism* or its apparent 'derivatives': inductive process and inductive method.

The clearest definition that I have found for the term inductivism was given by Fernando Gilot, in an article published in the journal *Palestra*, in 1961. He explained how inductivism was commonly seen, and said that people thought that the "concept of Inductivism is (…) constituted by different stages, amongst which one stands out, defined by a certain reasoning which draws conclusion from the particular to the general" (Gilot, 1961, p. 24). Similarly, in one of his articles, Carvalho explained that the "inductive process" was a process of "generalization" or a process to "draw conclusions"[131] (R. d. Carvalho, 1959a, p. 63). This is more or less what Riley da Motta said before, as I quoted him in chapter 2, when he said that the teacher "will draw conclusions with the class (…) from concrete to abstract, from particular to general" (Motta, 1934, p. 530).

Analysis of many texts of science educators indicates that they more or less shared Carvalho's, Motta's and Gilot's understandings above. According to the analysis of Portuguese articles and teachers' reports, the 'inductive process' was understood as something similar to a 'mental process' or a 'learning process', through which students were able to generalize from factual phenomena into more overarching ideas or principles. For instance, one teacher claimed that from the observation of "facts" one could reach the "truth" since "the natural way of human spirit is from the observation of particular cases to general laws" (Ramos, 1948, pp. 227-228). Another teacher conveyed a similar idea when said that "the senses, according to Comenius, are the door of soul by which students receive the first impressions, by which the first ideas penetrate, and which will later feed the superior faculties of the spirit"[132].

[131] In 1982, Carvalho wrote a book about experimental physics (R. d. Carvalho, 1982). There he points out the importance of the "experimental method" defended by Roger Bacon, and later by Francis Bacon, and added: "To observation and experimentation, already regarded necessary steps in the scientific research, was added the '*inductive process*', as the process to discover the general laws of Nature, after having collected the data in the previous steps" (p. 30)

[132]. MEN, AHME, fundo IEL "Relatório dos professores", box 55, Zulmira da conceição Calado Sarjento, Historical Archive 2556, academic year 1938-1939.

Such understanding of this kind of 'cognitive' process had strong consequences in pedagogy. Its influence in teaching practice was well explained by Carvalho himself, in the only article in which he developed his views on teaching method in IPW classes, written in 1959:

> The settled idea that the inductive method, supported by the experimental observation, is *par excellence* not only the scientific method but also the pedagogic one in physics, has its deep roots in the philosophical spirit of the eighteenth century when physicists praised experimentalism, repudiating all theoretical conception without experimental verification (R. d. Carvalho, 1959a, p. 61-62)

And because of the need of experimental verification, as Carvalho added, teachers used to take the "inductive method as the pedagogical method of physics teaching (…) expressions such as 'inductive method' and 'experimental method' are taken as synonymous" (R. d. Carvalho, 1959a, p. 61). Gilot also referred to "experimental and inductive methods" as synonymous, saying they were the "thinking steps, which starts from the facts captured by the senses and arrives in a certain law" (Gilot, 1961, p. 24). Teachers believed that inductivism was "the characteristic method of this discipline [the sciences]"[133], and tried to mimic this scientific method by using a pedagogical 'inductive method'. This idea is well described by another teacher's Official Report shown below, in this case pointing out the benefits in the use of school experiments:

> As is well known, the teaching of the physics-chemistry sciences is based on phenomena observation (...) and mainly in experiments, giving opportunity to

133 MEN, AHME, fundo IEL "Relatório dos professores", box 55. Francisco Manuel Meira da Costa Historical Archive 2554.

> observations. Thus students are taken to observe and study phenomena (...) until the truth is uncovered"[134].

If it is possible to summarize, the 'inductive method' was the means to make students go through the 'inductive process', and this was very commonly done with the support of experiments. It should be noted, however, that such 'inductive method' could be used in a number of ways (e.g. by questioning students verbally, by questioning with the support of demonstrations, or by making them manipulate experimental apparatus), and the use of experiments was *just one option*.

Now how do these two terms relate to heurism? They are much related because when we think of the 'heuristic method' the relationship between experimental activity and inductive process becomes very tight. The point I want to make is that this relationship was *essential* for the use of the so-called 'heuristic methods', since students were supposed to work with experiments and draw conclusions (i.e. go through the inductive process) as independently as possible (a relationship contested by Carvalho, as we shall see later). This understanding is explained in the Observations for IPW classes of the 1929 physics programme:

> Physics as an experimental science has, from the point of view of the so-called heuristic methods, a special importance since straightforward quantitative experiments can be performed and conduct students through the inductive method to the scientific interpretation of the phenomena (Decree 16362, 1929, p. 104)

[134] Carlos Cerdeira Guerra's Official Report, MEN, AHME, fundo IEL, box 9.

Chemistry teaching tended to follow the same orientation of the physics shown above, as the 1936 chemistry programme indicates:

> Its teaching, the same as the physics teaching should be experimental and as much inductive as possible (Decree 27084, 1936, p. 1270)

The appearance of these terms in official Decrees indicates that the use of heurism and the inductive method was encouraged nationwide, and that the debate around this matter was not limited to educational journals. Immersed in this context, the heurism seems to have been taken up by some teachers as they explained in their Official Reports:

> The method followed in the 5th year was the inductive, by the experimental and questioning form, and by the heuristic process. (…) With the experiments I used the questioning form in order to make students *induce*[135] the desired relationships[136]

> The inductive method was followed: using observed results, students enunciated on their own the law of attraction and repulsion between two magnetic poles [137]

Carvalho also tried to use the heuristic method and believed in existence of inductivism both in science and in teaching. However, he disagreed with the relationship between experiment and the inductive process. There is little evidence among Carvalho's contemporaries of the same understanding, which indicates a new

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[135] This means 'go through the inductive process'. In Portuguese: "induzir"
[136] MEN, AHME, fundo " Relatório dos Profesores", box 14, Historical Archive 761. Catarina Rosa Peralta' Official Report, teacher of the Liceu Rainha Santa Isabel, academic year 1951-1952.
[137]MEN, AHME, fundo IEL, "Relatório dos professores", box 55, Francisco Manuel Meira da Costa' Official Report, Historical Archive 2554, academic year 1938-1939.

comprehension of the pedagogical rationale for the use of school laboratory. The sections below will explain this matter.

4. Carvalho's use of the Socratic method in the beginning of his career

The presence of heurism in Portugal during the time Carvalho taught sciences prompt us to query what was Carvalho's impressions on this method and whether he used it or not. Carvalho started his professional activity in 1934 and at that time he also incorporated the word 'heurism' in his discourse. Nevertheless, it can be said that Carvalho's apparent adoption of this method in the beginning of his career was not entirely converted into its actual use. In Carvalho's first Official Report, which refers to the 1934-1935 academic year, he provided an account of his teaching activities with the support of experiments:

> It is after all the heuristic method which is used to direct the observation of the subject matter (…) Taking advantage of the benefits of the method, my intention was to make students interested; to thoroughly expel from the boy's spirit the idea that the lesson was boring (…) to give them the impression that the subject matter taught was casual and not previously planned; to encourage them to make watchful observations in accordance to pupils' age and, finally, give them the notion that study is simple and joyful.[138]

[138] For the sake of readability, this is not a literal translation. MEN AHME, fundo IEL "Relatório dos professores", box 49, Historical Archive 2322, academic year 1934-1935. Rómulo de Carvalho, Aggregate teacher of the Liceu de Camões.

It seems clear that, to Carvalho, the heuristic method consisted in guiding the students into an *apparent* unpredicted path, where the teacher conducted the conversation towards the conclusion he/she wanted to reach. In Carvalho's own words:

> The topics of the programme constituted a secret guide, which I carried with me and manoeuvred it without students perceiving the intention, placing them [the students] in it and making them follow it. A question, an observation, a phrase, were used as a provocation, apparently accidental, but satisfying the programme order (…) Altogether, the lesson was given, without anybody's effort, natural and spontaneous.[139]

From the excerpts above, although Carvalho calls such teaching method 'heurism', it can be inferred that he did not leave students to find things for themselves, as some of his contemporaries expected (e.g. Riley da Motta). Instead, although pretending that it was 'an accidental' situation, Carvalho *guided* students to draw the conclusion he wanted them to conclude using the 'Socratic method'. Carvalho's tendency to use the Socratic method appears in the beginning of his career, although at that time he did not seem aware of this. This was the only time I identified Carvalho saying he used the heuristic method (in the way he understood it). This later absence is his discourse reflects an unwillingness to use the heuristic method in the following years.

There is a great gap of time between the views above and the next available account by Carvalho of laboratory science teaching[140]. In the meantime, Carvalho

[139] Ibid

[140] In future Reports, Carvalho indicated that since he started his teaching activities, he wrote many Reports where he ratifies his educational beliefs. In the AHME in

only published articles turned to the history of science. That period covers the prevailing period of the 1936 liceal Reform (1936 to 1947), when the IPW was taught in the 2nd cycle. Only in January 1947 Carvalho wrote an article where he provided his first public opinions about the IPW. He claimed that for the best teaching it was needed to "provide schools with all needed material to the intended work, to divide students in groups as small as needed, in order to each of them, on his own, could carry out his work with full efficiency" (R. d. Carvalho, 1947a, p. 40). We can see that Carvalho was advocating students' direct experiment manipulation (the behavioural benefits of this direct manipulation were already discussed above), but he did not elaborate his thought beyond what is said above.

Given the little information available, it is not possible to make greater claims about Carvalho's impression about the heurism at least until the fifties. However, by that time Carvalho developed an understanding about what he saw as a distinction between "scientific method" and "pedagogical method" which placed the heuristic method in an uncomfortable situation.

5. A rationale for the use of the Socratic method?

It is difficult to assert when Carvalho became clear about the characterization of the Socratic method, but his preference for this method can be identified from 1934-1935, as we could see above. Yet he addressed this method more clearly in an article only published many years later, in the 1959 article mentioned before. This was

Lisbon, however, it can be found only three of Carvalho's Official Reports. They refer to 1934-1935, 1947-1948, and 1948-1949 academic years.

almost the only time he explicitly outlined the Socratic method and differentiated it from other teaching methods. I do not have any indication that by this article Carvalho intended to defend and promote such a method among science teachers. But rather he published it just as a consequence of his new job, since in 1958 Carvalho returned from Coimbra to Lisbon in order to take over the position of Metodólogo Teacher[141] (teacher trainer) in the Liceu Normal Pedro Nunes. The activity of preparing science teachers to teach in the liceus demanded of him an expertise in pedagogy, which certainly entailed deep knowledge about teaching methods. After he started his work as a Metodólogo Teacher, Carvalho frequently used the pages of the journal of the Liceu Normal Pedro Nunes, the *Palestra* (1958-1973), a journal of which he was also member of the editorial board in 1963, to communicate teachers throughout Portugal about any pedagogical issue which he felt might interest the science teaching community.

The article published in 1959 was entitled "Physics as a Teaching Objective" (*A Física como Objecto de Ensino*) (R. d. Carvalho, 1959a). Its tone is analytical and explanatory: his traditional genre when addressing teachers. Carvalho's aim in this article is to clarify what he called a "disordered chaos" in the pedagogical Methodology, saying "there is no methodology of Methodology". Carvalho tried to elaborate a clear distinction between the "scientific method" and the "pedagogical method", as they did not seem to be very well differentiated by other science educators:

[141] I will provide a full account of Carvalho's work as Metodólogo teacher in the next chapter.

> Methodology, as an explication of methods, can be considered both scientifically and pedagogically, i.e., it informs us as to the *methods used by the researcher* in his scientific investigation, and also to the *methods used by the teacher* who wishes to transmit his particular field of knowledge effectively. These two applications of methodology are quite distinct. It is *one thing, for example, to consider physics a science, and quite another to consider physics a teaching objective*. Both applications possess their own methodology, both affect the other, but both must also be clearly distinguished, according to the particular situation under study. However, in spite of their differences (which we consider evident), a writer will frequently confuse scientific methodology with teaching methodology. Moreover, the inverse situation also occurs (R. d. Carvalho, 1959a, p. 58, my emphasis)

This differentiation had important pedagogical implications. Carvalho did not believe students could generalize ideas to reach scientific laws/principles just by manipulating experiments. This distinction between scientific and pedagogical methods seems related to Carvalho's scepticism about the possibility to rely solely on the use of experiments in order to make students draw conclusions consistent with canonical scientific knowledge, as heurism advocates expected. Advocates of heurism thought that in Individual Practical Work (IPW) classes "The teacher will walk among them teaching as little as possible (…) [and] will leave them to draw conclusions" (Motta, 1934, p. 530). Unlike Riley da Motta, Carvalho did not agree that pupils could "find out things themselves" (Armstrong, 1898, p. 115) when working on their own with experiments. Instead, for him, the responsible element for the inductive process was *the teacher*. This is well spelled out in the excerpt below:

> Although the inductive process caused by experimentation is a solution used at secondary school level because of its easy successes, we do not want to neglect the real dangers it conceals. Between the experiment carried out and the respective inductive process that the former has been used to elicit, there is a great yawning abyss, even though the teacher may inadvertently marvel at the results obtained by his students. The teacher, accustomed to suggesting in some way what he wishes to transmit to his students, does not always recognize the 'suspension bridge' he has lowered over the abyss separating the experiment from its corresponding inductive process - the bridge over which his students have now victoriously passed. (…) The student, overwhelmed due to his beginner's understanding, will conclude only what we wish him to conclude, or what we believe most suitable for him to conclude (…) It is necessary to be careful in considering experiment as the fundamental basis of physics teaching because of its value as stimulant of the inductive process. *Actually it is not the experiment that gives rise to the inductive process*. It is us, the ones who teach, with the words we choose and utter during its performance, with our skilful insinuations, with our opportune pilfering, with our astute knowledge about students' knowledge and their circumstances. We are, utterly, the method, the process, the form, and the mode. Thus, in the final analysis, it is we who are everything: the method, process, form and mode. (R. d. Carvalho, 1959a, pp. 63-64, my emphasis)

In the same article he says that the teacher was free to choose between the "heuristic mode, where the student is placed in the (apparent) situation of the first discover of the studied phenomena, or the Socratic mode, where the teacher questions the student in perspicacious terms, of refined subtleness" (p. 61). Accepting the free choice between methods might indicate respect to other teachers' taste or hesitation in openly standing up for one side. But different from some of his contemporaries, from the excerpt above it can be inferred that Carvalho was advocating the Socratic method and not the heuristic method. In fact, we should note that when he identifies the interference of the teacher, with his "skilful insinuations" (and not the experience itself), as the cause of generalization, he not only indicates teachers' interference as an imperative condition in the learning process, but also his implicit preference for the Socratic method. This view is reinforced by one of Carvalho's former trainees in late fifties, Alcina do Aido, who said Carvalho's students "were excited by the experiences and by the guided dialog, which led them to draw conclusion themselves (…) whilst developing their critical spirit" (Aido & Bastos, 2001, pp. 33-34).

In 1958 Carvalho became Metodólogo teacher of the Liceu Pedro Nunes, and he wrote several articles for the journal *Palestra*, which aimed at supporting teachers with the use of experiments (R. d. Carvalho, 1958, 1961, 1962b, 1964, 1965, 1966a, 1967a, 1967b, 1967c). This was a painstaking work with information for liceal science teachers about the best way to set up and use school experiments. In each article Carvalho explored a certain apparatus, which aimed at teaching specific concepts in physics, in which is very clear that Carvalho expected students to draw conclusions. It is also possible to perceive that he expected the experiments could be used either by the teacher or by the students themselves. Unfortunately he does not make at any time explicit references to his preferred teaching method (perhaps respecting teachers' free will to decide what best suited them). But interestingly in some, few, parts of the texts he subtly indicates the need for guidance. For instance, teaching reflection angles in mirrors he says, at some point, that

> the student is then invited to search for this direction through the narrow tube… (…) After the law of equal angles of incidence and reflection has been discovered, the student should be informed that it would be possible place the tube where… (R. d. Carvalho, 1964, p. 111).

In another article, where he discusses experiments for the teaching of kinematics, the reference to the inductive process is clearer: after presenting a table with a set of data collected with the experiment, he says:

> In the case we have a class where the measures presented in the last table were carried out, it would be useful to make the following question: if the load which set the system in movement had a different weight, would we read the same figures? Everyone would understand, by intuition, that if the load was heavier, we would have a faster movement… (R. d. Carvalho, 1967c, p. 75).

To summarize, Carvalho did not deny inductivism. He even suggested it[142]. However, in his view, and in contrast with those who advocated heurism, teachers' participation in the learning process was essential. Consequently, as Carvalho also indicates in that article, since experiments could not be seen as responsible alone for any inductive process (but just as a stimulant), students working on their own with experiments should not prove very fruitful in generalizing laws. Until 1959, apart from the IPW usefulness identified earlier (the meaning of measuring, the development of care in observation, and organizational skills), Carvalho also believed that, guided by the teacher, either by demonstrations or by students' direct manipulation of experiments (IPW), pupils could be led to generalize principles/laws, to conceptualize.

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142 For epistemological reasons, "the indicated method will be the inductive: always in the 2nd cycle and many times in the 3rd" (R. d. Carvalho, 1959a, p. 61). He explains in the article it was by means of experiments and inductivism that classical physics evolved. Modern physics, on the other hand, has evolved by deductivism and experimental verifications.

By the sixties Carvalho seemed faithful to the Socratic method: the method "where the teacher questions the student in perspicacious terms, of refined subtleness" (R. d. Carvalho, 1959a, p. 61). However, he did not insist in spreading out his views to other teachers, perhaps because he did not have a robust enough rationale to make a case for the use of the Socratic method, and just had it for himself as his preferred one. As in the quotation above, Carvalho seemed to respect teachers' decision about whether to use of the heuristic or Socratic method. In fact, towards the end of his career, one can see Carvalho advocating teaching methods which seems to resemble heurism more than the Socratic method. Apparently he was, at least to some extent, influenced by the science education movements of the sixties. The next section will address this apparent change of view.

6. A shift from the Socratic method to "discovery learning"?

In 1970, Carvalho published two new articles addressing laboratory classes (these belong to the list of articles published at *Palestra* that I referred to in the section above). In one of them Carvalho was, as usual, explaining to the teachers the best way to set up and present an experiment. This time, the experiment aimed at teaching Archimedes' theorem[143]. Differently from the previous ones, in this article Carvalho provided more explicit orientation about teaching methodology. Arguably, the proposed methodology resembles a form of heurism. In his words:

[143] For some reason, Carvalho preferred to call Archimedes' 'theorem' instead of Archimedes' principle.

> The ideal was students themselves working, in benches for two, each pair with its private material, orientated by a written schematic plan, which would lead them from the beginning to the end, and in which they would write, by their initiative, all what teachers intended to get from them. (…) In the material impossibility in proceeding this way, there is always the possibility for us teachers, with the collaboration of some students taken in turns, to carry the work out, whereas the others watch and intervene orally (R. d. Carvalho, 1970b, p. 180).

In other words, students were supposed to work on their own, led by a written plan, and teachers should only intervene in the case of lack of proper material.

It is likely that by the time he wrote this article, Carvalho was influenced by the new science teaching movement of the sixties, when thinkers such as Joseph Schwab started advocating "inquiry" methods. After Armstrong, the new surge for "discovery learning" reached Portugal as they were being commented on the pages of educational journals and even Carvalho himself wrote about the *Physical Science Study Committee* (PSSC) (R. d. Carvalho, 1963b). PSSC along with the *Chemical Education Material* (CHEM) and others courses were created in late fifties in the US. Boosted by the Cold War, they belonged to a joint governmental and scientific effort to introduce the empirical and rational spirit into school science, as this opposed to the then "life-adjustment"[144] progressive-like curriculum of the time (Rudolph, 2002). These programmes achieved international influence, also reaching the famous British Nuffield science curricula on the sixties, which similarly promoted learning by doing, learning by enquiring, and investigations of problems and phenomena

[144] Rudolph refers to these kind of curricula as the "epitome of functional schooling, in which academic subject matter was marginalized in favor of courses designed to meet the immediate social, personal, and vocational needs of the student" (Rudolph, 2002, p. 4)

(Atkin & Black, 2003). In Portugal, in 1967, one of Carvalho's former trainees, whilst referring to CHEM and PSSC as the most updated science courses, said laboratory work was a "research work" (M. C. S. Rosa, 1967, P. 123). An article published in 1968 in the journal *Labor* with the title "New methods for the teaching of Physics and Chemistry – the Nuffield Project" (A. B. d. S. Nunes, 1968) points out that Prof. D.J. Millen, a member of the 'Consultative Committee' of the Nuffield Project, participated in a conference in Portugal in December 1967 to bring the news of the "new teaching methods". This teaching programme, as the article explains, "was firmly based in experimental work, done by students themselves" (A. B. d. S. Nunes, 1968, p. 357).

In the other 1970 article, with the title "An Overview of Present-day Physics Teaching" (Sobre o estado actual do ensino da Física) (R. d. Carvalho, 1970c), Carvalho indicated that the teaching of sciences in the Preparatory Cycle should be in accordance with the then "modern" method of teaching sciences with experiments. Again, Carvalho seemed more flexible about accepting students being led by written instructions, although the teacher might play some role:

> The common idea present in the expression "experimental teaching" is the conduct of classes in which teachers make students observe experiments performed by himself, asking, or not, for the collaboration of these students. (…) This kind of experimental teaching is, in its most basic form, the best we can reach in our liceus. (…) The experimental physics teaching, in *its most modern expression*, consists in having a class where the students, sorted in tables, two in each, with the didactic material on them, tries to discover the properties of matter, to provoke and observe the phenomena, measure magnitudes, establish numerical relationships, *everything through the*

experiment, according to a working plan devised to this end and *orientated by the teacher who reveals the theoretical aspects of the subject in study*, discusses them and make them clear (R. d. Carvalho, 1970c, p. 152, my emphasis)

Arguably, this excerpt is ambiguous. One could query whether Carvalho was suggesting that learning should rely on "the experiment according to a working plan" or "orientated by the teacher who reveals the theoretical aspects of the subject in study", or even on both within a sequence? However, also arguably, the excerpt above seems to indicate a shift in Carvalho's position from 1959 when he relied almost entirely on the teacher as the responsible for teaching.

It is difficult to pin down Carvalho's ideas on this matter of laboratory classes, because he did not write consistently about them. His texts were written decades apart, probably influenced by contingent needs (e.g. wrote in 1947 against the withdrawal of IPW from the General Course, and in 1959 to fulfil his duties as a Metodólogo teacher). In spite of this apparent shift of opinion, I think it is important to emphasize that Carvalho's works still present strong aspects of the Socratic method. For instance, just around the time he published the two articles above, Carvalho published in 1968 the book *Sciences of Nature* (discussed in detail in the last chapter), in which I argued that Carvalho used the Socratic method. This textbook was written for the Preparatory Cycle, whose legislation refers to the "most modern expression" (R. d. Carvalho, 1970c) of physics teaching, quoted in one excerpt above. According to the analysis presented in the last chapter, Carvalho indeed developed a book promoting students' direct manipulation of experiments, guided by the teacher, something congruent with the way he understood the Socratic method.

7. Conclusion

Carvalho's view for the use of school experiments might be summarized as follows:

a) regarding the **educational aim**, students should manipulate experiments directly, as this has educational benefits, such as developing organizational skills, the understanding of what measurement in science is, exercise careful observation, and fosters a questioning or inquiry mind. This is not new. As we could see in chapter 2, there were several liceal teachers who also suggested organizational skills, and interest for scientific research as some of its educational values; and

b) regarding the **teaching method,** the teacher is responsible for leading students to draw the conclusion he/she wants, preferably by the Socratic method with students manipulating the experimental apparatus.

Looking over his forty-year career, Carvalho seemed to present a shift of opinion on the use of teaching methods in laboratory classes, but in practice he seemed faithful to the use of the Socratic method, reflecting his commitment to guiding students to draw conclusions.

How are these issue related to the question of Carvalho's commitment to humanistic education, which is a central concern of this thesis? In particular, can the notion of the Socratic method be classified as humanistic? In the literature we can find scholars who point out to this link. According to UNESCO's current chair of humanistic studies Nimrod Aloni, this method is one of the educational principles of what “have become the immutable assets of classical-humanistic education” (Aloni, 2007, p. 16). The classical-humanistic education stems from the Greeks, who pursed the “human virtues” to live a fulfilling life, and that some of them, like Socrates, negated dogmatism or political authority to focus on “the essence of human life and the proper way of life for Man quâ Man” (Aloni, 2007, p. 14). The Socratic method - seen as a “teaching method done primarily through a dialogue between teacher and student, as compared to lecturing or experiential learning” - according to Rhee has “its spiritual root grounded in philosophical inquiry” (Rhee, 2007, pp. 881-882). The “Paideia Proposal”, a movement for educational reform in the US from the eighties, which values Dewey’s democratic educational views, and values criticality, autonomy, questioning as educational aims, also indicates the Socratic method in its proposal (Adler, 1982).

However, according to some views which also values autonomy, the Socratic method might face some problems. For instance, it has been claimed that, ultimately, instead of a conversation, the Socratic dialogues are, actually, a kind of argument, which is unbalanced in power and manipulative, as one of the parties has an agenda, a position to be defended and transmitted (Andrews, 1995). Therefore, instead of autonomy, one might argue that this setting fosters complacence or submission.

Despites its possible manipulative aspect, I suggest that Carvalho’s preference for the Socratic method whenever using experiments is related to his attempt to make learning more engaging and joyful (similar to his aims in his 1948 General Course chemistry programme). In fact, as I will explain in more detail in the next chapter, the dialogue between teacher and students was seen by Carvalho as a way to 'humanize' science education, chiefly, in his view, for it avoids subordination and enthuses/engages the student in the subject matter.

It might be argued that Carvalho's greatest achievement for a rationale for the use of experiments was the differentiation between 'scientific' and 'pedagogical' methods, and his acknowledgement of the impossibility of making students (re)discover, to generalize, on their own, scientific laws/principles. It is possible that this understanding underpinned the rationale for the use of the Socratic method. Indeed, as we could see before, Carvalho was clear that "it is not experience which allows the inductive process. It is we, the ones who teach, with the words we choose and utter during its performance, with our skilful insinuations". Even so, the impact of this understanding and the use of the Socratic method seem to have been small amongst teachers, as I have not identified in any of the primary sources that I have consulted the influence, the echoing, of such understanding within his teaching community. This may not be surprising as for some reason he did not write about or extend his argument for the use of the Socratic method after 1959.

At least in Carvalho's work, this differentiation between scientific and pedagogical methods seems to have an important educational consequences related to students' understanding of, if I may use modern terms, 'how science works' or the 'nature of science'. Years after Carvalho retirement, in 1979, he published an 'alternative' science textbook, divided into 18 small 'booklets' called *A Treasure of Science for Young Minds* (discussed in chapter 7), in which he explains to students about the impossibility of rediscovering scientific laws. This explanation seems to be important as it draws students' attention that their work in the school laboratory but does not represent a true scientific activity. Otherwise students could develop a distorted view about the ‘nature of science’. There are a number of more elaborated criticisms on discovery learning in the literature, some of them pointing out the philosophical flaws and the anti-scientific attitude underlying to this teaching method (Stevens, 1978), or associating it to what some see as the misinterpretation of scientific practice put forwarded by constructivists (Matthews, 1994). Carvalho was not a theorist who developed a well-structured understanding in this area, but his textbooks, written to students, present, perhaps in an intuitive way, the same concern in conveying appropriate views on the nature of science.

I wish to make a final claim about the association between Carvalho’s name and the use of experiments in science school, as the quotations at the beginning of this chapter intended to convey. Given what was said in the sections above, it might be suggested that the association commonly made between Carvalho’s name and experiments is not due to his theoretical views on the pedagogical use of laboratory classes, where students could have a chance to work directly manipulating experiments, but rather on his performance as a ‘demonstrator’ in classroom lessons, and his work to give support to other teachers. Part of the next chapter will address this issue.

Chapter 6

Carvalho and the training of teachers

1. Introduction

Scattered in several testimonies about Carvalho, one will encounter a number of claims that he was an outstanding (Costa, 1997a) and demanding teacher (Aido & Bastos, 2001). As a teacher trainer he is said to have helped out and encouraged many teachers all over the country with the use of experiments in classes (Gil, 1994). Overall he is often seen as a benchmark in science teaching in Portugal (Crato, 2006a). The aim of this chapter is to provide a critical and holistic account about Carvalho's work for the support of science teachers in his country. This is the last chapter devoted to Carvalho's work on "formal" education, but in contrast with the previous ones, this will provide perhaps a more nuanced account of Carvalho's teaching practice in classroom as well as his involvement with his students and teaching community.

Carvalho's involvement with the support of teachers had two main elements. It started more clearly in 1946, with the creation of the journal *Gazeta de Física*, of which he was co-founder and co-director, and broadened with the creation of the journal *Palestra* in 1957 for which he wrote several articles. These journals addressed both teachers and students. In 1958 he was nominated Metodólogo teacher (teacher trainer) in the iconic Liceu Pedro Nunes, in Lisbon. His work as a Metodólogo, although it reached only a smaller numbers of teachers[145], lasted a decade and reveals much of his thought in teacher training.

All the work carried out by Carvalho to support teachers gains deeper significance when the political and educational condition of his time is taken into account. For this reason, initially this chapter discusses the context of teachers training conditions when Carvalho became professionally active. This first section will also give some attention to the interference of the Salazarist ideology in liceal teachers' activity inside classrooms.

It then moves on to provide brief information about Carvalho's involvement with the journals, their significance in Portugal, and in Carvalho's career, together with some information about the content of his articles, which aimed at various educational issues. One of the most important of these issues was the mastering of

[145] In ten years as a Metodólogo, Carvalho had only eighteen trainees (R. d. Carvalho, 2010, p. 292).

the use of experiments for demonstration, notably marked by a number of articles written to explain, in detail, the best use of a massive new set of experiments, purchased by the Government in 1963. This work contributed, as I will argue, to the association of Carvalho's name with the use of experiments, mainly in physics.

The second part of this chapter will argue that much of Carvalho's work to improve the quality of science teaching in Portugal reflected the paramount importance he gave to the role of teachers in the teaching/learning process[146]. As he said in a late interview, "The teacher is the essential element of the whole teaching; it is essential this lively thing of the dialog between teacher and student" (Vasconcelos, 1989, p. 11). This view, as this chapter will seek to show, was the same during his whole life and conditioned the way he performed in the classroom and the way he instructed other teachers. For this reason, an account of Carvalho's view on science teachers' qualities and the importance of their training will be provided. Amongst other articles, two essays were consulted, written in very different moments of his career, the first in 1947 and the second in 1964. The chapter will explore these writings to outline Carvalho's concern with teachers' training conditions and his pedagogical views of a good science teacher. The main argument of this section is that Carvalho challenged his pupils to achieve high standards with suitable communication of scientific knowledge in accordance to their age. This entailed a range of specific knowledge and teaching skills.

The chapter will move on to scrutinize the relationship between Carvalho's rhetoric and practice, providing a flavour of Carvalho's performance in the

[146] This was not a consensus view in Carvalho's time. As we could see in chapter 2, advocates of heurism expected students to learn with as little support as possible.

classroom. It will be argued that his performance followed to a great extent his personal views of how a good teacher should be. It will be claimed that much of Carvalho's concern in communicating scientific knowledge rely, in his view, on the proper use of experiment demonstrations. The same concern can be seen in his work as Metodólogo teacher.

2. The context: Portuguese teacher training during Salazarism

It has been said that teachers' training programme in Portugal during Salazarism was anachronistic (Nóvoa, 2005, p. 41), because of its organization. From 1930 to 1974, its framework was kept the same: in the first three years of preparation, teachers were supposed to attend university courses for theoretical instruction in their specific disciplines (e.g. a prospective physics-chemistry teacher was supposed to attend a physics-chemistry undergraduate course[147]) then followed by one year of "pedagogical instruction" in a "*Faculdade de Letras*"[148] (V. Martins, 2010). The graduate students who wished to progress in teaching career and would like to virtually guarantee their places in schools, were supposed to apply for a two-year

[147] Students of this course attended disciplines such as physics of solid and fluids, acoustic, optics, heat, pure and applied chemical analyses, and organic chemistry (J. M. d. Araújo, 2006, p. 19).
[148] "Faculty of Humanities" is the best translation I can make. The disciplines, studied at the *Faculdade de Letras* included psychology and logic, secondary teaching pedagogy, history of pedagogy and methodology (Pintassilgo & Teixeira, 2011, p. 6).

non-paid ‘pedagogical placements’[149] of practical instruction in their disciplines in specific Liceus, called “Normal Liceus”, with the support of Metodólogo teachers (Nóvoa, et al., 2003).

