"STUDY OF ATMOSPHERIC PRESSURE" - A PROJECT UTILISING REMOTE EXPERIMENTS

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Abstract: The paper presents an application of Integrated e-Learning (INTe-L) in the project-based learning in university environment. It introduces the project assignments in Mechanics for the bachelor students majoring in "Teaching General Subjects". An important component of the educational process is laboratory work comprising an assignment targeted at the study of atmospheric pressure in a selected month in the towns of Trnava, Prague and Porto via real remote experiments on the Internet. The project steps include: collecting a certain amount of experimental data, processing it into tables and graphs using Origin software, and analysing the results. The implementation of INTe-L strategy into project-based learning in Natural Science and Technology subjects contributes to the integrated education in a highly interactive for

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1 Introduction

A method of Integrated e-Learning [1] based on utilising real, real remote and virtual experiments supported by e-learning materials has been applied for several years in training the students majoring in "Teaching General Subjects" study programmes in both bachelor and master degrees in the Department of Physics, Faculty of Education, University of Trnava. The INTe-L strategy is successfully being used in project teaching through integrating its components into the project assignments in Physics. The INTe-L-based project presented in this paper deals with measuring the atmospheric pressure in a selected period via real remote experiments in the laboratories located at the University of Trnava, Charles University in Prague and University in Porto, and are available free on the Internet.

2 Assigning the project by using the Integrated e-learning

The project topic: Study into the course of atmospheric pressure in a selected month in Trnava, Prague and Porto.
Motivation: Dear students, the objective of this project is the measurement of atmospheric pressure in Trnava (Fig. 1), Prague (Fig. 2) and Porto (Fig. 3). The atmospheric pressure is one of the meteorological issues we are being informed about every day. A human organism is permanently exposed to the effects of atmospheric pressure p_a. The atmospheric pressure p_a cannot be calculated from the relation $p_a = \rho hg$, since the air density changes with elevation. When ascending by 100 m, p_a decreases by approximately 1.3 kPa. Atmospheric pressure p_a changes also within the day. To forecast weather, forecasters have to be familiar with those changes. Do you want to know what the current atmospheric pressure in Trnava, Prague and Porto is? If so, you are welcome to visit the weather stations in real remote experiments at the Departments in three workplaces, located on the Internet: Faculty of Education, University of Trnava, Faculty of Mathematics and Physics, Charles University in Prague, Faculty of Engineering, University of Porto.

Figure 1 Trnava [2]

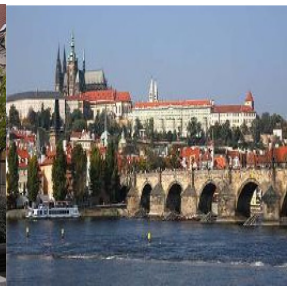

Figure 2 Prague [3]

Figure 3 Porto [4]

Read the project assignments carefully, and then start working. Work out the project on the basis of the knowledge acquired from textbooks, journals, encyclopaedias and consultations with teacher or other experts.

Basic principle of measurement: Atmospheric pressure in Trnava and Prague is measured by means of a manometer, an ISES unit, and is calculated for the sea level (taking into account the correction for the elevation of the place where the probe is located). The weather station in Porto is equipped with a Micromec Logbox centre. The software application collecting and recording the data from the station inside the data-basis (data logger) allows sharing the data on the website with the Internet. This automatically restarts the measuring cycle and synchronises the date and time recorders. The application was developed by means of LabVIEW 8.5.

To access the remote weather stations in Trnava [5], Prague [3] and Porto [6] by the Internet, students can use any web browser (MS Internet Explorer, Firefox, Opera, Netscape etc.) enabling Java support. Java must be installed (can be downloaded free on www.java.com) and active.

The project aim: The project aim is defined by the syllabus context of the subject of Mechanics for the 1st year bachelor degree students majoring in "Teaching General Subjects": physics with combination: mathematics, biology or English language and literature", and comprises the following steps:

- Acquiring information;
- Evaluating the acquired information;
- Discussing, co-operating and proposing solutions;
- Using the Internet and specialised literature to look up further information;
- Collaborating and bearing responsibility for the assigned tasks;
- Processing the information in a selected way;
- Presenting information without the loss of information value;
- Integrating the acquired knowledge into the real environment;
- Distinguishing independent and dependent physics variables;
- Developing language skills in mother tongue and foreign languages.

Time allotted: 1 week.

Skills involved: Students should have mastered the basic PC and Internet operations, work with Word text editor, Excel or Origin, and PowerPoint program.

Background: WWW sites devoted to the topic, Halliday, D. – Resnick, R. – Walker, J. Physics, Part 1 – Mechanics, VUT in Brno, encyclopaedia and other professional literature.

