

## SCIENCE CAN BE FUN – MURPHY’S LAW AND HUMOUR IN NATURAL SCIENCE

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**Abstract.** This article considers the possibility of implementing Murphy’s law and humour in teaching natural sciences. First, it describes the origin and development of Murphy’s Law, and considers the origin and defining of postulates arising from the research, scientific work and teaching practice. The central part of the paper deals with the use of humour in teaching mathematics and science, resulting from teaching practice. In addition, it presents the comic elements from films, TV series, cartoons, and school television programs, books for children and youth, and scientific popular literature. It considers the choice of the use of these media and their adaption to the needs of teaching natural sciences.

*Keywords:* natural science, humour, Murphy’s law, Murphy in science

### Introduction of the topic

At a global level, students’ interest in natural sciences is decreasing (Bojović & Šišović, 2003; Woest, 1997) according to the results of TIMS and PISA studies (Pavlović-Babić et al., 2006). The old didactic phrase: “*There are no boring lessons, only boring teachers*” (Stojkovic, 2011) confirms the need for constant evolution and innovation in teaching, which is reflected in popularisation of the natural sciences, which would lead to a better understanding and bring educational content closer to students and their needs. To make various lessons interesting and, above all, entertaining, it is possible to introduce extra-curricular content of humorous character. Humour (jokes and anecdotes from the lives of famous scientists) and Murphy’s Law are presented as part of a wide spectrum of potential instructional contents, which could primarily be applied in teaching natural sciences.

What is humour? Humour is a universal way of communicating, regardless of gender, age, culture or background. Humour can be found in every aspect of life, and can be a driving force in solving different problems — not only in day-to-day life, but in scientific research and teaching as well. The term “*humour*” derives from the Latin word “*humor*.” It means “*body fluid*” (According to humoral medicine of the ancient Greeks, the balance of fluids in the human body “*humours*”, controlled human health

and emotions) (Banas et al., 2011; Shiyab, 2009).

Laughter and comedy are two types of Humour (Shiyab, 2009). Laughter represents a psychological and physiological phenomenon, while comedy is defined as the creative act of one man's humorous capacity (Sorell, 1972; Langer, 2003). Also, humour includes communication, social (Robinson, 1977) and educational dimensions (Brunner, 2002).

Life situations, which cannot be defined by any natural laws, in other words, for which no rational explanation exists, define and explain the so-called Murphy's Law. The difference between morphology and scientific laws lies in their relative validity. Natural laws define the physical causes, condition phenomena, predict the results of physical interactions, whereas the (un)natural Murphy laws represent the failure of scientific methods to explain the world of human society and deal with the intent and purpose, with the factors which are not by nature physical (Stojkovic 2012).

### **The aim of arguments**

The main task of the article is not to examine the use of humour in teaching from the standpoint of pedagogy and psychology, but to focus on didactic and methodological dimensions and the importance of humour in teaching the natural sciences.

The main aim of this article is to highlight the importance of humour and Murphy's Law, as well as the possibilities of using them in teaching the natural sciences.

Since humour possesses a universal dimension, there appears a need for its wider, deeper and more intensive application in teaching, especially of natural sciences. First of all, teaching practice represents an inexhaustible source of alternative possibilities for the implementation of various types of humour within the teaching contents of natural sciences. The issues of modern science and scientific research, particularly its funny side, is considered and explained with the help of Murphy's Law, naming, analysing and defining its postulates and laws. The introduction of the principle of serendipity - the occurrence of fortunate and funny situations in science - in natural science teaching could explain a lot of discoveries and inventions, as well as depict the lives and work of famous scientists. The use of extracurricular contents, which include elements of humour from TV, films, books, scientific and popular press, are also discussed here.

Generally, the use of humour in teaching increases students' interest, motivation and focus (Markiewicz, 1974; Bryant et al., 1981; Rule & Auge, 2005), and helps to create a positive and creative working atmosphere (Powell & Andersen, 1985; Kassner, 2002) as well as reducing the fear (Perlini et al., 1999).

Most textbooks and other teaching materials contain little to no information on using humour in this way (Dickhäuser & Strachelscheid, 2011). Therefore, the use of alternative teaching materials will be suggested to introduce humour in teaching natural sciences, as a supplement and replacement of the existing teaching materials, which are rich with humorous elements.