Metodólogo teachers were teacher trainers, chosen amongst all teachers of a certain discipline by the rector of a Normal Liceu, to pass on their expertise in teaching methods and knowledge in pedagogy to those who wanted to be teachers. Being a Metodólogo teacher meant status and also a better salary, since only those with recognized competence were chosen, as Carvalho himself acknowledged (R. d. Carvalho, 2010, p. 279).

In practice, there were many teachers, classified as “eventual” science teachers, who taught in liceus without having attended the placement with the support of a Metodólogo (R. d. Carvalho, 1970a). This is because, as Carvalho pointed out, although an attractive training because of its quality, it was difficult to obtain since one had to dedicate two years of his/her life with no income[150], which explains the small number of teachers attending and graduating in the placement. For instance, during the six-year period from 1964 to 1970, in the three Normal Liceus in Portugal, only twenty eight teachers had finished the pedagogical training (R. d. Carvalho, 1970a).

Moving to issues more specific to science education, we can recall from chapter 2 that up to the forties there was encouragement for the use of experiments in

[149] Not only graduate students could apply. “Eventual Teachers”, who also taught without specific pedagogical train, could apply in order to have benefits in knowledge and privileges.
[150] Presumably therefore, only attracted students from specific social classes. This also can explain why the majority of trainees were women.

liceal science lessons. According to articles published in the journals *Labor* and *Liceus de Portugal*, there was a group of teachers committed to the use of experiments. However proper preparation for their use as demonstration and in the laboratory classes was quite another issue. By the end of the first half of the twentieth century, the need for improvement in teachers' preparation and teachers salary were issues recognized by all, including the Government itself (Pinto, 1946). Regarding the physics-chemistry undergraduate course (which served prospective secondary science teachers as part of their graduation), Armando Cyrillo Soares, a Portuguese physicist with special care about education and instruction, recognized, also in 1946, that "for a long time" it had been lamented how "backward" (A. C. Soares, 1946, p.4) physics-chemistry undergraduate courses were in comparison with other countries. From 1926 to 1946, attention to the quality of instruction inside Portuguese universities decreased dramatically. As he added, the great effort made during the First Republic (1910-1926) with notable improvement in the experimental practice in science university courses faded away due to legislation modification, deficient installation, worn out equipments, and unqualified people (ibid, p.4). Armando Gibert, another physicist with educational concerns, wrote in the first issue of the journal *Gazeta de Física* about undergraduate courses: "the experimental practice is a complete fiction!" (Gibert, 1946, p. 2).

Carvalho had similar an opinion to Gibert. Writing in 1947, also on the pages of *Gazeta de Física*, he was accusing those who write educational reforms of forgetting that "reforms are worthless without the preparation of those who will fulfil them" (R. d. Carvalho, 1947a, p. 39). Drawing on his own previous experience as an undergraduate student, Carvalho saw the four-year instruction in the university was of very little use regarding the knowledge and skills that a science teacher needs. In his opinion “the qualities which make the structures of a teacher are not acquired in the university”; the scientific preparation was “nearly useless”, and the pedagogical one even worse. He said this because he thought what is learnt in undergraduate courses rarely had direct application in a liceu classroom. The opinions shown here on teachers’ education will appear in some of Carvalho’s writings and conditioned his work for the support of science teachers, as we will see later.

At least until the sixties, the situation described above did not change much. However, certain initiatives carried out in the forties and fifties reveal the concern of some educators in improving the educational system. The creation of the journals *Gazeta de Física* and *Palestra* are representative of this quest. Carvalho worked for both of them, and both became important tools through which he communicated teachers throughout the country.   For this reason the next section analyses their role, and his involvement with them.

3. Involvement with the journals Gazeta de Física and Palestra

The *Gazeta de Física* was founded in 1946. Armando Gibert was the main name behind it. After returning from his doctorate course in Zurich in that year, he was influenced by the excitement of some mathematicians who had recently created the *Gazeta de Matemática,* founded in 1939 by Bento de Jesus Caraça and other mathematicians (Gaspar, 2007). *Gazeta de Matemática* and *Gazeta de Física* – or the “twin sisters” to use Carvalho’s expression (R. d. Carvalho, 2010, p. 245) - aimed at promoting scientific knowledge outside the research community.

According to Lidia Salgueiro, one of its former director, the *Gazeta de Física* was one of the first worldwide periodic journal dedicated exclusively to the teaching and popularization of physics (Salgueiro, 1997). Gibert’s aim was to promote the profession of physicist in Portugal, to support the liceal community, and to inform to the largest public possible what physics was about (Gibert, 1946). He wrote in its first issue to explain that the *Gazeta* had a triple purpose: “to contribute actively to the development and elevation of physics studies in Portugal”, “to clarify a wider public about the real position of the physics intervention in modern life”, and to “promote in everybody, including the industry segment, a greater interest for the ‘profession’ of physicists” (Gibert, 1946, p.1). Amongst those purposes, Gibert took special care to highlight the great need to rethink the undergraduate courses in physics, which (as was the general opinion) should give much greater attention to experimental practice and scientific knowledge. Since early nineties the Portuguese Government has been handing out free volumes of the *Gazeta* to all secondary school in the country (Souza & Fiolhais, 1993). The creation of the Gazeta de Física is a landmark in Portuguese physics teaching because during the first half of the twentieth century, all liceal teachers, including science teachers, used only the journals *Labor* and *Liceus de Portugal* to discuss all sort of pedagogical problems in sciences in the liceal level. There was no specialised journal turned to the teaching of sciences and the *Gazeta de Física* appeared to fill this gap. One of the sections of the *Gazeta de Física* was “Teaching of Physics in Secondary School”.

In a recent study, Júlia Gaspar (2007) has claimed that when Gibert was setting up the *Gazeta*, he wrote to science teachers throughout the country asking for contributions to the journal. "There was only one positive response", said Gibert: "Rómulo de Carvalho who became a diligent and very efficient collaborator" (Gaspar, 2007, p. 13). Carvalho and Jaime Xavier de Brito were the two liceal teachers who were part of the Gazeta's steering board. Being invited to be one of the directors of the Gazeta meant, for Carvalho, a "distinction" (R. d. Carvalho, 2010, p. 243).

The reason for Carvalho's nomination is rather difficult to point out. Carvalho said in his *Memórias* that his qualities as a university student had been identified in early thirties by Álvaro Machado, his lecturer and also an authority in physics teaching, who had invited him in 1936 to be physics lecturer in University of Porto (R. d. Carvalho, 2010, pp. 202-203). But the fact is that by 1946 Carvalho's professional achievements were not due to experiments in physics at all: his first noteworthy contribution only happened in 1948, with the publication of his controversial *chemistry* programme[151]. In Carvalho's own view, the reason for this rapid acknowledgement was due to the average low quality of teachers and to his "behaviour"[152] (R. d. Carvalho, 2010, pp. 203-204). Carvalho suggested in his *Memórias* that he was a very strict and right person, who gained prominence not because of his scientific knowledge, but because of his students' acknowledgement:

[151] By 1946, other relevant activities were: In 1935 he was named judge for entry exams of University of Coimbra[151]; from 1938 he was named the *chemistry* laboratory director of the Liceu Camões; and since 1940 he had written five articles in the realm of popularization of science, with a focus on *chemistry*.
[152] By "behaviour" he probably meant his correctness and commitment with his work.

They "distinguished me because they held me in high esteem and publicized me" (ibid, p. 204).

Carvalho became a regular contributor. Lidia Salgueiro said that "although there were many subscriptions amongst secondary teachers, their collaboration was scarce, except those written by Rómulo de Carvalho" (Salgueiro, 1997, p. 4). This productiveness was also remembered in the occasion of the award of his Honorary doctorate degree, which document applauds the fact he turned out to be the "most assiduous contributor of the *Gazeta de Física*"[153] (Gil, 1994, p.5).

Now turning to the journal *Palestra*, issued from 1958 to 1973, this was the 'pedagogical and cultural journal of the Liceu Normal Pedro Nunes', where Carvalho taught from 1958 to 1974[154]. As a 'Normal Liceu', the Pedro Nunes had the responsibility to provide pre-service instructions to trainee teachers of all disciplines, apart from being an adviser in pedagogy to other liceus.

Carvalho was part of the School Council (a group of teachers chosen by the rector) which created the *Palestra* ("Jornal de 10 de Outubro," 1958). Unlike the *Gazeta*, it did not focus on sciences. It was idealized with the aim to communicate activities carried out in the Pedro Nunes to others liceus and the general public, and also [apparently mainly] to publish texts of general culture and global education. In

[153] One of the reasons for this was that from early fifties onwards Carvalho was forced to find alternative means to publish, and the *Gazeta de Física* turned out to be the only place for publishing. It happens that the journal *Liceus de Portugal* had a short life (1940-1946); and in July 1951 Carvalho decided no longer to publish in *Labor* after having been involved with the debate with José Teixeira, one of its directors. From then on, Carvalho focused his support on science teaching activity mainly through the pages of journals *Gazeta de Física* and later on in the *Palestra*.
[154] Carvalho also taught in that liceu from 1948 to 1950. From 1948 to 1957 the Pedro Nunes was not a 'Normal' Liceu.

Carvalho's view, the journal aimed to be pedagogically useful to the whole community of liceal teachers, and even more useful for trainee teachers[155]. Its aim was to teach, educate, and inform, not like a bulletin, or a report, but like a friendly journal for reading and reflection. Publishing at the *Palestra* was a duty for all Pedro Nunes' teachers and demanded high quality work, Carvalho said[156].

Carvalho was as involved with the *Palestra* as he was with the *Gazeta*. He was also part of its director board and one of the most assiduous writers, publishing at least thirty articles, seeker of contributions to the journal, and even helped with the distribution of the journal[157]. For the difference in their scopes, the content of the articles naturally differed a lot, with more space for general education problems in the *Palestra*.

Mainly because of the Pedro Nunes' rector had just resigned (R. d. Carvalho, 2010, p. 275) the *Palestra* stopped being published in 1973. In 1974 the *Gazeta de Física* was incorporated by the Portuguese Society of Physics, created that year, and Gazeta's direction board handed over its duties to the Society (R. N. Rosa, 1996). For this reason Carvalho stepped down from Gazeta's director board in 1974, in spite of the invitation to carry on in that post (R. d. Carvalho, 2010, p. 244). The articles he published in these journals were to a certain extent part of his work as a Metodólogo teacher in the sense the journals were the media to reach teachers all

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[155] Carvalho remembered the creation of the *Palestra* on the occasion of the celebration of the 75th anniversary of the Liceu Pedro Nunes, in which he was invited to participate. See Carvalho's personal documents, BNP, Archive 40, box 55, folder "Entrevistas, inquéritos etc", and also see the invitation letter in 1986 in box 3, folder "Palestra"**.**

[156] ibid

[157] See for instance letter from Maria Stela de Morais Barros on the 9th of November 1967. BNP, Archive 40, box 4, folder "Correspondencia de Professores".

over the country. It is likely that this work contributed to diffuse Carvalho's knowledge, and broaden his views of teachers' qualities.

4. Carvalho's articles on the use of experiments

It has been said that Carvalho's articles in both journals where addressed to secondary and university students and teachers (R. N. Rosa, 2002), but it seems fair to say they targeted the latter in their overwhelming majority. The articles can be roughly classified into three categories: pedagogical ones, on the popularization of science, and articles about the use of school experiments in science lessons[158]. This classification may vary and even be extended, but they should cover well the large majority of articles, which were addressed to science, mainly physics teachers. It has been pointed out, however, that from 1946 to 1974 Carvalho's articles on the *Gazeta de Física* "consisted fundamentally in the description and suggestions of experiments" (Salgueiro, 1997, p. 4). Although this is an overstatement[159], Salgueiro's comment is useful to identify the importance of Carvalho's articles which addressed experiments. This association probably stem from the number of

[158] An overview upon some titles provides a flavour of the range of issues covered in his articles: "What atomic batteries are and how they operate" (R. d. Carvalho, 1949d), "Descartes' presence" (R. d. Carvalho, 1950c), "Consideration about elementary physics teaching" (R. d. Carvalho, 1952a), "New physics units system" (R. d. Carvalho, 1962c), "Albert Einstein" (R. d. Carvalho, 1956a), "Science and Art" (R. d. Carvalho, 1958), "Considerations on Archimedes' principle" (R. d. Carvalho, 1960a), "New ways to work with Torricelli pipes" (R. d. Carvalho, 1962b), "Description of the acoustic box" (Neva-Lehrgerat Nr 6-AKUSTIK) and its use (R. d. Carvalho, 1966a), etc.
[159] Approximately, there were 18 on pedagogy, 11 on the popularization of science, and 19 on experiments.

articles he published to explain the use of new set of experiments (laboratory instruments), which arrived in mass, in 1963, virtually in all Portuguese liceus, and left teachers without guidance.

It happens that the Ministry of Education, through the "Commission for the reimplementation of material in superior and secondary schools"[160], renewed the didactics material of schools during the three-year period from 1963-1966. Since 1947, when the Individual Practical Works (IPW) were moved from the 2nd cycle to the 3rd cycle (see chapter 2), laboratory classes lost room in the timetables, and the amount of compulsory experiments were reduced. Liceal science laboratories were suffering with the slow process of outdated, worn out, inappropriate, insufficient material, as one science teacher observed (Carmo, 1959, 1960a, 1960b).

Around that time Carvalho wrote a few articles through which he provided his understanding of the situation. Carvalho explained that "the physics laboratory of the Portuguese liceus received a great amount of material, not only usable to fulfil the current programme but also to illustrate subjects which might be part of a future, more updated programme" (R. d. Carvalho, 1967b, p. 101). In the Liceu Pedro Nunes only, where Carvalho was teaching at that time, the physics laboratory received in total 301 "titles" (experiments). In his understanding, mastering the use of experiments for teaching purposes became a great challenge for the majority of physics teachers: "the amount [of experiments] makes it difficult for teachers of this discipline to have the opportunity to learn how to handle them in full", not only because of the scarce free time but because some of them "did not have instructions"

[160] In Portuguese: "Comissão de Reapetrechamento em Material das Escolas Superiores e Secundárias".

and even if they did, they "were written in German, an unknown language for the majority of physics teachers" (R. d. Carvalho, 1965, p. 95).

Carvalho seemed to have assumed the responsibility to work out, test, and write articles to instruct about their use. Perhaps because Carvalho was, since 1958, Metodólogo teacher of physics and chemistry he felt morally obliged to provide support for the mastering of those experiments.

> Considering the situation, and wishing to be somehow useful, we decided to make public the practicing acquired with the use of some pieces, which handling might raise some doubts at least for the youngest teachers (R. d. Carvalho, 1965, p. 95).

He described many experiments, gave hints of alternative ways to improve their use, alerted teachers about specific problems, and informed them about experiments' history. A few years later Carvalho acknowledged that the situation had improved "spectacularly" (R. d. Carvalho, 1970c, p. 99). It is not known if there was any organized scheme for teachers' training for the use of this massive new set of experiments.

It is likely that this work is one of the reasons why Carvalho's name has been remembered in Portugal for the use of experiments in school science. His work in both the *Gazeta* and in the *Palestra* in the sixties attracted a good deal of gratitude, repeatedly remarked in the dozens of letters he received and kept[161]. As a teacher

[161] There are a number of examples in Carvalho's personal documents. See, for instance, letters from Helena Lopes on the 4th of November 1961 and Manuel da Conceição on the 4th of May 1962.BNP, Archive 40, Box 4, folder "Correspondencia de Professores".

wrote to him: “Thank you very much for your offer of the article about experiences with the oscilloscope. (…) Without this orientation that would be impossible for me to set the experiment up”[162]. Other teachers wrote to request help with their teaching: “nobody is better than you to do this”[163], whilst others went in person to the Liceu Pedro Nunes to thank him for all support[164].

Another probably reason for the association of Carvalho’s name with experiments is because of his performance in classroom and his work whilst being Metodólogo teacher. Carvalho’s enthusiastic support for the use of experiments through the journals and as a Metodólogo teacher reflected his emphasis on the importance of such activity in the classroom. But for him, the use of experiments was only part of what it meant to be a good science teacher. Teachers required many other qualities. In the following section we move to this broader perspective, examining his views on the key qualities needed by science teachers, and how those qualities could be promoted.

[162] Ibid, box 4, Folder “Correspondência de professores”, letter from Jorge de Autouguia in March 1974. See also letter from Maria de Jesus Lima, in February 1974.
[163] Ibid, box 4, folder “Correspondência de Professores”, letter from Leonor Maria Correia Vieira, on the 4th of February 1963
[164] Ibid, box 4, folder “Correspondência de Professores”, letter from Maria Stela de Morais Barros on the 9th of November 1967.

5. Carvalho's views on the qualities and preparation of a science teacher

> For me, the fundamental element in teaching is the teacher; the book has a very secondary role. If good, a teacher with a book, even without resources, in a tent, under a shadow of a tree, etc., can provide splendid teaching. And another one, with all possible advantages, may not offer anything of use. ("O Polémico Livro Único," 1988, p. 8)

> Teaching means turning the most common things we find in the world into objects of contemplation and reflection. We need to transform all that surrounds us, all that is strange - and yet part of our reality - into a real desire to understand. (Gedeão, 1992, p. 178)

> [Teachers] should be very understanding and even a little humble. He should not try to override students, should not think they are subordinated to them. (…) Besides of course [they] should have a good scientific preparation.[165] (Salema, 1996)

All the excerpts above were taken from interviews. It can be argued that they convey the three main pillars of Carvalho's thought around the teachers' place in the teaching/learning process. They are: the central importance he gave to teachers in this process; the need of great skills to communicate knowledge (particularly with the use of experiments); and the humanistic aspect of this profession: the exaltation of the human qualities of the teacher. This section will review his views on the critical issue: 'what makes a good science teacher?'

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[165] Carvalho answering the question "What are the qualities a good teacher should have?".

Of course as we have seen, Carvalho saw the teacher as central to the process. Within this, he stressed what might be called the key professional qualities, particularly excellence in communication. But, perhaps underpinning these qualities, we can detect how his emphasis on humanistic curricula was carried over into the humanistic quality which he looked for in members of the teaching profession; e.g. facilitating learning and care with the condition of the learner.

Given the centrality of teachers' role, new curricula, new didactic resources, new methods, etc, depended, in his view, on the teachers' training for its successful use (R. d. Carvalho, 1947a). For many times he stressed the importance of the teacher: "Teaching is successful sometimes and in certain places precisely because the individual teacher is effective" (Gedeão, 1992, p. 176). An association can be made between the responsibility of teaching/learning process he laid upon teachers and his care with an effective communication of knowledge. Aspects of his views can be examined in two documents, written in 1947 and 1964.

In 1947 Carvalho was requested to answer a questionnaire (probably from the Ministry of Education) about the then current organization of teachers' education. Carvalho's answers to the questionnaire were provided before he had any great involvement with teachers' support and more than ten years before he became a Metodólogo teacher. To promote the best teaching, he claimed, required demanding teacher training: "what I wanted the most was the training of future teachers with extreme rigour (…) Teachers must be good. Not mediocre, not even satisfactory. Good, only." [166]

[166] Page 4 of Carvalho's answer to the questionnaire. BNP, Archive 40, box 55, folder "Entrevistas e Inquéritos". It is not said who wrote the questionnaire.

Carvalho's answers to the questionnaire highlighted perhaps his greatest concerns in teachers' training, namely, the *gap between what university courses taught and what secondary teachers needed*. A liceal teacher, he believed, needed "a simplicity suitable to the observation of problems, (…) the improvisation of instruments which enthuses, instructs, and convinces" (p.2). He illustrated this by saying that a university students knows "integral calculus", but "does not know how to get a glass of water, a handful of ammonium salt and two metallic sticks to make a battery" (p.2). From these quotations, it seems that for Carvalho the central problem with teachers' preparation was to deal with the challenge to adapt the *abstract* knowledge acquired in the university into more *concrete* knowledge suitable for youngsters. In the 'Normal Liceus', as he said in the same questionnaire, the teacher "needed to learn to turn into facts everything which is taught in a lesson, experienced facts, alive ones, and even infantile[167] ones if needed" (p.2). The reader may recall that Carvalho's 1948 chemistry programme embodied the same views.

As another important aspect in teaching, Carvalho also pointed out in the questionnaire to the importance of the perfect use of the speaking language: "The word is a resource as needed as the devices which illustrate the exposition". The teacher was supposed to express "clearly, confidently, and properly" (p.3) – an important issue for Carvalho as we will see further below.

Regarding content, Carvalho urged the introduction of History of physics and chemistry, the experimental, technical and theoretical evolution both in the university

[167] Carvalho did not provide an example of what an 'infantile' fact is. I think what he is trying to convey here is that the teacher should adapt his/her vocabulary and examples according to what the pupil can understand.

undergraduate courses and in the pedagogical placements at the Normal Liceus. The importance of history in the teaching of sciences, as we could see in previous chapters, was closely related to context and meaningfulness in the communication of scientific knowledge. In 1947, this was Carvalho's understanding of its use in secondary school:

> The student who follows the line of the historical development of science (…) gets along it with a smile, truly enchanted, about man's struggle to conquer knowledge. Everything seems clear, evident, without mystery, without the false aspects of the acquisition of knowledge that does not have either connection or finality. (p.3)

One will probably think this is wishful thinking, and that at that time Carvalho minimized the challenges to teach science with the support of its history. But it should be also considered that this was a questionnaire to the Ministry of Education, not writing a report or an official document with more concrete consequences, and the enthusiastic, nevertheless simplistic, tone of his words could have influenced Ministry's future curricular decisions. What seemed to be the overall point of his answer to the questionnaire was that in order to teach efficiently, he argued for the utilization of concrete examples suitable to pupils' age, skilfulness with the use of experiments, and a wide use of the history of science for the sake of pleasure, and clarification. But for the understanding of Carvalho's pedagogical thought, this material is useful because it indicates a certain line of thought, reasserted nearly two decades later.

In 1964, now holding the position of Metodólogo teacher in the Liceu Pedro Nunes, Carvalho was asked by the Minister of Education to participate in Paris in a meeting which aimed at the elaboration of the "working plan of the French Region about physics teaching"[168], sponsored by OECD, which actually was a plan to develop a new physics syllabus[169]. This was a big event with the participation of several countries[170], each of which was designed to prepare a presentation of a specific theme and present it in a conference in the near future[171]. The Portuguese delegation, which had Túlio Lopes Tomás (Carvalho's friend and a great networker) as president, and Carvalho as his assistant[172], was asked to prepare a report entitled "La Formation du Professeur de Physique" (The training of a Physics teacher), also published one year later in the journal *Palestra* (Tomás, Carvalho, & Almeida, 1965). It is likely that Carvalho was in charge of writing the report. My supposition lays on the fact that he was the one in the group who wrote to the Minister to inform about the details of the meeting in Paris, and also for the great acknowledgment and approval, several times expressed in personal letters, that Tomás had for Carvalho's knowledge and writing skills. Furthermore, in spite of the distance in time, this document shares many similarities with Carvalho's answers to the questionnaire discussed above.

In the 1947 questionnaire Carvalho had already indicated concerns about suitable communication, but in the 1964 report he was more emphatic as advocating

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[168] In Portuguese: "programa de trabalho da sessão Regional Francesa sobre o ensino de Física". Letter from Carvalho to the Ministry of Education on the 6th of May 1964. Carvalho's personal documents, BNP, Archive 40, box 55, folder "Artigos etc".
[169] Such reference was made in an official letter from the General Direction of the Liceal Teaching , on the 5th of June 1964. BNP, Archive 40, box 55, folder "Artigos etc".
[170] Spain, Belgium, Switzerland, Luxemburg, Germany, and Turkey.
[171] A Conference took place in Sèvres, France, on the 28th of September to the 2nd of October 1964.
[172] The second assistant was Fernando Pinho de Almeida.

pupils' *engagement and enjoyment*. In Carvalho's view, a physics teacher needed to convey to the students that he was very well trained for his/her job. Thus, echoing Carvalho's previous concerns in 1947 with skilfulness on the use of experiments, the 1964 report stressed that the teacher was supposed to be much acquainted with his teaching resources, mainly great ability with experiments, mastering their rationale, and their mechanism:

> The fully trained physics teacher must not be purely an intellectual, since this has already done much harm to the teaching of science. He also must be a fully competent technician and be able, if needed, to take care, on his own, of the basic settings of his equipment. He must be open minded enough to answer any unexpected question from a student and explain with no problem the reason of an experimentation's failure. He must be able to assemble and disassemble in front of his class the basic equipment in order to describe their parts and features and to act the same way with his own reasoning, showing logical connections and leading his students to learn how to "assemble" their own reasoning by using logically assembled parts (Tomás, et al., 1965, p. 79-80)

There are other examples elsewhere which, possibly, can provide a contextualized example of the views he intended to convey in the 1964 Report. For instance, a few years earlier, in 1962, Carvalho wrote an article to inform teachers about the use of mercury when handling experiments with Torricelli's pipes.

> Handling this very beautiful liquid (there is no student who is not pleased to see it) demands permanent attention from who uses it. (…) All teacher's manipulation should proceed with exactness, soberness, and elegance. (R. d. Carvalho, 1962b, p. 48)

The 1964 report also conveys the idea that physics lesson should be something ‘spectacular’, and the teacher a ‘showman’, a flawless, precise, very able, and enchanting teacher, as the excerpts below suggest.

> …not only does the Physics teacher needs to have extensive information, scientific integrity, speech fluency, and to be enthusiast about the science he is teaching but also must he be skilled at manual work and talented at improvisation, have a sense of spectacle and above all, imagination (Tomás, et al., 1965, p. 78);
>
> He shall never forget that, despites the abundance and ingenuity of the auxiliary slides and the diversity of the materials he has, the fluent speech, the sharp sentence, the precise terminology, the clarity and logic will always be the noblest ways to express and to transmit knowledge – they will humanize it and physics cannot do without it. (ibid, p.80);
>
> …[the teacher should] not only consider technical skills but also and mainly the *human* part of the job since he will be teaching young people which he will have to understand and to lead. The teacher must be a kind of actor – and this metaphor seems relevant to us if we consider that a teacher who wants to keep his classes enthralled will have to act in some ways like an actor, from the way he occupies the “stage”, the way he speaks and the way he creates “suspense” during his course (ibid, p.82).

Although he acknowledged that “It is obvious that all these abilities, put together, are virtually impossible to reach a level of perfection” so that “they should therefore be considered as a purely ideal goal” (Tomás, et al., 1965, p. 80), it is remarkable the high level the report demands from teachers’ knowledge and skills.

In this report it is possible again to see the theme of a humanized physics teaching which is central to the argument of this thesis, though here in a somewhat modified form. Here, one can perceive that by humanize Carvalho meant teacher's dexterity in transmitting knowledge from what is intrinsically human (by teachers' words and gestures), in order to facilitating learning. The "human part of the job" seems to be Carvalho's concern with teachers' awareness of pupils' condition whilst young learners (i.e., the teacher must understand his students' needs and difficulties, and engage with them in the lesson).

All of what was said above addresses Carvalho's views on the 'characteristics' of a 'good' science teacher. However in the same 1964 report, Carvalho also tried to relate these characteristics with the ultimate ends of education. In his view, the ultimate aim was to encourage pupils developing a critical mind, to foster a solid citizenship by enriching the relationship between citizens and society. Speaking again with the ideal of a good physics teacher in mind, the report argues that:

> [Teachers'] pedagogical function must go beyond a simple educational role and have a real civic and social aspect. (…) He will teach [pupils] to infer from several elements the hidden law that rules them; to grow his critical faculties; to mistrust apparent ease and hasty conclusions; to get used to meditation and reasoning; to admire great scientific monuments such as Classical Physics and Modern Physics and their creators. (…) [Teachers] will teach [pupils] not to accept pseudo-scientific dogmas which were not submitted to experimentation; to contribute to freeing mankind from myths and superstition – because the school of Science is both a school of character and of complete education of man (Tomás, et al., 1965, p. 79)

These ends of education (e.g. criticality) were not addressed in Carvalho's answer to the 1947 questionnaire. This seems to be an issue that only occurred more clearly to Carvalho from the sixties, as his textbook *Sciences of Nature*, discussed in chapter 4, is an example. In the more recent literature, we can see a great number of educators claiming criticality and citizenship as strong characteristics of a liberal/humanistic education, such as those mentioned in the introductory chapter (e.g. Matthews and Aikenhead). However, in Carvalho's 1964 report, the connexion between teachers' 'enthusiastic' performance and the educational goals above are not very well spelled out. Perhaps the subtle reference above to history of science is a hint for this connexion, as his books published for the popularization of science during the sixties, discussed in the next chapter, seems to seek to foster these educational qualities by a careful discussion of the historical development of ideas in science.

Carvalho's views about the teacher's performance in classroom presented here were taken from documents. They are, therefore, 'ideas', perhaps not feasible to put into practice. The next section examines Carvalho's practice in the school science classroom working with pupils. This is followed by a section examining his work as a Metodólogo teacher, working with teacher trainees. The available evidence suggests that Carvalho's practice and training course followed very closely the ideas presented above.

6. Carvalho as a teacher

> ... we all know how much the weighted and correct word, the manipulation of objects and their exploration, the inquiry and experimental observation, were part of his teaching, were ingredients of his fascination. (R. N. Rosa, 2002, p. 82)

The laudatory tone of the excerpt above, written by Rui Namorado Rosa, a friend who worked with Carvalho for the *Gazeta de Física* in the seventies, represents well the view of some people who knew Carvalho as a teacher. Substantially drawn on former students' accounts about Carvalho, this section will provide a characterization of Carvalho as a teacher. It will cover a range of behavioural and pedagogical aspects of his approach, from his relationship with students, his concerns with the correct use of the Portuguese language, and the elegance with the use of experiments, to his concerns in teaching beyond the products of science, also exploring its social aspects.

What was Carvalho's 'image' amongst his students in the Liceu Pedro Nunes? The number of quotations below should indicate the image he left to the students who appreciate his work. Nuno Crato, Carvalho's student during the sixties, a mathematician and currently Minister of Education in Portugal, saw Carvalho as an especial, maybe curious, teacher:

> High, straight, always discrete but carefully dressed, sensitive but somewhat distant, he was demanding with himself and with others. He stood out for his

> reserved professionalism and for his superior knowledge, perceivable in the simplest chats. In an austere environment in itself [the liceu in the sixties] in comparison with current practices, Rómulo de Carvalho was pre-eminent for his rigour. (…) He spoke a perfect Portuguese with incisive sentences, simple, precise and clear. (…) It was perceivable that his main concern was to transmit a clear, sharp, and unequivocal message (Crato, 2006c, p. 9-10)

When we turn attention to Carvalho's performance in the classroom, the consulted testimonies tend to highlight Carvalho ability with the use of experiments. The quotations below are in a praising tone, but my interest here is to correlate Carvalho's characteristics as a teacher with his views as they appear in the 1947 and 1964 reports discussed above. Aníbal Pinto de Castro, Carvalho's student during the fifties in Coimbra, "still recalls the elegance of the gestures in manipulating test tubes and pipettes" (Fiolhais, 1997a, p. 16). Mariana Fernandes, his former trainee, stressed "the clarity [in his] explanation, in the detailed investigation, the beauty in [his] presentation" (M. T. Fernandes, 2001, p. 36), whilst José Francisco David-Ferreira, a biologist and former vice-rector of the University of Lisbon, who studied with Carvalho in the early forties, also described Carvalho as "an elegant and sober man, and his natural posture inspired respect" (David-Ferreira, 2001, p. 27). The physicist João Caraça, who was his student at Liceu Pedro Nunes from the age of thirteen, said Carvalho was for him a "true master" in sharing with students the experimental culture (J. Caraça, 1997, p.23), which motivated him very much to became a physicist, whilst former trainees said Carvalho had great "ability with his hands" (Aido & Bastos, 2001, p.33).

Carvalho has been also remembered for his effort to make students wonder about life and the natural world. João Caraça also said that Carvalho's classes sought to teach to search the physical meaning of things in the world. He added that Carvalho left his mark in trying to make students understand the everyday life and "our position in the cosmos" (p. 25). Carvalho recognized that the most thrilling part of teaching was to engage students emotionally, conveying the beauty of ideas and things, which entails the physics' laws and chemical reactions[173]. As Caraça confirmed, in a rather romantic way: "he demonstrated us daily (…) that dream is ever present in life" (J. Caraça, 1996b, p. 25).

