



## Scientific Literature in STEM Teaching and Learning With Innovative Curricular Lessons

Marina BA Minoli<sup>1</sup>

Royal Society of Biology, UK<sup>1</sup>

### Abstract

*The research path presented in this contribution refers to curricular training activities carried out over the years to motivate high school students to study STEM disciplines and to recover in an innovative way disciplinary deficiencies by involving them with active scientific reading strategies and guided activities. Starting from the international feedback that identifies in many middle and high school students little interest in reading scientific books also as an opportunity for human and cultural growth, different reading didactic paths with books written by scientists have been designed and created into the curricular lesson hours of some STEM disciplines. The teacher is involved in the choice of scientific books in relation to specific educational and cultural objectives within the lesson hours, in the creation of specific innovative reading guided analysis, and didactic itineraries in connection with scientific topics covered in class and with the specific recovery needs of individual students. The critical reading of different scientific books with reference to the key concepts presented by the teacher in the STEM lessons enhances the students' reasoning skills and analytical thinking. In the final phases of these STEM curricular Education courses were also some planned moments of cooperative working to realize some digital re-elaboration, for some aspects with the help of an AI platform for guided processing of concept digital maps starting from key scientific concepts and words identified by the students in the books. The students were highly engaged and interested in the various phases of these reading activities, which also served as a valuable recovery alternative for students with initial disinterest or difficulty in studying the STEM disciplines. These STEM reading teaching and learning itineraries strengthened both the written and oral communication skills of students, competencies that were verified over time through the completion of other tasks.*

**Keywords:** Active Book Reading; Scientific Literature for STEM Education; Innovative STEM Curricular Lessons

### Introduction

Analyzing the recent Eurostat data it reveals a general decline in reading interest among young people, which can be attributed to various factors, partly linked to new ways of engaging with cultural content. The European average of the percentage of reading among the population over 16 years of age stands at 52% with many differences between the European countries; the first place being 75% in Luxembourg, the last being 35,4% in Italy, 33,1% in Cyprus and 29,5% in Romania [1]. According to recent research, reading at the school level is perceived primarily as a technical exercise, devoid of its real educational value [2]. Early exposure to reading and maintaining a lasting relationship with books are predictive factors for the development of numerous skills, favoring personal and professional development [3]. It is considered important to educate focusing the interest on the reader, not focusing on the book. Reading education should not be aimed at simply proposing reading, but rather at developing a mental capacity and sensitivity that allows each individual to independently pursue the construction of their own personal culture. The principal objective of the STEM reading curricular courses created and implemented in high schools was to make students discover the passion for STEM interdisciplinary bioscience by educating in critical thinking. An achievable operational strategy is to bring young people closer to the work of the scientists by starting courses that include the integration of guided readings of STEM writings by excellent researchers into curricular activities [2]. Scientific figures are proposed whose training and cultural growth can be followed, considering the merits of the actions carried out and the difficulties in following one's objectives, using books that communicate the procedure of scientific research.



## Methods

The unifying theme of the proposed curricular courses is the exploration and dissection of two esteemed modalities of scientific dissemination and communication: books and web sites also with reasoned elements of AI. These dynamic resources enable students to engage with the methodologies of science and the swift progression of scientific advancements. In these activities, the teacher educational designer plays an important role in being the creator of new learning paths, realizing also scientific book talks as fundamental discussion phases with students and dialectical formative comparisons. The immersive reading of the scientific text, which engages students with passion, also as an opportunity for educational recovery - reviving both oral and written expressive skills - thereby motivating such activities within an intriguing context of scientific literature, while also adapting the work at different class levels.

## The Double Helix

One of the STEM books selected to construct curricular learning pathways is "*The Double Helix*" by James Watson: the scientific and human story of the discovery of DNA, a compelling narrative that chronicles the scientific and personal itinerary surrounding the discovery of DNA. This engaging account informally introduces the reader to the scientific path of James Watson starting from 1951, the year he joined Max Perutz research group at the Cavendish Laboratory of the University of Cambridge, where he met Francis Crick. Together, they embarked on a close collaboration that ultimately led to the definition of DNA's structure. Within the 29 chapters of the book, human and professional narratives intertwine, featuring some of the greatest minds of the physics, chemistry and biology of the past century, as well as the projects, endeavors, aspirations, collaborations, and competitions that still continue to characterize the work of the scientific research today. This book is important and useful educational resource with a historical contextualization of the molecular biology content learned by students during their high school education. It also introduces a dimension of the scientific word unusual for the students, wherein the human experience frequently supersedes the scientific persona. The guided and structured didactic reading activities of this book aids in comprehending the emotional intensity that marked the discovery of DNA's structure.

