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Two Cultures: Conveying Physics Through Literature?!

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"Literature in physics class? Oh, you mean physics texts and texts from physics books!" "No literary texts. They exist, those passages in literature that are directly related to physics." Contrary to schoolbooks, scientific facts are only incidental here and sometimes treated in a very imaginative way. For example, unsound physics are explained by magic. Physics becomes embedded into a context and introduced to support plots, adventures, and so on. This article intends to bring to light the possibilities of combining literature and physics in school lessons. In addition, the partial gap between natural science and humanities or social sciences will be addressed and attempted to be bridged.

Keywords: physics and literature, new ways, teach physics, confrontation

Introduction

No longer shall I sweat to teach
What always lay beyond my reach?
I'll know what makes the world revolve,
Its inner mysteries resolve,
No more in empty words I'll deal.
Creation's wellsprings I'll reveal!
Faust I (Goethe, 1808)

The famous quote by Faust is not only one of the core statements of the play, but also a core statement and driving force for many scientists. What makes this concept so special is that it can be found all through literature. Another interaction can be found in the word "quarks". It comes from "Finnegan's Wake", a novel by James Joyce: "Three quarks for Muster Mark" (Joyce, 1939).

At first glance, one thing seems obvious: Physics and literature are two contradictory areas of expertise which have no similarities and are therefore usually strictly separated from each other. This idea is supported by the fact that physics can instrumentalize its own language to describe its contents, namely, the mathematical language.

As an illustration of the difference between science and humanities here a quote by Novalis:

When no more numbers and figures feature
As the keys to unlock every creature,

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When those who join to sing and woo
Know more than the deeply learned do.
And in stories and in tales
One can find what world contains
Then swipe with one word arcane
All essence's amiss away.
Heinrich von Ofterdingen.
(Novalis, 1800)[1]

This quote represents a negative attitude towards the sciences. At the end of the article, this quote will be revisited and changed.

Is it really true that physics and literature are completely contrary and incompatible, or could this impression be faulty?

This article aims at demonstrating how strongly physics and literacy are interrelated and, more importantly, pointing out the opportunities that literature can bring to physics lessons.

Comparison of Science and the Humanities

At first glance, one would consider the notions of science and the humanities to be mutually exclusive (Kreuzer, 1969). They are referred to as two separate cultures, existing independently of each other. Table 1 lists some of these contrary classifications. The two selected quotations here serve to illustrate the extent to which the discrepancies of opinion appear in physics and literature, or natural sciences and spiritual sciences.

Table 1

The Two Cultures—A Juxtaposition

Science	**Humanities**
Resextensa (Descartes, 1641)	Rescogitans (Descartes, 1641)
Hard science (Helmholtz, 1862)	Soft science (Helmholtz, 1862)
Nomothetic (Windelband, 1894)	Ideographic (Windelband, 1894)
The outer	The inner
Realization/recognition/knowledge	Experience
Data & Facts	Love & Sorrow
Physics & Mathematics	Literature & Art
Objective	Subjective
Example: Koeppen (1995)	Example: Habermas (1968)
Researchers, engineers (Snow, 1963)	Authors, critics (Snow, 1963)
2nd principle of thermodynamics	Sonnets by Shakespeare (1609)
Die andere bildung.[2] (Fischer, 2003)	Bildung. Alles, Was Man Wissen Muß.[3] (Schwanitz, 1999)

The first quote originates from the writer von Koeppen:

> You are asking for my literary role models and influences—Now, I would like to tell you that new findings in physics, especially in modern physics have had influences on my development (…). There, I am receiving a paradigm that matches my premonitions in many ways.
>
> Koeppen (1995) (Translated by the authors)

[1] The first four lines were translated by Robert J. Richard (2010) himself, the last five lines were translated by the authors.
[2] The other education.
[3] Education. Everything you need to know.

Contrasting this is a quote by the philosopher Habermas:

> Findings in atomic physics stay, in their own right, without consequences for the interpretation of the world we live in. (…) Only when physical theories assists us to split atoms, only when the information is used in the development of productive or destructive powers, can their revolutionary practical impact penetrate into the literary consciousness of our world—History occurs in the instant of Hiroshima and not through the spreading of hypotheses about the transformation of mass and energy.
>
> Habermas (1968) (Translated by the authors)

Where the influence of science on daily life is recognized in the former, the latter illustrates an—unfortunately all too common—attitude in which the humanities deny the educational value of natural science, even today, whereas this is not the case as often, when in return natural sciences value the humanities.

