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Sun Exposition & Home Price

INTRODUCTION

Why do apartments in the same building have different prices? Why is a flat on an upper floor more expensive than one on a lower floor? We all know that this has got something to do with light and the luminosity of rooms. This teaching unit encourages students to conduct a field study and collect data on the surface area of apartments and windows, orientation and level of the floors as well as the prices of apartments depending on their orientation and floor level. Also, this teaching unit encourages students to examine the relationship between the varying real-estate prices, the economy, and related concepts of astronomy and earth sciences.

N.B.: In this text, the analysis of the sun exposition and direction refers to the sun in the Northern hemisphere.

Keywords
Prerequisites: sun daily path, latitude, elementary concept in statistics.

Interdisciplinary: This activity requires concepts of and involves topics in Astronomy, Geography, elementary Maths, construction formulas and Social Science. It requires fieldwork for collecting data, with the goal of familiarising students with their immediate social and geographical environment.

This teaching unit is recommended for students aged 15–17. It should be suitable for school curricula across Europe beginning with the last year of secondary school. The unit is perfect for international cooperation, as it allows data comparisons between cities of different countries. The unit can suggest statistics that evaluate and stress differences and analogies between countries, while relating them to latitude, population, prosperity, or other parameters. In the example provided here, three out of four cities share approximately the same latitude.

RESOURCES

All the activities are created for the purpose of data processing and analysis using a PC or a Mac. Spread sheets give an overview of price comparisons, especially if data from different regions or countries is being evaluated. We prepared a Java program for the astronomy part of the teaching unit. The program suggests helpful hints about sun radiance and latitude and encourages students to familiarise themselves with concepts such as energy, energy absorption, and radiance flux.

The student's guide and the Java application can be found at www.science-on-stage.de.

Programming: Students are encouraged to improve and develop further features in the Java program. So far, it calculates the average daily energy that reaches an apartment room and collects the data.

The Java program's preliminary activity is to collect data on the total amount of surface area covered for an apartment with south exposure, and on the latitude of that site. The Java program should help visualise the direction the sun's rays take against the backdrop of a generic profile of a south-facing window at the time of the equinox. This process will give you an idea of how important sun energy and latitude are, and it will calculate the daily amount of energy entering the apartment through the southern windows. At the same time, it keeps track of that part of sun's energy radiation per square meter that actually reaches the earth after atmospheric absorption.

We consider the Java program a key activity for this teaching unit.

CORE

Students are well-able to understand that light availability could be a good reason for paying more or less for a house or apartment. For instance, they easily observe that sunlight does not reach a first floor in the same way as it reaches an eighth floor. There could be buildings on the opposite side casting shadows on the lower part of "our" façade. As a result, the lower floors receive less light whereas the upper floors receive direct sunbeams.

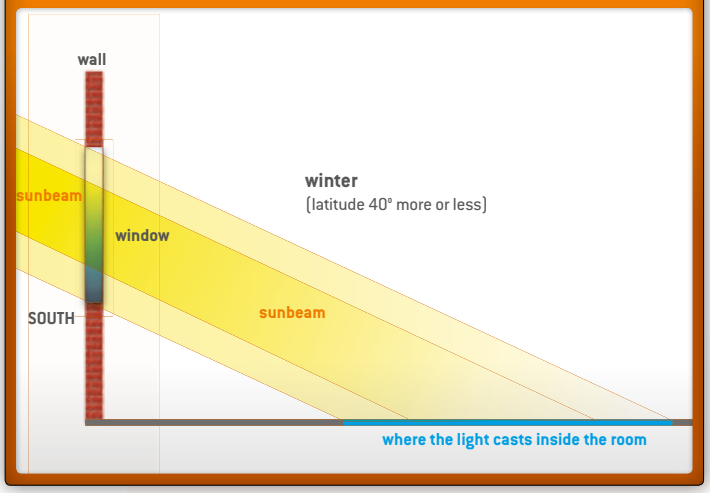
The same applies to orientation. A good orientation allows you to benefit from sunlight and heat.

We can observe how sunbeams enter through windows inside an apartment depending on the latter's orientation and the time of year.

In wintertime, at the south side of the building, the sunbeams shine through the window and fill a whole room. We have a warm and luminous hall. ①

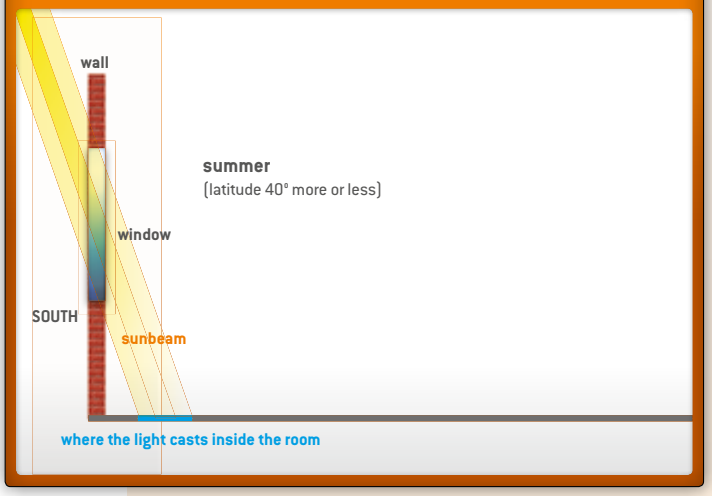
During the summer, sunbeams are cast on a wall. Light doesn't enter the room with too much intensity. The room is less warm than the west side, for instance. ②

① Sunbeams in winter



In these two pictures (①, ②), in which the wall faces toward south, we drew the inclination angles of the sunbeams at noontime. At this time, the sun reaches the maximum latitude on the horizon of a solstice day (December 21st, the winter solstice and June 21st, the summer solstice in the Northern hemisphere).