Specific tasks:

a) Collecting specific literature, e.g. encyclopaedia, professional publications, journals, electronic textbooks, etc.

b) Acquiring the materials necessary for the project implementation.
c) Installing Java program into PC.
d) Buying related CD-ROM.

Organisation: Students work in teams of three. After consultations with teacher, each team appoints the following positions:

- **Secretary** – a student who records the acquired information and procedures, and takes notes from teammates.
- **Organiser** – a student who organises the project work and bears responsibility for keeping the workplace clean and neat.
- **Presenter** – a student who presents individual projects to other teams and teacher.

The project venue: Physics classrooms at the Physics Dept., Faculty of Education, University of Trnava, students' households.

Cross-subject relations: Physics, Informatics, Mathematics, Environmental education, Slovak language, English language, Czech language and Geography.

Procedure:

1. Familiarising students with the project topic.
2. Familiarising students with the project objectives and tasks.
3. Selecting the presentation form (poster, PowerPoint presentation, Word doc, etc.).
4. Specifying the way of evaluation.
5. Searching information.
6. Elaborating projects.
7. Presenting projects.
8. Discussing individual projects with other teams.
9. Evaluating the outputs of individual teams.

Task 1:

a) Describe the remote experiments located in Trnava, Prague and Porto, on:
   - http://kf.truni.sk/index.php?option=com_content&view=article&id=59&Itemid=79;
   - http://www.ises.info/index.php/sk/laboratory/experiment/meteorological-station-in-prague;
   - http://experimenta.fe.up.pt/estacaometeorologica/index.php;

   and their arrangement and thing and write about differences.
b) Find the elevation of Trnava, Prague and Porto.
c) Find the values of atmospheric pressure on a selected day, month and year, measured by the weather station located in e-Laboratory at the Physics Dept., Faculty of Education, University of Trnava, website http://kf.truni.sk/.
d) In the displayed graph, observe the local maximum (the maximum value of atmospheric pressure) and local minimum (the minimum value of atmospheric pressure) in a selected period in one-hour intervals.
e) Determine the local extremes and global extreme, mean value and the most abrupt change of atmospheric pressure and the greatest rate of change (slope of pressure function).
f) Arrange the measured values of the atmospheric pressure in Table 1 using Excel or Origin programs.
g) Using the measured values, plot the curve of the atmospheric pressure dependence on the time (one-hour interval) for the given period.
h) Find the mean daily value of the atmospheric pressure $\overline{p_{a1}}$ and plot the graph.
i) Determine the sum of square of the deflections from the mean value and determine the sum of the positive and the negative deflections from the mean value in Table 1.
j) Calculate the standard deflection from the mean value.

Task 2:

a) Compare the course of atmospheric pressure and all the data determined in Task 1 for the same period with the data from the weather station located in the Project e-laboratory at the Faculty of Mathematics and Physics, Charles University in Prague on www.ises.info, and the Faculty of Engineering, University of Porto on http://experimenta.fe.up.pt/estacaometeorologica/index.php.
b) Transfer the measured values of atmospheric pressure into Table 2 in Excel or Origin programs and follows the same scheme of elaboration as in previous (Task 1d) -1 j).

Task 3:

a) Compare the course of atmospheric pressure in Prague in Task 2 for the same period in three consequent years and follows the same scheme of elaboration as in previous.
b) Transfer the measured values of atmospheric pressure into Table 3 in Excel or Origin programs.
c) Using the measured values, plot the curve of the time dependence of atmospheric pressure (one-hour interval) for the selected period.
d) Find the mean daily values of atmospheric pressure, $\overline{p_{a4}}$, $\overline{p_{a5}}$ and $\overline{p_{a6}}$ for the selected period and plot all the graphs into one figure.
e) Determine the total of square deflections from the arithmetic average; determine the total of deflections from the mean value from positive and negative values.
f) Calculate the standard deflection from the arithmetic average.

Equipment and aids: Remote experiments located in Physics Dept., Teacher-training College, University of Trnava, Faculty of Mathematics and Physics, Charles University in Prague and Faculty of Engineering, University of Porto, PC with Internet.

Description of equipment: The weather station at the Faculty of Engineering University of Porto (FEUP) (Fig. 4) comprises an anemometer, a wind rose, pyranometer for measuring solar radiation, rain gauge, sensors for measuring relative air humidity, temperature and atmospheric pressure, and pyrgeometer for measuring the atmospheric infra-red radiation spectrum.