Moreover, it discusses the selection and implementation of the existing postulates and the definition of new postulates of Murphy's Law in the natural sciences.

## **Theoretical framework**

### *History of Murphy's Law*

Generally, the beginnings of Murphy's laws date back to the period before the appearance of modern murphology in the 20th century. Most likely, famous scientists and researchers encountered the issues of Murphy's Law, which was certainly confirmed by their research works and experimentations (Schneider, 2009; Donald, 2013). One of the first versions of this law was given in 1877 by engineer Stephen Goranson (the unnamed version of the law at the time). Sometime later, in 1908 another version of this law appeared in the form of an aphorism by Bill Mullins.

The beginnings of modern murphology date back to the period after the Second World War, exactly to 1949, and are related to the launching chair experiments at the military base "Edwards" (Edwards Air Force Base Second Base) in California, USA (Upgrading and Murphy's Law 2013). The modern version of the law was named after the American military engineer, Captain Aloysious Edward Murphy, Jr. (1918 – 1990) from Wright Field Aircraft Lab, who worked on the development and testing of a catapulting seat (pilot-chair) attached to a missile-trolley. He uttered the famous sentence: "*If something can go wrong, it will*" (Murphy's Laws origin n. d.). According to another version, it was actually USAF Colonel John Paul Stapp (1910 – 1999), who studied the effects of acceleration and deceleration forces on humans, participated in certain tests, was in fact the first person that pronounced and defined Murphy's Law (Schneider, 2009). This led to the foundations of Murphy's Law on the basis of a large number of rockets failed tests (Schneider, 2009).

### *Murphy's law in natural science*

Basically, Murphy's Law could be formulated as a form of a philosophy of life. It represents a generally nonscientific and universal (analogous to natural sciences) law. The main topic of the murphology of research refers to the problematic of experimentation, which arises from practical and research-theoretical works. Not only scientists, but also teachers and students equally encounter Murphy's Law in teaching, lab and research work. (Stojkovic, 2012).

Murphology in natural science represents a special sub-group of the murphology of research. Certain laws, principles or postulates which occurred as a result of the interaction of Murphy's unscientific elements and logical-rational science are named after the person who defined the law (Bloch, 1998).

### *Murphy's law postulates*

There are a large number of laws, postulates and axioms within Murphy's law, which include not only the area of natural sciences, but also culture, ethics, technology, philosophy, etc. What will be introduced and explained here are some examples of postulates, directly resulting from research work and teaching practice.

*The first law of the laboratory* is: "Hot test tube looks exactly like the cold one" (Bloch, 1998).

When explaining the basic rules of the laboratory work (Mandić et al., 2005) it could be good to quote the first law of the lab. The hot test tube does differ from the cold one, unless confirmed by the sense of touch, which of course is not recommended! This example is very funny for them; a situation in which a person has a test tube “glued” to their hand is unthinkable for students (Stojkovic, 2012).

*Velilind's laws of experiments* are: “If repeated experiments can give different results, test only *once*.”; *Thumb's second postulate* – “Easily understandable, work acceptable untruthfulness is more useful than complicating and incomprehensible truth” (Bloch, 1998).

Many students, because of the complexity of certain items from science, do not understand the theory, principles and terminology. Therefore, it is sometimes necessary to reformulate of teaching contents in order to explain natural phenomena. Moreover, this leads to deviation from the basic didactic and methodological principles. For example, the term ozone hole is taken literally by most students; it is the “hole” in the atmosphere. For a student the greenhouse represents a “*big glass*” like a greenhouse, which hangs in the atmosphere and reflects the sun's rays. These examples directly derive from life experience (Stojkovic, 2012).

*Mann's law (general)* is: “If a scientist discovers a bombast fact, it becomes central to his theory. His theory will, in turn, become central to the whole scientific thought” (Bloch, 1998).

It is also necessary to explain to students which theories had a significant impact on the development of scientific thought and had been valid and central to science, before another theory. For example, the effluence of Dalton's atom theory in the 19th century, regardless of theory which is very old, 2500 years, which comes from ancient Greek, philosopher Leucippus (Leucippus, 5th century BC) and Democritus (Democritus, 460 – 370 BC) (atomos-smallest, indivisible particle) (Mandić et al., 2005). Then, experiments with the breathing of living beings, Anton Lavoisier (Antoine-Laurent de Lavoisier, 1743–1794) together with the famous mathematician and astronomer Pierre Laplace (Pierre-Simon, Marquis de Laplace, 1749 – 1827), who confirmed that breathing process is combustion, which, as Lavoisier claimed, occurred in the lungs, not in the tissues (Vićanović-Draškić, 2002)..