Artur Marques da Costa was another of Carvalho's student in the forties, who came to be a science teacher. He said his passion about experiments was due to Carvalho's influence (Costa, 1997a, p. 27). He also highlighted Carvalho's effort to draw attention to the social aspects of science, for his ability to make use of "interdisciplinarity" (Costa, 1997b, p.11), and to "evidence that Humanities and Sciences constitute a whole" (p. 13). In Costa words, there was always an emphasis on the "influence of science and technology over everyday life", and "the relation between science and society" (Costa, 1997b, p. 10). This relation encompassed, according to Costa, attention to scientific discoveries, the scientific progress and its consequences to our living, the scientific interpretation of ordinary everyday phenomena, the history of science, and how scientist should work together towards well-being. This is confirmed by David-Ferreira who said in his classes there was always room for the history of a character or of an episode, which illustrated the lesson, or for a comment about a book (David-Ferreira, 2001, p. 27). At least for Costa and his colleagues of the Liceu Camões, whenever they gathered "the first teacher we joyfully remember is Rómulo" (Costa, 1997b, p. 12). For him,

[173] Interview for "Jornal da Educação", year III, N° 24, June 1979.

Carvalho's image in the classroom and how it affected him and his colleagues is described in the following way:

> His enthusiasm when talking about the authors of discoveries, or of the adventure of man as a result of scientific evolution, of the interpretation of everyday life, of the union between theoretical knowledge and practical knowledge, of the philosophical dimensions and history of science, were a facet of his teaching (…) The demand for great exactness, in the exposition and in the experimentation in classes, was an attribute which marked, profoundly, my passage in his classes (…) the same demand was also manifested in the calculus, and in the language, spoken and written. (Costa, 1997b, pp. 10-11)

Apart from these public declarations, Carvalho kept some former students' letters, which repeated the same acknowledgment. For the "power of the emotional communication with students" and for the "example of a magnificent teacher" Carvalho "marked, expressively, doubtlessly, our youth"[174], said one of them. There are also thanks for his "knowledge and a great love for the [teaching] profession" which "profoundly marked" someone's life[175], or for the way he went along with students and their interests for physics and chemistry[176]. Students of decades ago, then studying abroad or already working, still used to send him letters with compliments and thanks for his lessons[177]. These letters ratify what came to be said on the occasions where the name of Carvalho was celebrated.

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[174] Letter from Jorge Tavares Rodrigues to Prof. Augusto Ferreira de Almeida in the occasion of a meeting of 1945 ex-students of the Liceu Camões. BNP, Archive 40, box 4, Folder "Correspondência dos antigos alunos".
[175] Letter from Antunes Gonçalvez, Carvalho's student at Liceu Pedro Nunes for seven years, written in February 1992. BNP, Archive 40, box 4, Folder "Correspondência dos antigos alunos".
[176] Letter from J. E Brigham da Silva, in September 1986, Carvalho's student in 1935-1936. BNP, Archive 40, box 4, Folder "Correspondência dos antigos alunos"
[177] See BNP, Archive 40, box 4, folder "Ensino".

It should be emphasized that all descriptions above were made in especial occasions, the majority after Carvalho's death, in which his name was being celebrated and praised. Therefore, the account above is very likely to be biased by the view of those who enjoyed the way he taught, who admired his personality. I did not find any account in the public domain which says otherwise. However this may be, they offer an image of a man who seems to have inspired real respect and indeed affection amongst his students.

7. Taking teaching training seriously: Carvalho as a Metodólogo Teacher

Carvalho told in his book *Memórias* how he ended up nominated Metodólogo. During the years Carvalho lived in Coimbra (1950-1958) he was always looking forward to moving back to Lisbon, his favourite and home city (R. d. Carvalho, 2010). His friend and teacher Túlio Lopes Tomás, who had great a network and also some influence with politicians, kept him informed about possible "Commissions", that is, working groups in Lisbon to which he could join. The chance appeared in 1956 when the Liceu Pedro Nunes gained back[178] the status of 'Normal Liceu', and therefore would congregate Metodólogo teachers of all disciplines. From one of Tomás' letters it can be inferred that he first tried to nominate Carvalho as the

[178] Until 1948 the Liceu Pedro Nunes was a 'Normal Liceu' with Carlos Cerdeira Guerra as a Metodólogo teacher of physics-chesmitry. See Official Report of Carlos Cerdeira Guerra, years 1948-1949 and 1949-1950, MEN, AHME, fundo IEL, box 9.

Metodólogo teacher at the Pedro Nunes just as an excuse to move him back to Lisbon[179], but the person chosen was Carlos Cerdeira Guerra, who had already worked as Metodólogo before in the same liceu. Nevertheless, as a Liceu Normal, the Pedro Nunes could also receive teachers from others liceus in 'special commissions'[180], and this is how Carvalho managed to move back to Lisbon (R. d. Carvalho, 2010, p. 331).

For unknown reason Cerdeira Guerra resigned and left the Liceu Pedro Nunes in 1958, only one year after Carvalho's arrival in that liceu (R. d. Carvalho, 2010). As was discussed in chapter 4 Carvalho and Cerdeira Guerra had been involved in unpleasant situations during the period when the latter assessed the compendiums of the former few years earlier: this may have shaken their relationship. Carvalho's *Memórias* doubtlessly indicates he disliked Cerdeira Guerra very much and he does not deny the possibility his colleague left the Pedro Nunes because of his presence there. Carvalho was then invited in 1958 by the rector of the Liceu Pedro Nunes to take over Cerdeira Guerra's place. In the letters I consulted or in Carvalho's writings I did not find any indication that Carvalho pursued to be Metodólogo. He accepted it as an "opportunity" to work more closely with people who were "willing to think seriously about educational issues" (R. d. Carvalho, 2010, p. 280). And this experience seems to have proved to be a very pleasant one: "It was ten years working with methodology which left me good memory and, as it seems, also to those who worked with me" (R. d. Carvalho, 2010, p. 281).

[179] See letter from Túlio Lopes Tomás to Carvalho on the 30th of October 1956. BNP, Archive40, box 4, folder "Correspondência de Professores".
[180] In a scheme called "Comissão de Servico", by which the Normal Liceu could hire any teacher for any reason which appear to be of its interest.

The testimonies of Carvalho's former trainees provide evidence of his practice whilst Metodólogo. There are not many accounts (as there were not many trainees), but it seems fair to say that Carvalho has been remembered by them mainly for three characteristics: the first speaks to the notion of 'humanizing education', the second his demanding professionalism, and the third his care with the flawless use of experiments. As we saw before, these are reflected in reports of his own teaching practice and in the 1947 questionnaire and 1964 report.

The phrase 'humanize education' has more than one connotation here. A first connotation is closely related to the meaning addressed to it in previous chapters: some trainees have stressed Carvalho's attention in setting up situations which allowed students to comprehend "everyday phenomena", to improve their "global and coherent view of the physical world", and also to encourage students' attitudes towards "responsibility and autonomy", to "refer to social, cultural, artistic, and even religious context, of the historical moment in which the discovery or the invent were concluded" (Aido & Bastos, 2001, pp. 33-34).

A second connotation is related to the positive aspects of his relationship with his former trainees. References like 'human qualities' or 'humanize science' seems to be just a way they found to say that despite a demanding Metodólogo he was thoughtful about trainees' ideas. For instance, one of them, Maria Cândida Seródio Rosa, his trainee from 1965 to 1967, described her relationship with him by saying that

> During my contact with him, it was always present that teaching is a job of great professionalism which demands a careful scientific preparation and the development of the human qualities of the teacher (…) Rómulo de Carvalho always demonstrated a great respect for my qualities as a person and as a teacher, listening with consideration my opinions, complimenting my work and my manifested aptness, encouraging me to make more and better. This did not prevent him from criticizing me severally when I did not do my best (M.C.S Rosa, 2001, p. 35).

Other testimonies share the same line of thought. Another former trainee pointed out that Carvalho had "an uncommon sensibility, but tried to hide it behind an apparent coldness, and did not miss the opportunity to humanize science" (M. T. Fernandes, 2001, p. 36). Two other former trainees pointed out that Carvalho tried to draw their attention to the problems of the teaching/learning activity "without imposing us a defined teacher model", since his aim was to encourage them to "find and develop [their] potentialities which allowed [them] to create [their] personal model of teacher" (Aido & Bastos, 2001, p. 33).

In the quotations above there is also a certain characterization of Carvalho as a demanding Metodólogo. Indeed, from the eyes of his trainees, more than a 'humanist' this seemed to be his most salient characteristic.

> Carvalho always fulfilled, rigorously, his duties as Metodólogo: for his assiduity, punctuality, (…) for the high moral meaning, I would say of a mission, with which he faced his profession (M. T. Fernandes, 2001, p. 36).

Even people who studied in the liceus during the time Carvalho was a Metodólogo teacher recall well his reputation for being a demanding person. A former liceal student in the sixties commented that trainees even from outside Lisbon knew about “the high level [Carvalho] demanded from his trainees and thus inculcated in them this fundamental ingredient of the nature of scientific activity” (Silva, 1997, p. 45). This characteristic influenced his training course, as Aido and Bastos explain:

> The lesson plans we presented to him were criticized, not only from the didactic and scientific point of view, but also from the point of view of the correct use of language. (…) There was an enormous concern with the elegance of the oral and written language. (…) There was the need to highlight well whenever a new term appeared, writing boldly on the blackboard and, when possible, present its etymology, in order to facilitate comprehension and its meaning (Aido & Bastos, 2001, p. 34)

According to the opinion of these former trainees, there is little doubt that Carvalho tried hard to pass on to them the image of the teacher as a master of knowledge and presentation. This image was related to the performance of experiment demonstrations. Aido and Bastos also pointed out that

> A concern he sought to inculcate with greater emphasis was the need, in the eve of a lesson where the use of an experiment was foreseen, work it out with great care, trying out all the material in all details, in order to avoid any flaw which could put in risk the conclusion it was intended to draw. He warned us to the fact that a failed experience could imply in teacher’s discredit with students what could trigger, sometimes, disciplinary problems (Aido & Bastos, 2001, p. 34)

Maria Sá, another former trainee, remembers his “keenness and enthusiasm with the experimental activity” (Sá, 2001, p. 38). In similar vein, David-Ferreira has pointed out that Carvalho “became a reference, for students and teachers, as a practitioner and promoter of the experimental way in the teaching of science" (David-Ferreira, 2001, p. 27).

The picture which emerges above suggests a committed and demanding teacher trainer. How credible is it? This section is drawn on the public testimonies of a small number of former trainees. It is likely that they have omitted possible criticism on Carvalho's work. Nevertheless, this picture matches very well with the testimonies of other sources which, probably not just a coincidence, pointed out the same characteristics: a correct and demanding person.

In other later accounts about science teaching, Carvalho maintained his demanding view about teachers' preparation. Carvalho, repetitively, stressed the importance with adequate communication and with the proper use of experiments, a "painstaking activity, which demands serenity, dedication and large availability of time" (R. d. Carvalho, 1970a, p. 115). Unfortunately, at least from Carvalho's perspective, teacher training in Portugal in the seventies failed to maintain his idealistic - long and demanding - training scheme. Reforms at the end of Salazarism undermined what Carvalho believed to be the best training, as the next section will explain.

8. The end of an era in Portuguese science teacher training?

> My impression is that teaching has always been bad, in all situations, either under previous governments or current ones. And, naturally, always will be. Perhaps it is even getting worse. After living 90 years I have noticed that things, socially, always get worse. Why, I do not know (Naves, 1996, p. 24)

Carvalho said these words in an interview a few months before he died. They reveal his disappointment with education, his dissatisfaction with it, as he repeated it so many times in different occasions. Subtly, it also reveals something not very much treated in secondary sources: Carvalho's feeling that education in the liceus deteriorated after 1974, when a democratic regime was established. How are we to understand this slightly disturbing conclusion?

It happens that, on the one hand, as is well documented, the Salazarist regime interfered in the liceal education (Ó, 2002, p. 408). For instance, it increased teachers' and students' control such as by the use of the "school notebook"[181] and the "planner"[182] (Nóvoa, 2005, p. 73), these closely supervised by rectors. On the other, Salazarism gave prominent position to the role of the liceus within the Portuguese educational system. The liceus were the place to educate the 'elite' and it cannot be denied that these controlling tools were also intended to maintain the liceal status as the educational institution with excellence in teaching. They intended to educate students with good manners. It is therefore likely that Carvalho's work as a liceal science teacher was, in spite of all difficulties, benefited by this rigid disciplinary system[183].

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[181] In Portuguese "caderno escolar" ou "caderneta escolar", it was used to gather information about students' school life and meant to be students' "biography" (Nóvoa, et al., 2003, p. 57)

[182] In Portuguese "caderno diário", students used them to write down what they were studying in classroom. It was the means for teachers communicate with parents about students' school development and for parents and rectors to monitor students development and teachers' job.

[183] Despites being benefited, reference to Carvalho position against the Salazarist ideology will be explained in the next chapter.

Carvalho indeed enjoyed the austere and disciplined environment of the Portuguese Liceus, which the Dictatorship perpetuated. It is not just a coincidence that he officially[184] retired in January 1975[185], when he had completed forty years of teaching, but also because of the fall of the Dictatorship on the 25th of April 1974. Asked in an interview why he decided to leave the liceu at that time, he said it was because of the disorder which ensued (Salema, 1996). In another interview, comparing the two regimes, he said:

> Before I did not know anything of what was going on. Nobody could speak. Currently I do not know anything of what is going on, because everybody speaks at the same time (Naves, 1996, p. 24).

He confirmed this in his *Memórias*:

> The situation then experienced profoundly discontented me. Everywhere I turned, I just heard crudeness, jokes, smiles, songs, laughs, swearing, everything in the widest democratic way (R. d. Carvalho, 2010, p. 327).

It was not a question of supporting or not the fall of the Dictatorship, the fact is that the new situation changed unbearably for many of those used to the austere, highly controlled times. Some of Carvalho's contemporaries, for instance, although regretting his loss, understood and supported his decision. As one science teacher wrote in 1975,

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[184] He requested retirement on the 9 October 1974 (Carvalho, 2010, p. 328).
[185] Carvalho's personal document, BNP, Archive 40, box 4, folder " Vida Profissional" .

> The environment experienced in our schools makes teachers' mission even more arduous, so that for sometimes it is difficult to keep calm and with mental balance, essential in our profession[186]

whilst his great friend Túlio Lopes Tomás, in a supportive and envisaging letter, said: "You did well. It is sad the official teaching has lost you. But a man with your disposition, wherever he is, doesn't stop"[187].

The changes in teacher training started appearing even before 1974. Carvalho resigned from his appointment as a Metodólogo teacher in 1969 (R. d. Carvalho, 2010, p. 281). In the same year a new scheme was established, which seems to have marked the end of the 'elitist era' in teacher training. The term 'elitist' is appropriate if we think in economic terms. During the eleven-year period that Carvalho worked as a Metodólogo, many teachers who graduated in university were forced, against their will, to go find their places in schools without the demanding two-year non-paid placement in the 'Normal Liceus', since only few could afford it without any income. To amend this situation from 1969-1970, eventual teachers could now attend a one-year placement and teach, at the same time, in the liceus with full salary guaranteed, what increased significantly the amount of trainees, now in the hundreds (R. d. Carvalho, 1970a).

Whilst the new scheme would increase the number of trainees, it would probably lower the quality of training: Carvalho's main concern. In 1970, by means of two articles in which he assessed the general science teaching condition in

[186] BNP, Archive 40, box 4, folder "Vida Profissional", Letter from Bernardo de Carvalho Homem to Carvalho on the 3rd of February 1975.
[187] Carvalho's personal documents, box 4, folder "Vida Profissional", letter from Túlio Lopes Tomás on the 11th of July 1975.

Portugal, Carvalho made a claim that all teachers were supposed to receive a bursary to attend the two-year training course as full-time students without the need to work in schools (R. d. Carvalho, 1970a). As he argued, the low quality of teachers who could not attend the placement in its traditional version led to difficulties in communicating well to pupils, mainly with the use of experiments, since those teachers simply rejected their use (R. d. Carvalho, 1970c).

> The practice in the methodology in physics (and chemistry) has shown us that the pedagogic placement needs to last two years. It is not only convenience: it is a necessity indeed. Of course a two-year course will be convenient for trainee teacher as long as he is paid as any other teacher. (…) Physics in the liceal level, chiefly in the 2nd cycle, cannot be taught with gradients or with integrals. Mathematically treated, all the subjects are developed without hesitation, but liceal students need the physical interpretation of phenomena, not its mathematical exploration (…) Young teachers, arriving fresh from University, know to develop mathematically the force field theory, for instance, without difficulty, but when they are placed before fifteen years old boys to whom they need to communicate the meaning of potential difference, they feel empty. Physics is full of these difficulties. (R. d. Carvalho, 1970c, pp. 145-146)

One can see that Carvalho was claiming dignity for the teaching class. He criticized the bad quality in teacher training for the lack of status and even for their wages. In an unusual assessment, and contrasting general opinion that the first problem in education was to sort out teachers' salary, he said the educational problem "is less represented by the fact that teachers earn little" than "the fact, more profound and significant, that it is possible to earn little".[188] In other words, teachers are underpaid because they are not well trained.

It is not surprising, as Carvalho proudly stated, that at the time he worked as Metodólogo before 1969 an "admirable set of excellent teachers" from "Lisbon, Porto, and Coimbra" (R. d. Carvalho, 1970c, p. 145) were being sent to classrooms every year. This "admirable" group he referred to was the privileged small group of trainees that he and other few Metodólogos could orientate, during two whole years, in the most refined details. He truly believed that "the central element of the problem [in teaching] is the man" (R. d. Carvalho, 1970c, p. 145) and ended by saying:

> through everything and against everything (…) this is our contribution, as people. The rest, we cannot be responsible for (R. d. Carvalho, 1970c, p. 155)

9. Conclusion

The account provided in this chapter about Carvalho's views on teacher training should be understood within the context of his time. After 1947 science teachers in the General Course in the liceus had only a blackboard and classroom demonstrations to teach (see chapter 2). It is possible that it was because of this setting that his work stood out in comparison with other liceal teachers. In an

[188] Answering the question "What do you consider more important and urgent in a liceal reform?" in the newspaper Diário de Lisboa, on the 15th of February 1968.

interview few months before he died he was asked whether the use of experiments was common at his time, to which he replied:

> I would not be the only one, but rare were those who did it. Speaking only would certainly make students fall asleep (M. L. Nunes, 1996, p. 16)

So, apart from his gift in communicating in a stimulating way, if we recall the previous chapters, Carvalho's work was marked by his ceaseless intention to do more and better than what was being done.

I would like to suggest that this last point is related to his commitment with the teaching profession. To look more broadly than the themes of this chapter, Carvalho has been also described as a tireless educator, not only involved with science teaching, but also with several different activities in the school he taught: A former student during the sixties has said that in the Pedro Nunes he used to organize "many cultural activities from theatre to literary sections". This behaviour made him according to this former student "more important than the rector", something that contributed to an image "culturally and humanely very rich of Rómulo de Carvalho" (Sousa, 2006, p. 59). Carvalho's work in the direction of the *Gazeta de Física* and the Pedro Nunes' journal *Palestra* as well as his teaching built on his general commitment with the education system as a whole.

If we recall the three sections above which address Carvalho's ideas on teacher training, his own practice in classroom, and his work as a Metodólogo teacher, one can perceive a robust and coherent teaching practice "programme", which encompassed the theoretical and the practical dimensions. One can possibly conclude that Carvalho was a demanding teacher and teacher trainer simply because of the intrinsic difficulty of teaching. As he observed: "… the truth is that teaching is one of the most difficult things in the world"[189] (Gedeão, 1992, p. 177).

Carvalho was a secondary teacher, not a scholar dedicated to research and publishing elaborated peer reviewed articles. His writings had only slight reference to other studies – it is likely that much of his ideas come from the reflection of his own practice. As a possible analysis on his understanding about teaching practice, Carvalho's great concern was with the transposition from the 'canonical knowledge' (found in books) into the 'taught knowledge' (as this is communicated to students). If I may risk using a contemporary term, this blending of content and pedagogy has also been addressed by Lee Shulman (Shulman, 1986, 1987) and many others in recent years through the notion of the pedagogical content knowledge (PCK).

This concern with knowledge transposition is closely related with the characteristics of what I have been calling since chapter 3 a 'humanistic approach in education'. This concern speaks to issues such as teaching suitability to pupils' age and conditions, and consequently with meaningfulness. However, in this chapter I also pointed out other possible connotations for, in broad terms, a humanistic education. One of them was the value that Carvalho attributed to teachers' dexterity in transmitting knowledge from what is intrinsically human (by teachers' words and gestures). The other was pointed out by his trainees as the kind of gentle and respectful relationship he engaged with them. These alternative connotations seem particularly appropriate to raise here because of the teacher-students close interaction

[189] Although a less prominent issue, as we could see also because he believed it was only by having high quality professionals that this class could gain higher respect from society.

addressed in this chapter, present both in teaching practice with pupils and in his work as a Metodólogo teacher with his trainees.

Carvalho's work as a Metodólogo teacher marked the end of his career in the liceu. It is not an exaggeration to say that because of his texts published in journals along with his work as Metodólogo, and as the author of a national programme and of some Sole Books, by the seventies Carvalho enjoyed great acknowledgement for his work. But in terms of public acknowledgement, another activity - his work on the popularization of science with the publication of several articles and books – was more prominent. This became a milestone in his career which consolidated his name as a well-known and respected science educator. The next chapter will examine this work.

Chapter 7

Carvalho and the popularization of science

1. Introduction

Previous chapters scrutinized Carvalho's work and thought on 'formal education', i.e., for the Liceu: his 1948 chemistry programme, his compendiums, his views on the use of experiments, and his support to liceal pre- and in-service science teachers. The current one will examine Carvalho's work on the popularization of science, which might be classified as a kind of 'informal education', since this endeavour surpassed the boundaries and the formalities of the curricular constraints of the liceal education. Although informal, the material Carvalho produced in this endeavour will be considered here as part of his contribution to science education, and part of his pedagogical work.

Carvalho's audience was wide-ranging: he wrote for teachers, middle-class students, but also to the layman, working-class people, and even the countryside peasant. He wrote many articles and books with great attention to the History and Philosophy of Science (HPS), which will be examined in detail here. The chapter will initially address Carvalho's first articles, pointing out his writing style, and how his work evolved into more relevant books. Afterwards it will examine: Carvalho's books on the history of chemistry that he wrote for the *Cosmos Library*; then the book collection *Science for Young People*, also on history of science; next, his book *Physics for the People*, written for the 'peasant'; then it will provide an analysis of Carvalho's book *What Physics Is* on the philosophy of science; and finally will address a collection of booklets entitled *A Treasure of Science for Young Minds*, which has been claimed to be an example of Carvalho's 'pedagogical thought' (J. S. d. Costa, 1996). The examination of these works will provide the evidences which underpin the two main arguments set out below.

As we could see in previous chapters, Carvalho's pedagogical work was marked by his concern with meaningfulness, an important issue which, I have claimed, can be seen as part of a humanistic approach in science education. The first argument in this chapter is related to this aspect of his work. Carvalho's articles and books on popularization of science addressed the scientific development and sought to give meaning to our current technological world. The chapter will point out that Carvalho's work has been praised for his engaging writing style. To use Carlos Fiolhais's words (a well-known physicist in Portugal today, who has followed up

Carvalho's work on the popularization of science), Carvalho had the gift to "make common the most uncommon things and uncommon the most common things of the universe" (Fiolhais, 1996, p. 21). It will be argued that this style enthused youngsters to read, understand science, and pursue scientific careers.

As another issue addressed in this chapter, relates to the claim that Salazarism promoted a "closed society" to innovation, and that the acquisition of books and scientific journals was "forbidden to the majority of teachers", for economical and social reasons (F. Silva, 2008, p. 125). This raises the question of how Carvalho's work on popularization was conditioned by that setting, and whether this work affected the fascist ideology. In this regard, the chapter begins with a brief account of the work of Bento de Jesus Caraça on education. His name stands out in the struggle against the Salazarist ideology because of its revolutionary aspect, and for this reason he was targeted by the fascist regime. It then shifts to an examination of Carvalho's work, which also aimed at educating those who could not study sciences in school and, in a repressive regime, diffused knowledge about the great achievements of men of science around the world. In this context, it will be argued, Carvalho's endeavour had also a libertarian purpose, and can be classified as a liberal/humanist project. However, intriguingly, Carvalho was never targeted by the Salazarist regime as Caraça and many others were. In order to shed light on this matter, the chapter concludes by examining Carvalho's political inclination, and the possible reasons why his writings on popularization did not affect the Salazarist ideology.

2. Bento de Jesus Caraça: Liberal education for the people

As we may recall from chapter 2, the fall of the Portuguese first Republic (1910-1926) resulted in the dawn of the Salazarist regime. The republican regime was instituted along with the desire of a cultural revolution, by a social regeneration (Pintassilgo, 2006a). Many educators - such as António Sérgio, Jaime Cortesão, Teixeira de Pascoais, Leonardo Coimbra, Raúl Proença - who supported the democratic ideology of the first Republic, founded in 1911 the "Portuguese Renaissance". This was an important cultural movement which aimed at the "elaboration and cultural diffusion regarded necessary to the desired social regeneration" (Pintassilgo, 2006b, p. 94): it intended to "regenerate the country through education" (p. 95). It aimed at empowering society collectively, offering to all people access to instruction, education, culture, by means of books, conferences, libraries, magazines, newspapers, schools etc.

Portuguese *Popular Universities* played an important role within this 'Enlightening' endeavour to educate the people in the beginning of the twentieth century, and had Jaime Cortesão as perhaps its most active promoter (Manso, 2003; Pintassilgo, 2006b). Through Popular Universities it was intended to bring to the 'people' the written culture normally reserved to the 'elite'. Allegedly, they were an open space for *all* social classes, a "project for social and cultural integration" (Pintassilgo, 2006a, p. 98). Although paying particular attention to the disciplines of history and sciences, Popular Universities did not present a rigid curriculum, but one which "encompassed all subjects relevant to the prosecution of its educational ideals"

(Manso, 2009, p. 2). Their classes' framework was organized in terms of "conferences" of a variety of themes, freely chosen by the speaker (B. d. J. Caraça, 1929, p. 212). The speakers were likely to be "intellectuals, imbued of libertarian and anarchist ideals" (Manso, 2003, p. 55). Caraça believed this institution was supposed to complement the official teaching in schools, with free programmes, and could be an alternative way for adults to learn what they could not in school (B. d. J. Caraça, 1931). The liberal ideal behind Popular Universities was undermined by Salazarism: Jaime Cortesão was imprisoned in 1940 and then exiled until 1957 (Pintassilgo, 2006b) and the Popular Universities extinguished in 1945 (Manso, 2009). However its spirit to educate the 'people' endured and was disseminated by Caraça and others.

Bento de Jesus Caraça (1901-1948) was one of the most important people to diffuse knowledge to the people during the Salazarist regime. Carvalho acknowledged Caraça was a "revolutionary" man (R. d. Carvalho, 2010, p. 245). Caraça became involved with democratic movements, fought for the culture of the labouring classes, and openly accused Salazar of establishing an anti-democratic school (R. d. Carvalho, 1986). He has been described as an "ethnomathematician" (Bebiano, 2001a, p. 11) because of his understanding that the development of mathematics is highly conditioned by social issues, by the environment, by human enterprise. Not surprisingly, Caraça gave substantial support to the ideals of the Portuguese Renaissance, and explained part of his liberal thought in the journal *Seara Nova* with the well-known essay entitled *The Individual's Integral Culture* (*A Cultura Integral do Indivíduo*) (B. d. J. Caraça, 1939). This was originally presented in a 1933 conference to an organization entitled *Free Youth*[190] (*Mocidade Livre*).

[190] This Free Youth is different from the *Mocidade Portuguesa* [The Portuguese Youth Brigade], the latter decreed into existence on 11 April 1936 for the purpose of

Before the extinction of Popular Universities, and with the same aim to provide general culture to a wide audience, Caraça founded in 1941 a book collection of a range of themes[191] entitled *Cosmos Library* (*Biblioteca Cosmos*), a collection of works of Portuguese and foreign authors, which enjoyed "seven years of successful and exemplary action to the cultural diffusion" (R. N. Rosa, 2002, p. 85). Carvalho wrote two books for this collection (R. d. Carvalho, 1947c, 1948b). Promoting culture to the masses was Caraça's ideological mainstream, who believed knowledge was a weapon against oppression (Bebiano, 2001a, p. 14). More than a hundred books were published by the *Cosmos Library*, 793,500 units sold (ibid), and the amount of books still vastly sold today in second-hand bookshops throughout Portugal attests its popularity. *Cosmos Library*'s ultimate aim, as Caraça explained, was to educate the layman and to foster a "free mind" (B. d. J. Caraça, 1947, p. 12). As it is said in the preface of the first book published in the *Cosmos Library,* M. Iline's *The Man and the Book* (*O Homem e o Livro*) (Iline, 1941), it was the *Cosmos Library*'s intention to give to the largest amount of people "general culture, (…) provide a general worldview, physical and social worlds, its construction, its life and its problems"[192] (B. d. J. Caraça, 1941b, p. 1). The *Cosmos Library* was a concrete action against Salazar's disdain about people's education. In Caraça's words: "To the

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moulding the moral character of young people and instilling in them a devotion to the Motherland.

[191] Themes and authors' nationality ranged vastly: e.g. Gino Saviotti's *History of Italian Theater*; André Cresson's *The Philosophical systems*; Ferreira de Mira's *Foundations for Rational Feeding*; Alberto Candeias's *Darwins' Life and Work*; Ilídio Sardoeira's *Life's Origin*; John Baker's *Biology in everyday life,* Colin Ronan's *A Guide to the Cosmos*, Herbert Read's *Art and Society*; Alberto Quintanilha's *The Scientific Foundations of Sexuality*, etc.

[192] Caraça's pedagogical ideal was intimately related to insert the aspects of our social life into education, not only presented in his Cosmos Library, but also in the teaching of mathematics, as he did in his *Fundamental Concepts of Mathematics* (Conceitos Fundamentais da Matemática) (B. d. J. Caraça, 1941a).

opinion, frequently defended, that the march of civilization and progress of culture are elite's exclusive works, we oppose that they are product of action of all men" (B. d. J. Caraça, 1941b, p. 2) [193].

Caraça did not restrict his work for the democratization of knowledge to the working classes; he also acted in the political arena. On many different occasions, Caraça wrote as though he was proclaiming a social revolution. He openly attacked Salazar's fascist ideal of resignation and stagnation. His name is also associated in 1944 with the *Anti-Fascist Movement Unit* (*Movimento de Unidade Anti-Fascista* – MUNAF) and in 1945 with the *Democratic Unit Moviment* (*Movimento de Unidade Democrática* – MUD) (Bebiano, 2001b). Because of his ideology, Caraça was dismissed from his Professorship by a disciplinary process with political character in 1946 (Nóvoa, 2003, p. 269); he was "put into jail, (…) suffered very much and did not resist injuries" (R. d. Carvalho, 2010, p. 245). He died very young in 1948 at the age of forty-seven, and "without his vitality and with the Dictatorship's pressure, the Cosmos Library project also died" (R. N. Rosa, 2002, p. 85).

Caraça was a representative of a group of people who worked against the reactionary fascist government. The authoritarian and anti-liberal aspect of Salazarism might be seen as dramatic; and indeed was for all those who dared to oppose publically Salazar's ideals, with a number of teachers of the Liceu and University Professors being dismissed for ideological reasons.

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[193] Parallel to the *Cosmos Library*, Caraça also founded in 1947 the *Giant Cosmos* (Cosmos Gigante), a collection which aimed at offering texts with high quality scientific rigour from renown scientists such as "Arthur Thomson, Julian Huxley, E. Ray Lankester" in order to foster "free mentality and scientific tonality in the Portuguese citizens" (B. d. J. Caraça, 1947, pp. 11-12).

Arguably, Carvalho's work for the popularization of science is also a representative of this resilience. Carvalho wrote one very important book (*Physics for the People*) which was addressed to people who did not have the chance to study this discipline in their lives. The objective of this book, as we will see later, was similar to the Popular Universities'. The physicist Rui Namorado Rosa has claimed that Carvalho was motivated by a deliberate intention to inform a population in need for scientific knowledge (R. N. Rosa, 2002). Rosa is convinced that Carvalho "surely noticed and was afflicted by the general backwardness in the teaching system as well as the general lack of access to culture by many youngsters and adults who were not within his reach" (Rosa, 2002, p. 83). But, intriguingly, Carvalho never had any problems with the dictatorship. Why?