Another excellent example of the seeming importance of science compared to the humanities is a comparison between the Second Law of Thermodynamics and two sonnets by Shakespeare. At first glance, this is questionable; the selection is based on an anecdote, described by D. Schwanitz (1999). This anecdote is about a party where the question about whether it is of importance to know the aforementioned law is posed. The author supports the claim that it isn't important, since it is not part of general knowledge.

No system can take energy as heat from a single reservoir and convert it entirely into work without additional net changes in the system or its surroundings.

(Second Law of Thermodynamics: Kelvin Statement quoted by Tipler and Mosca, 2004)

Therefore, "a perpetuum mobile" of the second kind is impossible, whereas Shakespeare's sonnets are rated as important.

Sonett XVIII

> Shall I compare thee to a summer's day?
> Thou are more lovely and more temperate:
> Rough winds do shake the darling buds of May,
> And summer's lease hath all too short a date:
> Sometime too hot the eye of heaven shines,
> And often is his gold complexion dimmed;
> And every fair from fair sometime declines,
> By chance or nature's changing course untrimmed;
> But thy eternal summer shall not fade
> Nor lose possession of that fair thou owest;
> Nor shall Death brag thou wander'st in his shade,
> When in eternal lines to time thou grow'st
> So long as men can breathe, or eyes can see,
> So long lives this, and this gives live to thee.

Sonett LXXXI

> Or I shall live your epitaph to make,
> Or you survive when I in earth am rotten;
> From hence your memory death cannot take
> Although in me each part will be forgotten.
> Your name from hence immortal life shall have,
> Though I, once gone, to all the world must die:
> The earth can yield me but a common grave,
> When you entombed in men's eyes shall lie.

Your monument shall be my gentle verse,
Which eyes not yet created shall o'er-read;
And tongues to be your being shall rehearse,
When all the breathers of this world are dead;
You still shall live (such virtue hath my pen),
Where breath most breathes, even in the mouths of men.
Shakespeare (1609)

A note on the sonnet above: Does science not do this as well? Is science not also about the (possibly abstract) beauty of nature? Thus, science conserves knowledge for a distant posterity. This can be regarded as a concept of complementarity, which will be discussed in this article at a later time.

Reading Habits Among Young People

The results of the Programme for International Student Assessment (PISA)-study 2009 have shown very clearly that there are gender differences regarding reading performance. As an example for the country Austria, girls are better than boys in all subjects who were tested (Schwantner & Schreiner, 2010). When taking a deeper look into the reading habits of Austrian students, 50% of youths do not read in their free time. Sixty-one percent of these students are boys but only 39% are girls, which clearly show a strong gender-specific difference (Schwantner & Schreiner, 2010). In light of this, it should be terrifying for Austria that the second largest proportion of male non-readers is found here, behind the Netherlands (Schwantner & Schreiner, 2010). The neighboring country of Germany also shows great deficits in the area of reading between female and male adolescents: According to PISA, 51.8% of boys only read when they are required to. In the case of girls, the figure is 26.4% (Schilcher & Hallitzky, 2004). As a hobby, reading does not seem to be worth considering. Possible reasons can be found, for example, in the strong interest in modern media (film, computer, and mobile phones) (Schilcher & Hallitzky, 2004). In addition, German language teaching is dominated by content that is more attractive to female readers:

(a) Literature, which copes with problems and emotions;

(b) reading and writing of poems;

(c) expressing one's opinion.

The expression of feelings and attitudes leads to a defensive attitude in male adolescents (Schilcher & Hallitzky, 2004).

The gender-specific difference in reading behavior with respect to what is read is shown in Table 2.

Table 2

Preferred Reading Material of Adolescents (According to Schilcher & Hallitzky, 2004)

Male students	**Female students**
Non fiction	Literature which copes with problems and emotions
Instructions	Fiction
Biographies/autobiographies	Poetry
Science fiction	Children's & youth's books
Fantasy	
Adventure novels	

As can be seen in Table 2, male and female students show highly different reading habits apart from the adventure novel, which is read by both male and female adolescents.

Literature in Physics Lessons

This chapter will show the significance of physics in literary works and the possibilities it presents for physics lessons.

Creating Texts

In physics lessons, the writing of texts is mostly restricted to physics texts. These include: observations, protocol descriptions, mnemonics, evaluations, calculations, and experiment descriptions.

