PHD THESES

DEVELOPING MOTIVATIONAL STRATEGIES IN PHYSICS EDUCATION

NAGY ANETT

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2005

1. SCIENTIFIC BACKGROUND, PURPOSE OF INVESTIGATIONS

"Pure logical thinking cannot yield us any knowledge of the empirical world, all knowledge of reality starts from experience and ends in it." (Albert Einstein)

Physics as a natural science seeks to answer the questions that arise in the world around us. Our knowledge of Physics helps us understand natural phenomena and the important effects influencing human life.

Still, presently, the standing and the popularity of Physics as a school subject, is negative both in Hungary and abroad. Recently many scientists and teachers have endeavoured to change this disadvantageous situation by developing more and more up-to-date methods. Of course, no best solution exists and most probably the future will not bring us a one and only method that will in all circumstances encourage students to gain enough impetus for their academic efforts. In my study therefore I introduce and analyse several motivational tools that have the potential to increase the popularity of Physics as a school subject at various levels and in various circumstances.

In the first part of my work I summarise the findings of national and international studies. While outlining the significant international studies encompassing several countries, I highlight the findings of research into the testing of students of the subjects, paying special attention to the knowledge of natural sciences and the popularity of these subjects.

The aim of the second part of my paper is to interpret the concept of learning motivation and to explore its pedagogical application. During a theoretical overview I introduce the development of the concept of learning motivation leading up to its present interpretation. I compare the various definitions of learning motivation, their similarities and differences.

In the third part of this work I focus on potential motivational strategies that assist the students in a better understanding of Physics and also encourage teachers to make the subject more interesting. Following the short description of each strategy is an example as illustration.

One of the fields of motivation is the usage of simple everyday objects in the Physics lesson. This gives a chance for the student to relate the lesson content to reality. I collected or adapted experiments that can be carried out with the help of simple tools available even at the students` home.

Using simple tools for experiments has been present many times in the history of teaching and popularising Physics as a result of scientist-teachers` work. In the next part of my thesis I detail the interesting experiments conducted by two such famous scientists.

Games in teaching Physics is not a novelty, which I prove in a short overview of the literature. Games can both raise and sustain students` interest, while examining the physical background, they can be used to raise simple and complicated issues and they also give us the opportunity to carry out qualitative or quantitative experiments.

Choosing the right topic is fundamental in shaping students` attitude towards a subject therefore it is essential that Physics as a school subject adapts to the new expectations of our society. In order to describe a new approach to choosing the right topic, I have chosen a short segment of the Physics syllabus, i.e. discussing the conservation of momentum. In this part of my paper, besides introducing experiments modelling simple and more complex phenomena, I collected samples of facts as well as interesting details from the history of the science, and examples from the animal kingdom and Biology.

Besides the motivational tools used in the lesson, there is also a possibility to raise and sustain students` interest outside the classroom. I have organized and launched a competition entitled Let's play with Physics!. The aim of this competition is not to make students solve calculation tasks but to lead them to a better understanding of the world around us, to popularise Physics through the use of simple tools and experiments that can be conducted at home. A topic presented in an interesting manner, a logical lesson plan helps the student

acquire knowledge more quickly and solidly, but the learning process itself can also be improved and speeded up.

Motivating students is not only important in the secondary school but also in higher-education, since demotivation from sciences even at lower levels can be experienced there too. During our research we have attempted to find a remedy to this tendency, and we developed the syllabus for Complex Science Training, which targets to shape a complex perception of trainee teachers of sciences. In my paper I describe one of the most significant elements of the research work, that is the Science lab, which discusses some very important everyday topics in a practice-oriented way from an integrated scientific point-of-view.

II. SUMMARY OF RESEARCH FINDINGS

1. In my research I examined and, from a methodological aspect, classified the different motivational strategies (procedures to enhance students' interest) that can be successfully applied in Physics Education in the different age groups. My focus was on students' experiments in the Physics classroom and through their experiments, the positive impacts on their attitude towards the subject, which have been documented in Hungarian and international studies (3).

2. After consulting the relevant literature, I collected, adapted and developed experiments that can be performed with simple, everyday objects available even at the students' home. Therefore, students could link the notions studied in Physics lessons to reality, and teachers were provided with some help as to how students could carry out experiments with simple objects. To broaden students' knowledge in Physics, these experiments can be interpreted, explained and applied at different levels according to the age group of students (4, 10).