More precisely, events, comic, funny, unforeseen circumstances from everyday life, practice and scientific work could serve as the basis for the formulation, and creation of new postulates of Murphy's law.

#### *Definition of the new Murphy's law postulates*

During one of the lectures at the ATEE Conference in Braga, opening of a bottle of mineral water (after long shaking) caused a strong burst due to the release of gas, which resulted in a brief interruption of lecture due to the effect of Chatelier's principle “*if a system in chemical equilibrium is subjected to a disturbance or constraint (such as a change in pressure, temperature, or concentration of a reactant), it tends to change in a way that opposes this disturbance. The equilib-*

*rium will shift so as to tend to counteract the effect of the disturbance*” (Sharp, 2003), and laughter of the present colleagues. The impact of external factors on the lecture takes moves in the direction of shortening the duration of lecture and thereby preventing any further (un)wanted external factors, which is inversely proportional to the participants.

This represents not only a humorous version of the Chatelier’s principle according to Murphy’s Law postulates, at social events, but also proves that similar situations make scientific work more interesting. In addition, they can be a strong motivating factor, the source of a spiritual creativity, for further research and scientific work.

#### *Humour in natural science*

Humour in teaching can intensify the activity of students, but also help in student-teacher-student communication. The comical segments are related to: sketches, jokes and anecdotes from the lives of famous scientists (Stojkovic, 2011).

Despite the large number of jokes and anecdotes about mathematics and natural science as well as teaching topics and lessons, the pupils’ answers, solving tasks in school or at home can be, as teaching practice shows, extremely humorous, funny and mischievous. In addition, this shows the state of mind and creativity of students but not the knowledge about laws or theories. Without doubt students with exceptional creativity are capable of achieving better and bigger results in the teaching of natural science. The purpose of this should be to motivate students.

No matter whether answers are right or wrong, they should be collected, and the humorous solutions discussed with students. They can certainly be a positive factor and inspiration for teaching science, especially among the students who show weaker achievements.

The success of the use of comic elements will largely depend on the ability and talent (sense of humour) of the teacher, as the creator of “atmosphere” in class (Halveka, 2000).

#### *Humour in mathematics*

Mathematics (as a theoretical discipline, applied science) offers a large selection of humorous elements (jokes, anecdotes, funny situations etc.) (Fig. 1 a and b) and their implementation in teaching. Because of its close connection to the natural sciences as well as other areas such as engineering, technology, computer science, there are numerous possibilities for the use of elements of humour from mathematics in teaching the subjects: physics and chemistry.

Thus, the teaching of mathematics and other natural sciences enables the use and application of alternative teaching materials, in addition to textbooks. Tests, homework, worksheets, materials from the Internet, other books or from a school magazine could be a source of additional information of processing, understanding and learning, but also the basis for the exploitation and use of school (students’) humour (Fig. 2 a and b) in mathematics teaching.

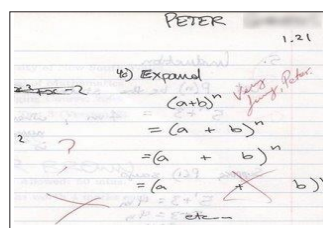


a Fig. 1. Mathematical jokes<sup>1)</sup>

3. Find x



a



b

Fig. 2. School or students' mathematical humour – comic students' answers from mathematical tests<sup>2)</sup>

### *Humour in physics, biology and chemistry*

Characteristically, various discoveries in natural sciences (physics, biology and chemistry) took place as a result of lucky coincidences or when solving problems, on the principle of serendipity (according to the story under the title: “*The three princesses of Serendip*” (Donald, 2003)).

Life and work of the famous physicists (like Einstein and Schroedinger) (Gleđić, 2007), anecdotes and funny situations from their lives can be useful in teaching physics. Jokes and anecdotes on the topic of physical laws and principles (gravity, electromagnetism), quantum theory, microcosms and its building blocks can serve as a basis for their understanding.