## Active STEM Reading Educational Activities

The active reading activities were proposed at two levels: as an exercise in reinforcing knowledge and addressing expressive challenges encountered during the two-year cellular biology curriculum and in the concluding phase of the high school molecular biology course. This approach enables students to not only retrace pivotal milestones in the discovery of DNA but also to assimilate the methodologies employed by scientists by immersing themselves in the research contexts, understanding the interpersonal dynamics within, the necessity for collaboration, and the inevitable conflicts, despite the emergence of the digital approach that has transformed the operational methods among scientists. "*The Double Helix*" presents a contemporary perspective on scientific research and provides a candid depiction of the operational and managerial challenges that scientists continue to confront today, albeit in altered forms. The educator proposes ten inquiries to steer the analysis of various facets of the text, to which students, organized into small groups, written responses for a subsequent phase of inter-group discussion. Guided reading and digital re-elaboration tasks are developed collaboratively by pairs of students in the two-year program realizing digital some presentations brief descriptions of each chapter with particular emphasis on the narrative settings, the professional profiles of the scientists referenced, the experimental methodologies, and the discoveries. For each chapter, students are tasked with identifying an image that epitomizes its fundamental content. Both the two-year and three-year high school students are requested to articulate, with motivation, a personal evaluation of interest for each chapter (high, medium, low), substantiating their judgments based on established criteria of scientific rigor, narrative engagement, and the complexity or simplicity of the storytelling. Furthermore, students in the three-year program are encouraged to reflect on the formative significance of this book, drawing from James Watson's insights regarding the guiding influence of certain readings on Francis Crick's endeavors, as well as to meticulously examine the twelve concluding reviews presented at the end of the book to summarize the content by schematizing the judgments in favor and the criticisms of James Watson's work, asking individual students if they



identify in particular with the thought of one of the reviews read, expressing in writing the reasons for the choice for a subsequent comparison work in the context of a class Book Talks. The students of the three period year in groups of three are subsequently involved in writing a personal motivated judgment on the entire work, with specific references also to the following evaluation criteria:

- potential target audience of the book and prior knowledge needed to read the text
- dissemination effectiveness of the proposed topic
- informative and educational value of the book
  - clarity in the exposition, also taking into account the scientific terminology used, simple or complex
- historical contextualization, partial or adequate
- exemplification of the book reading , banal, not always effective, effective
  - level of knowledge proposed, simple, medium, high

## Results

In the proposed activities all students have carried out with maximum involvement both individual and collaborative co-working activities, demonstrating excellent skills in re-elaborating and digitally presenting all results. To educate in critical thinking, all students were invited to articulate their impressions of the world of scientific research described in the book, analyzing the image that emerges from the words of Watson, such as the scientific difficulties and human relationships described, evaluating the current differences in today's research in this sector, interviewing a researcher in the sector with specific questions [5]. The meeting with the molecular biologist was scheduled at the end of all the work carried out on the book, an analysis of the scientists who had the greatest narrative space in the text, choosing one per group on which to carry out bibliographical and scientific in-depth studies, motivating the interest for the preference. In the final phases of these STEM Education courses were also some planned moments of cooperative working to realize some digital re-elaboration, for some aspects with the help of an AI platform for guided processing of concept digital maps starting from key scientific concepts and words identified by the students in the book.

## Book Reading to Realize Interdisciplinary Education

This book also offered the opportunity to create in-depth courses in collaboration with teachers from different disciplines; high attention to the figures of the protagonists of the chemical and physical sciences of the last century, to the places of discoveries, to scientific journals and to experimental techniques of structural biology. In particular, the technique of crystallography with X-ray diffraction that allowed the discovery of the three-dimensional structure of DNA was explored, starting from the book to build a course in which a necessary collaborative approach is identified between specific skills of excellent biochemists and physicists. The analysis of the photographs of the X-ray diffraction of protein molecules and nucleic acids and the related difficulties of interpretation by the various scientists represent key elements of the narration of the experimental aspect of the book. The collaborative path between the biology and physics teachers proved to be very effective. Starting from the reading of the experimental applications described in the book, the students were encouraged to analyze some photographs of different molecules, discussing the operational and interpretation difficulties of the intrinsic nature of the technique. Activities integrated into a structured and guided didactic itinerary to bring young people closer to the work of the scientist with also the reading and the comparative reworking of the biographies of some scientists cited in the "*Double Helix*" who have been fundamental for the development of biology, highlighting the inevitable interactions between the different basic STEM disciplines (mathematics, physics, chemistry) that have been fundamental for the development of biology.