3. I tried and tested all the experiments collected and improved in real school environment (the Physics classroom). In addition to my publications, I have held lectures on several occasions to students of all ages – from the upper primary to the university level. To promote and ensure the wider use of experiments in the Physics classroom, I annually held a presentation on experiments with everyday objects at the Meeting of Hungarian Secondary School Physics Teachers. (11)

4. "Outdoors" is a new trend in the teaching of natural sciences. As the first Hungarian applier of the method's philosophy, I organized and launched "Let's Play Physics" in Southern Hungary. This is an experiment competition that students can enter directly, independently of their primary or secondary schools. "Let's Play Physics" aims not at completing quantitative exercises, but at discovering the world around us, at popularising Physics through everyday objects and through experiments that can be conducted at home (7, 8, 12, 15).

5. I represented Hungary at the "Physics on Stage" international educational conferences, which aimed at changing the presently disadvantageous position of Physics with the participation of educational politicians, experts and a great variety of European Physics teachers. The members of the Hungarian delegation for the prestigious "Physics on Stage" conferences were appointed every year through a series of national selection conferences upon the applicability of the materials to be used in the Physics classroom presented to a board of examiners. My experiments presented at the national selection conferences, upon

the decision of the board of examiners, have proved suitable for representing Hungary in the past three years at this international conference. (2, 9)

6. Given the knowledge of motivational strategies, I worked out a supplementary material for the teaching of the conservation of momentum, an area of mechanism. This new approach of teaching the different areas of the subject encompassed around one particular topic is a novelty to the traditional structure. Teaching the different areas of Physics structured in groups of topics is an opportunity for reviving the less motivated students' interests by showing several various aspects of the same topic. Apart from the experiments modelling simpler as well as more complicated phenomena, I also collected data and interesting details from the history of science, the animal kingdom and Biology. In my study I am going to show a way how, beyond the facts, this chapter of Physics can be expanded and improved with different motivational strategies that, in harmony with the students' different background knowledge due to their age differences, can ensure differentiated lessons as well. (5, 10, 14)

7. Games in teaching is a great motivating factor as, through games, those students can get motivated whose attitude towards Physics is below the average. As an example, I examined the movement of a yo-yo. I examined the stability conditions of movement by changing the parameters of an unfixed rigid body that revolves round an axis (a yo-yo). I determined the correlation between the rectangular yo-yo's stable revolving and the parameters of the yo-yo. I proved the accuracy of the statement with experimental results. (11, 13)

8. I participated in a Faculty educational experiment funded by KOMA (Public Foundation for the Modernization of Public Education). We developed a syllabus for Complex Scientific Training. The objective of the training course is to shape a complex perception of trainee teachers of sciences through using and connecting the teaching materials of different science subjects. I took part in a decisive element of the training programme, the development of a Science laboratory that would focus on several key issues of our everyday lives through an integrated scientific aspect in a practice-oriented way. In organizing the laboratory, I used both the project method and the method of teamwork, by this means encouraging the participating students. (1, 3, 6)

9. Introducing Physics as a science of measure in the Physics classroom is not easy (due to lack of tools and time). When developing experiments, I examined through different geometric models in detail the transmission characteristics of standing waves evolving in the air. In the study of resonance-cases, in one particular setting (a glass pipe and a tuning fork) it was possible to examine the role of the geometric data (length of pipe and diameter of pipe) and the value of the final correction factor. Upon my experiments, some of the resulting values were the same as those determined in the international scientific literature, whilst some proved different. (13)

10. An example for a quantitative exercise, conducted with simple, everyday objects (substances), is the studying of bubbles in liquids. I examined in great detail the size change of a carbon dioxide bubble as a function of time, and through an experiment, determined the growth-rate of the bubble diameter. By further experiments, I observed the movement of bubbles and determined the bubble acceleration by applying two methods. My results proved the theoretically defined connection between the bubble radius and its rise velocity.

III. Publications and lectures related to this thesis

1. Papp, K. Nagy, A.: *Complex Science Education in Gradual Teacher Training*. In: Quality Development in Teacher Education and Training, 2nd International GIREP Seminar 2003 Selected Contribution, Forum, Udine, 2004. 314-319.

2. Nagy, A. Papp, K. Molnár, M.: *Gyorsabban, magasabban, erosebben.* Fizikai Szemle 2004/3. 97-106.

3. Papp, K., Nagy, A.: *Tanár szakos hallgatók komplex természettudományos ismereteinek fejlesztése – egy oktatási kísérlet elso tapasztalatai,* Iskolakultúra, 2004/04. 29-41.

4. Papp, K., Nagy, A.: *Hungarian teachers with suitcases full of 'treasures'.* Physics Education, September 2003. 448-451.

5. Papp, K., Nagy, A., Miklós, M., Bohus, J.: *Two unforgettable experiments of Hungarian scientists*. Physics Education, September, 2003. 385-387.

6. Papp, K., Nagy, A.: *Complex science education in gradual teacher training.* „Quality Development in Teacher Education and Training" Second International Girep Seminar 2003. 54.