Figure 4 Weather station at the Faculty of Engineering, University of Porto [6]

The measuring hardware of weather stations at the universities in Trnava and Prague consists of ISES (The Internet School Experimental System) and the attached modules: thermometer, pressure gauge and light sensor (Fig. 5). Software used for the

remote experiments and the server-client connection was modular ISES WEB Control software. The thermometer is protuberant form the window for about 20 cm (Fig. 6), the manometer is located inside the laboratory and the photometer is focused horizontally to the sky. In fact, the photometer is not a heliograph, as it does not collect sunshine from the whole hemisphere. The thermometer is partly shielded from the direct solar radiation.

Figure 5 Experimental arrangement of the remote experiment "Weather monitoring" in Trnava, utilising an ISES set, www.ises.info

Figure 6 Experimental arrangement of the remote experiment "Weather station" in Prague, utilising an ISES set, www.ises.info

Measurement procedure:

Task 1

a) Click http://kf.truni.sk/, to enter e-Laboratory.
b) Find the experiment by the title "Weather monitoring".
c) Select "Start the experiment" from the menu on the web by clicking the link.
Note: A short delay may occur due to the delay in connecting your computer to the corresponding server and retrieving data. Be patient. After a while, depending on the speed of your connection, you can see the current values of atmospheric pressure, temperature and intensity of solar radiation in Trnava.
d) Click "Measuring the atmospheric pressure", select the period of the record; choose the identical day and month of the last year, then click "Graph".
e) The graph enables viewing local maxima (minima) and global maximum (minimum) of the atmospheric pressure over the selected period.
f) Notice the labelling of both independent and dependent physical variable scales.
g) Look at the graph and identify the lowest and the highest values of the atmospheric pressure (global extreme) over the selected period in one-hour intervals.
h) Determine the local extremes, mean value and the most abrupt change, of atmospheric pressure and the greatest rate of change (slope of pressure function).
i) Transfer the measured values of atmospheric pressure into Table 1 in Excel or Origin programs.

Table 1 Measured values of atmospheric pressure in Trnava of.....

Measurement No	t [h]	p_{a1} [hPa]	Δp_{a1} [hPa]	p_{a1}^2 [hPa^2]
1 . 24				
		$\overline{p_{a1}} = \ldots$		

j) Using the measured values, plot the curve of the time dependence of atmospheric pressure (one-hour interval) for the selected period.
k) Determine the mean daily value of the atmospheric pressure $\overline{p_{a1}}$ for the selected period and plot the graph.
l) Determine the sum of square of the deflections from the mean value, determine the sum of the positive and the negative deflections from the mean value in Table 1.
m) Calculate the standard deflection from the arithmetic average σ_{p_1}.
n) Record the resulting average daily value of atmospheric pressure $p_{a1} = \overline{p_{a1}} \pm \sigma_{p_1}$.

Task 2

a) Click www.ises.info to enter the Project of e-laboratory.
b) Look up the experiment by the title "Weather station in Prague", start it and follows the same scheme of elaboration as in previous Task 1, it mean.
c) After opening the page "Pressure monitoring", select the time interval of the record, choose the identical day and month of the last year as in Task 1 and click "Display".
d) Compare the courses of the values of atmospheric pressure and all the data determined in Task 1 from the same period with the data from the weather station located in the Project e-laboratory at the Faculty of Mathematics and Physics, Charles University in Prague.
e) Transfer the measured values of atmospheric pressure into Table 2 in Excel or Origin programs.

Table 2 Measured values of atmospheric pressure in Prague of.....

Measurement No	t [h]	p_{a2} [hPa]	Δp_{a2} [hPa]	p_{a2}^2 [hPa^2]
1 . 24				
		$\overline{p_{a2}} = \ldots$		

f) Using the measured values, plot the curve of the time dependence of atmospheric pressure (one-hour interval) for the selected period.
g) Determine the mean daily value of the atmospheric pressure $\overline{p_{a2}}$ for the selected period and plot the graph into the same picture in point f).
h) Determine the sum of square of the deflections from the mean value, determine the sum of the positive and the negative deflections from the mean value in Table 2.
i) Calculate the standard deflection from the arithmetic average σ_{p_2}.
j) Record the resulting average daily value of atmospheric pressure $p_{a2} = \overline{p_{a2}} \pm \sigma_{p_2}$.
k) Click http://experimenta.fe.up.pt/estacaometeorologica/inde

x.php to open WWW of the weather station at the University in Porto.

l) After opening the page in the part of "Database", select the time interval of the record, choose the identical day and month of the last year as in Task 1, and click the empty square next to the title "Atmospheric pressure", then click OK. You open a document in Excel program with the measured values of atmospheric pressure for the selected period.

m) Compare the courses of the values of atmospheric pressure and all the data determined in Task 1, from the same period with the data from the weather station located at FEUP.

n) Transfer the measured values of atmospheric pressure into Table 3 in the Excel Origin programs.