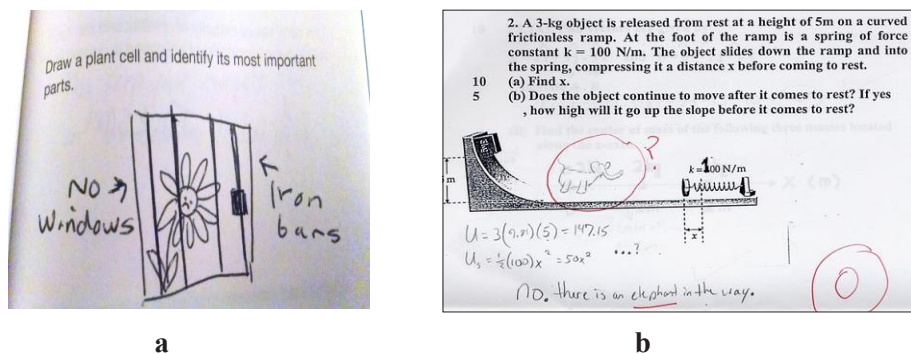
The source of anecdotes and funny events can certainly be biographies of famous scientists, available on the Internet, in addition to books and popular science magazines. In finding and preparing the information from the life of famous scientists, before lessons, students are also engaged. Interesting facts and details from the biography of the scientist's humorous character, especially in terms of their research work, the problems they faced during experimentation, does not represent only a comic element, but also approaching and understanding the meaning and application of scientific theories, definitions, and concepts in everyday life.

For example, the emergence and development of the microwave oven is a product of a completely random action of the microwave from radar device that caused melting of chocolate of Chief Engineer and the appearance of stains on his trousers. This led to the experimentation with popcorn and explosion of an egg directly into the face of the main engineers and assistants. Then, the invention of the telephone as a result of the translation error of an article from German to English, and theft of the original patent of the telephone. (Donald, 2003).

Biology offers a selection of various jokes related to the living world around us (Figure 3a, left), ecology, botany and zoology, which are very popular among students. Many discoveries in medicine and pharmacy that occurred quite by accident (the invention of penicillin) (Donald, 2003) have been defined and implemented under the rules of (unscientific) Murphy's law.

An example of this is the life and work of Charles Darwin (1809 – 1882), not only as a famous biologist, but also a protestant priest and devotee of geology, which is marked by a series of random, unpredictable and quite comical situations during the famous five-year Galapagos expedition (1831 – 1836), which led to the definition of the theory of evolution. The discovery of the bacteria Botulus (eng. Sausage) was actually a consequence of poisoning epidemics in the German city Wuerttemberg after a degustation of sausage, and smoking ham in a small Belgian village. One of the first elixirs against scurvy was an idea of a British colonial admiral, a mixture of rum and lime juice (Grog, named after the captain's jacket Grogram; it was made of wool and silk) (Donald, 2003).

Chemistry teaching offers great possibilities of using humorous contents (Fig. 3 a and b), which is reflected in the presentation of the funny side of scientific research, explanation of theories, composition and structure of molecules, chemical equations, and many discoveries in chemistry, etc.



**Fig. 3.** Humour in biology and physics – humorous students' solutions of the task from homework and worksheets<sup>3)</sup>

The discovery of ozone ( $O_3$ ), allotropic modification of oxygen ( $O_2$ ), is a side effect of the electrolysis of water, whose scent reminds of the scent of the air during and after a storm. Finding of cellulose and explosive substances is linked to an unexpected outcome of experiments with a mixture of nitric ( $HNO_3$ ) and sulfuric acid ( $H_2SO_4$ ) and one dishtowel. The synthesis of artificial colours is the result of a lack of natural resources for producing drugs against malaria (quinine), drinking gin and tonics, and mercury (Hg) from a broken thermometer accidentally during the lab procedure for synthesis of aniline, which led to the collapse of the British monopoly on the production of indigo (Donald, 2003).

Also, it is necessary to encourage and enable students to perform sketches or, in consultation with other teachers and students during the school year, organise a special lesson (*“Hour of Humour”* or *“Funny Chemical Theatre”*) (Stojkovic, 2011). In sketches, students could play famous scientists, their teachers, or other students in various comic situations from school, life, etc (Stojkovic, 2011). This not only encourages creativity and innovation, but also increases interest of students to learn the natural sciences, putting them in the position of researchers, scientists, confronting and getting to know the basics and problematic of scientific work.