This question will be addressed at the end of this chapter. Before, however, we need to examine in more detail the characteristics of some of Carvalho's works on popularization of science. The sections below examine a number of Carvalho's articles and books on popularization, and characterizes them in terms of content, approach, and intended purpose.

3. Forgotten works: Carvalho's Journal and Magazine articles.

Carvalho's first five articles on the popularization of science were written from 1940 to 1943 (R. d. Carvalho, 1940a, 1940b, 1941a, 1941b, 1943) and were published in the educational journals *Labor* and *Liceus de Portugal*, which explain the reason for the low visibility: pedagogical, administrative, and cultural issues dominated the content of the articles published in these journals, and by their content and genre it can be inferred they were in their overwhelming majority written by and for educators and governmental authorities (e.g. the *Liceus de Portugal* was a journal published by the government and commonly published government's activities).

One of the remarkable characteristics in these articles is his passion for History, as Carvalho's first five articles are entirely devoted to the History of chemistry and alchemy. Carvalho indeed said in his *Memórias* that since the time he was a student he had "a particular desire to explore the History of chemistry, to discover the details of its progress over the centuries" (R. d. Carvalho, 2010, p. 244). Another characteristic is his notorious fascination for the beauty of chemistry, and even its relationship with arts, which in his understanding surpassed the traditional chemistry taught in schools. This understanding seems to be ever present in Carvalho's mind as he wrote in his third article in 1941. In his words:

> Those who think chemistry is confusing, full of formulae, of odours, and of dangers, will find strange that chemical phenomena can serve literary manifestations (R. d. Carvalho, 1941a, p. 621).

The reader may wish to recall that the excerpt above anticipates some of the greatest characteristics of Carvalho's chemistry syllabus, written in 1948 (discussed in chapter 3), and even his poetry, the first book of which was published only in the fifties. Another characteristic is his particular and perhaps rare interest in the etymology of chemical naming. The titles of the articles are in this sense quite suggestive, such as *Linguistic Metamorphosis of the Venus of Metals*[194] (R. d. Carvalho, 1940b), or *The Fraudulent Aspect of Alchemy* (R. d. Carvalho, 1941b). Indeed Carvalho was passionate about the Portuguese language, "our beautiful language" (R. d. Carvalho, 1940b, p. 216), as well as being very interested in finding out the reason why things are as they are. So, for instance, very commonly in his writings, after introducing an interesting, puzzling, paradox situation, he used to ask something like "Why is this kind of heating given the name double-boiler[195]?" (R. d. Carvalho, 1940a, p. 578); and following the query comes a detailed answer.

From 1946, Carvalho's articles on the popularization of science started gaining more visibility as he started publishing in just-launched popular magazines and the journal *Gazeta de Física,* where he was part of the steering group. I identified at least three magazines[196] where Carvalho published: *Ver e Crer*, *Átomo,* and *Mundo Literário*. Overall, the magazines aimed at informing the layman with general knowledge, whereas the *Gazeta* had amongst other purposes the aim to "clarify a wider public about the real position of the physics intervention in modern life" (Gibert, 1946, p. 1), with a special section for the popularization of science[197].

Although having more visibility, the articles published in these magazines are probably almost as little known as are those published in the *Labor* or *Liceus de*

[194] "Venus of Metals" is an ancient name for copper.
[195] The Portuguese name for "double-boiler" is "banho-maria".
[196] Apart from these, Carvalho also published articles in the magazine *Vértice* and in the "Bulletin of the Portuguese Language Society" (Boletim da Sociedade de Língua Portuguesa) (R. d. Carvalho, 1950b, 1951a, 1952c, 1954a, 1956b), on which Carvalho addressed the people's ill-use of the Portuguese language. Carvalho ended up being a member of this society (R. d. Carvalho, 2010, p. 243), a rare event for a science school teacher. These facts reveal much of Carvalho's inclination to the "humanities" as well as it backs up the argument for Carvalho's great concern with the proper use of language in communication.
[197] In Portuguese, the section "Divulgação e Vulgarização".

Portugal. Naturally, Carvalho's articles were diluted amongst hundreds of others articles, and I did not find any relevant account of the impact of Carvalho's magazine articles for the popularization of science in Portugal in that period. Carvalho's articles published in the *Gazeta de Física* have been receiving more attention by secondary sources, probably influenced by the importance of this journal in the scientific panorama in Portugal since then.

All these magazines, as well as *Gazeta de Física*, appeared at the same moment in Portugal, when the population was suffering with the lack of general culture readings, as this is what can be inferred when their aims are spelled out: The *Ver e Crer*, first published in 1945 and with more than two hundreds collaborators, aimed to serve "a public wishing to read something simultaneously accessible and advantageous: a light reading without the pompous weight of academic communicative aspect" ("Dois anos de Trabalho," 1947, p. 3). *Mundo Literário* was first published in 1946 also with a broad scope. It covered art, science, and literature, and aimed at "filling an inadmissible void felt by everybody" ("Editorial," 1946, p. 1). It also recognized that at that time there was "a huge divorce between the public and the noblest activities of the spirit", and hoped the magazine would answer readers' "real problems and curiosities" (ibid). *Átomo* was launched in 1948 as a "magazine for the scientific and technical diffusion"[198]. It had a more specific scope as it published all kind of scientific curiosities, the majority in one or two-page articles. The existence of these magazines indicates that readings on science and

[198] Letter from *Átomo*'s direction to Carvalho on the 16th of March 1948, where the *Átomo* invited Carvalho to contribute with some articles to the magazine. Available at National Library, Lisbon, Archive 40, box 3, folder "Átomo, Mundo Literário, Ver e Crer".

other areas were accessible to the public during Salazarism. Information seemed not to be, per se, a problem for the regime. I will return to this issue later.

The five-year period from 1946 to 1951 was one of high productivity in Carvalho's life. Apart from being a full-time teacher, in this period he wrote a national chemistry programme (1948), some schoolbooks, two books for *Cosmos Library*, and at least twenty-nine articles in different places. In the above referred to magazines, he wrote fifteen which can be more clearly classified as on the popularization of science (R. d. Carvalho, 1946a, 1946b, 1947b, 1947d, 1947e, 1947f, 1948a, 1949a, 1949b, 1949c, 1949d, 1950a, 1950c, 1951c, 1951d). Afterwards Carvalho started writing his books for the collection *Science for Young People* and his production of articles diminished and became more spaced. Even so, until the end of his career in 1974, he wrote at least forty-six more articles, of which nine might be regarded as on the popularization of science (R. d. Carvalho, 1953c, 1960b, 1963a, 1966b, 1968c, 1971, 1973a, 1973b).

The characteristics of the articles that he wrote from 1946 to 1951 followed up those pointed out in his first articles. The first striking characteristic is that amongst the fifteen articles published in this period, thirteen were in the realm of History of science. It seems that the relevance of scientists' works in the past and the consequent power of science to transform our world fascinated Carvalho. He constantly drew attention to these in his writings:

> Those who follows the spectacular development of modern techniques and appreciate the equipments, often gigantic, of great organisms where thousands of scientist work in persistent investigations, feel inclined to smile when they recall the contribution that some man of science of the past gave to scientific

progress. The Oersted's case, which we will recall, is one of the most interesting. (R. d. Carvalho, 1951d, p. 3)

In fact, he praised many names. In the group of fifteen articles from 1946 to 1951 in consideration, nine of them focused on work and life of scientists and discoverers, paying attention to their philosophical thought, overcome challengers, curiosities, frustrations etc. The celebrated names were Papin, Edison, Piccard, Daguerre, Oersted, Langevin, Descartes, Lorentz, and Einstein. Carvalho repetitively tried to draw attention that our modern world is an *achievement*, built up by the work of men like these. So he says: "the use of photography is so banal today that we do not take ourselves to think about this problem, which solution seemed really impossible" (R. d. Carvalho, 1951c, p. 10), and then he goes on to appreciate Daguerre's work.

This last sentence also suggests another particular aspect in his writings: the detailed explanation of how people managed to get round in all kind of problems. So, from Galileo's and Descartes' efforts, Carvalho describes the difficulties to "determine, for the first time, the light speed"(R. d. Carvalho, 1949b, p. 5), and the history of "How the electric charge was measured" (R. d. Carvalho, 1946b, p. 13). Of course, in a one or two-page article these explanations were limited. His books, written few years later, are more sophisticated as they offered a more detailed account of these endeavours.

Carvalho also had a particular interest in conveying the real activities of scientists, what they really looked for, opposing, as he suggested, to the fantasy commonly shared by ordinary people (R. d. Carvalho, 1948a). Carvalho was not a ‘romantic’ author (Feijó, 2006), but a ‘realist’ one. In other words, he was not a professional ‘storyteller’, as some historians have described populist writers with little commitment with scholarly literature (Shortland & Yeo, 1996). For instance, against the Piccard’s “spectacular” experiences which at that time played with people’s imagination, he wrote:

> In general, researchers’ work are done in the silence of laboratories, patiently, ignored, led by a new concept that commonly escape from the interweaved net of observed phenomena (R. d. Carvalho, 1948a, p. 51).

In another example, in his article about Thomas Edison, it was Carvalho’s aim to

> present some aspects less known [of his life] which is perhaps set aside by that peculiar spirit of biographers who pull their heroes out of common life as though everything in them were supernatural (R. d. Carvalho, 1947d, p. 8).

Apart from the attention drawn to well-known names in history of science, the examination of Carvalho’s first articles reveals a concern with contextualization and as engaging reading. These articles can be seen as a prelude of some of his most known works in the *Cosmos Library*, discussed below, and the book collection *Science for Young People*, discussed in the following section.

4. Contributions to the Cosmos Library

Carvalho's first books on the popularization of science were published in the forties in Caraça's *Cosmos Library*, whose purposes (to provide general culture to the layman, foster a free mind etc), were described before.

The first book was entitled *The Hermetic Science* (*A Ciência Hermética*) (R. d. Carvalho, 1947c), and intended, as Carvalho says in its preface, to be the first volume "of a vast and complete History of Chemistry" (p. 5). His plan, however, did not work out. Only the second volume was published in the following year entitled *The Egyptian Embalming* (*O Embalsamamento Egípcio*) [199] (R. d. Carvalho, 1948b), since Caraça died in 1948 and so did the *Cosmos Library*.

The great attention Carvalho gave in the articles he published during the forties and the two books he wrote to the *Cosmos Library* aimed, in the first place, at answering his own queries about our past (R. d. Carvalho, 2010). Perhaps his greatest motivation to write these books was to write about themes unavailable in the Portuguese language. This is explained in his *The Hermetic Science*: "the lack of consulting bibliography with a scientific character, old and modern, causes the despair of those who [need to] consult it" (R. d. Carvalho, 1947c, p. 137).

[199] The referred to books might not be considered historical works, because they are solely drawn on secondary sources. As I said in the first chapter of the thesis, Carvalho indeed carried out many very important historical works in the realm of science and education, but most of them were published only after his retirement in 1974.

In the first book, Carvalho addresses the roots of modern chemistry, whereas the second addressed the substances, techniques, and legacy of the ancient embalming process. When one reads the content of these books, it is likely he/she will conclude they are the development of Carvalho's studies initiated few years before. Also, all the characteristics highlighted above, such as great attention to etymology of chemical naming, are easily identified.

Carvalho's *The Hermetic Science* and *The Egyptian Embalming* already indicated what probably is the main characteristic in Carvalho's writing style: Carvalho's ability to communicate knowledge with *simplicity and clarity*. Some people who read his books at the time they were published, frequently highlighted these characteristics. There are several examples. For instance, after having read the second book *The Egyptian Embalming*, a friend said in a letter:

> This [book] confirms the opinion left by the reading of the first. They are excellent books of culture, both for the criteria of reposition, and for the great language"[200].

Carvalho's way of writing very quickly gained distinction, as it seems people could identify his writings for his unique style. For instance, in another letter, also regarding *The Egyptian Embalming*,

> the exposition of the subject is like everything you write, clear and suggestive, and if on the book cover your name was not written, after reading a few lines I'd quickly say it is your work[201]

[200] Letter from his friend Barbosa Soeiro to Carvalho in 1948. BNP, Archive 40, box 2, folder "Ferreira da Silva, Que é a física, Embalsamamento".

In another letter:

> I recognized in the work, for the division of subjects, for the way they were treated, for the meticulous contents, your very personal prose and the method you use in everything[202]

The frequency with which people highlighted the same characteristics in his writing style certainly is an evidence of this distinctiveness. Perhaps, Carvalho's success was due to the fact that he wrote "in the first place to those who do not know anything" (Salema, 1996, p. 2), as he said in a newspaper interview. Indeed, this seems to be one of the touchstones in Carvalho's pedagogical work as a whole and on popularization in particular: an intense concern with the condition of the learner, which is also a touchstone in some views of a humanistic approach in science education.

Another touchstone both in Carvalho's work and to some views of humanistic science education is the need to contextualize science learning, which the use of History of science is believed to fulfil (Matthews, 1994). Carvalho's long work during the forties with extensive exploration of the history of science seems likely to have prepared him to write what probably became his most important work on the popularization of science: a few years later in 1952 he started publishing in a new book collection entitled *Science for Young People.*

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[201] Letter from a friend 'João' to Carvalho on the 22nd of April 1948, BNP, Archive 40, box 2, folder "Ferreira da Silva, Que é a física, Embalsamamento".
[202] Letter from Sérgio Manuel da Silva to Carvalho on the 28th of April 1948, BNP, Archive 40, box 2, folder "Ferreira da Silva, Que é a física, Embalsamamento".

5. Science for Young People

Carvalho had moved to Coimbra in 1950 and to “entertain his idleness” (R. d. Carvalho, 2010, p. 234) decided to

> organize a collection of works on the popularization of science, aiming at the youth, focused on the historical evolution of events which led humanity to the current state dominated by science and techniques (R. d. Carvalho, 2010, p. 234).

In the same tone of the magazines’ purposes discussed above, he said in the preface of its first book that the practical purpose of this collection was to “fill the lack of educative and instructive readings for young people” (R. d. Carvalho, 1952b, p. 3). Carvalho intended to be just one of the authors of this collection. Apparently, he had in mind to do something similar to the *Cosmos Library*, but limited to science subjects, as he invited other authors to write about Geography, Astronomy, Biology etc (ibid). For reasons which are not recorded, he ended up being the sole author of nearly the whole collection. It published only nine books, of which Carvalho was the author of eight. Carvalho said in an interview these books were “practically unknown” for in a then recent book exposition in Lisbon, “it did not display even one of mine” (A. Martins, 1965, p. 15). This might have been just an unfair example. For if the information he provides in his *Memórias* about the number of editions is precise, the collection should have sold around 45000 copies (R. d. Carvalho, 2010, p. 234).

Their titles say much of what they are about: *History of Photography (1952), History of the Telephone (1952), History of Balloons (1953), History of Static Electricity (1954), History of the Atom (1955), History of Radioactivity (1957), History of Nuclear Energy (1962), and History of Isotopes (1962)*. He explained in the preface of the first book, “It is not intended, by these little books, to value the Science but to value the Man who has created it” (R. d. Carvalho, 1952b, pp. 3-4). One important characteristic of his writings, perceived by many contemporaries as we shall see later, was how these histories were told: commonly, Carvalho travelled back in time in order to help people ‘experience’ life in remote periods. There are many examples in which Carvalho tried to emphasize the thrilling moments scientists (should) have experienced, as he described situations which would likely engage youth and the layman with reading. Fiolhais, who also has a number of works on popularization, recently said that Carvalho told histories “as though it was today, as though he was seeing it” (Fiolhais, 2006, p. 37). The excerpt below exemplifies his way to describe situations.

> After setting up everything, Bell leant over the transponder in order to make one more attempt and said to the membrane: *Do you understand what y say (sic)?* So, another-world voice, fantastic, stirring, shaken of emotion, which seemed to come out from the watch’s spring, responded: *Yes, I understand you perfectly!* (R. d. Carvalho, 1952b, p. 76)

However, as pointed out before, Carvalho was not a ‘romantic’ writer, and tried to convey the world as real as it is. He stressed that: “In science, like in everything else, high level results are only achieved by continued persistence” (R. d. Carvalho, 1962a, p. 34). Indeed, in spite of this effort to make reading perhaps more attracting for “young people”, in Carvalho’s writings there is a concern to communicate faithfully, a commitment to the ‘truth’. In his own words, as he explained in a 1958 letter to his former student who became his friend and critic of his poetry, Jorge de Sena, these books did not contain “either fairies or miracles” (Gedeão, 2004, p. 311).

Apparently Carvalho managed to strike a balance between scholarly literature and a kind of writing suitable to a wider audience. The excerpt above about Bell evidences another important characteristic of these books: they go far beyond simple factual historical accounts. In spite of all apparently added fantasy, this is not their main characteristic. These books do a great deal of work to discuss in detail the unfolding of scientific discoveries, trying to understand scientists’ research working plans, pointing out where they have failed, what they have done to succeed, in a painstaking description of scientists’ development of reasoning. Carvalho commonly used the following strategy: He first posed how a scientific problem arose through history, either through men’s inquiry into nature, or through the challenges given the limitation of a certain theory etc, and then provoked curiosity within the reader about the achievements made. As an example:

> I believe it would upset the reader interested in these stories if I did not tell him how it was possible to get to such extraordinary results (R. d. Carvalho, 1962a, p. 16).

According to Fiolhais, books such as *History of Nuclear Energy*, published in the beginning of the sixties, were particularly touching in a period, post World War II, where nuclear energy and the atomic nucleus played with youngsters’ imagination. In his view (what is probably one of the greatest challenge in the teaching of History of Science in secondary levels), these books show that modern science “is made of construction, of curiosity and effort of real men and women” (Fiolhais, 1997a, p. 15).

In *Science for Young People*, the distinctiveness of Carvalho’s writing style also drew readers’ attention, with Carvalho’s ability to explain with clarity and simplicity also being recognized in this work. The historian António Manuel Nunes dos Santos describes his own experience with these books thus:

> In the end of each reading, of each chapter or text, the explanations become obvious (…) and at the end one exclaims ‘clearly! Evidently!’” (Santos, 1996, p. 18).

Carvalho also received many letters from readers who highlighted his “clarity in the exposition and his inclination as a researcher”[203]. Carlos Fiolhais said these books

> Revealed new science to young people, in a prose with remarkable freshness and elegance. With them we enjoyed sciences (…) Physics-chemistry sciences have, in fact, the popular reputation of unintelligibility and boredom, but Carvalho made and makes this view look like an evident unfairness (Fiolhais, 1996).

But perhaps more important than the content and the uniqueness of Carvalho’s writing style was the civic work it managed to fulfil. These books appeared in a very repressive moment in Portugal, right after university staff members were exiled, and the *Cosmos Library* and *Popular Universities* died out or were shut, as pointed out before. In the opinion of Regina Gouveia, who worked with Carvalho in the

[203] Letter from Mário Costa de Almeida to Carvalho on the 9th of January 1958. BNP, Archive 40, box 4, folder “Correspondência de Professores”.

seventies, Carvalho wrote these books “maybe because he knew that knowing is one of the main ways to citizenship and freedom” (Gouveia, 2006, p. 127).

Furthermore, during the fifties, a curious Portuguese reader could only find information about these subjects in detail in foreign books. There was no other Portuguese writer doing what Carvalho did. Fiolhais said this collection “was not only science for young people, it was new science for the people” (Fiolhais, 2006, p. 37). Amongst many other letters that Carvalho received during the time he published these books, it is said the collection *Science for Young People* “fills brilliantly an existing gap in the literature for the popularization of science”[204]. The following excerpt was written by Fernando Pinho de Almeida, a philosopher who exchanged many letters with Carvalho. It provides a nuanced assessment of the importance of this collection to the moment Portugal was suffering. As far as the availability of books of this genre is concerned, the backwardness in scientific knowledge, and even the self-denigrating view of the Portuguese people at that time, he said:

> … I think they are admirable for the clarity of exposition and language simplicity with the sharp advantage over the careless translations of foreign books which appear about (…) We live in a stuck compartment and we don’t follow nor comprehend the quick and disconcerting advance currently processed in civilized countries.[205]

If not the most important civic work of this collection, these books are nevertheless particularly significant since there is evidence that they encouraged many youngsters to pursue scientific careers. The books “led many young students to

[204] Letter from Maria Estrela Vieira to Carvalho on the 11th of November 1962. BNP, Archive 40, box 4, folder “Correspondência de Professores”.
[205] Letter from Fernando Pinho de Almeida to Carvalho on the 7th of February 1963. BNP, Archive 40, box 4, folder “Correspondência de Professores”.

the world of nuclear particles, of structure of matter and of radiation" (Costa, 1997b, p. 10). This fact has been repeated by many who could read these books during their youth and now are science teachers, philosophers or physicists. According to António Manuel Nunes dos Santos, these books "directly or indirectly seduced many of us to follow scientific careers" (Santos, 1997, p. 18). Unfortunately, as Santos pointed out when he interviewed Carvalho (Gedeão, 1992, p. 172), a book collection like this, "which not only dealt with purely scientific areas, but also with technological developments (...) hasn't been published since" . "It's a tremendous shame!", agreed Carvalho.

Questioned on a later occasion about the aims of his work for the popularization of science, Carvalho said this:

> was a work susceptible to help others to comprehend their environment. Not only to students, but to the general public. There were many boys and girls who were not in school. Thus they had a way to know about things (Naves, 1996, p. 25).

There are two important things here in this quotation, to which I will return later. Firstly, the "environment" to which Carvalho refers is the physical or the scientific environment without a clear link to the social and political environment lived during Salazarism. Secondly, these books might have been more suitable to teachers or liceal students than to boys and girls with little education or to a workman, as he suggested above. This latter audience was more evidently addressed in Carvalho's book *Physics for the People*, in two volumes, published in 1968 (R. d. Carvalho, 1968b), to which I will turn attention below.

6. Physics for the People

This book is unique in Carvalho's career for several reasons. Perhaps its most important characteristic is that it aimed at an audience very 'distant' from the liceus: the working class people. It seems to have had some ideological intentions.

As a sign of his ideological aims, in his book *Memórias* Carvalho describes *Physics for the People* as "a pioneer work, by the way with no followers, which intended to promote popular culture at a time the word 'people' was still used" (R. d. Carvalho, 2010, p. 238). Here Carvalho did not make any use of history or philosophy of science, and used everyday language to communicate suitably to the "peasant or workman" (R. d. Carvalho, 1968b, p. 5) who would like to learn more about sciences and did not have the opportunity to learn at school. In other interviews, Carvalho described this book as an attempt to give people "the answers to the questions they never really asked" (Salema, 1996, p. 2),

> a chat with a supposed interlocutor, to whom I teach how certain things work and what is the reason they are as they are (Naves, 1996, p. 25).

The vocabulary used in this book is deliberately very colloquial, thus not the same used in school textbooks, or in his previous books. The aim is to catch reader's attention, as Fiolhais sees it: "the atom is not addressed, but it is given remarkable lessons on how to catch imagination in respect to world's function" (Fiolhais, 1997b, p. 35). This is perhaps a rare book in Portugal where the author puts understanding above the orthodoxy of scientific vocabulary. In the preface of *Physics for the People*, writing as though the book was something just between Carvalho and the "workman", he wrote these words:

> Don't show this book to any instructed person because they would certainly find many reasons to censor my words. He would think this is not well explained, that inappropriate words were used, that this is not as I say etc etc. And he would be right. But don't worry about this. This is just for my friend. When you are relaxing take the book and entertain yourself reading it (R. d. Carvalho, 1968b, Vol. 1 p. 5)

In about five hundred pages divided into two volumes he explained to "my friend" the world around us. This book taught optics, magnetism, electricity, hydrostatics, gases, thermodynamics, force, pressure, magnitudes etc, in a very provocative, or 'inquiry' way. Carvalho was a man obsessed in making people understand what was behind things' functioning:

> One thing is knowing what is going on; another thing is knowing why this goes on (R. d. Carvalho, 1968b, Vol. 1 p. 230).

Every five or six pages, Carvalho came up with a new question such as "Has my friend ever thought that the air has weight? What do you reckon? Has it or not?" (Vol. 2, p. 79), or something like: "My friend has certainly seen many pulleys but maybe don't know all benefits we can take from them. Let's talk about this" (Vol. 1, p. 176).

The book addressed the natural world. It helped the reader to understand the natural and technological world around him or her. But because this book was written for the working class, it has been said that it conveyed an ‘atmosphere of democracy’. José Mariano Gago, Professor of physics in Lisbon, former Minister of Science and Technology, said he imagined this book

> in modest libraries, in employee groups of auto-didactics, given the politics of scientific culture for citizenship this book seemed to inspire (Gago, 1996, p. 22)

Gago seems right as this was the only book written by Carvalho that was likely to have caused some problems with the regime. Túlio Lopes Tomás, Carvalho’s great friend, having read *Physics for the People,* wrote to Carvalho and then warned him:

> But do you really think the people want to be instructed? (…) and if you manage to make the masses believe ‘Rómulo de Carvalho’ is the pseudonym of…. Armando de Oliveira[206], the exile will be total![207]

However, Carvalho never had any problems with the Salazarist regime because of this book, perhaps because it did not use words like ‘freedom’ or ‘citizenship’, or perhaps because it simply did not sell (with 500 pages it might have been costly). Carvalho says in his *Memórias* that this book sold very little, it “fell in silence”, and the “workman and peasants to which it openly was addressed, did not take any profit from it” (R. d. Carvalho, 2010, p. 238). This might not be entirely true: António Vitor Guerra, then director of a municipal library in Figueira da Foz, wrote to Carvalho as early as 1969 requesting a copy, because this was constantly

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[206] I could not identify who Armando de Oliveira was. But I think it does not affect the intelligibly of the message.
[207] Letter from Túlio Lopes Tomás to Carvalho on the 28th of December 1968. BNP, Archive 40, box 4, folder “Correspondência de Professores”.

requested[208]. This book is a landmark in the history of Portuguese education, as it was recently republished; now with a different name: *Day to day Physics* (*Física no Dia a Dia*) (R. d. Carvalho, 1995a), as the word 'people' in contemporary settings sounds awkward.

7. Philosophy of Science

Over the decades in which Carvalho wrote for the popularization of science there are many occasions where he also tried to interpret and disseminate its philosophy. Carvalho's writing about philosophy has, in my opinion, a threefold historical importance. Firstly, it fits in the collective effort to provide the Portuguese audience with more cultural and liberal readings, as the *Cosmos Library* and the magazines discussed above intended. Secondly, popularizing the philosophy of science in the mid-twentieth century seems to be a rare case, even on a worldwide scale, and speaks to later efforts in science education to inform secondary students with the knowledge of this discipline. And thirdly, it is the representative, in the History of Science, of a *particular* understanding of the epistemology and ontology of a certain time. For this reason, I will try to analyse the philosophy of science communicated in Carvalho's writings, as well as possible influences he might have received.

[208] BNP, Archive 40, box 2, folder "Física para o Povo".

Carvalho started addressing this theme in some of his articles published as early as in the forties and fifties (R. d. Carvalho, 1947b, 1949a, 1950a, 1950c, 1953c). The books of the collection *Science for Young People*, published over a ten-year period from 1952 to 1962, have some references to epistemology and ontology, although this is not what most distinctively characterizes them.

What Physics is (*Que é a Física*), on the other hand, was his first book entirely dedicated to philosophy, published in the late fifties (R. d. Carvalho, 1959c). This is a collection of texts, chosen by Carvalho, of French scientists/philosophers of the twentieth century, which are preceded by Carvalho's introduction to the theme: he makes a review of the development of physics from the Greeks, to the classics, to the moderns. This book comprises selected parts of five works: Poincaré's *Science and Hypothesis*; Duhem's *Physics Theory*[209]; Jacques Picard's *The Role of Chance in the Scientific Discoveries and Inventions*[210]; Louis De Broglie's *Matter and Light*; and Jean-Louis Destouches' *Modern Physics and Philosophy*[211]. In spite of its potential historical value for the Portuguese science education, there is very little written about this book, which might indicate that few people even know about its existence. Carvalho does not even mention it in his *Memórias* and I found only one brief comment about it in a 1959 newspaper article[212]. In spite of its limited popularity, it influenced figures such as José Mariano Gago to be a physicist (Gago, 1996).

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[209] Free translation
[210] Free translation
[211] Free translation
[212] The brief comment is on the newspaper Diário Popular on the 26th of March 1959, section Registros Biográfico: "A remarkable work for its clarity language and smooth exposition, constituting, differently from the compendiums, an indispensable book for those who study for obligation or for pleasure the natural phenomena".

Philosophy was one of Carvalho's greatest passions since youth, as he was a voracious reader of many French philosophers during the time he was doing his undergraduate course in city of Oporto (J. M. d. Araújo, 2006). The years he spent in that city, from 1928 to 1931 (ibid), should have been of particular importance to his understanding of philosophy of science. At that time, as Carvalho says in his *Memórias,*

> My bedside books were usually Flammarion's *Philosopie Scientifique*. They were Poincaré, Abel Rey, Gustavo Le Bon, Le Dantec, Binet, Claparede, Pieron, Mach, Bachelier… (…) Here I have one on my hands. Here it is, with underlines and scribbles, Poincaré's *Science et Méthode*… (R. d. Carvalho, 2010, p. 178).

It is doubtless very difficult to assess the individual weight of these philosophers in Carvalho's understanding of the philosophy of science and its use in education. Nevertheless there seems to exist similar aspects between Carvalho's understanding of *ontology* and *epistemology* and of Poincaré's, Duhem's, Descartes', and Paul Langevin's, as discussed below.

Paul Langevin, a French physicist who visited Portugal in 1929 (Fitas, 2005) was probably one of the philosophers (and pedagogues) who Carvalho admired the most. Carvalho wrote about Langevin's philosophical thought in 1947. A first important aspect of Langevin's attitude towards knowledge, which Carvalho praised very much, was that Langevin did not have "scientific prejudice" (R. d. Carvalho, 1947b, p. 12). He accepted the instability and the ephemeral aspect of physics laws, and was open for more adequate representations of nature.

This understanding is more clearly expressed in Carvalho's article about Descartes' philosophy, published in the *Gazeta de Física*. Regarding Descartes' *Discourse on Method*, where this philosopher reveals his "constructive doubt" (R. d. Carvalho, 1950c, p. 107), Carvalho suggested that all students, regardless of their future, should take this work as an "indispensable primer to modelling [their] spirit" (ibid).

It was Langevin's understanding of ontology in science that Carvalho considered to be highly sophisticated, and reproduced this in many of his articles and books. According to his words below, it can be inferred that Carvalho and Langevin seemed to be instrumentalists, i.e., they believed it was pointless trying to describe how nature actually *is*, but science's aim was to create suitable theories to describe nature. In Carvalho's words:

> The physicist's purpose – Langevin tells us in one of his magnificent writings – is to construct an adequate representation of reality. (…) Only a superiorly lucid spirit escapes the naïve presumption in touching the reality of facts. Langevin, who besides being a physicist was a remarkable thinker, understood how subjective is the reality of things and, plainly, did not search for reality but for its most adequate representation (R. d. Carvalho, 1947b, p. 12)

Carvalho seemed very secure about this view, and tried to disseminate it to students, and to the layman: writing in 1950 for the magazine *Átomo,* he queried about the true existence of the atoms, and the role of atomic hypothesis in the following terms:

> It is not worthy protesting against the choice of this hypothesis in the name of an alleged logic. (…) It is not worthy because nobody states that "it is like

> that", but only "that there is convenience in supposing it is like that" (…). Hypothesis is a working tool and not (we should insist) the expression of a truth. Between the two, the most suitable to the easy interpretation of phenomena was chosen. It was said by a certain philosopher that Science does not possess any truth neither expects it will do. (…) Summing up, matter is constituted of atoms, by hypothesis (R. d. Carvalho, 1950a, p. 4-5).

One might feel tempted to think this "certain philosopher" referred to above is Langevin, but the same idea is conveyed by other philosophers who Carvalho regarded of great value. Poincaré, for instance, one of the names appreciated in Carvalho's *What physics is*, says in his *Science and Method* that "We may dream of a harmonious world, but how far will it fall short of the real world!" (Poincaré, 2003, p. 22). This is also Duhem's view in *The Physics Experiment*, present in Carvalho's *What Physics is.* In many pages Duhem develops the idea that "between the theoretical fact, precise and rigours, and the practical fact, of vague and imprecise contours as everything revealed by our senses, there cannot have equivalence" (R. d. Carvalho, 1959c, p. 90). He adds later: "In its true meaning, a physics law is neither true nor false. It is just approximate" (p. 93). The view of scientific laws as ephemeral pervades all of Carvalho's works. In 1979, when introducing to the young reader his view of 'what science is', he explained that

> It is pointless posing the question of whether a scientific hypothesis is or is not 'true'. This has no meaning. The hypothesis must be useful, that is, it should serve to interpret certain facts which experiment confirms. Many have been the scientific hypothesis presented in all times that, later on, were rejected (R. d. Carvalho, 1979a, p. 6)

When we turn to epistemology, i.e., theory of how knowledge is justified, generated or acquired, Carvalho's understanding of it seems to be less stable, which, somehow, also echoed the different comprehensions held by the philosophers mentioned above.