7. Papp, K., Nagy, A.: *Simonyi Károlyra emlékeztünk Szegeden.* Természet Világa, 2002. november. 175-176.

8. Nagy, A., Papp, K.: *Játsszunk fizikát! – Simonyi Károly Emlékverseny.* A fizika tanítása, Mozaik Kiadó, 2003/1. 8-13.

9. Nagy, A.: *A fizika színre lép - magyar szemmel*. A fizika tanítása, Mozaik Kiadó. 2002/4, 19-25.

10. Nagy, A., Papp, K., Molnár, M., Bohus, J.: *A fizika nagyszeru, mert egyszeru.* A fizika tanítása, Mozaik Kiadó. 2002/4, 13-19.

11. Papp, K., Nagy, A., Molnár, M., Bohus, J.: *Physics is mighty as it is easy.* Developing Formal Thinking in Physics" Selected Contributions, Editrice Universitaria Udinese, Italy, 2002. 236-239.

12. Nagy, A.: *Játsszunk fizikát! - Gábor Dénes nyomában. Kísérletes verseny fizikából.* A fizika tanítása, Mozaik Kiadó. 2001/4, 22-25.

13. Papp, K., Nagy, A., Molnár, M., Bohus, J.: *Physics is mighty as it is easy.* „Developing Formal Thinking in Physics" First International Girep Seminar, 2001. 42

14. Bohus, J., Nagy, A., Papp, K.: *Egy kis múltidézés: két „elfelejtett" kísérlet.* Módszertani lapok, 2000. 6. évf. 4. szám, 33-36.

15. Papp, K., Nagy, A.: *Kísérletes verseny fizikából: Játsszunk fizikát - Jedlik nyomában.* A fizika tanítása, Mozaik Kiadó, 2000/4. 11-13.

POSTERS:

1. *Módszertani morzsák – mnemotechnika az iskolában (Mnemotechnics in Schools)*
   III. Pedagogical Conference, Budapest, October 9-11. 2003.
2. *Szesz(ély)es fizika ("Alcoholic" experiments)*
   II. Pedagogical Conference, Budapest, October 24-26. 2002.
3. *Faster, higher, stronger*
   Tavaszi szél, DOSZ Conference, Gödöllo, April 13. 2002.
4. *Motivációs stratégiák a fizika tanításában (Motivational Strategies in Physics Education)*
   Tavaszi szél, DOSZ Conference, Gödöllo, April 14. 2002.
5. *Faster, higher, stronger*
   Physics on Stage 2, Noordwijk, Hollandia,. April 2-7. 2002.
6. *Motivációs kísérletek 10-14 éves diákoknak (Motivational Experiments for pupil)*
   I. Pedagogical Conference, Budapest, October 25-27. 2001.
7. *A fizika nagyszeru, mert egyszeru (Physics is mighty as it is easy)*
   Tavaszi szél, DOSZ Conference, Gödöllo, April 20-22. 2001.
8. *A Játsszunk fizikát - Gábor Dénes verseny (Play with Phsyics –Dennis Gabor Competition)*
   44. National Conf. for Secondary School Physics Teachers, Gödöllo, April 7-11. 2001.
9. *Physics is mighty as it is easy*
   Physics on Stage, Genf, Svájc, November 1-6. 2001.

LECTURES:

Egyszeru kísérletek (Simple experiments)
Nagy László Physics Competition, Final, Kazincbarcika, March 4. 2005.

Science Laboratory
Physics on Stage 3, Focus on Teachers, The Netherlands. November 7-11. 2003.

Természettudományos laboratórium (Science Laboratory)
Physics on Stage 3, National Conference. Székesfehérvár, September 13. 2003.

Science Laboratory
2nd Girep Seminar, Udine, Italy, September 2-7. 2003.

Noies kísérletek (Feminine experiments – not only for women)
Meeting of Physics Teachers, Csongrád county, Szeged, May 12. 2003.

Játsszunk fizikát! - Egyszeru kísérletek (Let's Play with Physics – Simple experiments)
Physics afternoon, Cseresznyés kollégium, Hódmezovásárhely, May 7. 2003.

Noies kísérletek – Nemcsak noknek!(Feminine experiments – not only for women) (I. Prize),
46th National Conf. for Secondary School Physics Teachers, Esztergom, April 14. 2003.

Optikai csalódások (Optical Illusions)
Experimental Competition in Physics, Szeged, March 1. 2003.

Játékos kísérletek (Playful Experiments)
Weöres Sándor Primary School, Szeged, February. 24. 2003.

Szeszélyes fizika (Alcoholic Experiments)
Summer Academy, Újvidék, July 9. 2002.

Faster, higher, stronger
Tavaszi szél, DOSZ Conference, Gödöllo, April 13. 2002.