Teaching topics in chemistry can be processed not only using Murphy’s law postulates, but also the implementation of jokes and anecdotes.

#### *Humour in films, TV series, books and cartoons*

Elements of humour from films, TV series, school TV programmes, cartoons, school journals, magazines, comic books, and the internet could also be used in science teaching during the processing of various teaching topics. First, it is necessary to select those teaching contents which are based on the facts of scientific theories and hypotheses, research; then, adapt the selected contents taking into consideration the age, needs, and interests of the students.

Among numerous films, books, TV shows, TV series from school education programmes it is necessary to choose



Fig. 4. Jerry Lewis in the role of Nutty Professor<sup>4)</sup>

representatives and most popular examples, which include humorous, interesting, entertaining and funny contents, and deal with the issues and problems of modern natural science.

Within film movies an example is *Nutty Professor* (1963, 1996 and 2008) (Fig. 4): whose main topic is an epic discovery of a mysterious chemical formula, created in a laboratory of an eccentric professor of biochemistry (Film the Nutty Professor n. d.). This “magic” formula enables the total transformation of one personality to another (the modern version of the classic work “*Strange Case of Dr Jekyll and Mr Hyde*”, 1886 by Robert Louis Stevenson, 1850 – 1894) (Dr. Jekyll and Mr. Hyde Plot Overview n. d.) (Table 1).

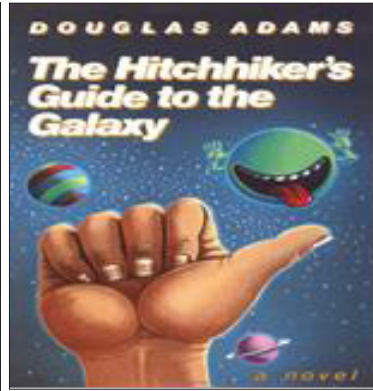
*Back to the Future I, II and III* (1985 – 1990) (Fig. 5): is considered to be one of the most popular films ever made. Its main subject is the invention and use of the car-time machine, where the main protagonists, a failed rock musician and an eccentric scientist, experience a series of life threatening and comical situations (Back to the Future 1985 n. d.; Back to the Future Part II 1989 n. d.; Back to the Future Part III 1990 n. d.). It represents a parody of certain topics in physics, especially the theory of relativity (Table 1).

**Table 1.** Humour in films, TV series, books and cartoons

| Film                                                                                                            |                                                                                                                         | Book                                                                                                                           | TV Series                                                                                                                                                    | Education TV Programme                                                                                               |
|-----------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|
| Nutty Professor                                                                                                 | The Hitchhiker's Guide to the Galaxy                                                                                    | Back to the future I, II and III                                                                                               | Big Bang Theory                                                                                                                                              | Stargazing                                                                                                           |
| Genre                                                                                                           |                                                                                                                         |                                                                                                                                |                                                                                                                                                              |                                                                                                                      |
| comedy                                                                                                          | SF Comedy                                                                                                               | SF Comedy/ Parody                                                                                                              | Comedy/sitcom                                                                                                                                                | popular science                                                                                                      |
| Teaching subjects                                                                                               |                                                                                                                         |                                                                                                                                |                                                                                                                                                              |                                                                                                                      |
| Chemistry/ biochemistry – organic synthesis, DNK, proteins, pharamacology – synthesis of new organic compounds. | Physics – theory of relativity, time travel, quantum physics, chemistry, technology – alternative form of energy/fuels. | Murphy's Law, cosmology, physics, chemistry, biology, space travel, alien life form, origin of space and life, philosophy etc. | Mathematics, physics – quantum physics, chemistry – quantum chemistry, new technology, aerospace engineering, biology/ microbiology, medicine, astrophysics. | Astronomy, planetology, cosmology, astrophysics, astronautics, space technology, Cosmo- and geochemistry, geography. |



**Fig. 5.** Michael J. Fox (as Marty McFly) and Christopher Lloyd (as Emmett Lathrop “Doc” Brown) in the film “*Back to the Future II*”<sup>5)</sup>



**Fig. 6.** The front or title page of the Book “*The Hitchhiker's Guide to the Galaxy*” (Author, Daglas Nöel Adams, 1952–2011)<sup>6)</sup>

As for books, an example would be: *The Hitchhiker's Guide to the Galaxy* (1978): (Fig. 6): is a kind of Murphy's law version, first of all, a parody of life, science, philosophy, religion (*The Hitchhiker's Guide to the Galaxy* n. d.), by structure very similar to the Monty Python's *Flying Circus* (1969 – 1974). According to this book, a film under the same name was filmed (2005) (Film *The Hitchhiker's Guide to the Galaxy*) (Table 1).