Table 3 Measured values of atmospheric pressure in Porto of.....

Measurement No	t [h]	p_{a3} [hPa]	Δp_{a3} [hPa]	p_{a3}^2 [hPa^2]
1 . 24				
		$\overline{p_{a3}} = \ldots$		

o) Using the measured values, plot the curve of the time dependence of atmospheric pressure (one-hour interval) for the selected period.

p) Determine the mean daily value of the atmospheric pressure $\overline{p_{a3}}$ for the selected period and plot the graph.

q) Determine the sum of square of the deflections from the mean value, determine the sum of the positive and the negative deflections from the mean value in Table 3.

r) Calculate the standard deflection from the arithmetic average from σ_{p_3}.

s) Record the resulting average daily value of atmospheric pressure $p_{a3} = \overline{p_{a3}} \pm \sigma_{p_3}$.

Task 3

a) Compare the course of atmospheric pressure in Prague in Task 2 over the same period of three consecutive years.
Note: You can get the data of 3 May 2003, when the experiment was launched. The record of the whole interval is rather inconsistent (several distortions, the building refurbishment, server maintenance etc.). Many experimenters (clients) can connect simultaneously. You can view their addresses in the box "Connected users"

b) Transfer the measured values of atmospheric pressure p_4, p_5, p_6 into Tables 4, 5 and 6 in Excel or Origin programs.

Table 4 Measured values of atmospheric pressure in Prague of.....

Measurement No	t [h]	p_{a4} [hPa]	Δp_{a4} [hPa]	p_{a4}^2 [hPa^2]
1 . 24				
		$\overline{p_{a4}} = \ldots$		

Table 5 Measured values of atmospheric pressure in Prague of.....

Measurement No	t [h]	p_{a5} [hPa]	Δp_{a5} [hPa]	p_{a5}^2 [hPa^2]
1 . 24				
		$\overline{p_{a5}} = \ldots$		

Table 6 Measured values of atmospheric pressure in Prague of.....

Measurement No	t [h]	p_{a6} [hPa]	Δp_{a6} [hPa]	p_{a6}^2 [hPa^2]
1 . 24				
		$\overline{p_{a6}} = \ldots$		

c) Using the measured values, plot the curve of the time dependence of atmospheric pressure (one-hour interval) for the selected period (individual years) and a common graph in dependence of the atmospheric pressure as time function (one-hour interval) for all the years surveyed.

d) Find the average daily values of atmospheric pressure $\overline{p_{a4}}$, $\overline{p_{a5}}$ and $\overline{p_{a6}}$ for selected period and plot them in graphs.

e) Determine the sum of square of the deflections from the mean value, determine the sum of the positive and the negative deflections from the mean value in Tables 4, 5 and 6.

f) Calculate the standard deflection from the arithmetic average for individual measurements σ_{p_4}, σ_{p_5} and σ_{p_6}.

g) Record the resulting mean daily value of atmospheric pressure for 4 years and plot the curve in the graph of the dependence of atmospheric pressure on time (one-hour interval) for all the years surveyed.

h) Discuss the results of measurements, prepare conclusion.

Project evaluation: Point scale 1 – 20 points. A student can acquire:

10 points max. for quality of the topic explanation, according to the following criteria: topic development (2 points), topic coverage (2 points), comprehension of classmates (2 points), raising the interest (2 points), achieving the objectives and tasks of the assignment (2 points).

10 points max. for the form of presentation and related visuals: poster – own drawings, concise data, physical relationships, summary details, symbols and unit of physical quantities, schemes, pictures form journals, PowerPoint presentations, Word documents etc.

3 Conclusion

Atmospheric pressure p_a is a major meteorological element. The pressure is an important environmental quantity, influencing straightforward daily our psychic and mood. Its changes and the rate of those changes are very important in weather forecast. The increase of atmospheric pressure usually indicates the advent of sunny weather p_a with low clouds, while the decrease of pressure indicates the accession of cloudy and rainy weather. Generally, people hardly realise the influence of p_a on a human organism in everyday life, except for those sensitive to weather changes. The goal of the project was to show how meaningful is possible to utilize the internet and remote experiments in education process.

Our experience with project learning showed that, besides acquiring the required knowledge of Physics, students enhance their information literacy, while realising the relationships of various physical phenomena with real world. Also during the active work the students enhanced their skills how to process bulk of date, their processing and evaluation, how to create graphs, how to insert more graphs into one figure, etc.

The new form of project learning with remote experimenting via the Internet proves to be a suitable motivation element in learning the subjects of Natural Science and Technology.

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