Egyszeru tanulói kísérletek (Simple Pupil Experiments)
Radnóti Miklós Grammar school, Szeged, April 8. 2002.

Gyorsabban, magasabban, erosebben (Faster, higher, stronger)
45th National Conf. for Secondary School Physics Teachers, Salgótarján, March 26. 2002.

Érdekes jelenségek - egyszeru kísérletek (Ineteresting Experiments)
Lat's Play Physics! -Simonyi Károly, Szeged, March 8. 2002.

Rakéta-elv kísérletekben (Rocket-principle with experiments)
Experimental Competition in Physics, Szeged, March 2. 2002.

Gyorsabban. magasabban, erosebben (Faster, higher, stronger)
Physics on Stage 2, National Conference. Székesfehérvár, February 17. 2001.

Physics is mighty as it is easy
First Girep Seminar, Udine, Italy, September 5. 2001.

Csoportos tanulói kísérletek folyadékokkal (Pupil Experiments with liquids)
Physics Camp, Deszk, June 20. 2001.

Terülj, terülj asztalkám - kísérletek konyhai eszközökkel (1st. Prize) *(Experiment in the Kitchen)* 44th. National Conf. for Secondary School Physics Teachers , Gödöllo, April 7-11. 2001.

Kísérletek folyékony nitrogénnel (Experiments with liquid nitrogen)
Experimental Competition in Physics, Szeged, March. 24. 2001.

Rejtélyek és buvészmutatványok a fizikaórán (Misteries and Tricks in Physics Classroom)
Cseresnyés kollégium, Hódmezovásárhely, March 22. 2001.

Játsszunk fizikát! - Egyszeru kísérletek (Let's Play with Physics – Simple experiments)
Gabor Dennis Competition, Szeged, March 2. 2001.

Physics is mighty as it is easy
Physics on Stage Conference, Genf, Switzerland, November 1-6. 2000.

A fizika nagyszeru, mert egyszeru (Physics is mighty as it is easy)
Physics on Stage 2, National Conference, Székesfehérvár, sSptember 23. 2000.

Rejtélyek és buvészmutatványok a fizikaórán (Misteries and Tricks in Physics Classroom)
43rd National Conference for Secondary School Physics Teachers, Keszthely, April 18. 2000.

Játsszunk fizikát! (Let's Play Physics)

Jedlik Ányos Competition, Szeged, February 26. 2000.

Kellenek-e a "buvészmutatványok"? (Do we need tricks?)
National Meeting of Teachers in Science Education, Debrecen, October 28. 1999.

Rejtélyek és buvészmutatványok a fizikában (Misteries and Tricks in Physics Classroom)
József Attila Grammar-school, Makó, April 21. 1999.

*Rejtélyek és buvészmutatványok a fizikaórán, Játékos kísérletek (*I. díj) (*Misteries and Tricks in Physics Classroom)* OTDK Conference, Nyíregyháza, April 1. 1999.

Rejtélyek és buvészmutatványok a fizikaórán (Misteries and Tricks in Physics Classroom)
TDK Conference, SZTE, Szeged, November 3. 1998.

CONFERENCES:

Physics on Stage 3. November 8-15. 2003.

III. Pedagogical Conference, Budapest, October 9-11. 2003.

Physics on Stage 3, National Conference, Székesfehérvár, September 12-14. 2003.

2nd Girep Seminar, Udine, Italy, September 1-6. 2003.

46th. National Conf. for Secondary School Physics Teachers, Esztergom, April 12-16. 2003.

II. Pedagogical Conference, Budapest, October 24-26. 2002.

Summer Academy, Újvidék, July 9. 2002.

Tavaszi szél, DOSZ Konferencia, Gödöllo, April 12-14. 2002.

Physics on Stage 2, Noordwijk, the Neherlands, April 2-7. 2002.

45th. National Conf. for Secondary School Physics Teachers, Salgótarján, March 24-27. 2002.

Physics on Stage 3, National Conference, Székesfehérvár, Februray 2-4. 2002.

I. Pedagogical Conference, Budapest, October 25-27. 2001.

1st International Girep Seminar, Udine, Italy, September 2-9. 2001.

Tavaszi szél, DOSZ Coneference, Gödöllo, April 20-22. 2001.

44th. National Conf. for Secondary School Physics Teachers, Gödöllo, April 7-11. 2001.

Physics on Stage Conference, Genf, Switzerland, November 4-12. 2000.

Physics on Stage, National Conference, Székesfehérvár, September 22-24. 2000.

43. National Conference for Secondary School Physics Teachers, April 16-20. 2000.

National Meeting of Teachers in Science Education, Debrecen, October 27-29. 1999.

OTDK Conference, Nyíregyháza, March 31. - April 2. 1999.

TDK Conference, University of Szeged, November 20. 1998.