The first time Carvalho addressed epistemology in his writings on popularization of science was in 1950, when he praised the name and philosophy of Descartes. On this occasion, it seems evident that Carvalho shared Descartes' empiricist[213] view. Carvalho said that:

> Experiments are, in the Cartesian attitude, an irreplaceable and indispensable source of knowledge. (…) This very lucid spirit [Descartes'], of revolutionary norms which, after three centuries, became simple as they are in the bedrock of all scientific acting (R. d. Carvalho, 1950c, p. 107).

Poincaré, as can be concluded from his text used by Carvalho in *What physics is,* acknowledged the importance of theories to orientate what scientists should look at when performing an experiment. However, he also believed that "The experiment is the sole source of truth. Only from it we can receive some teaching and some certainty. Nobody can contest this statement" (Poincaré, 1914, p. 55).

In Carvalho's handbook entitled *The Scientific Experience,* published in 1979, the same empiricist view seems to be conveyed. Coincidently or not, similarly to Poincaré's text, the very first sentence of this book is: "All knowledge is given by the experiment. Science, which is knowledge, is given by experiment" (R. d. Carvalho, 2004, p. 40).

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[213] In the sense they saw treating experiments as the main source of knowledge.

This handbook was of many published from late seventies. It amounts to Carvalho’s last work on the popularization of science, and has been described as Carvalho’s most sophisticated work on this field, as we shall see below.

8. A Treasure of Science for Young Minds

Carvalho’s *A Treasure of Science for Young Minds* (*Cadernos de Iniciação Científica*) encompassed eighteen little booklets, with sixteen pages each, published from 1979 to 1985. They were recently republished in a book format (R. d. Carvalho, 2004).

Carvalho says in his *Memórias* these booklets were an old dream, an introduction to science which aimed at students *from 9 to 15 years old,* as mentioned before. Carvalho wished these booklets to be “very well illustrated, tempting to the eyes, which presented to youngsters basic knowledge of physical sciences, as an initial stimulus to make them, willingly, accept wider explanations” (R. d. Carvalho, 2010, p. 350) He confessed to João Sá da Costa (owner of the *Editora Sá da Costa,* which firstly published this collection) that these booklets “constituted his pedagogical thought” (J. S. d. Costa, 1996, p. 35).

These booklets overlapped many subjects taught in a traditional secondary physics course[214], but in spite of this, as António Manuel Nunes dos Santos said, these booklets presented “a style infinitely distant from the ‘compulsory’ bulky books that the liceus imposed to us” (Santos, 1997, p. 18). Chiefly the first two booklets (*The Discovery of the Physical World*, and *The Scientific Experiment* – both published as early as 1979) gave substantial attention to the Philosophy of Science[215]. These two first booklets discuss themes like what scientists do, what a scientific hypothesis is, difference between facts and phenomena, what is understood by the laws of nature, the uniqueness in scientific language, the role of experiments in science, measurements and so forth. These ideas are in the background of the whole collection as they are constantly recalled in the others booklets of the collection.

Carvalho believed, as he said in the first book of the collection, that “one of the causes” for students’ “failure” in science was due their “lack of confidence (...) with basic ideas without which it is impossible progress in the studies” (R. d. Carvalho, 1979a, p. i). Carvalho’s son, the physicist Frederico Carvalho, says the objective of this work is to “introduce the fundamental concepts of physical sciences”. Although it does not intend to tell a history of science (as the collection *Science for Young People* did), they paid particular attention to

> the characters who somehow contributed over time to the advancements of science and techniques, and to the historical circumstances in which these

[214] Their titles in English, according to Auretta and Santos (Gedeão, 1992): *The Discovery of the Physical World, The Scientific Experiment, The Particle Nature of Matter, Molecules, Atoms and Ions, Crystalline Structures, Energy, Forces, Weight and Mass, Chemical Reactions, The Composition of Air, Atmospheric Pressure, Static Electricity The Electric Current, Magnetism and Electromagnetism, Electronics, Radioactivity, Radiant Energy, Waves and Particles*.

[215] Today, this characteristic could certainly be classified as either *How Science Works* or *Nature of Science.*

> advancements occurred, highlighting the constructive collective character both of ideas and of material fulfilments of science and techniques (F. Carvalho, 2004, p. 10).

Indeed, when one scrutinizes *A Treasure of Science for Young Minds*, Carvalho's concern, once again, with the important figures in the history of science stands out. Nevertheless this concern is only one of the characteristics of Carvalho's "pedagogical thought", presented in this work. Another remarkable characteristic is the absence of physics formulae in the whole collection. Carvalho was very clear that, in the first years, students were supposed to be taught a kind of 'conceptual science', as he disliked the synthetic aspect of formulae in students' first contact with the either physics or chemistry. This is indeed an important aspect in Carvalho's thought: an idea he first presented in is 1948 chemistry programme, as we could see in chapter 3.

Naturally, Carvalho's pedagogical understanding of science education evolved over his four decades as a physics and chemistry teacher; and we should note that when he wrote these booklets he was already over seventy years old, already retired, very experienced as a textbook writer both for formal and informal education. At this age Carvalho enjoyed a wide acknowledgement for all his work as a pedagogue, as a science writer, as a historian, and as a poet. Therefore there was beforehand a natural good expectation from the public, as his previous works were in general so well received. As an example, right after the publication of the first handbook, in a Lisbon newspaper it was said: "A Treasure of Science for Young Minds is an original initiative. (...) Regarding its aims, it is just needed to say it is

Rómulo de Carvalho's authorship"[216]. One can find in Carvalho's personal documents a number of letters praising his ability to write with simplicity and clarity. These people were probably Carvalho's acquaintances, and they tend to compliment Carvalho. They nevertheless also suggest the high-standard of these small books, at least in the Portuguese context of the seventies.

> A work of art and clarity, which makes extremely accessible themes which in nature are not[217]

> Our youth now has the opportunity to read with pleasure something that can help them to interpret the surrounding phenomena[218]

> These booklets are in the same level of the foreigners[219]

> The students got excited with the text presentation and simplicity[220]

> I thank you not only for the youngsters to whom they are addressed (…) but also for myself as a teacher, for it helps me to clarify ideas[221]

Carvalho was in fact very satisfied with the outcome of his work. He said they were "very beautiful booklets" (R. d. Carvalho, 2010, p. 351), although, in his

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[216] Newspaper (O) Lisboa on the 8th of June 1979.
[217] Letter from Ilídio Sardoeira to Carvalho in October 1980. BNP, Archive 40, box 3, folder "cadernos de iniciação científica".
[218] Letter from Maria Odete Canelas de Castro to Carvalho on the 9th of October 1979. BNP, Archive 40, box 3, folder "cadernos de iniciação científica".
[219] Letter from Maria Luíza Guerra to Carvalho on the 19th of May 1979. BNP, Archive 40, box 3, folder "cadernos de iniciação científica".
[220] Letter from Maria Gabriela to Carvalho on the 24th of March 1979. BNP, Archive 40, box 3, folder "cadernos de iniciação científica".
[221] Letter from Maria Gertrudes to Carvalho on the 16th of March 1979. BNP, Archive 40, box 3, folder "cadernos de iniciação científica".

opinion, sold very little for they did not comply with official programmes (ibid). Or maybe, as his friend Ilídio Sardoeira warned him[222], they were too expensive.

In 1997, the physicist Carlos Fiolhais appeared making a note on the pages of the *Gazeta de Física* that from the seventies up to that date no other work had come up with the same characteristics (Fiolhais, 1997a). In 2004, more than twenty years after their first publication in late seventies, and in spite of eventual outdated information in chapters concerning more recent developments in physics, these booklets were re-published for, as his son emphasised, their "educative value" (F. Carvalho, 2004, p. 10).

The sections above present the characteristic and the impact of various Carvalho's work on popularization of science. Their analyses also indicate that Carvalho's work on popularization gave great emphasis to the history and philosophy of science, to context, and to the understanding of one's surrounding world. Associated with Carvalho's apparent gift to communicate with clarity, this work presents strong aspects of a humanistic approach in science education, which intends to be meaningful and inclusive. This work can also be seen as with another humanistic connotation, which is related to the repressive moment Portugal lived during Salazarism. The section below will address this matter.

[222] Letter from Ilídio Sardoeira to Carvalho in October 1980. BNP, Archive 40, box 3, folder "cadernos de iniciação científica".

9. A subtle activist?

It is not so easy to quote Carvalho's political views and relate it to his work. Carvalho's declarations of his political position were disclosed only many years after the end of Salazarism in his book *Memórias* (R. d. Carvalho, 2010). There it seems clear that Carvalho was definitely not one of the supporters of the regime and had, as he revealed, "communist" inclination since youth (R. d. Carvalho, 2010, p. 141). I do not have evidence to characterize Carvalho as a communist, but in this section we shall see that he had a 'libertarian' worldview which, in this sense, did not fit in the fascist ideology.

I shall now return to the ideological issue that I raised at the beginning of this chapter: if Carvalho wrote books with a similar aim of the Popular Universities', why was Carvalho not targeted by the fascist regime?

One possible explanation is that, even though popularization of science in a fascist regime can be characterized as 'libertarian', Carvalho was not, so to speak, a traditional activist engaged in political parties and public demonstrations of an ideology. During the New State he never published any text questioning the fascist ideology, or its alienating educational strategy. This attitude was never very clearly explained, perhaps because he deliberately avoided justifying his neutrality. Carvalho recognized in a newspaper interview, during his life as a teacher he had "always been a political animal, although without political intervention" (Vasconcelos, 1989, p. 10). A few years later, he ratified this, saying: "In fact I never wanted to interfere in anything (…) Within my capabilities, I wanted to intervene in what I could be useful for a certain group of people" (M. L. Nunes, 1996, pp.15-16). As a concrete example of the consequence of his apparent neutrality, when in late forties many staff members and assistants of Faculty of Science of the University of Lisbon were dismissed[223], Carvalho remained untouched as one of the editorial members, contributing to the journal *Gazeta de Física* (R. N. Rosa, 2002).

Another possible explanation is related to his motivations. His book *Physics for the People*, written to the 'peasant' aimed at educating the population which could not learn at school, and speaks to the aims of the *Popular Universities*, which intended to spread culture and 'free people'. But in Carvalho's case, as he explained in an interview, his primary motivation to write for the 'people' was personal. It simply pleased him: it

> arose, of course, as a consequence of being a teacher. What I communicated by words, it pleased me to communicate by writing and with a broader character. For instance, take Physics for the People: Pure pleasure, and a continuity of the profession taken to the exterior [to a wider audience beyond the liceu] (Rocha, 1994, p. 104).

Likely, Carvalho was aware of the potential political implications of his work, but this was not an act of 'heroism' of someone who was trying to 'save' a country. What seems more likely is that popularizing science was not, per se, a problematic issue in fascist regimes. Actually, as it was recently claimed (Gavroglu, 2012), popularization of science always follows a hidden ideological agenda, which might,

[223] This affected the direction of *Gazeta de Física*, including its founder Armando Gilbert who lost his assistantship in the physics department, and had his doctoral degree recognized in Portugal only in 1974 (Gaspar, 2007)

or not, be used to reassert the authority of the hegemonic ideology. What ultimately mattered for fascist regimes was the way the knowledge was communicated, or how the knowledge was "managed" (Tabernero, et al., 2012).

To understand this issue we should first note that although many scientists were targeted by the Salazarist regime for ideological reasons and forced to leave the country (Perez, 1997), in fascist regimes scientific knowledge and specific research groups were in fact valued and supported because of their importance in the establishment of 'self sufficient' schemes of food supply from their colonies, a scheme called *autarky* (Gaspar, Gago, & Simões, 2009). Popularizing science could serve, for instance, the interest to validate such schemes. As a concrete example, a recent case study on popularization of science in Spain before and during Franco's dictatorship (Tabernero, Jiménez-Lucena, & Molero-Mesa, 2012) has shown how overtly different science knowledge was circulated when it was done by libertarian movements (e.g. anarchist trade unions) and by the Spanish fascist government. The way knowledge was circulated affected the "inclusion-exclusion dynamics": whereas the former used "strategy of *questioning* the *social, political* and *cultural* establishment" (p. 70, my italics) and "avoided technocratic interference by physicians, as professionals, in the union" (p. 71), the later wanted to alter the flux of knowledge in an asymmetrical way, from "a few" to "the many", as they aimed at indoctrination and *social cohesion*.

Therefore, in Carvalho's case, although questioning, inquiring, and wondering played great part in his writings, these were fairly limited to the natural, not social-political, world. He communicated scientific (chiefly physics and chemistry) knowledge in a dialogical and inclusive approach, which encouraged people to think about nature's beauty, about the functioning of the technological devices in the surrounding world, and the scientific endeavour of 'scientists' (the development of their understanding about nature behaviour) and even its philosophical implications. To return again to a central theme of this thesis, all this amounts indeed to what can be described as a 'humanistic science education'. However, Carvalho wrote books which would inseminate people's mind with the dominant scientific culture. Therefore, although this has great value for scientific literacy along with one's socialization and enculturation, his work did not foster the development of an understanding of, say, their social condition, the democratization of their society, or class struggle. In other words, it did not fit in more radical humanistic approaches with the political purpose of transforming oppressive conditions in society - as the Brazilian educator Paulo Freire would have envisaged (P. Freire, 1970), and whose use in science education has been advocated (dos Santos, 2009). Carvalho did not touch (at least explicitly) ethical, ideological, or power relations issues of which the comprehension is essential for the transformation of a society as Bento de Jesus Caraça wanted and deliberately worked for. Therefore, although the dissemination of knowledge in a closed society can still be described as a libertarian endeavour, the content and the way Carvalho popularized knowledge did not seem to have threatened the status quo.

However, I wish to make a claim here that Carvalho in fact intervened politically, but in a 'disguised' way. Not as a science teacher but as a poet. As discussed in the introductory chapter, Carvalho has been described as a 'multifaceted' man, with an inclination both to sciences and humanities. Unlike his work on popularization of science, as will be discussed below, Carvalho's work as a poet (the pseudonymous António Gedeão) reveals he was a great critic of the Salazarist regime, and this appears to be his most outspoken message (this is only one of the many aspects of his poetry). Apparently, in the view of this science teacher and poet, poetry, more than popularization of science, seemed to be the more appropriate channel for communicating ideological messages. Of course, Carvalho's poetry does not belong to his work on popularization of science (although in many of his poems he used scientific vocabulary). However, in the context of his position in relation to the fascist regime, which this section has also been trying to address, it seems appropriate to provide a brief account here on how he used his poetry as ideological tool.

For many times Carvalho said he just wanted to be useful for other people. On one of these occasions, when in an interview Carvalho was requested to explain what 'useful poetry' means, he answered in these terms: "It is normal that people have interrogation about life. When they read a poem they might feel stronger to keep fighting". Politically?, he was asked, "Absolutely, in a 'polis' sense." (Rocha, 1994, p. 101).

He explained in his book *Poetic Text as a Social Document*[224] (O texto poético como document social) (R. d. Carvalho, 1995b), he saw the role of poets as someone "attentive to the surrounding and involving occurrences, in the social environment in which the poet moves"; and that the qualities of the poetry are "defining signs of a certain society" (R. d. Carvalho, 1995b, p. VII). Poetry aimed thus at being "useful",

[224] This book in another example of Carvalho's keenness to understand the historical evolution of our culture: in nearly four hundred pages, Carvalho selected "dozens of poetic texts all over our History" which had the purpose to "illustrate the attention that poets paid to the to their exterior realities" (R. d. Carvalho, 1995b, p. VII). From century XII to the end of Salazarism, the book presents history viewed through the eyes of poets and their poems.

as he saw himself more as “a craftsman than as an artist” (Rocha, 1994, p. 104). In fact, as early as 1965 he said in an interview that “being a poet, for me, is as important as being a cabinet-maker or a locksmith. I am an element of a society and I try to be useful” (A. Martins, 1965, p. 15).

In this sense, in his opinion, poetry and prose could not be distinguished by content but solely by the rhythm. In the political arena, whereas Caraça and others used prose to convey a libertarian ideology, he used poetry. In his own words:

> A poetry of combat might have nothing of ‘poetic’ [meaning not beautiful], but it still is poetry as long as fulfils certain rules. A combat without contracted hands pointing towards someone else’s neck, is nonetheless still a combat (Rocha, 1994, p. 104)

At least part of his poetry had an identifiable political bias, and was written with the aim to possibly shake youth of the fifties and sixties, when Gedeão published his first poems. Take for instance the poems below, which are representative of many others of his authorship:

Field of concentration[225] [Campo de Concentração] (1956)

Your eyes, birds that you cast
above the earth's bitterness,
which drink the essence of things
as if these things were limitless;
your eyes, opened wings,
begot flight in the cloister of my face,
and questioned the shadows, the vigilant shadows

[225] Translated by Christopher Auretta and Marya Berry (Gedeão, 1992).

of my supposed sleep.

Go, now. Do not question me, for I have nothing to say.
This, that, and that over there, are neither that, nor that over there,
They are nothing. [nor this.]
Or maybe not nothing.
Maybe simply this:
a dawn's panic,
a malaise called «I exist».
(Gedeão, 1992, p. 39)

Black Woman's Tear[226] [Lágrima de Preta] (1961)

I found a black woman
who was crying
I asked her for a tear
In order to analyze it.

I collected the tear
taking a lot of care
in a test tube
very well sterilized.

I looked at it from one side
from the other, and from the front:
it looked like
a very transparent drop.

I used acids,
bases, and salts,
drugs used

[226] Free translation

in these cases.

I experimented it in cold
experimented in fire
and at all times
I got the usual

Neither signs of black
nor vestige of hate
water (almost everything)
and sodium chloride.

One will likely read from the two examples above an anti-fascist message: they are sensitive about the atrocities and prejudices provoked/promoted by fascist ideologies. The excerpt below taken from another interview with Carvalho conveys the idea that his poetry was a deliberate attempt to spread hope. Explaining why he started publishing only in the fifties, he said:

> It was a time of excitation and political activity (…) and it seemed to me my poems could help people's hope for change and democracy in the Portuguese life (…) I thought some of these poems could be useful, could be exciting, that students in Coimbra [where he lived in the fifties] could get interested in that poetry, repeat it, declaim it, sing it, as it came in fact to happen (Vasconcelos, 1989, p. 10)

Indeed, for the physicist Rui Namorado Rosa, Carvalho's poetry marked his generation:

> In the sixties, a period of convulsion and perplexity, particularly painful in Portugal, his poems were particularly read, recited in students' *soirees*, used as song lyrics and taken to the people. 'Poem for Galileu' [Poema para Galileu] and 'Philosopher's Stone' [Pedra Filosofal] marked my generation, contributing to preserve hope and strengthen the fight for a better future (R. N. Rosa, 1996, p. 22)

It is not clearly known why Carvalho was not targeted by the Salazarist regime because of his poetry, although his theatre play RTX 78/24 (Gedeão, 1963) was censored for, in Carvalho's own opinion, it "ostensibly tackled the State's repressive values" (R. d. Carvalho, 2010, p. 446). Following up my previous possible explanation for not being targeted, Carvalho has been described by his former students as a sober, reserved and demanding person, a respected teacher in an elite institution such as the Portuguese Liceu, neither a revolutionary nor a 'loud' person who fiercely tried to organize people against the fascist government (Crato, 2006c). The fact he was not involved in organized political movement, did not actively work (as Caraça and others did) to overthrow or at least change the political structure, should have left him in an apparent neutral position. Possibly, although one might claim that Carvalho shared his humanistic worldview and his discontentment with aspects of the fascist ideology, the tone of his words was not thought of being inciting. Alternatively, his words were expressions of his own grief after WWII, about the outrageous atrocities that human beings are capable of.

10. Conclusion

As we could see in this chapter, according to some testimonies, Carvalho had a special ability to communicate knowledge to a range of different audiences. It is likely that such ability stems from the fact that Carvalho was a science teacher – someone who arguably had mastered scientific knowledge - who was also strongly inclined to the so-called 'humanities', a poet and historian. Perhaps the combination of these activities enabled him to strike a right balance between scholarly knowledge and an engaging writing, suitable to a wide range of public. Much of Carvalho's ability to communicate scientific knowledge, as well as the extensive use of history and philosophy of science in his writings, speak to what was discussed in previous chapters: his concern with meaningful learning. His work on popularization has a historical significance not only because of its pedagogical aspects, but also because it was carried out in a fascist regime, which gives it a libertarian connotation, as I argued.

If I may link this study with contemporary research in science education, drawn on what was discussed here, an important note on the teaching of History and Philosophy of Science (HPS) can be made. In the specialized literature, one will likely find a great number of studies in the literature which point out the alleged educational benefits for the use of HPS in secondary school science. Most of their claims seem fall in at least one the following purposes: to a) improve understanding of science content and scientific skills; b) encourage students (because it is enjoyable and meaningful) to pursue scientific disciplines/careers; and c) enhance citizens' *critical thought* in a number of social-political issues. What we can learn from Carvalho's work on popularization is that whilst 'a' and 'b' seem more likely to be fulfilled by books on the popularization which focus on the development of ideas in science, we should be more sceptical about ‘c’. The non-problematic aspect of Carvalho’s ‘libertarian’ work in a fascist regime makes one wonder about the extension of the alleged benefits of the use of either “inquiry” or HPS in science education as means to foster a critical and engaged citizen in social issues if the study is limited to the functioning of the natural world. Indeed, in the context of education during Salazarism, popularization of science did not pose, apparently, any threat to the Portuguese fascist regime. Even Carvalho’s most ‘ideological’ works, such as *Physics for the People*, did not face any censorship. Perhaps the dictatorial regime saw it as an entertaining reading, but unable to mobilize or incite the people against the government. Nevertheless, from this account we can see that even in the shadows of a repressive Dictatorship, there were humanistic initiatives taking place in Portugal, which, in whatever dimension, or in whatever extension, probably touched people, and made them wonder about life, about nature, about human achievements.

Chapter 8

Final Remarks and Conclusion

The introductory chapter indicated that the aim of this thesis is to provide a historical account on the characteristics and impact of Carvalho's pedagogical thought and work within a professional and political context. Every chapter addressed one or more of Carvalho's activities in different educational areas, such as curriculum development, textbooks, use of experiments, teacher training, and popularization of science. In this chapter I will recall and critique the main chapters' arguments, providing further comments and conclusions.

Chapter 3 addressed Carvalho's 1948 chemistry programme, which has been claimed to be controversial with the suppression of chemical formulae and equations, and the teaching of everyday substances (Beato, 2005). As we could see in Chapter 2, before 1948, chemistry programmes gave emphasis to the teaching of the 'canonical' knowledge, little concerned with context and pupils' everyday life. In order to understand this “radical” shift in chemistry teaching, Chapter 3 aimed at addressing what underpinned Carvalho’s rationale, and what was the impact of this change. It was argued that Carvalho was concerned with the ‘kind’ of scientific knowledge which was supposed to be taught in the General and Complementary courses respectively of the Liceu. In the former, his programme offered the teaching of a more ‘material’ object of knowledge, with a utilitarian aspect, whereas in the latter a more ‘abstract’ object of knowledge. Before memorizing a formula and learning how to solve a number of numerical problems, Carvalho believed that pupils were supposed to learn substances’ characteristics, properties, origins etc. This understanding shed light in Carvalho’s decision to suppress abstract knowledge from the General Course, and also explained the source of controversy. In addition, it was claimed that because of the pressure of what I called ‘the conservative forces’, Carvalho’s programme was modified in 1954, which limited its impact in the actual practice of science teaching in Portugal.

It was also suggested that Carvalho’s concern with the teaching of scientific content suitable to pupils’ age and with meaningful learning can be described as a ‘humanistic approach’ in science education. It is humanistic in the sense that it cared about pupils’ condition as learners and their interests; in the sense it was an inclusive teaching in the General Course. The analysis of Carvalho’s rationale contained in chapter 3 is very important to this thesis because it seems to be the bedrock of his pedagogical thought. Indeed, as I argued at appropriate points in the thesis, the same concern in teaching only what can be meaningfully learned, as well as using a teaching method which would attract and engage pupils in the learning process, appeared in many other activities.

Take for instance Carvalho's work as a textbook writer. One of the objectives in Chapter 4 was to identify what might have affected the 'quality' of his textbooks in the fifties and sixties. It was suggested that, possibility affected by the little support and lack of time in the Sole Book contest, Carvalho did not overcome the traditional textbook approaches, which caused referees to reject his General Course chemistry compendium. In the sixties, however, now fully supported, he wrote the textbook *Sciences of Nature* to the 'Preparatory Cycle'. This book explored the 'material' surrounding world, potentially meaningful to youngsters' everyday life, and also guided a child to 'inquiry' about natural phenomena, carry out some simple experiments, and draw conclusions from what he observed. It was argued that the characteristics of this textbook speak very closely to his 1948 chemistry programme.

Perhaps more important than the different contexts between the Sole Book contest and the Preparatory Cycle, when one looks over the arch of twenty-years 1948-1968, it can be also concluded that although in the forties Carvalho was able to *propose* a new 'humanistic' chemistry teaching, only in the sixties did he seem prepared to write a textbook which would fulfil its aims. In other words, if we think of Carvalho's work on curriculum development, it can be claimed that it took twenty years to Carvalho materialize the 'spirit' of his 1948 syllabus into a textbook.

It should be noted that, regarding syllabi and textbooks, Carvalho's understanding on the most appropriate content and teaching approach were conditioned by his views on what the 'aims of general education' were. In other words, when Carvalho raised the question "what is the purpose of the General Course?" (see Chapter 3, section 4), he was explaining that 'what' and 'how' we teach depend on the aims of education. He said

> I only consider myself a chemistry teacher when I teach in the 3rd cycle [Complementary course]. There, students are, for me, chemistry students (R. d. Carvalho, 1951e, p. 199).

I argued that Carvalho believed that the General Course was not a place to teach chemistry or any other discipline in a strict sense, but it should provide as much of a wide and comprehensive education as possible to help students cope with everyday situations. That is, in his view, the study of physics and chemistry in the first years was important as a simple part of an *interwoven utilitarian whole*.

Carvalho wrote his chemistry programme in 1948, right after the end of World War II. It is not clear whether this fact affected Carvalho's views on education, i.e., whether he was compelled or not to emphasize 'social efficiency' rather than subject matter in the General Course. But in other countries (as I indicated in Chapter 5) a correlation between the aftermath of WWII and "life-adjustment" or "functional" curricula of "progressive educational practices" has been made (Rudolph, 2002). In the US, it has been claimed that these curricula were in line with John Dewey's value of "true learning", i.e., they valued content with pupils' "immediate interest" (p. 21). The historian John Rudolph points out that the goal of these curricula was "to provide classroom experiences that would meet the daily personal and social needs of all students, particularly those not served by the existing academic and vocational curricula at the secondary level", so that life-adjustment curricula valued "real-life problems - problems that would naturally generate student interest" (Rudolph, 2002, p. 18). Probably, Carvalho had in mind the same educational aims of those who advocated these kinds of life-adjustment curricula, since at least in Rudolph's characterization of them, they matched to a great extent Carvalho's 1948 programme.

In fact, in the history of science education there are a number of projects which can be called "progressive", "life-adjustment", "inclusive", which have also been referred to as "humanistic". For instance, as early as in the nineteenth century, one can see English philosopher Herbert Spencer addressing the question "What knowledge is of most worth?" (Spencer, 1861). Spencer was claiming for a utilitarian education, concerned with citizenship, with the welfare of family and society. More recently, studies have claimed that certain curricula approaches such as *Science-Technology-Society* (STS) (Donnelly, 2004; Donnelly & Ryder, 2011) and *History and Philosophy of Science* (HPS) (Matthews, 1994) have promoted humanistic approaches in science education. Among other reasons, the characterization as 'humanistic' is because STS curricula emphasize the understanding of science in the context of a human experience, valuing therefore the mutual influence between technology and its social consequences (Mansour, 2009). In the case of HPS, also among other reasons, it has been argued that HPS fosters active citizenship, responsible environmental behaviour, and social reconstruction (Hodson, 2008).

In this international scenario, we should also consider whether Carvalho was influenced (in the sense of inspired) by other educators or educational projects. Considering in particularly his 1948 General Course programme and his textbook *Sciences of Nature* published in 1968 it is not clear whether he was directly influenced by other educators of his or previous times. It might be the case that he was influenced by some English educators, since, we should recall from chapter 3, he quoted some of them in his debate with José Teixeira.

However, more likely, Carvalho might have received some influence from the educational views of the French physicist Paul Langevin. This supposition is based on the fact that in 1947 Carvalho published an article about him (R. d. Carvalho, 1947b). In that article Carvalho acknowledges what a great physicist Langevin was, exploring and praising Langevin's view about science, and indicates that he attended Langevin's talks in Lisbon and Oporto in the thirties. In 1932 the journal Labor published one of Langevin's talks at the Société Française de Pedagogie (Langevin, 1932). The similarity between the ideas expounded by Langevin and Carvalho's 1948 programme is apparent. Langevin defined general culture as everything that prepares one to the contact with reality (material, psychological, and moral realities), regardless his/her future professional specialization. He spoke about the contribution of the physical sciences to such end, i.e., the importance of it to the "general formation of men" and to his "preparation for life in all aspects" (p. 11). In his opinion, sciences, in the first years of study, should be taught with *Lessons of Common Things*. Only later he recommended the teaching of more abstract concepts. Also in this final stage he recommended use the History of Science to convey the notion of scientific life, and of progressive development of ideas. Langevin noted the importance of science to both intellectual and manual activities, but understood that the most important achievement is to make students understand and love the collective effort of adaptation to our world, and the sense of human evolution, that sciences represent. If one recalls the organization of Carvalho's chemistry programme for the 2nd and 3rd cycles, one will likely conclude that it shared the same rationale above, set out by Langevin.

Still regarding chapters 3 and 4, it is important to point out here some limitations in the analysis they provided. The Historical Archive of the Ministry of Education in Lisbon has a dense estate of documents from the time of the Salazarist regime. However, I did not manage to encounter all information I needed either because I did not realize where to find them or because some archives still lack an inventory. The lack of some pieces in this jigsaw caused difficulties of interpretations or questions without answers.

To give an example, Carvalho suggested in his book *Memórias* that he worked in the "structure" (Carvalho, 2010, p. 289) of the Preparatory Cycle in late sixties (discussed in chapter 4). In the Historical Archive of the Ministry of Education in Lisbon, I did not manage to find any information about Carvalho's work for this cycle: Teachers' Official Reports date only up to 1965, and I found no reference to his book *Sciences of Nature* in the 'School Textbooks' (*Manuais Escolares*) section of the Archive. Also, from 1968 to 1973 in the journals *Labor* and *Palestra* there is no elucidative accounts of Carvalho's participation in the structure of this cycle. The only relevant information is available in Carvalho's personal documents: this is a document from 1959, when the Preparatory Cycle was still under consideration, by which Carvalho gives his opinion to the Ministry of Education about how should be the aspects of science teaching in this cycle. Carvalho says the Preparatory Cycle should teach "a scientific view, very basic, of the universe". He stresses the need for the development of "observational" and "critical" spirits, as well as correct language and proper expression, "everything within the level of elementary characteristics of pupils' age"[227]. Regarding teaching

[227] See Carvalho's personal documents at National Library in Lisbon. Archive 40, box 55, folder "inqueritos e entrevistas": Tittle of the document: "Resposta aos

methodology, Carvalho recommended, as in his 1948 programme, *Lesson on Common Things*. Coincidence or not, these aspects were very similar to those described in the programme of *Nature of Science* (the science discipline of the Preparatory Cycle), published nine years later[228]. I hope that in the future more information about Carvalho's involvement with the development of the structure of this cycle will enable researchers to enlarge the information provided here.