But could there be a different approach? Perhaps by creating imaginative physics texts (Dammaschke & Strahl, 2010). However, this creative processing of physical knowledge into written form requires a little more time for which there is often no room in regular physics education. For this reason, the possibility of interdisciplinary teaching is a possibility, whereby physics education and text productions take place within German lessons. This point will be revisited later on.

Let's take, for example, Michael Ende's illusory giant scene from Jim Button (Ende, 1960). Here, pupils could easily write a letter to the editor, explaining why this concept cannot work. However, in order for them to have sufficient professional knowledge to argue their claims in an argumentative manner, the necessary expertise is required. This is given in the preceding physics course of the physics. Another, more factual possibility could be the creation of manuals (for radio, pocket watches, etc.).

In order to stimulate the imagination of the students, it might be of advantage to have them write an inner monologue. For example, they are to put themselves in the shoes of a well-known scientist and report on their breakthrough invention or the discovery of a physical phenomenon, which subsequently led to a revolutionary invention. In order to do so, the pupils are in need to use subject-specific terms which are covered in physics lessons before the writing task. This way, Thomas Edison and the invention of the light bulb, Benjamin Franklin and the lightning conductor, and Michael Faraday and the generator could become the subject of German lessons.

Impacts/Observations of Science in Literature

Literature in the field of physics education also offers the opportunity to discuss the impact of scientific findings, their usefulness/uselessness, and scientist's responsibility. Literary examples include:

M. Shelley	Frankenstein
F. Dürrenmatt	The Physics
B. Brecht	Life of Galileo
M. Houellebecq	The Elementary Particles
M. Rio	Le Principe d'incertitude
J. P. Toussaints	Monsieur
P. Deville	Das Perspektiv
D. D. Giudice	Atlante occidentale, Lines of Light
J. Volpi	In search of Klingsor
D. Brown	Illuminati

Physics in Literature

Texts on Physical Conditions

Some works in literature, English studies, and philosophy deal with the effects of science on literature (Dilmac, 2012, 2014; Emter, 1995). However, physics is usually not dealt with in these works, even though A. Schopenhauer (1819) or S. Freud (1895), for example, has used physical knowledge to underpin philosophical thoughts (Schopenhauer, 1819; Freud, 1895).

An exceptional author is Alan Lightman, who as a physicist has already written several books on physics in the literary sense, two of which now be discussed: Einstein's Dreams (Lightman, 1993) and Time for the Stars (Lightman, 1992).

In "Einstein's Dreams", Alan Lightman (1993) has the character of Einstein have dreams over time. In each of the 30 dreams, there is a time phenomenon. The dreams are named by date; they are placed between 14.04.1905 to 28.06.1905 in the book. For example, the first dream in 14.04.1905 assumes the idea that time is cyclic and repeats itself again and again in a circle. The dream in 24.04.1905 is exciting as well. It picks up the phenomenon of objective universal time perception and the subjective personal perception of time. In "Time for the Stars," the biography of a physicist is presented in an unusual way. The book by G. Gamow (1940) *Mr. Tompkins in Wonderland* falls into the same category. It describes the effects of the theory of relativity on everyday life and raises the question of what would happen if the speed of light was slowed down (*c* only 30 miles per hour, ergo about 48 km/h).

Unfortunately, this story is currently only available as an antiquarian book, but can be requested from Alexander Strahl.

Direct Physics

The most interesting texts for teaching physics are those in which physics is directly dealt with. The length of such texts varies from one half to several pages, and can be found in some passages in some books:

M. Ende	Jim Button and Luke the Engine Driver
	Jim Button and the Wild 13
Several/unknown	Wise Men of Gotham
S. King	The Stand
E. A. Poe	The Mystery of Marie Rogêt
Ovid	Metamorphoses III
G. Schwab	Gods and Heroes of Ancient Greece
J. W. von Goethe	Faust I
R. E. Raspe	The Adventures of Baron Munchausen
J. Gaarder	Sophie's World
D. Mitchell	Cloud Atlas
R. Schrott	Tropen
H. G. Wells	The Invisible Man
K. Mahr	Perry Rhodan 3 (Galactic Alarm)
T. Pratchett	The Unadulterated Cat
T. Pynchon	Slow Learner
E. Hemingway	A Day's Wait
F. Lelord	Hector finds time
J. Verne	Journey to the Center of the Earth
A. Weir	The Martian
For Chemistry:	
A. Bradley:	Flavia de Luce. The Sweetness at the Bottom of the Pie
	Flavia de Luce. The Weed That Strings the Hangman's Bag

Two editions of the *Praxis der Naturwissenschaften*[4] are noteworthy here since they deal with the subject matter of physics and literature (Lotze, 2008, 7/57) and chemistry and literacy (Obendrauf, 2008, 5/57)

[4] The magazine *Praxis der Naturwissenschaften* is available in German language only.

respectively. For chemistry, there is a German-language book dedicated to the topic (Schwedt, 2009). In English, there is little literature on the subject (Dietrich, 2011; Manos, 2014).