## Integrated Book Reading Activities: 27 Biographies of Scientists

The aim of all realized didactic actions was to make evident the double path from man to science and from science to man, through the historical contextualization of some discoveries and the analysis of



the biography of some researchers who have dedicated themselves with rigor and seriousness to science. In this work of analysis of the biographies it was useful to guide the students to conduct independent research on the aspects of everyday life and on the different contexts of maturation of the interest and passion of the scientist for his own field of research, as well as on the motivations to continue working with determination even in cases of defeat and difficulty. To create a path of this type, the guided reading of the book by John Brockman "*Curious Minds* " was also fundamental, which collects the essays of 27 scientists who tell which contexts and events of their childhood led them to make science their profession. Among the scientists proposed there are also biologists and naturalists who address their educational path in a simple and linear way, explaining what it means to be a scientist and how the method of communication has changed over time. In particular, groups of three students from the two-year and three-year periods of the classes involved created an information sheet about the chemist Max Ferdinand Perutz, Nobel Prize winner in 1962, identifying the fundamental elements of the educational path, the reasons for attributing the Nobel, the difficulties in the professional path, the value of the research carried out.

### Discussion

The book "*Double Helix*" presents numerous places where the human and scientific adventure of the discovery of the structure of DNA took place. The histories of research centers and universities, scientific societies that have represented significant points of departure for studies of international excellence were therefore analyzed with guided research:

1. Royal Society
- 2- University of Oxford
- 3- University of Cambridge - Cavendish Laboratory

The structure of the discovery of DNA was published in the journal Nature, an analysis process was therefore started starting from two current paper copies and two digital copies of the journal Nature, after having read the article by James Watson, guiding the students to a comparative description with two copies of the journal Science, evaluating the structure of both, also the spaces dedicated to news, book reviews and scientific advertisements for a short verbal presentation. All these activities have represented an excellent educational opportunity for the three-year students who have fully involved themselves with a high curiosity for knowledge, demonstrating that they are actively learning interesting aspects of the scientist's communication work. STEM reading paths created over time with multiple integrated activities always make student readers protagonists of the reading, analysis, research, re-elaboration and communication process, the opportunity in reading a scientist's book to design and create engaging learning and orientation paths. Digital skills have been well integrated into the educational itineraries created, allowing students to recover disciplinary and expressive skills both oral and written, to deepen and think critically about information with the research method, to express reasoned evaluations, to document all the results of the reading work and to communicate the same both within small work groups and between different classes. Reading education paths, not simple scientific reading proposals carried out independently by students, but opportunities for human and cultural growth beyond STEM disciplines for an innovative Open Book Education [6].

### Conclusion

Innovative STEM curricular lessons with scientific books were created and realized to promote passion for scientific literature proposing the active reading of Nobel Prize's Books and other scientists. The work carried out has educated the critical use of the proposed reading sources, the analysis of scientific language in the context of specific biological themes, including the Discovery of DNA with the book by James Watson, proposing an integrated, innovative and non-standardized but flexible and adaptable teaching approach. Methodological innovation of STEM teaching that has also proven useful for filling cultural STEM lacunae [7], an engaging recovery of knowledge and skills of students less motivated to study scientific disciplines or with real difficulties especially in the use of scientific language, recovery opportunities that by actively involving in the reading of the book have



filled the widespread failures of extracurricular recovery with additional lessons and often characterized by the sole re-presentation of concepts or contents not really motivating the study to scientific knowledge. A new way of learning STEM disciplines for key ideas by reading authors who have directly dealt with science. Activities that make the reader the protagonist, not the book which is the tool of the teaching path that helps students to overcome even the separation between the scientific and humanistic areas, operational methods with which it is possible to start the approach to aspects of STEM interdisciplinary, also promoting border biological disciplines with fascinating aspects of high innovation without neglecting the historical contextualization of the theme of the book. The guided STEM reading activities carried out at curricular level have demonstrated the concrete and effective possibility also of carrying out career guidance with orientation teaching actions designed and implemented by the teacher within the context of a passionate operational complexity that identifies the important master role as a project protagonist together with the students of the classes.

## REFERENCES

- [1] Eurostat report August 2024, EU
- [2] Marina BA Minoli, "*Evolution of Science Teaching*", *Active Science* - Turin University, 4/2015
- [3] D. Izzo, B. Ciurnelli, E. Carlotti, "*Reading promotion or Reading Education?: Schools Educational Choices and their Consequences*", *Effects of Reading*, V. 3 N. 1 2024
- [4] Marina BA Minoli, "*Scientific Books in STEM Teaching*", USR IFOM Science Centre Lombardy, Milan, 4/2004
- [5] Marina Minoli, "*To motivate in studying Bioscience*", *Teachers Guide Book*, Pearson Editor, USA, 2011
- [6] Alexander Hanna Licht et al, "*Open Book of Educational Innovation*", European Schoolnet, Bruxelles, 11/2017
- [7] Grant Bage, "*Lessons and lacunae? Practitioners suggestions for developing research-rich teaching and learning: angles on innovation and change*", *Innovation in Education an Teaching International*, pp 150-161, UK, 04 2018