As another example, I have not found who the author of the 1948 physics programme was. This was important information because the 1948 physics programme to the 2nd cycle was also modified. It could be argued that it employed the same rationale used in the chemistry programme. Similar to the chemistry's, the physics programme stressed the necessity in making its study "light, clear, and simple" and to "familiarize the student with the most ordinary and important physical phenomena" and to be "linked to everyday life" (Decree 37112, 1948, p.1155). The physics programme also took the same "radical" measure in withdrawing physical formulae from the General Course (2nd cycle). I do not have evidence of the extent that Rómulo de Carvalho might have influenced its rationale or even perhaps written some of its parts. If the case, this would open a new field to be explored in Carvalho's pedagogical work. Future researchers might wish to know that one possible name for its authorship is Carlos Cerdeira Guerra. He was the sole other constituent of the 7th group (the Physical-chemistry Sciences group) who participated in the process of re-elaboration of disciplines' programmes alongside Rómulo de Carvalho since 1941 when Riley da Motta was the Director-General of

quesitos [não mostra os quesitos] da Circular n°2 da secretaria Geral do Ministério da Educação Nacional, de 14 de Janeiro de 1959."

[228] See Portaria 23601 of 09/09/1968, Official Daily Bulletin of the Portuguese Government, I Série, 213.

Liceal Education. Another possible name is of Túlio Lopes Tomás, as in 1951 he wrote to Carvalho saying he was thinking about modifying the physics programmes[229].

Chapter 5 addressed Carvalho's understanding of the pedagogical use of experiments in school science. This chapter sought to examine more critically why Carvalho's name is so associated with the use of experiments, and what Carvalho's teaching method was. It was argued that the Socratic method was Carvalho's preferred method, using a 1959 article and his textbooks to support the claim. Unlike heurism, this method values the role of teacher in the teaching/learning process. It was claimed that the use of the Socratic method was underpinned by Carvalho's distinction between the 'scientific' and 'pedagogical' methods. Carvalho believed that educators did not realize they were different.

It was also argued that Carvalho did not try, at least emphatically, to persuade other teachers to use the Socratic method, perhaps because he was not entirely secure about the understanding of its rationale, particularly the distinction between 'scientific' and 'pedagogical' methods. We should note that in Carvalho's time, this was (and still is) indeed a difficult understanding not only in Portugal. The historian George DeBoer has pointed out that since late fifties, when PSSC and other educational projects were created, "confusion often surrounded the inquiry goal" (DeBoer, 1991, p. 207). For instance, similarly to Carvalho, writing in 1964, the American educator James Rutherford, who was involved in the creation of the

[229] Letter from Tomás to Carvalho on the 7th of July 1951. Carvalho's personal documents. National Library, Archive 40, box 4, folder 6.

Harvard Project Physics[230], attempted to make a distinction between "inquiry as content" from "inquiry as a pedagogical technique" saying that the former is "inquiry as it appears in the scientific enterprise", whereas the latter was to use of "the method of scientific inquiry to learn some science". In other words, Rutherford believed that inquiry in school science could be used with both aims: to learn the process (or 'the method') and the product of science. DeBoer claimed that Rutherford was "one of the few people to distinguish between the inquiry aspects of science and inquiry as a pedagogical method" (p. 208). Of course there is no decisive understanding for this issue, but more recently, it has been claimed that the view of the teaching of 'science as process' "reflects both an inadequate analysis of the nature of the scientific enterprise and an inappropriate view of learning" (Millar & Driver, 1987, p. 3). As we could see, as early as in the fifties, Carvalho already seemed to understand that IPW classes were inappropriate to learn about the 'processes' of science.

Indeed, as I argued before, Carvalho presented great concern with possible pupils' misinterpretations of, to use more modern terms, 'how science works', or the 'nature of science', when the so-called 'inductive method' was used. Not only in his 1959 article, but also in his *A Treasure of Science for Young Minds,* published from late seventies, he indicates very clearly to teachers and students the 'fake' aspect of pupils' 'scientific' activity in school science. The debate upon that pedagogical use of experiments is a complex issue on its own right, and for the lack of evidences I cannot make further claims about Carvalho's opinion on this matter. However, this seems to be an important element in Carvalho's pedagogical thought, as it speaks with contemporary debate in education, and probably deserves further scrutiny.

[230] Created in 1962 by a group of educators and physicists of Harvard University, this project, unlike PSSC, gave great attention to History and Philosophy of Science in physics teaching, and had a more contextual approach.

Chapter 6 examined Carvalho's work as a Metodólogo teacher and his articles published in the journals *Gazeta de Física* and *Palestra* in order to support physics teachers with the use of school experiments. In particular, the aim of this chapter was to examine Carvalho's views on what makes a 'good' science teacher and what he did to help teachers to fulfil its qualities. This chapter also aimed at examining Carvalho's own performance in the classroom. It was argued that Carvalho's practice was aligned with his views on good teaching practices, and that his articles on the use of experiments should have had an impact on the association commonly made between his name and the experimental sciences.

Two main aspects seem to have marked Carvalho's work on the support of teachers. One of them, which is a pedagogical aspect, follows very closely his views on his 1948 programme, which is the appropriate communication, suitable to pupils' learning condition. Indeed Carvalho was very concerned with teachers' ability to adapt what is learnt in university courses to a kind of language which youngsters could comprehend. This concern seems to be the backbone of his great attention with the proper use of experiments, and with the use of a clear and precise language. Carvalho never referred to his 1948 programme as 'humanist', but he said in his 1964 Report that, more than facilitating learning by using resources, the teacher would 'humanize teaching' if he/she made the most of his/her human attributes, such as "the fluent speech, the sharp sentence, the precise terminology". This view reveals that Carvalho believed and advocated a teacher-centred teaching, and valued teachers' participation in students' learning. The Socratic method, by which the teacher would guide students to draw conclusions, is aligned with this supportive perspective in the role of the teacher. Because of his ability with experiments, his ability to, as João Caraça and others said, make his students wonder “about their position in the Cosmos”, his knowledge about the History and Philosophy of science, his “perfect Portuguese” and all other attributes pointed out by his former students, it can be claimed that Carvalho centralized teaching on himself, apparently with some success. In a context of teacher-dependence on pupils’ learning, it is not difficult to understand why he was so demanding with teachers’ performance: a teacher was to be a ‘showman’, should have a “sense of spectacle”, he said.

The second aspect is his commitment with his profession. Carvalho took very seriously his work as a Metodólogo. He said in his autobiography *Memórias* and in various interviews that he just wanted to be ‘useful’ to people, and this might be a way to explain his commitment. However, as I indicated before, Carvalho also presented a notorious concern with the dignity of the teaching profession and its social value. Carvalho hardly elaborated this view either in his writings or interviews, but his claims for two-year non-paid training for all physics-chemistry teachers is an indication of this care. In sum, Carvalho believed that only by having a highly professionalized class, teaching would gain respect, and be socially and financially valued and rewarded.

The analysis of Carvalho’s writings on teacher education combined with the testimonies of former students and trainees offered a new, overarching, perspective of Carvalho’s activity for the improvement of the practice of teaching. Carvalho offered a rationale for a teacher-centred teaching setting. Because he managed to put in practice his own ideal of a ‘good’ science teacher, and given the positive impressions he left in students and trainees, perhaps the most important conclusion one can make from this chapter is that a teacher-centred setting can be successful if the teacher displays the skills and knowledge prescribed by Carvalho.

Chapter 7 examined Carvalho's work on the popularization of science. This was the only chapter after Chapter 1 which was not focused on the Liceal teaching. And because this work reached a much wider audience, possible ideological aspects of his work were also examined. The chapter addressed the content and writing style of his articles and books, also whether he communicated any anti-fascist ideological message, and, as a consequence, whether he was targeted by the Salazarist regime or not.

I argued that Carvalho managed to strike a reasonable balance between scholarly literature and an engaging reading, which would attract youngsters' attention. Apparently this balance was achieved because of Carvalho's multifaceted background. He had a scientific degree but he was naturally inclined to the so-called humanities, passionate about history, literature, and languages. It is likely that one who reads Carvalho's books on History and even his autobiography *Memórias*, will perceive that he had a gift in telling stories. Importantly, Carvalho's books influenced a number of students to pursue scientific careers at a special moment in Portugal, just after many scholars were dismissed from their academic positions.

The weight of his multifaceted background on his various activities has in fact been pointed out by other sources. For instance, Jorge Couto said it was very likely that Carvalho's "rationalist spirit" has "inspired" some of his poems (Couto, 2006, p. 11), or in another example that he "fulfilled a rare synthesis among many fields of knowledge, fertilizing them in this crossing, constructing an original work both in the scientific and artistic branches" (R. N. Rosa, 1996, p. 22). Carvalho indeed recognized that he had a "scientific education, which allied to his literary inclination, allowed [him] to embrace the world in a globalizing view" (Gedeão, 2004, p. 309).

At this point we can recall what was pointed out in the introductory chapter, that Carvalho said his decision for pursuing a scientific instead of literary career was more influenced by financial and professional opportunities than by his inclination to sciences. Possibly, had he chosen the other route he would have succeeded. In fact, given the number of historical works – which from 1953 to 1994 encompasses 35 articles (R. d. Carvalho, 1996, 1997)[231] and the many lengthy historical studies he produced (R. d. Carvalho, 1959b, 1973a, 1979b, 1981, 1982, 1985, 1986, 1987a, 1987b, 1993, 1995b, 1996) – it seems fair to say that Carvalho always was a historian by inclination without an official degree in the subject. Central to the point I want to make, Carvalho seemed to be a very curious person, a wondering mind, very keen to learn about the origin of things, and discover what the historical roots which make things be, or be seen, as such today. To give one example of his keenness, in one of his historical studies, a book entitled *History of the Royal School of Nobles of Lisbon* (*História da Fundação do Colégio Real dos Nobres de Lisboa*), he said in its introduction: "Our condition of being a Physics teacher, and a certain inclination to think about Historical roots, led us to study the origins and the progress of that discipline in Portugal" (R. d. Carvalho, 1959b, p. 7). I suppose that this same keenness to understand our current practices/activities, and why things are as we see

[231] These are two Collections of [Carvalho's] Historical Studies, recently published by University of Évora, which does not include his writings on the popularization of science.

them today, also underpinned much of his pedagogical beliefs in science education, and in particular his work on the popularization of science.

Carvalho's work on popularization belongs to the humanistic effort of a number of educators in Portugal to democratize knowledge. Perhaps, in comparison to Caraça's or Cortezão's work on the support of, for instance, *Popular Universities*, Carvalho's contribution might be seen as marginal, but it is undeniable that he tried to reach the same audience as these two and other educators did. Whether he wrote with political aims in mind, or not, is difficult to assert. Carvalho said he did not. But the fact he was not criticized by the regime seems to be related, as I argued, to the fact he did not incite people to think about social-political issues. The conclusions we can take from this chapter provides a new, broader, understanding of the significance of Carvalho's contribution to this field. Possibly important to current research in the use of science education to promote critical thinking, the conclusions drawn on this particular case study might shed light on the claims that studying science in school will foster socially-engaged citizens.

An important aspect of his work, that requires further study, is the applicability of his texts today, which potentially has serious learning implications. For instance, Carvalho's *A Treasure of Science for Young Minds*, which published eighteen booklets from 1979 to 1985, were reedited few years ago (R. d. Carvalho, 2004) based on the claim that they still have great educational value. The philosophy of science conveyed in these booklets is of course the philosophy of his time, which is likely to be different to more recent understandings of this subject. And although it has been claimed that there is no closure in contemporary accounts of the philosophy of science (Good & Shymansky, 2001), a proper and comprehensive study of

Carvalho's understanding of philosophy of science still waits to be done. In addition, the book *Physics for the People* was also recently republished (R. d. Carvalho, 1995a) along with a very successful hands-on exposition[232], set up to demonstrate school students some of the experiments proposed in the book. These initiatives in giving life back to landmark works should be valued, but, in terms of its actual use in school, in my opinion, they must be done cautiously and with consideration of its inevitably outdated information.

A humanistic project?

Can Carvalho's work in science education be seen as a humanistic project? As we could see, this is indeed an argument which pervades the whole thesis. This characterization can prove important when one tries to position Carvalho's work either within a national or international context. However, we should note beforehand that, as the summary of the chapters above indicate, this thesis provided a historical account on Carvalho's contribution to science education which goes beyond this possible characterization.

In order to address the question above, we must take into account the different connotations that the word 'humanistic' carries in Carvalho's different activities. As a first connotation, Carvalho's 1948 chemistry programme for the General Course and in his textbook *Sciences of Nature* were characterized as

[232] For more information about this exposition: http://www.pavconhecimento.pt/visite-nos/exposicoes/detalhe.asp?id_obj=1303, accessed on 21/06/2013.

humanistic because of their utilitarian aims and their concern with pupils' cognitive condition, with meaningful learning. Of course, the understanding in this thesis that utilitarian and meaningful learning can be characterized as humanistic is influenced by the analysis on other educational projects which took place over the twentieth century and before. It might be useful to provide here general characteristics of what is seen by some educators as humanistic approaches in science education. The Table 6 below is based on a review of humanistic perspectives in science education since the nineteenth century.

Table 6 - Humanistic approaches in science education (Cf. Aikenhead, 2006, p. 3)

Included	Excluded
Induction, socialization, or enculturation into students' local, national, and global communities that are increasingly shaped by science and technology.	Induction, socialization, enculturation, or indoctrination into a scientific discipline.
Citizenship preparation for the everyday world	Pre-professional training for the scientific world.
Savvy citizens cognizant of the human, social, and cultural dimensions of scientific practice and its consequences.	Canonical abstract ideas (curricular content) most often decontextualized from everyday life but sometimes placed in a trivial everyday context.
Attention to several sciences: established science, frontier science, and/or citizen science.	Emphasis on established science only.
Multiscience approach reflecting international perspectives (including ingenious science).	Mono-science approach founded on universalism (Western science).
Emphasis on science-in-the-making.	
Knowledge *about* science and scientists.	Knowledge of canonical science.
Moral reasoning integrated with values, human concerns, and scientific reasoning.	Solely scientific reasoning using habits of mind
Seeing the world through the eyes of students and significant adults.	Seeing the world through the eyes of scientists alone.
Learning in interacting with the everyday world and includes intellectual achievement, personal change, forming new self-identities, recognizing social political power, and perhaps practical or social action.	Learning is an intellectual task focused on acquiring scientific knowledge and scientific habits of mind.
Playing in the subculture of science as an outsider.	Identifying with the subculture of science as an insider.

Aikenhead (2006) points out that this traditional, canonical, science-centred, "pure science", teaching whose characteristics are roughly set out on the right hand side of the table above is not directly usable in science-related everyday situations and has distorted the image of science and scientists. He says the canonical approach does not help pupils "to learn science content meaningfully" (p. 27), as the goal of "learning canonical science meaningfully is simply not achievable for the majority of students in the context of traditional school science" (p. 28). And as a consequence, for the lack of meaningfulness, students pretend they have learned something, playing the game referred to as "Fatima's rules" (Aikenhead, 2006, p. 28).

Recalling the rationale of Carvalho's 1948 chemistry programme for the General Course, one will likely recognize that there are much similarity between the left-hand side of the table above and Carvalho's views on science education. I argued that Carvalho advocated an inclusive science education, an education which would suit pupils' learning capabilities and interests. I suggested that this understanding was the bedrock of this pedagogical thought, which also conditioned his work in the next decades.

As another connotation, on the support of teachers, the word humanistic it is related to the central and imperative role of teacher in the teaching/learning process. This characterization was provided by Carvalho himself. He understood that by making the most of what is intrinsically human (gestures and words), in order to adapt and communicate the canonical knowledge into something pupils' could comprehend, would humanize science education. Furthermore, Carvalho also contributed to the improvement and dignity of the class of teaching. In a broad perspective, if we take that humanistic projects aim at fostering 'Man [and humanity] at their best', commonly valuing freedom, autonomy, criticality, logical reasoning, social responsibility (Aloni, 2007), solidarity, and integration of the human community (Bokova, 2010), it is likely one will also see Carvalho's work on the support of teachers as humanistic.

The idea of solidarity and integration of the human community leads us to the third and last connotation for the word humanistic in this thesis. At least in Portugal, educational endeavour which intended to fight against the fascist regime are normally referred to as humanistic. Carvalho's participation in the collective effort to democratize knowledge with his writings on the popularization of science during Salazarism can then be seen as such. His writings on popularization, which explored the history and philosophy of science, also fit in the characterization of humanistic approach in science education presented further above: these writings intend to make accessible to everyone scientific knowledge in a contextual and meaningful way.

Was this a 'project' in the sense that he had a pedagogical agenda, a plan? Possibly. However, most likely, his pedagogical work occurred spontaneously, unfolded within the dynamics of his life. Carvalho can be seen as a secondary science teacher keen to somehow change the nature and the quality of education, mainly in the Portuguese Liceu. He seemed to have a certain distinct understanding of the role of science education in the liceal curriculum, but his involvement with either curriculum development, or textbooks, or teacher training was greatly dependent on life and professional contingencies. For instance: Riley da Motta's dismissal in 1947, which paved Carvalho's way to become the author of the chemistry programme; also, the invitation to be part of *Gazeta de Física*'s steering group; his attempt to move from Coimbra back to Lisbon in the fifties, which led him to become Metodólogo teacher with Cerdeira Guerra's resigning; and his textbook *Sciences of Nature* probably would not have existed without Sá da Costa's encouragement. Therefore, perhaps more than a pedagogical agenda, these and other contingencies seem to have set out his involvement with big educational contributions. As an exception, his work on popularization was indeed a long-term project, which started in early forties when he wanted to write "of a vast and complete History of Chemistry", as I pointed out before, and lasted until the eighties.

Carvalho was a full-time secondary teacher, naturally a time-consuming profession. Regardless of the 'quality' of his work or however it can be characterized, Carvalho's dedication to science education reflected in the number of works published is a remarkable achievement. In many respects he was an autodidact, this work flourished from his own and unsupported initiative, to somewhat fill a gap he had in his own education. He said in the conversation already quoted many times:

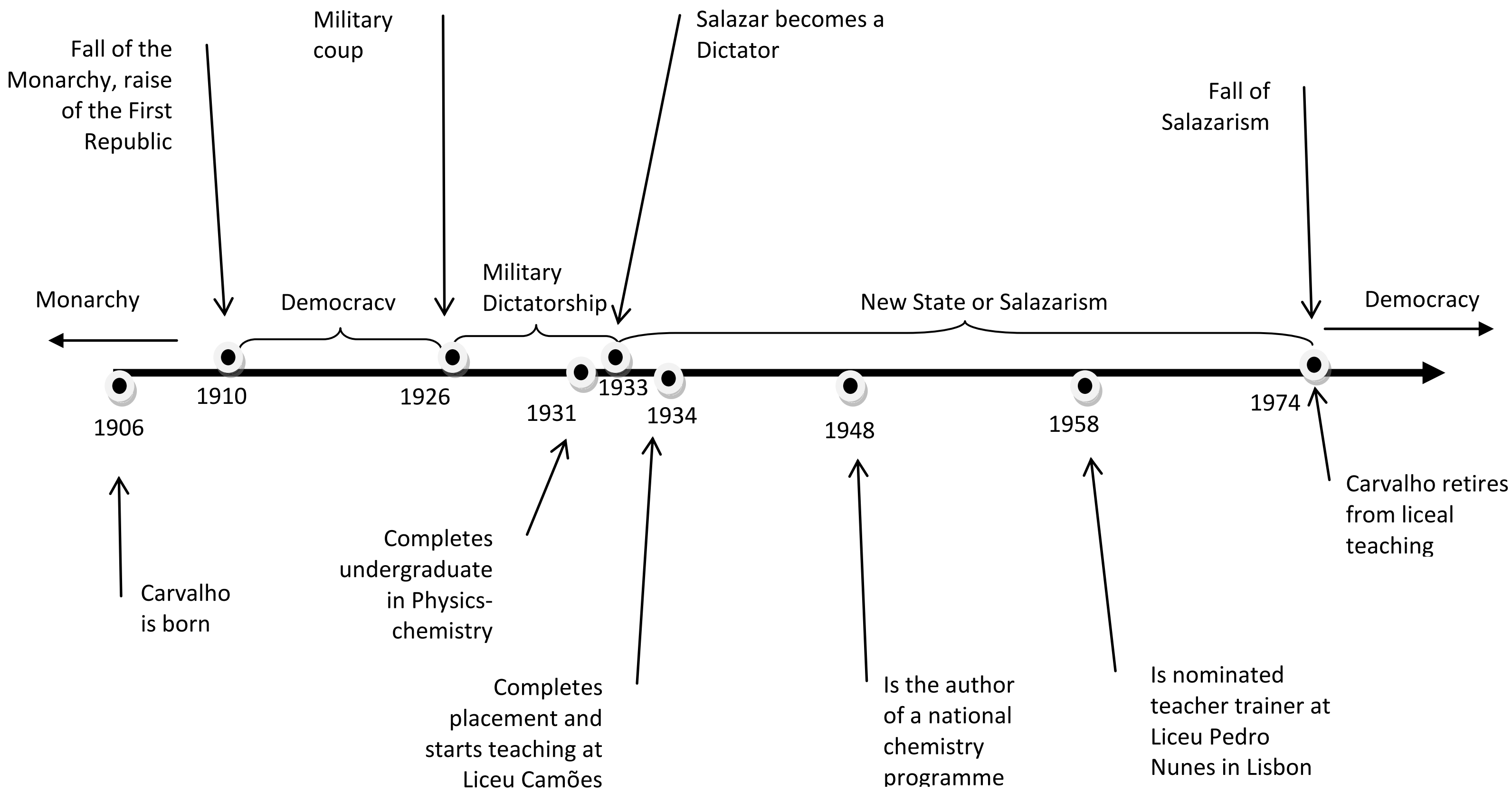
> I don't have a single positive recollection of my entire student career. Everything that I did I did on my own initiative. All the pleasure that I derived from my studies in science, in scientific observation and experimentation and in literature, I did all by myself. All of this was exclusively the fruit of my own efforts (Gedeão, 1992, p. 171).

Perhaps, whether Carvalho's work on pedagogy was a 'project' or had an 'agenda', it has always been conditioned by his unusual way of seeing things. In an interview only three months before he died, at the age of ninety, he was asked: "Are you a man with a foot on humanities and a foot on sciences or are you on one field looking at the other?”. He answered:

> Well, I see things in a different manner. Why cannot what is called humanities also be applied to the sciences? Humanities and sciences are the same thing, they are ways to learn in Nature and in society what is going on. I cannot really see how it can be said that I have one foot on each side. I have both settled on the ground and from this place I look at both things and connect them as much as possible. I see everything as a single action of human vision (Salema, 1996, p. 3)

Appendix 1

Summary of key dates in Carvalho's career in relation to the different political regimes which ruled Portugal over the twentieth century



Appendix 2

TABLE 3: Sketch of 1936 and 1948 Chemistry programmes' contents in the 2^{nd} cycle (General Course) [233]

1936 (4^{th} Year)	**1948 (3^{rd} Year)**
Bodies and substances. Simple experiences to deduce the notions of chemical phenomena and of elements. Experimental and elementary study of the elements: hydrogen, oxygen, and azote. Experimental and elementary study of a compound: **Water**. Experimental and elementary study of a mixture: **Air**. Notion of compound, mixture, combination, and decomposition; chemistry's object. What is understood by metalloid and by metal. Laws of mass conservation and of defined proportions. Practical meaning of symbols of the elements and of formulae of compounds. Volume of the gaseous stage represented by the chemical formulae; volumetric composition of a gaseous compound with gaseous components; practical rule to the approximate calculus of the density of a gas or steam, when its molecular formula is known. Simple volumetric calculus. Classification of chemical phenomena.	**Air** – Proofs of its existence. The consequence of its weight. Atmospheric pressure, and proofs of its existence. Body combustion in the air. Proportions of oxygen and azote in the air. Animals' and plants' breathing. Metal heating in the air. The mercury heating. Lavoisier's experiment. History of the discovery of the oxygen and of the azote. Priestly. Oxygen preparation from sodium chloride. How gas is kept. Weight of one litre of oxygen under laboratory's pressure and temperature. Slow combustions (rust), oxidation, oxidants, and bottles. **Water** – the existing water on the Earth: in the rivers, in the sea, drinking water, salty water, limestone water. Filtration, decantation, solubility, saturated solutions, cooling through dissolution, salt separation in the saline and in the laboratory, distilled water, the Liebig's cooler. Separation of water's components. Recognize that oxygen and hydrogen are its components. Hydrogen production by means of zinc and sulphuric acid. Notions of analyses and synthesis. History of hydrogen and water composition discoveries. Cavendish, Nicholson. Use of hydrogen in aerostats. Lavoisier's law, Proust's law. Weight *meaning of the OH_2 formulae*.

[233] In 1936 the 2^{nd} cycle encompassed years 4^{th}, 5^{th}, and 6^{th}. The 1947 Reform altered it to years 3^{rd}, 4^{th}, and 5^{th}.

1936 (5th Year)	1948 (4th Year)
Experimental and very elementary study of the most important metal and metalloids: chlorine, brome, iodine, sulphur, phosphorus, sodium, aluminium, iron (…); practical notion of valence. General idea of the chemical naming: anhydrides, oxides, hydroxides, acids, bases, and salts; combination of metalloids with hydrogen; experimental study of sulphurous anhydrides, carbonic (..); Oxygenized acids: experimental study of sulphurous acids, azotic, phosphoric; Generalities about salts. General study about some of the most important salts: chlorate, sulphates, nitrates (..); Study of hydroxide of potassium, sodium, ammonia, and calcium.	**Coal**: Presentation of the various kind of artificial and natural coal. Observation of exemplars. How wood coal is obtained. Power of gas absorption. Ordinary gunpowder. Ashes. Formation of anhydride carbonate and how to recognize this gas. Carbon element. Origen of the natural amorphous coal. The Portuguese coal. Hard coal. Presence of methane in mines and the danger of the firedamp. Davy's lamp and the importance of its invention. Properties of metallic net. Citation and presentation of the most important substances extracted from tar. Industrial importance of the hard coal. Illumination gas. Dangers in gas installation. Appreciation of the Bunsen's burner. Careful observation of the flame. Other fuels: natural petroleum, most important petroleum regions, petroleum wells. Animal coal. Its collection and application. The diamond and productive regions. Varieties. Their value as jewellery. Their industrial value. Graphite. Applications. **Wine**: Vineyards and copper sulphate. How wine is made. Glucose. Alcohol fermentation. Wine distillation. Sugar cane spirits (Cachaça). Mixture of alcohol with water. Alcoholic richness. Alcohol as dissolvent, as fuel. Transformation of wine into vinegar. Red and white wines. Sparkling wines. Obtainment and composition of the most common drinks, like beer, cider, liqueur, and sparkling drinks. **Wood**: Its dry distillation. Main obtained products: metilic alcohol, acetic acid, acetone, and their industrial value. Useful information about some products of vegetal origin: resin, varnish, rubber, ebonite, camphor, perfumes. **Grease**: What grease is. References to its components. General properties. Its importance in alimentation. **Olive Oil**: Olive oil's production. Oleic acid. Oil's General properties. Vegetal and animal oils. Portuguese oleaginous. Industrial value. **Soap**: Grease saponification. The soup industry. Physical and chemical action on laundry. Glycerine. Nitro-glycerine and dynamite. Tallow candle's industry. **Milk**: Main components: water, grease, casein, lactose. Butter, margarine, and cheese production. Milk's alimentation wealth. **Sugar**: Sugar cane and beetroot's production, extraction and refining. Sugar's alimentation wealth. **Flour**: Wheat, corn, avena, and rye flours. Starch extraction. Gluten. Potato's gluten. Bread's manufacture. Starch transformation during digestion. **Cotton:** Celluloses. Where to find it. How to obtain it. Paper industry. Gunpowder cotton. Artificial silk. Cellophane. Cellulosic varnish.

1936 (6th Year)	1948 (5th Year)
Organic chemistry. Experimental and elementary study of some of the most important hydrocarbon: methane, acetylene. Summary study of petroleum, illumination gas, and the flame; Experimental study of the ordinary alcohol, of the glycerine, of the aldehyde acetic, acetic acid, ordinary ester. References to grease, soap, stearic candles. Carbon hydrates: glucose, sucrose, amid, celluloses; references to gunpowder-cotton and to artificial silk; Elementary study of some of the most important aromatic hydrocarbon: benzene, naphthalene. Turpentine and camphor. Phenic acid and aniline.	**Metals**: their physical properties. Careful observation of the most usual metals: Iron, aluminium, copper, zinc, leader, stannous, chrome, nickel, and mercury. Reference to silver, platinum, gold and wolfram. Careful observation of the most important Portuguese minerals. Their location in Portugal or in the Portuguese Empire. Careful observation of the most common arrays. The sodium and the potassium. Light and heavy metals. Phenomena interpretation. The use of phenolphthalein. Soluble and insoluble oxides. Notion of base. **Metalloids**: How they are distinguished from metals. The sulphur: how and where is extracted. Physical properties. The carbon sulphur. Sulphur’s industrial importance. The phosphorus: where is extracted, properties, and applications. The product of the sulphur and phosphorus combustion. Neutralization. Notion of salt. Acids, bases, and salts naming. Action of acids upon metals (list of several cases) Action of acids upon salts (list of several cases)

Appendix 3

	TABLE 4: Sketch of the 1936 3rd cycle Chemistry programme
7th year	Acidity and Bacidity; neutralization; solutes; principle of alkalimetry and acidimetry; Constitution of matter: Atoms, molecules, ions; Laws of combinations (weight and volumetric); Proportional numbers. Chemical formulae and equations. The most general process to determine atomic and molecular weights. Duolong and Petit's law, Mitscherlich's, Avogrado-Ampere's and Raoult's laws. Theoretical density of gases and steams; molecular volume; atomicity of element's molecules; atomic volume. Structure formulae; isomer; allotropy. Elementary exposition of the Arrhenius' theory (electrolytic dissociation); Hydrolyse. General idea of element classification. Mendeleev's Periodic classification. Notion of atomic number. Elementary notion of radioactivity, of atom structure, isotope and isobar.

TABLE 5: Sketch of the 3rd cycle 1948 Chemistry programme

6th year	The evolution of the notion of element; Aristotle; The alchemists. Stahl's flogist theory; Scheele; Priestley. Lavoisier's chemical revolution. Combination of elements in defined proportions. Reaction between compounds. Different compounds with same elements (Dalton) and with one element in common (Ritcher). Proportional and equivalent number of elements. Symbols and formulae (Berzelius). Hypothesis of descontinuit of matter in antiquity. Dalton's atomic hypothesis. Gay-Lussac's law and Avogrado's hypothesis. Distinction between atom and molecule. Molecules' atomicity. Molecular and atomics' weights. Atomic weight referent to the 16th part of the oxygen's atomic weight. Thermal dissociation. Weight and volumetric meaning of compounds' formulae. Empirical and molecular formulae. Determination of atomic weight of gaseous and non-gaseous elements. The atomic heat: Dulong and Petit's law. Isomorfism and hemeomorfism: Mitscherlich's law. Determination of molecular weight of cristaline substances and organic soluble substances. General division of elements in metal and metalloids. Reason for the names of some families: halogens, alkaline metals, alkaline earthl, and earth metals. *Avalente elements*: Azote preparation, chemical difference between rare gases, and their molecular heat and atomicity. *Natural state of elements*: gold, silver, platinum, mercury, copper. Extraction process of zinc, nickel, lead, iron, tin, arsenic. *Allotropic state of elements*: the ozone, its production. How it is distinguished from oxygen. Phosphor allotropy, atomistic interpretation, transformation between white and red phosphor. Carbon's multiform. *Elements with reduction character*: Carbon and Aluminium, industrial redactors. Hydrogen redactor. Action over iron oxide. Notion of chemical equilibrium. Sulphur redactor. Alkaline metals. *Elements with oxidizing characteristic*: Main compound which liberates oxygen: chlorate, perchlorate, hypoclorite, hydrogen peroxide, azotic acid; clorine. Periodic element classification. First attempts to classify (Chancourtois, Newlands). Series, groups and periods etc. *Radioactive elements and radioactivity*: Becquerel's discovery. Radioactivity is an atomic property. Currie's discovery: polonium and radio. General property of substances. Radioactive Portuguese minerals. Alpha, Beta and Gama rays. Helium production. The atom is not indivisible. Energetic levels. Radioactivity families. Isotopes and its constitution. Isobar. Atomic mass and mass number. Transmutation. artificial creation. Uranium split-off. Chain reaction. Atomic energy.