Use of Literature in Physics Lessons

In the eyes of many students, physics has nothing to do with their everyday world: It is purely theoretically and is disconnected from real life (Kubli, 1998). Physics is regarded as a closed system which, apart from the mediation of formulas and mathematical tools, cannot do anything else. To counteract this prejudice, it is recommendable to embark on a new path of physics. Physics should be regarded as a cultural asset which contributes to science and the humanities, whether it is philosophy, history, or literature (Kubli, 1998).

While reading or reading aloud a text with physical content, a multitude of questions can arise among pupils: Can the described situation be realized, or is it pure fiction and an author's stroke of imagination? Would it be possible to create the described situation? E.g., by recreating an experiment or an invention? Developing such questions arouses curiosity, which in turn can stimulate motivation. Thus, the use of literature can bring benefit to the teaching of physics that is not to be underestimated (Pospiech, 2005; 2008):

(a) New access to physics;
Deviation from standardized school physics;
Creation of individual access.
(b) Activating autonomy;
Developing individual questions;
Independent research;
Necessary comprehension of basic concept of physics and scientific methods for text apprehension.
(c) Activating physical and literary knowledge;
Students can achieve success by using knowledge from other subjects;
Scoring points through literary knowledge, strong argumentation in discussion rounds.
(d) Preferences are taken into account;
Wish for discussions;
Proportion of student's speaking time is increased.
(e) Work method training;
Critical reading;
Identifying physical facts;
Potential development of experiments to verify text claims;
Procuring information;
Drawing conclusions.

By participating in discussion sessions or recurring existing literary knowledge, literature can open up access to physics to all those who have less interest in science or are more reserved. These pupils will be able to score by using knowledge from other disciplines. Books as a medium could play an important role, especially for the encouragement of girls in physics lessons. According to the PISA study in 2009, girls' reading levels are significantly higher than their male counterparts (Schwantner & Schreiner, 2010). Frequently, girls tend to identify with the protagonists, which can also lead to a link between physics and their own living environment in literature with physical content (Schilcher & Hallitzky, 2004).

Another important point is the potential of interdisciplinary teaching. Günther and Labudde (2012) mentioned some relevant reasons why one should choose interdisciplinary instructions:

(a) The matisation of the everyday and application oriented contexts.
(b) Take learners along;

Drawing on prior knowledge and prior experience.

(c) Linking new knowledge to other subject areas;
Sustainable learning;
Promotes networked thinking.

(d) Motivation support;
Teaching content referencing reality and everyday life;
Proximity to living environment is recognized.

(e) Linking learning contents with societal problems;
Key issue according to Klafki (as cited in Günther & Labudde, 2012).

(f) Promoting interests through interdisciplinary projects;
Students can control learning processes individually;
Offers the possibility to contribute individual strengths and ideas.

(g) Enforcement of interdisciplinary competences.

(h) Enforcement of media competence.

(i) Gender equality;
Alternative access to school subjects.

Another important topic initially comes from the didactics of multilingualism which cares about students using second or foreign language in regular German classes. According to Rösch (2009), multilingualism is seen as a normal condition for humans whereas monolingualism is just an exception. Therefore, an important topic for school education is to promote children, which are capable of speaking more than one language. This should not happen in German classes only but also in other classes by using the so-called “jargon”. In that way, classes like mathematics and natural sciences can contribute to the promotion of multilingualism by picking specific text types, such as the writing of protocols for experiments in physics and chemistry or to understand tasks in mathematics (Rösch, 2009).

One could ask the question: “Why are physics and German taught in a cross disciplinary way?” Would not it appear to be more appropriate to combine physics with other natural sciences, such as biology, chemistry, or mathematics? But German and physics can also benefit enormously from each other. A reason for interdisciplinary teaching is, for example, the strengthening of interdisciplinary competences, which include reading competences. These are in urgent need of funding, especially for Austrian youths, which came to light in the latest PISA study 2009. Here, Austria’s youths were ranked 31st, a poor result amongst the 34 Organisation for Economic Co-operation and Development (OECD) countries (Schwantner & Schreiner, 2010).