Within the TV series: *The Big Bang Theory* (2007 –) (Fig. 7), a very popular comic series of recent production, where story unfolds around a group of friends (in the jargon: geeks and nerds); they are physicists, an aerospace engineer and astrophysicist (*The Big*



**Fig. 7.** Scene from the TV series “*The Big Bang Theory*”<sup>7)</sup>

*Bang Theory* n. d.). This series is rich with geeks on the subject of quantum physics, technology, mathematics, and science in general. In addition, it is a parody of the popular sci-fi series, “*Star Trek*” (Table 1).

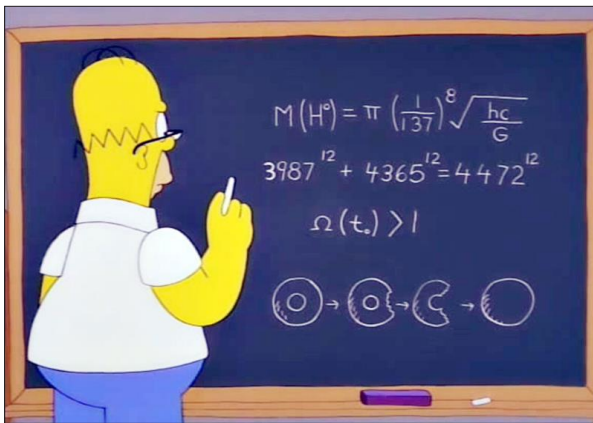
As example of TV series of educational programmes *Stargazing* (2011–2015) (Figure 8): the educational documentary

(live show) from the BBC production, which deals with topics from astronomy (Stargazing Live BBC Two n. d.). In addition to this series they broadcasted a special edition dedicated to children and youth (CBeebies Stargazing BBC 2015) (Table 1).

The best indicator, an example of this, where various scientific issues are primarily processed, through the prism of humour and parody though, is the Simpsons TV cartoon series. The

Simpsons represent one of the most popular, most watched and longest broadcast cartoon series for adults and young people in the world. Although it is about the comedy and the parody of modern society, school and political systems and the world today, this TV series also deals with academic and scientific topics. Particular topics that are processed and discussed are mathematical theorems (jokes about calculus, pi and Fermat's last theorem) (Clark, 2015).

It is little known that in the episode "*In the Wizard of Evergreen Terrace*" (1998)



**Fig. 9.** Homer Simpson has solved Higgs Boson mathematical equation (season 10, the second episode)<sup>9)</sup>



**Fig. 8.** Dr. Brian Cox and Dara Ó Briain, the presenters of the live show "*Stargazing*"<sup>8)</sup>

(Fig. 9) occurs the solution of mathematical formulas for the Higgs boson—14 years before the announcement by CERN. For high scientific standards, ideas and scientific discoveries in the TV series have been delegated to experts, professors and researchers from universities in America, who are hired by the production of TV series as expert advisers. Some of the episodes were dedicated to the world-renowned scientists, inventors and astronauts, such as Stephen

Hawking, Steven Jay Gould, Elon Reeve Musk and Buzz Aldrin. In addition, a number of discoveries, patents, new technologies, ecological fuel, are dealt with.

So watching the series, films TV programmes, reading books and magazines does not only mean enjoying the unique entertainment for all generations but also acquiring the basic foundation for learning natural science through humour and fun.

### **Concluding remarks**

All over the world, students' interest in the natural sciences has been decreasing (Osborne et al., 2003; Stefanova et al., 2010; Najafi et al., 2012; Aina & Akanbi 2013). One of the many opportunities to increase interest and popularise natural science among children and youth lies in the intensive implementation of elements of humour in the teaching. Therefore, it is necessary to prepare, develop, try out teaching and didactic materials with humorous elements, and strive to increase the volume of humorous contents during the processing of teaching lessons and units, as well as its introduction into the teaching curriculum. The importance of humour is not reflected in its application in teaching with a pedagogical-psychological-didactic-methodological point of view, but it rather has a universal character. Humour contributes to overcoming the cultural, social, economic, generational barriers and differences among pupils and teachers.