7th year	*Ionic theory*: what mineral and organic substances are. Electrolytes. Arrehnius hypothesis. Ions. Cations and anions. Ionic reactions. Ionic equilibrium. Degree of dissociation. Application of Raoult's law. Electric current effects through electrolytes. Passage from ions to atoms. Elements obtaintion by electrolytic means (chlorine, fluorine, hydrogen, oxygen etc). Acids action over metals. Difference between hydrogen and its ion. Notion of Ph. The OH ion behaviour. Neutralization. Solutes. Indicators stained: phenolphthalein and litmus. Formation of salts. Salty solutions. Bertollet's rules. Complete ionic reactions. Electropositive and electronegative elements. Distribution in Mendeleev's frame. Electrovalence. Electronic interpretation. The NH_4 ion. Oxidation reduction. Etc. *Organic Chemistry*: What organic compounds are. How it is recognized. Most frequent organic elements. Molecular and empiric formulae formed with carbon and hydrogen, or carbon, hydrogen, and oxygen. *Aliphatic compounds*: Hydrocarbon. What they are. Naming. Carbon chains. Formulae. Methane. Its derived halogens. Petroleum. Illumination gas. Its composition and production. Fuel and illuminating power. Study of flame. Ethylene and acetylene hydrocarbons. Naming. Berthelot synthesis. Alcohols: Preparation. Primary, secondary and tertiary alcohols. Naming. Acid action over alcohol. Reaction speed. Chemical function. Methanol. Wood dry distillation. Ethanol. Ether. Preparation, properties and application. Aldehyde. Naming. Formic aldehyde. Moderate oxidation. Ordinary acetone. Organic acids naming. Soup and candle industry. Reference to a number of acids. Notion of amine and amid. Naming. General properties of those compounds. Carbohydrate. Industrial catalyst. Organic synthesis. *Aromatic compounds*: General characteristic. Aromatic hydrocarbon. Benzene. Its synthesis. Chemical functions. Special reference to benzilic acid, aldehyde and benzoic, benzoic acid, and aniline. Phenol function. Ordinary phenol. Naphthalene. Canfor. Anthracene. General notion of alkaloid, vitamins, and plastic.

Appendix 4

Pictures taken from Carvalho's 1968 *Sciences of Nature* for the Complementary Course, with a boy performing experiments. The use of these pictures in this thesis were authorized by Carvalho's son Frederico Carvalho.

mesma forma quer o coloques dentro do copo, da chávena ou do prato *(fig. 66)*.

Aqui tens pois uma diferença entre um sólido e um líquido: *o sólido tem forma própria*, isto é, tem sempre a mesma forma; o líquido não tem sempre a mesma forma.

E quanto ao volume? Se puseres o teu lápis em diferentes lugares o seu volume varia? Não varia, certamente.

E o volume do líquido (da água, por exemplo) que passas do copo para a chávena e da chávena para o prato, varia com isso? Também não. Então dirás:

Fig. 67 — O Pedro está deitando areia fina por um funil para dentro de um copo e a areia vai tomando a forma do copo. Que pensas disto? A areia será um sólido ou um líquido?

A matéria no estado sólido caracteriza-se por ter forma própria e volume próprio.

A matéria no estado líquido caracteriza-se por não ter forma própria mas ter volume próprio.

42

67. A MATÉRIA NO ESTADO GASOSO

Que se passará quanto aos gases relativamente ao seu volume e à sua forma? Para responderes vais fazer uma experiência.

Pega numa seringa com o êmbolo bastante puxado para trás (conforme vês na figura 68) e tapa o orifício de saída com um dedo. Dentro da seringa existe ar que ocupa um certo volume e tem uma certa forma. Agora, sem retirares o dedo do orifício de saída, faz força para que o êmbolo penetre na seringa *(fig. 69)*.

Como vês, o ar que lá estava dentro lá continua; simplesmente ocupa agora menos volume.

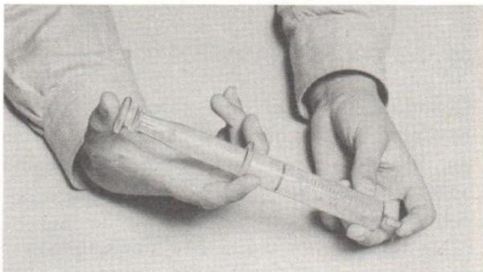


Fig. 68 — A seringa contém um certo volume de ar.

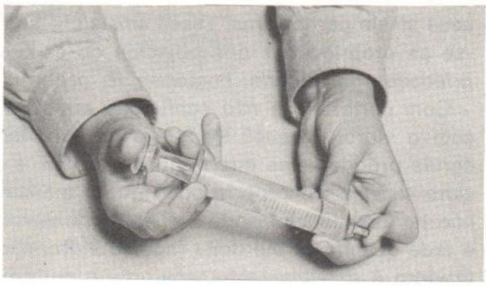


Fig. 69 — Forçando o êmbolo a avançar a mesma massa de ar ocupa agora um volume menor. Conclui que os gases não têm volume próprio.

Conclui-se que *a matéria no estado gasoso não tem volume próprio e, portanto, também não tem forma própria.*

Figure 1: Page 204 of Rómulo de Carvalho's Sciences of Nature (Ciencias da Natureza) (1968)

Fig. 163 — O Pedro prepara-se para experimentar a acção do vinagre sobre o calcário. A operação vai ser feita num tubo de vidro chamado *tubo de ensaio*. Lá está um suporte de madeira de dois andares com seis tubos de ensaio em cada andar. O Pedro começa por tirar um pouco de calcário do frasco servindo-se de uma *espátula* que é uma lâmina de metal, de plástico ou de vidro, estreita para caber mesmo num frasco de boca pequena, comprida para ir até ao fundo, e pouco flexível. Se a espátula tiver o feitio de uma calha côncava, melhor.

Fig. 164 — Agora o Pedro vai introduzir o calcário no tubo de ensaio. Para isso coloca o tubo quase horizontal e introduz nele a espátula até ao fundo. Feito isso põe o conjunto em posição vertical para que o calcário se instale no fundo do tubo, e retira a espátula. Os tubos de ensaio devem estar sempre bem secos.

Fig. 165 — O Pedro colocou a espátula no suporte dos tubos de ensaio, tirou a rolha do frasco do vinagre, colocou-a cautelosamente sobre a mesa assentando nela a parte da pega, deitou no tubo 3 ou 4 gotas de vinagre e roçou a boca do frasco pela boca do tubo para não perder nenhuma gota. Ao mesmo tempo foi observando o que se passava e viu que o vinagre fazia efervescência com o calcário. O resultado observa-se melhor estando o calcário partido em pedaços pequenos. Repete o que o Pedro fez com todas as cautelas que te foram ensinadas.

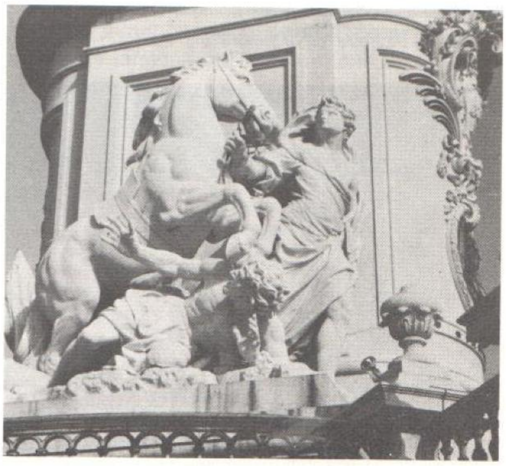


Fig. 166 — O calcário é muito empregado em obras de estatuária. A fotografia representa o conjunto de uma das faces laterais da estátua equestre de D. José, no Terreiro do Paço, obra do século XVIII, do escultor Machado de Castro. É de calcário de Pero Pinheiro, perto de Sintra.

99

Figure 2: Page 205 of Rómulo de Carvalho's Sciences of Nature (Ciencias da Natureza) (1968)

Fig. 182 — Repara bem como se filtra. O funil está enfiado numa proveta que ao mesmo tempo que o segura recolhe o líquido filtrado. O líquido do vaso onde se deitou a terra do jardim não se verte directamente para o funil. Encosta-se o bico do vaso a uma vareta de vidro e verte-se o líquido, devagar, sem nunca se encher o funil. Quando essa parcela estiver filtrada, deita-se mais. Como vês o líquido filtrado já vem límpido. As partículas que estavam suspensas ficaram retidas no papel de filtro.

de plantas, palha, etc. A água de uma jarra que teve flores durante alguns dias serve muito bem.

175. A ESTERILIZAÇÃO DA ÁGUA

Entre os seres que podem encontrar-se na água, existem uns chamados *micróbios*, que são causadores de doenças mais ou menos graves, a que ficam sujeitas as pessoas que bebam essa água. A operação destinada a destruir tais micróbios chama-se *esterilização* da água. «Esterilizar» significa «tornar estéril», isto é, não permitir o desenvolvimento da vida.

Esteriliza-se a água, por exemplo, fervendo-a. A fervura, que se dá a 100 °C, destrói

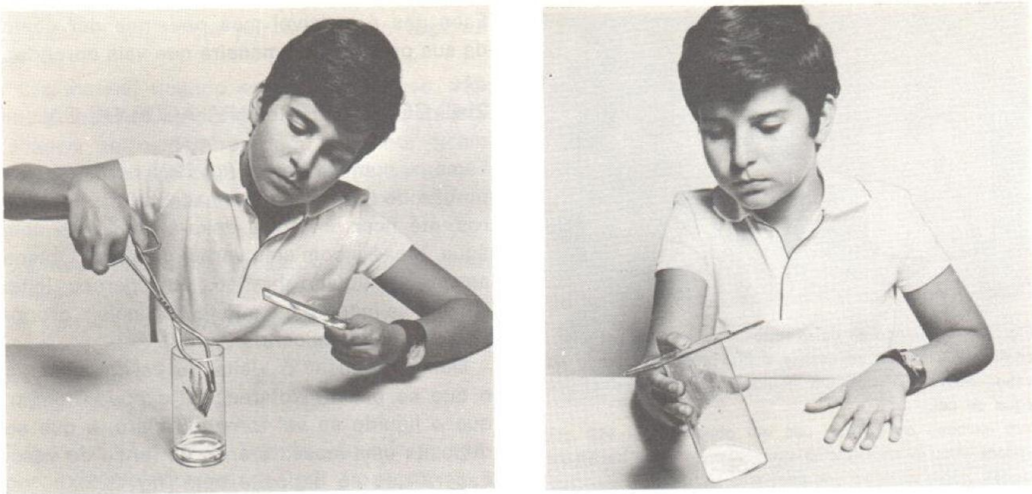
108

Fig. 183 — Sobre a mesa vês uma tina de vidro onde se deixaram estar folhas secas e fragmentos de palha em água durante 4 ou 5 dias. O Pedro retirou um pouco dessa água com uma *pipeta* (tubo de vidro afilado) e está a deixar cair uma gota sobre uma lâmina rectangular de vidro que tem na mão, e igual a outras que estão sobre a mesa. Aí também, ao lado das lâminas, vê-se uma caixa com outras lâminas quadradas e muitíssimo finas, que se chamam *lamelas*. Depois de deixar cair a gota de água sobre a lâmina, o Pedro cobrirá a gota com uma lamela e colocará o conjunto no microscópio que tem junto de si.

grande número desses micróbios. A água já se pode então beber depois de arrefecida, guardando-a bem tapada, e agitando-a um pouco para que algum ar se dissolva nela pois a fervura expulsou o ar que continha e que é necessário para o nosso organismo.

Outro processo de esterilização, que se usa para grandes quantidades de água, consiste em juntar-lhe uma porção, bem calculada, de um líquido chamado *água de Javel*, que elimina todos os micróbios. Faz-se isso às vezes para esterilizar a água com que se abastecem as povoações, mas é necessário ter cautela na porção de água de Javel empregada porque, sendo de mais, dá mau sabor à água. Diz-se então que a água «sabe a cloro», e diz-se assim porque a água de Javel contém, na sua composição, uma substância chamada «cloro».

Figure 3: Page 206 of Rómulo de Carvalho's Sciences of Nature (Ciências da Natureza) (1968)



Figs. 227 e 228 — O Pedro introduziu quatro paus de fósforo, a arder, no copo com um pouco de água de cal no fundo. Quando estiver quase terminada a combustão retirará o que resta dos paus de fósforo e tapará o copo com uma lâmina de vidro (fig. 227). De seguida agitará o copo e notará que a água de cal (que estava límpida) se torna turva (fig. 228). O que a turvou foi o dióxido de carbono resultante da combustão da madeira dos paus de fósforo.

Se queimasses papel, álcool ou gasolina, o resultado seria o mesmo. A água de cal turvava sempre porque todas essas matérias produzem dióxido de carbono por combustão.

216. O CARBONO

A razão por que a madeira, o carvão, o papel, o álcool, a gasolina, etc., dão dióxido de carbono quando ardem é porque na composição de todas essas matérias figura uma mesma substância que se chama *carbono*. Durante as suas combustões o oxigénio do ar combina-se com esse carbono e dá um *óxido de carbono* que vulgarmente se designa por anidrido carbónico ou gás carbónico. O seu nome científico é dióxido de carbono.

Uma vela quando arde também produz dióxido de carbono porque, nas matérias que formam a vela, existe carbono.

Faz a respectiva experiência. Deita água de cal no teu copo e põe a vela a arder dentro dele, servindo-te da pinça ou suspendendo a vela de um arame fino para a poderes introduzir e retirar melhor do copo. Deixa-a ficar aí, a arder, durante uns três minutos. Retira-a depois, tapa o copo com a lâmina de vidro, agita-o bem e vê se a água de cal ficou turva. Deve ter ficado e já sabes porquê.

130

217. O AR EXPIRADO CONTÉM DIÓXIDO DE CARBONO

Vais fazer outra experiência. Deita um pouco de água de cal num tubo de ensaio e sopra-lhe por um tubo de vidro, estreito, cuja extremidade deve mergulhar no líquido. Sopra o tempo que for preciso até notares que a água ficou turva *(fig. 229)*.

Por que teria turvado a água de cal? Porque o «ar» que tu sopraste, vindo do teu organismo, traz consigo dióxido de carbono.

Tu inspiras o ar que contém oxigénio. Este, como já te disse, vai provocar oxidações (que

Figure 4: Page 207 of Rómulo de Carvalho's Sciences of Nature (Ciencias da Natureza) (1968)

Bibliography

The unpublished sources set out below were consulted in this research, but not all of them were used in the text. The cited or quoted ones were also indicated at appropriated points in the thesis in footnotes, in order to facilitate their identification. The rest of the bibliography which follows has been entirely confined to works acknowledged or quoted in the text.

Unpublished sources

1) At the *Arquivo Histórico do Ministério da Educação (Historical Archive of the Misnitry of Education)*, in Lisbon, the following "Fundos", "Séries" and boxes were consulted:

<u>* Fundo da Inspecção do Ensino Liceal (IEL)</u>

<u>Série "Relatório dos Professores"</u>
Boxes: 2, 5, 9, 12, 14, 55.

<u>*Fundo da Direcção Geral do Ensino Liceal (DGEL)</u>

<u>Série "Diversos"</u>
Boxes: 13-1790; 13-1869; 13-1750; 13-1514; 13-1755; 13-2270; 13-2808; 30-3524; 30-3524; 30-1580; 30-1581; 30-

<u>Série "Manuais Escolares</u>"
Boxes: 15-1470; 15-1835; 15-1847; 15-1848; 15-1929; 15-2005; 15-2118; 15-2124; 15-2509; 15-2604; 15-2618; 15-2627; 15-2846; 15-3474; 15-1931; 15-2031; 15-2091; 15-2102; 15-2106; 15-2146; 15-2506; 15-2587; 15-2011; 15-1875; 15-1835; 15-2622; 15-2627; 15-2483.

Série "Exames"

Boxes: 16-2092; 16-2483; 16-1716; 16-1718; 16-1963; 16-2624; 16-2893.

Série "Consultas, circulares, normas e regulamentos"

Boxes: 6-2665; 6-2668; 6-2664; 6-2666; 6-2665; 6-2669; 6-3386.

Série "Processos"

Boxes: 11-1499; 11-1510; 11-1512; 11-1744; 11-1516; 11-2310; 11-1495.

2) Rómulo de Carvalho's personal documents are archived at the *National Library in Lisbon*, in the section "*Reservados*", the Archive 40 (Espólio 40). The following files were consulted:

In Box 2

Files: "Artigos de Jornal", Colégio dos Nobres", Dicionário de História de Portugal", "Ferreira da Silva, Que é a Física, Embalsamamento", "Física para o Povo".

In Box 3

Files: "Átomo, Mundo Literário, Ver e Crer", "Avulsa", "Biblioteca Breve", Cadernos de Iniciação Científica", "Caloust Gulbenkian", Ciências da Natureza", "Labor", "Palestra", "Relaões com a Rússia".

In Box 4

Files: "Ensino", "Pasta 6", "Atlântida Editora", Correspondência de Profs.", Correspondências", "Envelopes avulsos", "Ensino liceal em Portugal", "Vida Profissional", "Pasta N8".

In Box 6: This box presents no separate files.

In Box 55

Files: "Artigos etc", "Currículum Vitae", "Entrevistas, Inquéritos etc". There is one finle in this box without identification.

Governmental Decrees

Decree 3, Diário do Governo de 3 de Novembro de 1905, I Série, N° 250 (1905).

Decree 3091 Ministério da Instrução Pública, Diário do Governo de 17 de Abril, I Série, N° 60 (1917).

Decree 16362 Ministério da Instrução Pública, Diário do Governo de 14 de Janeiro, I Série, N° 11 (1929).

Decreto 21103, Ministério da Instrução Pública, Diário do Governo de 14 de Abril de 1932, I Série, N° 89 (1932).

Decreto 26611, Ministério da Educação Nacional, Diário do Governo de 19 de Maio, I Série, Nº 116 (1936).

Decree 27084, Ministério da Educação Nacional, Diário do Governo de 14 de Outubro, I Série, N° 241 (1936).

Decree 36507, Ministério da Educação Nacional, Diário do Governo de 17 de Setembro, I Série, N° 216 (1947).

Decree 36508 Ministério da Educação Nacional, Diário do Governo de 17 de Setembro, I Série, N° 216 (1947).

Decree 37112, Ministério da Educação Nacional, Diário do Governo de 22 de Outubro, I Série, Nº 247 (1948).

Decree 39807, Ministério da Educação Nacional, Diário do Governo de 7 de Setembro, I Série, N° 198 (1954).

Decree 47480, Ministério da Educação Nacional, Diário do Governo de 2 de Janeiro, I Série, N° 1 (1967).

Rómulo de Carvalho's books and articles[234]

Carvalho, R. d. (1940a). Apontamento sobre o significado e a origem da palavra "banho-maria". *Labor*(109), 578-582.

Carvalho, R. d. (1940b). Metamorfoses Linguisticas da "Venus dos Metais". *Liceus de Portugal*(3), 214-219.

[234] This list is not exhaustive. The references nevertheless amount to Carvalho's main texts consulted for this thesis.

Carvalho, R. d. (1941a). O "nitro" de Salomão e de Jeremias. *Liceus de Portugal*(8), 621-626.

Carvalho, R. d. (1941b). O aspecto fraudulento da alquimia. *Liceus de Portugal*(15), 1199-1206.

Carvalho, R. d. (1943). Cobalto - O diabinho. *Liceus de Portugal*(26), 2128-2132.

Carvalho, R. d. (1946a). Acerca do Asém. *Liceus de Portugal*(53), 533-535.

Carvalho, R. d. (1946b). Como se mediu a carga do electrão. *Gazeta de Física, I*(1), 13-17.

Carvalho, R. d. (1947a). Acerca dos trabalhos práticos de Física nos Liceus. *Gazeta de Física, I*(2), 39-41.

Carvalho, R. d. (1947b). A Atitude Mental de Langevin perante os Problemas Científicos. *Mundo Literário*(37), 12-13.

Carvalho, R. d. (1947c). *A Ciência Hermética*. Lisboa: Cosmos.

Carvalho, R. d. (1947d). Curiosidades da Vida de Edison. *Mundo Literário*(49), 8-9.

Carvalho, R. d. (1947e). O Primeiro Barco a Vapor. *Ver e Crer* (28), 33-38.

Carvalho, R. d. (1947f). Os valores da constante dieléctrica espacial. *Gazeta de Física*, *I*(4), 108-110.

Carvalho, R. d. (1947g). Sobre a correlação entre a Matemática e a Fásica no ensino liceal. *Gazeta de Matemática, VIII*(31), 11-13.

Carvalho, R. d. (1948a). As Aventuras do Professor Piccard. *Ver e Crer*(43), 51-57.

Carvalho, R. d. (1948b). *Embalsamamento Egípcio*. Lisboa: Cosmos.

Carvalho, R. d. (1949a). As dimensões do universo molecular e atómico. *Átomo, II*(14), 9.

Carvalho, R. d. (1949b). Como foi determinada, pela primeira vez, a velocidade de propagação da luz. *Átomo, II*(22), 5,14.

Carvalho, R. d. (1949c). A Escolha do Metro como Unidade de Medida. *Ver e Crer*(54), 25-32.

Carvalho, R. d. (1949d). O que são e como funcionam as pilhas atómicas. *Gazeta de Física, II*(1), 17-19.

Carvalho, R. d. (1950a). Os Átomos Existem? *Átomo, III*(31), 3,5.

Carvalho, R. d. (1950b). Os nomes dos últimos elementos Químicos descobertos. *Boletim da Sociedade de Língua Portuguesa, 1*(8-9), 46-48.

Carvalho, R. d. (1950c). Presença de Descartes. *Gazeta da Física, Lisboa*, *2*(4), 107-108.

Carvalho, R. d. (1951a). Defasagem e corrente alternada. *Boletim da Sociedade de Língua Portuguesa, II*(5), 124-125.

Carvalho, R. d. (1951b). Esclarecimento. *Labor*(115), 55-57.

Carvalho, R. d. (1951c). No 1.o Centenário da Morte de Daguerre, o inventor da fotografia. *Átomo, IV*(42), 10.

Carvalho, R. d. (1951d). No Centenário da Morte de Oersted que descobriu o electromagnetismo. *Átomo, IV*(46), 3-6.

Carvalho, R. d. (1951e). O ensino das fórmulas e das equações químicas no 2° Ciclo do ensino liceal. *Labor*(113), 198-205.

Carvalho, R. d. (1952a). Considerações sobre o ensino elementar de Física. *Gazeta da Física, Lisboa, 2*(8), 197-200.

Carvalho, R. d. (1952b). *História do Telefone*. Coimbra: Atlântida.

Carvalho, R. d. (1952c). A linguagem, Reflexo da Mentalidade. *Boletim da Sociedade de Língua Portuguesa, III*(10), 352-353.

Carvalho, R. d. (1952d). *História da Fotografia*, Coimbra: Atlântida

Carvalho, R. d. (1953a). *Compêndio de Química para o 3.° ciclo* (2a Edição ed.). Lisboa: Livraria Studium.

Carvalho, R. d. (1953b). *Ferreira da Silva, homem de ciência e de pensamento (1853-1923)*. Porto: Tip. da livraria Simões Lopes.

Carvalho, R. d. (1953c). No primeiro centenário de Lorentz. *Gazeta da Física, 2*(10), 175-178.

Carvalho, R. d. (1953d). *História dos Balões*, Coimbra: Atlântida.

Carvalho, R. d. (1954). Será o cancro da Lingua uma doença incurável? *Boletim da Sociedade de Língua Portuguesa, V*(6), 258-261 e 281.

Carvalho, R. d. (1954b). *História da Electricidade Estática,* Coimbra: Atlântida.

Carvalho, R. d. (1955). *História do Átomo,* Coimbra: Atlântida.

Carvalho, R. d. (1956a). Albert Einstein (1879-1955). *Gazeta de Física, III*(4), 89-96.

Carvalho, R. d. (1956b). A desintegração da Linguagem por intermédio da Energia Atómica. *Boletim da Sociedade de Língua Portuguesa, VII*(4), 151-154.

Carvalho, R. d. (1957). *História da Radioactividade,* Coimbra: Atlântida.

Carvalho, R. d. (1958). Ciência e Arte. *Palestra*(1), 20-27.

Carvalho, R. d. (1959a). A Física como Objecto de Ensino. *Palestra, 4*, 57-64.

Carvalho, R. d. (1959b). *História da fundação do colégio dos Nobres em Lisboa*. Coimbra: Atlântida.

Carvalho, R. d. (1959c). *Que é a Física*. Lisboa: Arcádia.

Carvalho, R. d. (1960a). Considerações sobre o Princípio de Arquimedes. *Gazeta da Física, III*(9), 251-254.

Carvalho, R. d. (1960b). Posição Histórica da Invenção do Nónio de Pedro Nunes. *Palestra*(9), 46-76.

Carvalho, R. d. (1961). Novo dispositivo para apreciar a variação do volume de uma massa de água com a temperatura. *Palestra*(12), 57-64.

Carvalho, R. d. (1962a). *História dos Isótopos*. Coimbra: Atlântida.

Carvalho, R. d. (1962b). Novas maneiras de trabalhar com os tubos de Torricelli. *Palestra*(14), 43-54.

Carvalho, R. d. (1962c). Novo sistema de unidades físicas. *Gazeta da Física, IV*, 45-53.

Carvalho, R. d. (1962c). *História da Energia Nuclear*. Coimbra: Atlântida.

Carvalho, R. d. (1963a). Homenagem a Pascal. *Palestra*(16), 21-37.

Carvalho, R. d. (1963b). O ensino elementar da Cinemática por meio de gráficos. *Gazeta da Física, Lisboa, IV*(4), 97-110.

Carvalho, R. d. (1964). Novo dispositivo para o estudo experimental das leis da reflexão da luz. *Palestra*(20), 109-113.

Carvalho, R. d. (1965). Descrição e utilização do cronómetro eléctrico e acessórios destinados ao estudo da queda livre. *Palestra, 22*, 95-101.

Carvalho, R. d. (1966a). Descrição do material da Caixa Acústica (Neva-Lehrgerat Nr 6-AKUSTIK) e da sua utilização. *Palestra*(26), 77-95.

Carvalho, R. d. (1966b). Os nomes portugueses na carta da lua. *Palestra, 27*, 63-68.

Carvalho, R. d. (1967a). Discriminação do material entregue ao Laboratório de Física do Liceu Normal de Lisboa (Pedro Nunes). *Palestra*(30), 101-119.

Carvalho, R. d. (1967b). Metodologia do 7.° grupo. *Palestra*(30), 101-119.

Carvalho, R. d. (1967c). Utilização do aparelho de círculos para o estudo do movimento uniformemente acelerado. *Palestra*(29), 69-80.

Carvalho, R. d. (1968a). *Ciências da Natureza Vol. 1*. Lisboa: Sá da Costa.

Carvalho, R. d. (1968b). *Física para o Povo Vol. 1 e 2*. Coimbra: Atlântida.

Carvalho, R. d. (1968c). A máquina que levou da cova a estátua equestre. *Palestra, 33*, 45-60.

Carvalho, R. d. (1970a). O ensino liceal da Física de 1964 a 1970. *Gazeta de Física, V*(1), 2-7.

Carvalho, R. d. (1970b). O estudo experimental do Teorema de Arquimedes. *Palestra*(37-39), 179-185.

Carvalho, R. d. (1970c). Sobre o estado actual do ensino da Física. *Palestra* (37-38-39), 141-155.

Carvalho, R. d. (1971). O magnete chinês do Museu Pombalino da Universidade de Coimbra. *Palestra*(40), 47-59.

Carvalho, R. d. (1973a). A doutrina heliocêntrica de Copérnico e a sua aceitação em Portugal. *Palestra*(42), 73-106.

Carvalho, R. d. (1973b). O Quadrado Mágico de Albrecht Durer. *Palestra*(41), 7-13.

Carvalho, R. d. (1974a). *Ciências da Natureza Vol. 1* (9th ed.): Sá da Costa.

Carvalho, R. d. (1974b). *Guia de Trabalhos Práticos de Química: para o ensino complementar do ensino liceal* (13 ed.). Lisboa: Atlântida.

Carvalho, R. d. (1979a). *A Descoberta do Mundo Físico* (Vol. 1). Lisboa: Sá da Costa.

Carvalho, R. d. (1979b). *Relações entre Portugal e a Rússia no século XVIII*. Lisboa: Sá da Costa.

Carvalho, R. d. (1981). *A actividade pedagógica da Academia das Ciências de Lisboa nos séculos XVIII e XIX*. Lisboa: Academia das Ciências de Lisboa.

Carvalho, R. d. (1982). *A Física experimental em Portugal no século XVIII*. Lisboa: Instituto de Cultura e Língua Portuguesa.

Carvalho, R. d. (1985). *A Astronomia em Portugal no século XVIII.* Lisboa: Instituto de Cultura e Língua Portuguesa.

Carvalho, R. d. (1986). *História do Ensino em Portugal - Desde a Fundação da Nacionalidade até o fim do Regime de Salazar-Caetano*. Lisboa: Fundação Calouste Gulbenkian.

Carvalho, R. d. (1987a). *História do Gabinete de Física pombalino da Universidade de Coimbra : desde a sua fundação (1772) até ao jubiléu [sic] do professor italiano Giovanni Antonio Dalla Bella (1790)* Coimbra: Universidade de Coimbra.

Carvalho, R. d. (1987b). *A história natural em Portugal no século XVIII*. Lisboa: Instituto de Cultura e Língua Portuguesa.

Carvalho, R. d. (1993). *O material didáctico dos séculos XVIII e XIX do Museu Maynense da Academia das Ciências de Lisboa*. Lisboa: Academia das Ciencias.

Carvalho, R. d. (1995a). *A Física no dia-a-dia*. Lisboa: Relógioa D'Água.

Carvalho, R. d. (1995b). *O Texto Poético como Documento Social*. Lisboa: Fundação Calouste Gulbenkian.

Carvalho, R. d. (1996). *Actividades científicas em Portugal no século XVIII*. Evora: Universidade de Evora.

Carvalho, R. d. (1997). *Colectania de Estudos Históricos (1953 - 1994)*. Évora: Universidade de Évora.

Carvalho, R. d. (2004). *Cadernos de Iniciação Científica*. Lisboa: Relógio d'Água.

Carvalho, R. d. (2007). *As origens de Portugal - História contada a uma criança*. Lisboa: Fundação Calouste Gulbenkian.

Carvalho, R. d. (2010). *Memórias*. Lisboa: Fundação Calouste Gulbenkian.

Motta, A. A. R. d., & Carvalho, R. d. (1950). *Noções Elementares de Química: de harmonia com os programas do 3.°, 4.° e 5.° anos*. Lisboa: Livraria Studium.

Motta, A. A. R. d., & Carvalho, R. d. (1952). *Noções Elementares de Química: de harmonia com os programas do 3.°, 4.° e 5.° anos* (2.ª ed.). Lisboa: Studium.

António Gedeão's books

Gedeão, A. (1956). *Movimento Perpéuto*. Coimbra: Atlântida.

Gedeão, A. (1958). *Teatro do Mundo*. Coimbra: Atlântida.

Gedeão, A. (1961). *Máquina de Fogo*. Coimbra: Atlântida.

Gedeão, A. (1963). *RTX 78 / 24* (2a. ed.). Lisboa: Guimarães e Cia.

Gedeão, A. (1967). *Linhas de força*. Coimbra: Atlântida.

Gedeão, A. (1968). *Poesias Completas*. Lisboa: Sá da Costa.

Gedeão, A. (1983). *Poemas Póstumos*. Lisboa: Sá da Costa.

Gedeão, A. (1990). *Novos Peomas Póstumos*. Lisboa: Sá da Costa.

Gedeão, A. (1992). *António Gedeão: 51 + 3 Poems and other writings*. Lisboa: History and Science Unit, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa.

Gedeão, A. (1997). *Poemas Escolhidos*. Lisboa: Sá da Costa.

Gedeão, A. (2004). *Obra Completa*. Lisboa: Relógio D'Água.

Contemporary Publications

Almeida, V. M. d. (1950). *Lições de Química para o 2.o Ciclo dos Liceus*. Porto: Porto Editora.

António Augusto Riley da Motta (1937). *Labor*(78), 338-339.

Armstrong, H. E. (1884). On the teaching of Natural Sciences as part of the Ordinary School Course and on the method of teaching Chemistry in the Introductory Courses in Science Classes, Schools and Colleges. In W. H. Brock (Ed.) (1973), *H. E. Armstrong and the teaching of Science (1880-1930)* (pp. 74-89). Cambridge: Cambridge University Press.

Armstrong, H. E. (1889). Suggestion for a course of elementary instruction in Physical Science. In W. H. Brock (Ed.), *H. E. Armstrong and the teaching of Science (1880-1930)* (pp. 90-98). Cambridge: Cambridge University Press.