The difference in performance between girls and boys seems to be of special significance here: in terms of literacy, Austria’s female pupils are about 41 points ahead of their male counterparts (Schwantner & Schreiner, 2010).

One important contribution to this frightening PISA result is the amount of reading promotion in the German language: Whereas the elementary school still contributes to the promotion of reading competency, a shift occurs in the transition to the secondary level, which mainly deals with teaching literature (Gold, 2010). In the course of this, the required reading competency is generally simply assumed, even if it is not yet present in many pupils.

The use of literature in physics education can thus make a significant contribution to the promotion of this interdisciplinary competence.

Examples

Here are two examples to illustrate the collection.

The first example is from: Jim Button and Luke the Engine Driver by Michael Ende (1960):

> "Oh, Lukas!" Jim gasped, his teeth beginning to chatter of fear, "Now we are done with!"
>
> "I don't think so", Lukas replied. "Maybe the giant might even be able to tell us, how we get out of this darned desert."
>
> Jim was left speechless. He was not sure what to think. Suddenly, the giant lifted both hands, folded them and shouted with a thin, dingy voice: "Please, please, you strangers, do not run away! I do not wish to harm you!" The giant's voice should have sounded like thunder, but that surely was not the case. What could be the reason for this?
>
> (…), Well, friends, "He shouted, with his thin voice, "I am coming now!" And with this he began to move toward Jim and Lukas. But what happened now was so amazing, that Jim opened his mouth and nose and Lukas forgot to suck on his pipe. The giant approached step by step and with every step became a little smaller. When he was maybe a hundred meters away, he was not much taller than a small steeple. After another 50 meter, he was just the size of a house. And when he finally arrived at Emma, he was the same size as Lukas the locomotive driver. He even was almost half a head smaller. In front of the two amazed friends was standing a lean old man with a fine and gently face.

Possible work assignments and questions would be:

a. Why is Mr. Tur Tur an illusionary giant?
b. Which fact is switched for Mr. Tur Tur?
c. Draw Jim watching Mr. Tur Tur and Lukas and include the angles.

The second example is out of The Little Prince by Antoine De Saint-Exupéry (1946):

> That was how I had learned a second very important thing, which was that the planet he came from was hardly bigger than a house! That could not surprise me much. I knew very well that except for the huge planets like Earth, Jupiter, Mars, and Venus, which have been given names, there are hundreds of others that are sometimes so small that it is very difficult to see them through a telescope. When an astronomer discovers one of them, he gives it a number instead of a name. For instance, he would call it "Asteroid 325. I have serious reasons to believe that the planet the little prince came from is Asteroid B-612".

Possible work assignments and questions would be:

The small prince comes from Asteroid B 612. It has a radius of 5.5 meters and a mass of 5.7 10^5 kg:

a. calculate the density of the asteroid;
b. compare the density of B612 with the planets in our solar system;
c. calculate the gravity on B612;
d. calculate the little prince's necessary escape velocity to leave the asteroid.

An Implementation

The various possibilities literatures can contribute to physics lessons were demonstrated in a few examples. They range from discussions on the impacts of scientific knowledge, the responsibility of scientists, and the possibility or impossibility of certain literary writing to the writing of imaginative texts combined with expertise. As a result, the learner will not only have a new approach to physics, but also a link between knowledge and learning contents with social problems as well as the promotion of interest and motivation.

This work shows that the supposed gap between science and the humanities is, in fact, only a small gap which can be resolved with ease and open-mindedness.

In conclusion, here is the Novalis quote mentioned in the beginning with a slight alteration:

When no more numbers and figures feature
As the keys to unlock every creature,
When those who join to sing and woo
Know more than the deeply learned do.
So will in images and odes
True history appear,
when knowledge silently floats
to men willing to hear.
Fischer (2003)[5]

Unfortunately, there is still a gap between the humanities and science to many people, although both should be part of the educational canon of every human being. It is not a question of a duality, but one of interconnectedness. In physics, this idea was characterized by Niels Bohr's complimentary principle (Bohr, 1934). It means that there are excluding, contradictory descriptions of a situation with reciprocal supplements which contribute to the understanding of the whole Completum (lat. completeness and completion). Both areas can be mutually beneficial and should not try to dispute each other's importance. Literature opens up a lot of potential for teaching the subject of physics and access to interdisciplinary teaching. It can help broaden the horizon of the students and shows that physics is important in all areas of being/life.

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