The main aim of using humour is to popularise the natural sciences among students and young people. Regardless of the unscientific foundation of Murphy's law, its principles could increase interest in science, as well as increase understanding regarding the complexity of scientific and scholarly research. In particular, the comic situations in the lives of famous scientists, accidental discoveries, and unpredictable outcomes of experiments reveal the influence of serendipity factors, unpredictable and lucky circumstances in science and research work. Elements of humour from written media such as magazines and journals, as well as electronic media such as TV and the Internet can strongly motivate students to learn about the natural sciences.

### **Implication to teacher education**

Interests of modern teaching are primarily the improvement of the overall quality of teaching, adapting educational contents to the needs and interests of students, popularization of natural sciences, openness to implementing new ideas and freedom of choice of teaching contents (Stojkovic, 2011): the use of humour and Murphy's law in science teaching.

In addition, the role of teachers as initiators, motivators and creators of teaching atmosphere is of great importance. Constant innovation, cooperation, creative work, personal interests and skills of teachers are prerequisites for students' opportunity to approach natural phenomena in an interesting, entertaining, funny and popular way. A teacher's role in the creative field of work, as a methodologist,

motivator, mentor, designer of the teaching environment, innovator and researcher, would be aspiration towards new ideas (openness to change). This means that their task is to cooperate and exchange ideas with other colleagues in order to modernise and improve teaching (Halveka, 2000).

There is not only need to apply elements of humour to the teaching process, but also to prepare and create teaching and didactic materials on this topic. Therefore, there is need for an intensive and comprehensive investigation of the use of humour in the teaching of natural sciences, primarily at an international level, with the participation, involvement and cooperation with foreign colleagues, in order to popularise the natural sciences, under the slogan “*Science can be fun.*”

**Acknowledgments.** The idea and inspiration for writing the article on the topic of humour and Murphy’s Law derives from the teaching practice, a number of voyages, participation in conferences, seminars, held lectures, presentations, also from life, and a close encounter with a variety of “*bad luck*” situations. The article is based on the poster presentation from 2015 at the 40<sup>th</sup> Annual ATEE Conference at the University of Glasgow.

## NOTES

1. a [http://www.mathematicianspictures.com/images\\_mugs/CMUG\\_179W\\_MATH\\_ST\\_MPWH\\_3300.jpg](http://www.mathematicianspictures.com/images_mugs/CMUG_179W_MATH_ST_MPWH_3300.jpg)  
b <https://s-media-cache-ak0.pinimg.com/736x/97/21/f1/9721f1e6e-02ace8c5688e60019df919e.jpg>
2. a <https://brianmlucey.files.wordpress.com/2014/08/findx.jpg>  
b <http://mathproblems.info/images/math5.jpg>
3. a <http://i3.kym-cdn.com/photos/images/original/000/736/964/1fb.jpg>  
b [http://board.raidrush.ws/anhang/43928/377437969\\_d0f88c6342.jpg](http://board.raidrush.ws/anhang/43928/377437969_d0f88c6342.jpg)
4. <http://uploads.neatorama.com/images/posts/208/70/70208/1394687189-0.jpg>
5. <http://www.pufferfishdisplays.co.uk/wp-content/uploads/2014/01/Stargazing-4.jpg>
6. [http://vignette4.wikia.nocookie.net/hitchhikers/images/1/11/The\\_Hitchhiker's\\_Guide\\_to\\_the\\_Galaxy.jpg/revision/latest?cb=20140520174710](http://vignette4.wikia.nocookie.net/hitchhikers/images/1/11/The_Hitchhiker's_Guide_to_the_Galaxy.jpg/revision/latest?cb=20140520174710)
7. <http://filmconcertslive.com/wp-content/uploads/2015/02/BTTF2.jpg>
8. [http://vignette3.wikia.nocookie.net/bigbangtheory/images/0/05/Leonards\\_Labor.jpg/revision/latest?cb=20120223131633&path-prefix=de](http://vignette3.wikia.nocookie.net/bigbangtheory/images/0/05/Leonards_Labor.jpg/revision/latest?cb=20120223131633&path-prefix=de)
9. <http://www.geek.com/wp-content/uploads/2015/03/o-SIMPSONS-570.jpg>

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