Armstrong, H. E. (1897). The aim and practice of teaching Chemistry. In W. H. Brock (Ed.) (1973), *H. E. Armstrong and the teaching of Science* (pp. 99-109). Cambridge: Cambridge University Press.

Armstrong, H. E. (1898). The Heuristic method of teaching or The art of making children discover things for themselves. A chapter in the History of English Schools. In W. H. Brock (Ed.) (1973), *H. E. Armstrong and the teaching of Science* (pp. 110-120). Cambridge: Cambridge University Press.

Armstrong, H. E. (1903). *The teaching of scientific method and other papers in education*. London: Macmillan and Co.

Cantos, P. J. d. (1928). Trabalhos práticos de física da 6ª classe realizados no liceu de Póvoa do Varzim em 1927-1928. *Labor*(15), 301.

Caraça, B. d. J. (1929). Os Objectivos da Universidade Popular Portuguesa. In J. Caraça (Ed.) (1970), *Conferências e outros Escritos* (pp. 209-213). Lisboa: Edições João Sá da Costa.

Caraça, B. d. J. (1931). As Universidades Populares e a Cultura. In J. Caraça (Ed.) (1970), *Conferências e outros Escritos* (pp. 3-10). Lisboa: Edições João Sá da Costa.

Caraça, B. d. J. (1939). *A Cultura Integral do Indivíduo: Problema central do nosso tempo*. Lisboa: Seara Nova.

Caraça, B. d. J. (1941a). *Conceitos Fundamentais da Matemática* (Vol. 1). Lisboa: Cosmos.

Caraça, B. d. J. (1941b). Prefácio *In: O Homem e o Livro*. Lisboa: Cosmos.

Caraça, B. d. J. (1947). Prefácio In B. d. J. Caraça (Ed.), *Panorama de Ciência Contemporânea, Colecção Cosmos-Gigante* (Vol. I). Lisboa: Cosmos.

Carmo, A. S. d. (1959). Acerca do Ensino das Ciencias Físico-Químicas. *Labor, XXIV*, 206-210.

Carmo, A. S. d. (1960a). Acerca do Ensino das Ciencias Físico-Químicas. *Labor, XXIV*, 296-301.

Carmo, A. S. d. (1960b). Acerca do Ensino das Ciencias Físico-Químicas. *Labor, XXIV*, 330-335.

Dois anos de Trabalho (1947). *Ver e Crer*(25), 3-4.

Dr. António Augusto Riley da Motta (1940). *Labor*(108).

Editorial (1946). *Mundo Literário*(1), 1.

Figueiredo, A. S. M. (1927). Programas de Física e Química: elaborados segundo o plano de remodelação do Ensino Secundário do ex-ministro da instrução, sr. dr. Santos Silva. *Labor*(7, 8, 9), 172-179.

Gibert, A. (1946). Em nome da Direcção. *Gazeta de Física, I*(1), 1-3.

Gilot, F. (1961). Da Metodologia Científica e sua Respectiva Didáctica. *Palestra*(12), 19-31.

Hood, G. F. (1943). Some aspects of exmamination questions in chemistry. *School Science Review, XXIV*(93).

Iline, M. (1941). *O Homem e o Livro*. Lisboa: Cosmos.

Jornal de 10 de Outubro. (1958). *Palestra, I*, 69-73.

Langevin, P. (1932). O ensino das Ciências Físicas e a Cultura Geral. *Labor*(39-40-41), 11-16, 71-73, 140-142.

Machado, Á. R. (1927). Reflexões sobre os programas de Física e Química dos Liceus. *Labor*(9), 314-321.

Magalhães, A. M. (1952). Trabalhos Prático de Química. *Labor, XVI*(119), 425-428.

Martins, A. (1965, 28/04). Ser poeta é, para mim, tão importante como ser marceneiro ou serralheiro. *Jornal de Letras e Artes*, pp. 1-15.

Motta, A. A. R. d. (1930). Do ensino prático da física e da química nos liceus. *Labor*(26), 246-251.

Motta, A. A. R. d. (1934). Do ensino das Ciencias Físico-Naturais. *Labor*(56), 527-530.

Nunes, A. B. d. S. (1968). Novos Métodos para o Ensino da Física e da Química - o Projecto Nuffield. *Labor, 32,* 355-373.

Pereira, A. N. (1928). Trabalhos práticos de Física no curso complementar do Liceu de Vila Rea. *Labor*(15), 294-300.

Perkin, W. H., & Lean, B. (1913). *An Introduction to Chemistry and Physics: Vol. I*. London: Macmillan and Co.

Pinto, L. F. L. (1946). Aspectos do problema do ensino. *Liceus de Portugal*(53), 511-515.

Poincaré, H. (1914). As Hipóteses em Física. In R. Carvalho (Ed.) (1959), *Que é a Física* (pp. 55-74). Lisboa: Arcádia.

Poincaré, H. (2003). *Science and Method*. London: T. Nelson and Sons.

Prieto, F. (1928). Intensificação do trabalho laboratorial no ensino secundário. *Labor*(12), 115-118.

Prudente, J. N., & Esteves, F. S. (1938a). *Guia de Trabalhos Práticos de Química para o 4.º, 5.º e 6.º anos dos Liceus*. Porto: Maranus.

Prudente, J. N., & Esteves, F. S. (1938b). *Lições de Química*. Porto: Maranus.

Prudente, N., & Esteves, F. S. (1940). *Lições de Química*. Porto: Livraria Simões Lopes.

Prudente, N., & Esteves, F. S. (1946). *Lições de Química*. Porto: Livraria Simões Lopes.

Ramos, A. C. d. S. (1948). Acerca do estudo educativo da Física. *Gazeta de Física, I*(8), 226-228.

Rosa, M. C. S. (1967). Como organizar os Trabalhos Práticos de Física e de Química exigidos pelo actual Programa, para que os alunos tirem dele maior proveito. *Palestra*(29), 123-139.

Sampaio, Á. (1927). Os trabalhos práticos de Sciências-Naturais. *Labor*(7), 180-182.

Sampaio, M. L. (1950). *Noções de Química*. Porto: Livraria Simões Lopes.

Sarmento, J. (1947). Professor Doutor Álvaro Machado. *Gazeta de Física*, *I*(2), 33.

Schwab, J. (1978). Eros and Education: A discussion of One Aspect of Discussion. In I. Westbury & N. Wilkof (Eds.), *Science, Curriculum, and Liberal Education* (pp. 105-132). Chicago: University of Chicago Press.

Smith, A., & Hall, E. (1902). *The teaching of chemistry and physics in the secondary school*. London: Longmans, Green, and Co.

Soares, A. C. (1946). Ensino e Investigação. *Gazeta de Física*, *I*(1), 3-5.

Spencer, H. (1861). *Education: Intellectual, Moral and Physical*. London: Watts & Co.

Tavares, J., & Sampaio, Á. (1929). Programas do curso complementar de Sciências. *Labor*(19), 177-200.

Teixeira, J., & Nunes, A. B. d. S. (1975). *Compêndio de Química: 3.º ano (antigo 5.º)*. Porto: Porto Editora.

Teixeira, J. A. (1951a). Algumas Notas. *Labor*(112), 115-120.

Teixeira, J. A. (1951b). Comentando um esclarecimento. *Labor*(116), 223-230.

Teixeira, J. A. (1951c). De novo os programas. *Labor*(114), 273-284.

Teixeira, J. A. (1953). As Normais Dificuldades de uma Disciplina do 3.º Ciclo. *Labor*, *XVII*(128), 304-305.

Teixeira, J. A. (1954). *Compêndio de Química: para o 2.° ano dos liceus*. Porto: Porto Editora.

Teixeira, J. A. (1955). *Compêndio de Química: 2.º Ciclo dos Liceus (Livro Único)*. Lisboa: Empresa Literária Fluminense.

Teixeira, J. A., & Tavares, J. (1951). A volta dos Programas: um alvitre. *Labor*, *XV*(113).

Tilston, J. (1949). The Teaching of Symbols, Formulae and Equations in Chemistry. *School Science Review*, *XXX*(112), 429-432.

Tomás, T. L. (1952). Ainda o programa de Química do 2.º ciclo. *Labor*(118), 355-362.

Tomás, T. L., Carvalho, R. d., & Almeida, F. P. d. (1965). La Formation du Professeur de Physique. *Palestra*(22), 78-92.

Modern Publications

Adão, Á., & Remédios, M. J. d. (2008). Memória para a frente, e... o resto é loteria dos exames. A reforma do ensino liceal em 1947. *Revista Lusófona de Educação, 12*, 41-64.

Adler, M. (1982). *The Paideia Proposal*. New York: Touchstone.

Aido, A. d., & Bastos, M. G. (2001). Rómulo de Carvalho enquanto metodólogo. In L. Corte-Real & M. Lourenço (Eds.), *Pedra Filosofal: Rómulo de Carvalho / António Gedeão* (pp. 33-34). Lisboa: Museu de Ciência da universidade de Lisboa.

Aikenhead, G. (2003). *Review of Research on Humanistic Perspectives in Science Curricula*. Paper presented at the European Science Education Research Association (ESERA) conference.

Aikenhead, G. (2006). *Science Education for Everyday Life: Evidence-Based practice*. London: Teachers College Press.

Aloni, N. (2007). *Enhancing Humanity: The Philosophical Foundations of Humanistic Education*. Dordretcht: Springer.

Alves, L. A. M. (2009). Ensino Técnico - uma necessidade ou uma falácia? Notas para a compreensão da filosofia do ensino técnico em Portugal. In L. A. M. Alves, P. R. d. Sousa, T. T. Morais & F. M. V. Araújo (Eds.), *Ensino Técnico (1756-1973)* (pp. 17-55). Lisboa: Editorial do Ministério da Educação.

Amador, M. E. D. d. A. B. (2007). *O Ensino Experimental da Física nos liceus até ao segundo quartel do século XX.* Unpublished Dissertação de Mestrado, Universidade de Coimbra, Coimbra.

Andrews, R. (1995). *Teaching and Learning Argument*. London: Cassell.

Araújo, J. (1996). Prefácio In: *Actividades Científicas em Portugal no Século XVIII* (pp. VII). Évora: Universidade de Évora.

Araújo, J. M. d. (2006). *Rómulo de Carvalho na Universidade do Porto*. Porto: Editora da Universidade do Porto.

Atkin, J. M., & Black, P. (2003). *Inside science education reform: a history of curricular and policy*. Buckingham: Open University Press.

Baiôa, M., Fernandes, P. J., & Meneses, F. R. d. (2003). The Political History of Twentieth-Century Portugal. *e-Journal of Portuguese History, 1*(2), 1-18.

Barros, J. T. L. d., & Henriques, R. P. (1987). A educação do Estado Novo nos anos 30 - Com base na rejeição de uma proposta de livro de 1933. In A. C. Pinto (Ed.), *O Estado Novo: das Origens ao Fim da Autarcia (1926-1959)* (Vol. II, pp. 149-158). Lisboa: Fragmentos.

Barroso, J. (1995). *Os Liceus: Organização Pedagógica e Administração (1936-1960)* (Vol. I). Lisboa: Fundação Calouste Gulbenkian.

Beato, C. (2003). *A Disciplina de Ciências Físico-Químicas da Reforma Liceal de 1947.* Unpublished Dissertação de mestrado, Universidade de Lisboa, Lisboa.

Beato, C. (2004). A política do livro único na reforma liceal de 1947: o caso da disciplina de Ciências Físico-Químicas. *Cadernos de História da Educação, 3*, 55-64.

Beato, C. (2005). Para a história da disciplina de ciências Físico-Químicas: os programas da reforma liceal de 1947. *Revista de Educação, XIII*(2), 5-28.

Bebiano, N. (2001a). Bento Caraça e a Matemática, aquela Difusa Substância. *Gazeta de Matemática*(141), 11-23.

Bebiano, N. (2001b). Bento de Jesus Caraça: Esboço Biográfico. *Gazeta de Matemática*(141), 9-10.

Bokova, I. (2010). A New Humanism for the 21st Century (This text is a first contribution to UNESCO's reflection on a new humanism. It has been adapted from an address delivered by the Director-General of UNESCO in Milan (Italy) ed.). Paris: Sector for External Relations and Public Information of UNESCO.

Brock, W. H. (1973). *H.E. Armstrong and the teaching of science 1880-1930*. Cambridge: Cambridge University Press.

Cabanas, M. I. M. (2008). A História de Portugal revisitada por Rómulo de Carvalho/ António Gedeão: Ilustrações sobre o quotidiano medieval para crianças e adultos. *Labirintos, 4*(1), 1-17.

Caraça, J. (1996a, 06/11). Magia de Ensinar. *Jornal das Letras/Educação,* p. 21.

Caraça, J. (1996b, 24/11). Rómulo de Carvalho, desde há 38 anos meu Professor. *Diário de Notícias,* p. 25.

Caraça, J. (1997). Experimentação e aprendizagem nas ciências. *Gazeta de Física, XX*(1), 23-25.

Carvalho, C. (2012). *Rómulo de Carvalho - António Gedeão (Príncipe Perfeito).* Lisboa: Editorial Estampa.

Carvalho, F. (1998). Prefácio *As origens de Portugal - História contada a uma criança* (5 ed. 2007 ed.). Lisboa: Fundação Calouste Gulbenkian.

Carvalho, F. (2004). Introdução. In R. Carvalho (Ed.), *Cadernos de Iniciação Científica* (pp. 9-12). Lisboa: Relógio D´Água.

Carvalho, F. (2006a). *Prof. Rómulo de Carvalho - O homem e o pedagogo*. Paper presented at the Comemoração do 1º centenário do nascimento do Prof. Rómulo de Carvalho.

Carvalho, F. (2006b). *Rómulo de Carvalho: um perfil e um testemunho pessoal. As inclinações da juventude e a escolha da profissão*. Paper presented at the Conferência Nacional de Física.

Carvalho, F. (2008). Professor e Poeta: o rosto do Homem nos seus versos. *A Página da Educação, 17*(181), 21-24.

Carvalho, F. (2011). A intervenção pedagógica de Rómulo de Carvalho no ensino da Física e na divulgação do conhecimento científico. *Gazeta de Física, 34*(2), 2-8.

Chaves, I. M. B. d. C. (2008). *Trabalhos Práticos Liceais em Perspectiva Histórica: O caso dos trabalhos de Electricidade e Magnetismo.* Unpublished Dissertação de Mestrado, Universidade de Aveiro.

Costa, A. M. d. (1996, 06/11). O paradigma do Mestre. *Jornal das Letras/Educação,* pp. 20-21.

Costa, A. M. d. (1997a). Actividade Experimental e Trabalho de Projecto no Colégio Militar: alguns resultados dos últimos anos lectivos. *Gazeta de Física, 20*(1), 26-27.

Costa, A. M. d. (1997b). Rómulo de Carvalho. *Gazeta de Física, 20*(1), 10-13.

Costa, J. S. d. (1996, 20/11). Um Humanista na Ciência. *Jornal das Letras/Educação,* p. 35.

Couto, J. (2006). Apresentação In M. Rêgo & F. Lopes (Eds.), "*António é o meu nome", Rómulo de Carvalho* (pp. 9-11). Lisboa: Biblioteca Nacional de Portugal.

Crato, N. (2006a). O professor é o método, o processo, a forma e o modo. In M. Rêgo & F. Lopes (Eds.), "*António é o meu nome", Rômulo de Carvalho* (pp. 23-28). Lisboa: Biblioteca Nacional de Portugal.

Crato, N. (2006b). Os textos pedagógicos e didáticos de Rómulo de Carvalho. In N. Crato (Ed.), *Rómulo de Carvalho - Ser professor*. Lisboa: Gradiva.

Crato, N. (Ed.). (2006c). *Rómulo de Carvalho - Ser Professor*. Lisboa: Gradiva.

David-Ferreira, J. F. (2001). Memória de um professor exemplar: Rómulo de Carvalho. In L. Corte-Real & M. Lourenço (Eds.), *Pedra Filosofal: Rómulo de Carvalho / António Gedeão* (pp. 27-28). Lisboa: Associação de Apoio ao Museu da Universidade de Lisboa.

DeBoer, G. (1991). *A History of Ideas in Science Education*. New York: Teachers College.

Donnelly, J. (2004). Humanizing Science Education. *Science Education, 88*(5), 762 - 784.

Donnelly, J., & Ryder, J. (2011). The pursuit of humanity: Curriculum change in English school science. *History of Education, 40*(3), 291 - 313.

dos Santos, W. (2009). Scientific Literacy: A Freirean Perspective as a Radical View of Humanistic Science Education. *Science Education, 93*(2), 361-382.

Doutoramento "Honoris Causa" do Dr. Rómulo de Carvalho. (1995).

Feijó, E. T. (2006). Rómulo de Carvalho e a Ciência e os Estudos da Literatura e da Cultura. In C. Vieira & I. R. Novo (Eds.), *António Gedeão & Rómulo de Carvalho: novos poemas para o homem novo* (pp. 65-72). Castelo da Maia: ISMAI.

Fernandes, M. T. (2001). Rómulo de Carvalho enquanto Metodólogo. In L. Corte-Real & M. Lourenço (Eds.), *Pedra Filosofal: Rómulo de Carvalho / António Gedeão* (pp. 36-37). Lisboa: Museu de Ciência da Universidade de Lisboa.

Fernandes, R. (1967). *Ensino: sector em crise*. Lisboa: Prelo.

Fernandes, R. (2006). Rómulo de Carvalho, historiador da educação. In M. Rêgo & F. Lopes (Eds.), "*António é o meu nome", Rómulo de Carvalho* (pp. 29-36). Lisboa: Biblioteca Nacional.

Ferreira, H. d. C. (2003). *A evolução da escola preparatória - o conceito e componentes curriculares*. Braganca: Instituto Politécnico de Bragança.

Fiolhais, C. (1996, 06/11). O alquimista. *Jornal das Letras/Educação,* p. 21.

Fiolhais, C. (1997a). Os meus livros preferidos de Rômulo de Carvalho. *Gazeta da Física, Lisboa, 20*(1), 15-17.

Fiolhais, C. (1997b). Rómulo de Carvalho: As ideias, as experiências, e três pequenas sugestões. *Gazeta de Física, 20*(1), 35-36.

Fiolhais, C. (2006). Os Livros que Rómulo de Carvalho nos Deixou. In C. Vieira & I. R. Novo (Eds.), *António Gedeão & Rómulo de Carvalho: novos poemas para o homem novo* (pp. 35-42). Castelo da Maia: ISMAI.

Fitas, A. (1996). Apresentação. In R. d. Carvalho (Ed.), *Actividades Científicas em Portugal no Século XVIII* (pp. XI-XV). Évora: Universidade de Évora.

Fitas, A. (2005). The Portuguese Academic Community and the Theory of Relativity. *e-Journal of Portuguese History, 3*(2), 1-15.

Fitas, A., & Videira, A. (2007). Guido Beck, Alexandre Proca, and the Oporto Theoretical Physics Seminar. *Physics in Perspective, 9*(1), 4-25.

Freire, A. M. (1993). Um olhar sobre o ensino da Física e da Química nos últimos cinquenta anos. *Revista de Educação, III*(1), 37-48.

Freire, P. (1970). *Pedagogy of the Oppressed*. New York: The Seabury Press.

Gago, J. M. (1996, 06/11). Parabéns. *Jornal das Letras/Educação,* p. 22.

Gaspar, J. (2007). Armando Carlos Gibert (1914-1985), o fundador da Gazeta de Física. *Gazeta de Física, 30*(2-3), 12-13.

Gaspar, J., Gago, M. d. M., & Simões, A. (2009). Scientific life under the Portuguese dictatorial regime (1929-1954): the communities of geneticists and physicists. *HOST, 3*.

Gavroglu, K. (2012). Science popularization, hegemonic ideology and commercialized science. *HOST, 6*, 85-99.

Gil, F. B. (1994). Laudatio at the Doutoramento Honoris Causa do Dr. Rómulo de Carvalho, Evora.

Good, R., & Shymansky, J. (2001). Nature-of-Science Literacy in Benchmarks and Standards: Post-Modern/Relativist or Modern/Realist? *Science & Education, 10*(1-2), 173-185.

Gouveia, R. (2006). António Gedeão e a Ciência. In C. Vieira & I. R. Novo (Eds.), *António Gedeão / Rómulo de Carvalho: novos poemas para o homem novo* (pp. 125-136). Castelo da Maia: ISMAI.

Grácio, S. (1986). *Política Educativa como Tecnologia Social: As reformas do ensino técnico de 1948 e 1983*. Lisboa: Livros Horizontes.

Guimarães, F. (1996, 06/11). A Poesia como 'Máquina de Fogo'. *Jornal das Letras/Educação,* p. 19.

Hodson, D. (2008). *Towards Scientific Literacy: A teachers guide to the History, Philosophy and Sociology of Science*. Rotterdam: Sense Publishers.

Hodson, D., & Prophet, R. (1983). Why the science curriculum changes – evolution or social control? . In J. Brown, A. Cooper, T. Horton, F. Toates & D. Zeldin (Eds.), *Science in Schools* (pp. 163-180). Philadelphia: Open University Press.

Jenkins, E. W. (1979). *From Armstrong to Nuffield*. London: John Murray.

Law, S. (2011). *Humanism: A very short Introduction*. Oxford: Oxford University Press.

Layton, D. (1973). *Science for the People*. London: George Allen & Unwin Ltd.

Louro, M. L. E. (2001). O "Príncipe Perfeito". In L. Corte-Real & M. Lourenço (Eds.), *Pedra Filosofal: Rómulo de Carvalho / António Gedeão* (pp. 57-58). Lisboa: Museu de Ciências da Universidade de Lisboa.

Manso, A. (2003). Jaime Cortesão e as Universidades Populares da Renascença Portuguesa. *Teoremas de Filosofia, 8*, 55-63.

Manso, A. (2009). *Bento de Jesus Caraça: A Demanda pela Educação Integral do Indivíduo*. Paper presented at the X Congresso da SPCE: Pluralidade do Conhecimento e Educação Mesa nº 42 - Comunicação nº 56.

Mansour, N. (2009). Science-Technology-Society (STS) : A New Paradigm in Science Education. *Bulletin of Science Technology & Society 29*, 287-297.

Marques, F. M. (2003). *Os Liceus de Portugal: Arquitectura, Currículo e Poder*. Lisboa: Educa.

Martins, G. D. O. (2001). Rómulo de Carvalho: Sabe encantar. In L. Corte-Real & M. Lourenço (Eds.), *Pedra Filosofal: Rómulo de Carvalho / António Gedeão* (pp. 51-53). Lisboa: Museu de Ciência da Universidade de Lisboa.

Martins, M. E. d. C. (2009). *Perpectivas de Professores de Física e Química do Ensino Básico sobre o uso de Trabalho Laboratorial.* Unpublished Dissertação de Mestrado, Universidade de Lisboa, Lisboa.

Martins, V. (2010). *As Ciencias Físico-Químicas em Coimbra durante a Primeira República.* Universidade de Coimbra, Coimbra.

Matthews, M. R. (1994). *Science Teaching: The Role of History and Philosophy of Science*. London: Routledge.

Millar, R., & Driver, R. (1987). Beyond Process. *Studies in Science Education, 14*, 33-62.

Mónica, M. F. (1978). *Educação e Sociedade no Portugal de Salazar*. Lisboa: Editorial Presença / Gabinete de Investigações Sociais.

Mota, T. S. A. d. (2001). *História do Ensino da Geologia em Portugal.* Unpublished Dissertação de Mestrado, Universidade do Minho, Braga.

Naves, F. (1996, 24/11). Um Poeta da Ciência. *Diário de Notícias,* pp. 24-25.

Niza, J. (1996, 06/11). Fundir palavras com reagentes. *Jornal das Letras/Educação,* p. 18.

Nóvoa, A. (2001). Prefácio *A Mocidade Portuguesa e o Liceu*. Lisboa: Educa.

Nóvoa, A. (2005). *Evidentemente, histórias da Educação*. Nova Oeiras: Asa.

Nóvoa, A. (Ed.). (2003). *Dicionário de Educadores Portugueses*. Lisboa: Asa.

Nóvoa, A., Barroso, J., & Ó, J. M. N. R. d. (2003). O Todo Poderoso Império do Meio. In A. Nóvoa & A. T. Santa-Clara (Eds.), *Liceus de Portugal: Histórias, Arquivos, Memórias* (pp. 17-73). Porto: ASA Editores.

Nóvoa, A., & Santa-Clara, A. T. (Eds.). (2003). *Liceus de Portugal: Histórias, Arquivos, Memórias*. Porto: ASA Editores.

Nunes, F. (1997). Apresentação. In R. d. Carvalho (Ed.), *Colectânea de Estudos Históricos (1953-1994)*. Évora: Universidade de Évora.

Nunes, M. d. F. (2006). Rómulo de Carvalho: Um Historiador da Ciencia, Percursos e Poética. In C. Vieira & I. R. Novo (Eds.), *António Gedeão & Rómulo de Carvalho*. Castelo da Maia: Edições ISMAI.

Nunes, M. L. (1996, 06/11). Rómulo António de Carvalho Gedeão: O Físico Prodigioso. *Jornal das Letras/Educação,* pp. 15-17.

Nunes, N. (2001). Caráter humanístico e filosófico da Poesia de António Gedeão. In L. Corte-Real & M. Lourenço (Eds.), *Pedra Filosofal: Rómulo de Carvalho e António Gedeão* (pp. 59-61). Lisboa: Museu de Ciência da Universidade de Lisboa.

Ó, J. M. N. R. d. (1990). *O lugar de Salazar: Estudo e antologia*. Lisboa: Alfa.

Ó, J. M. N. R. d. (2002). *O Governo de si mesmo.* Unpublished Tese de doutoramento, Universidade de Lisboa, Lisboa.

Ó, J. M. N. R. d. (2009). *Ensino Liceal (1836-1975)*. Lisboa: Editorial do Ministério da Educação.

O Polémico Livro Único. (1988, 25/10). *Jornal das Letras/Educação,* p. 8.

Pais, J. M. (2003). A Crise do Regime Liberal Republicano: Algumas Hipóteses Explicativas. In A. C. Pinto (Ed.), *O Estado Novo: das Origens ao fim da autarcia (1926-1959)* (Vol. I). Lisboa: Fragmentos.

Perez, I. (1997). Movimento matemático 1937-1947: meio século depois. In J. M. Mascarenhas & I. Perez (Eds.), *Movimento Matemático* (pp. 9-24). Lisboa: BMRR.

Pessoa, C. (2001). Pedra Filosofal: Uma exposição sobre Rómulo de Carvalho. *Gazeta de Física*, *24*(2), 16-19.

Pintassilgo, J. (2006a). Imprensa de Educação e Ensino: Universidades populares e renovação pedagógica. *Cadernos de História da Educação, 5,* 83-94.

Pintassilgo, J. (2006b). O Debate Sobre as Universidades Populares na Imprensa Portuguesa de Educação e Ensino: O Exemplo de "A Vida Portuguesa" (1912-1915). *HISTEDBR On-line, 24*, 93-101.

Pintassilgo, J., & Teixeira, A. (2011). A Formação de Professores em Portugal nos anos 30 do Século XX (Algumas reflexões a partir do exemplo dos professores de matemática). *Revista HISTEDBR On-line*(43), 4-20.

Rêgo, M., & Lopes, F. (Eds.). (2006). "*António é o meu nome", Rómulo de Carvalho*. Lisboa: Biblioteca Nacional.

Rhee, R. (2007). Socratic Method and the Mathematical Heuristic of George Polya. *St. John's Law Review*, *81*(1), 881-898.

Rocha, R. (1994, 04/06). Rómulo de Carvalho: O Homem é o Exemplo do Desumano. *Expresso,* pp. 100-104.

Rosa, R. N. (1996, 06/11). Cruzar Saberes. *Jornal das Letras/Educação,* p. 22.

Rosa, R. N. (2002). O Pensamento e a obra de Rómulo de Carvalho no contexto de sua época. *Vértice, 104*, 81-95.

Rosas, F. (1986). *O Estado Novo nos Anos Trinta: Elementos para o Estudo da Natureza Económica e Social do Salazarismo (1928-1938)*. Lisboa: Editorial Estampa.

Rudolph, J. (2002). *Scientists in the classroom: The Cold War reconstruction of American science education*. New York: Palgrave.

Sá, M. h. A. e. (2001). Rómulo de Carvalho enquanto metodólogo. In L. Corte-Real & M. Lourenço (Eds.), *Pedra Filosofal: Rómulo de Carvalho / António Gedeão*. Lisboa: Museu de Ciência da Universidade de Lisboa.

Salema, I. (1996, 24/11). Humanidades e ciências é tudo a mesma coisa. *Público,* pp. 2-4.

Salgueiro, L. (1997). A Epopéia do começo da Gazeta de Física. *Gazeta de Física, 20*(1), 3-5.

Santos, A. M. N. d. (1991). Foreword In: *António Gedeão 51 +3 poems and other writings*. Unidade de História e Ciência da Faculdade de Ciência e Tecnologia da Universidade Nova de Lisboa, 9-10.

Santos, A. M. N. d. (1996, 06/11). Um Renascentista do Século XX. *Jornal das Letras/Educação*, pp. 17-18.

Santos, A. M. N. d. (1997). Meu caro Dr. Rómulo de Carvalho. *Gazeta de Física, 20*(1), 18-19.

Saraiva, C., Malaquias, I., & Valente, M. (2007). O electromagnetismo nos manuais de física liceais entre 1855 e 1974. *Gazeta de Física, 30*(2), 36-42.

Shortland, M., & Yeo, R. (Eds.). (1996). *Telling Lives in Science: Essays on Scientific Biography*. Cambridge: Cambridge University Press.

Shulman, L. (1986). Those Who Understand: Knowledge Growth in Teaching. *Educational Researcher, 15*(2), 4-14.

Shulman, L. (1987). Knowledge and Teaching: Foundations of the New Reform. *Harvard Educational Review, 57*(1), 1-22.

Silva, C. M. d. (1997). Uma aprendizagem da Física quatro décadas atrás: a propósito de Rómulo de Carvalho. *Gazeta de Física, 20*(1), 41-45.

Silva, F. (2008). *O Ensino da Física em Portugal na Sequência da Reforma de 1947.* Unpublished Dissertação de Mestrado, Universidade Nova de Lisboa, Lisboa.

Silva, M. C. (2008). *Análise da Evolução dos Currículos nos Exames Nacionais de Físico-Química entre 1952-2005*. Paper presented at the Cultura Escolar Migrações e Cidadania - Actas do VII Congresso LUSO-BRASILEIRO de História da Educação.

Simões, A. (2012). Introduction: communicating science, technology and medicine. *HOST, 6*, 6-14.

Soares, L. D. (2006). A literatura infanto-juvenil de Rômulo de Carvalho. In M. Rêgo & F. Lopes (Eds.), "*António é o meu nome", Rómulo de Carvalho* (pp. 37-47). Lisboa: Biblioteca Nacional.

Sousa, M. R. d. (2006). António Gedeão / Rómulo de Carvalho. In C. Vieira & I. R. Novo (Eds.), *António Gedeão / Rómulo de Carvalho: Novos Poemas para o Homem Novo* (pp. 59-62). Castelo da Maia: Edições ISMAI.

Souza, B. J., & Fiolhais, C. (1993). Cinquentenário da Gazeta de Física. *Gazeta de Física, 20*(1), 2.

Souza, B. J., & Fiolhais, C. (1997). Pelo Ensino Experimental de Ciências. *Gazeta de Física*, *20*(I), 22.

Tabernero, C., Jiménez-Lucena, I., & Molero-Mesa, J. (2012). Scientific–medical knowledge management through media communication practices: a review of two opposite models in early 20th century Spain. *HOST, 6*, 64-84.

Teodoro, A. N. D. (1999a). *A Construção Social das Políticas Educativas: Estado, Educação e Mudança Social no Portugal Conteporâneo. Vol. I.* Unpublished Tese de doutoramento, Universidade Nova de Lisboa, Lisboa.

Teodoro, A. N. D. (1999b). *A Construção Social das Políticas Educativas: Estado, Educação e Mudança Social no Portugal Conteporâneo. Vol. II.* Unpublished Tese de doutoramento, Universidade Nova de Lisboa, Lisboa.

Valente, V. P. (1973). *O Estado Liberal e o Ensino: Os Liceus Portugueses (1834-1930).* Lisboa: Gabinete de Investigações Sociais do Instituto Superior de Economia.

Vasconcelos, J. C. d. (1989, 14/03). António Gedeão: Ele sabe - e sonha. *Jornal das Letras* pp. 8-11.