② Sunbeams in summer



Let us consider here, the behaviour of the sunbeams when the wall is facing east and west. In doing so, we will be in a position to compare the advantages and disadvantages of different orientations and draw the relevant conclusions.

When the wall faces east, orientation is also quite good because sunbeams enter the room during the early hours of the morning.

The winter is very pleasant because the sun warms the entire room and floods it with light. In the summer, the sunbeams work in a similar way and, although the sun heats more intensely than in the winter during the same hours, it is higher up on the horizon and the sunbeams enter only part of the room. An apartment's orientation toward the East is probably the second best one, compared to an apartment with a south-facing orientation.

If the wall faces west, the conditions of heat and light will change.

In wintertime the sunset is very early and the room only receives the last sunbeams of the day. They hardly heat the room. On the contrary, in summertime the apartment is already very hot when sunbeams begin to enter the room, due to the external temperature.

Input

Input data for the Java program is:

- The constant solar radiation reaching the earth: It can be considered a constant value of about 200W/m^2 but we decided to make it a variable parameter to be adjusted for different weather and climate conditions;
- The latitude;
- The total surface area of south-facing windows.

Analysis

We can assume that the solar radiation reaching the earth's surface in terms of energy per time unit per square meter is approximately 200W/m^2 (see also home.iprimus.com.au/nielsens/solrad.html).

We calculate the sun's average noon-time altitude on the horizon during a period of one year from its altitudes at equinoxes. This angle is the complementary angle of the latitude. The latitude angle is also equal to the angle that the external apartment walls and windows (perpendicular to the horizon) form with the sunlight coming parallel to the earth's surface. We can consider the amount of energy entering the apartment per time unit as the flux of the solar energy penetrating the surface area of the window. That can be defined as F=R*S*sin(λ), with λ being the latitude of the apartment site. We then average this radiation for the apartment's orientation, assuming it hits the windows' total surface area for 6 hours per day.

That means we have to multiply F by 6 hours (be careful to convert hours into seconds) and by the total surface area of external walls with windows facing south, to get the amount of energy per day. See Picture ③.

Output

The numeric output must be the average energy received through the south-facing windows of the apartment's south-facing walls on an average day.

The program should also draw:

- The window's profile, with the direction of sunrays on equinox, shows the angle between sunrays and window's surface, corresponding to the latitude
- The geographical latitude of the site on equinox

[These two graphics are currently under development. A constant graphic is shown. Nevertheless, students can figure out the Java code and adjust it to their latitude.]

CONCLUSION

In a pilot project of this activity, different groups of students, in every country, visited apartments and shops asking for information about the district, inhabitable area, prices, orientation, following the "Guide to students" at www.science-on-stage.de. They were interested in diverse information, so they wanted to know the prices for different city districts.

It could be interesting to write a short commentary about the difficulties students are faced with when it comes to obtaining information about apartment prices. Many times, salespersons were aware that students did not want to buy the apartment. The seller (in the pilot project) did not meet with our students, which is one of the reasons why the data might not always be accurate.

This activity is most valuable when performed as part of an international cooperation project, or at least when it involves different cities and regions in the same country. That way, students are able to compare totally different conditions in terms of climate, latitude, orography, and economical and geographical situations.

Interesting data can be obtained with respect to latitude, social situation, the country's flats policy, effective influence and activity of the sun during daytime.

The input parameter "Radiance from the Sun" can be used to "modulate" the geographical, orographical and meteorological conditions. Starting from the averaged value of 200 W/sqm, the solar radiation can be increased for lower latitudes, favourable climate conditions, annual meteorological situation, and average cloud cover.

Home activity

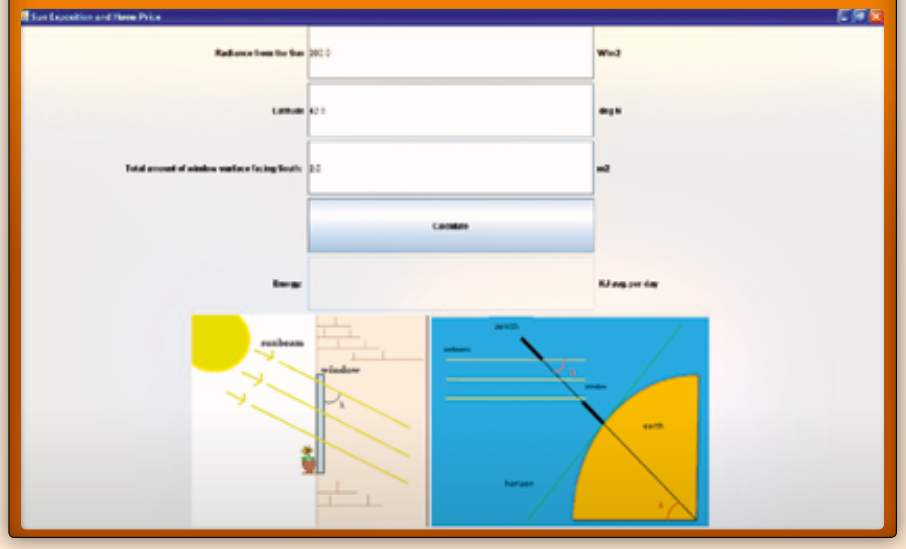
Data collection, forms completion, data exchange with international partner schools, data input into spreadsheet and/or Java program, graphics, comments.

Students could also perform some programming, at least for spread sheets.

Students may also want to figure out the reasons why the graphics' output looks the way it does, while trying to relate it to geographical, social, and economical causes.

An interesting outcome could be the publication of the results in local newspapers of all participating cities, so the schools may even initiate a kind of city-partnership activity.

③ **Screenshot of the Java program**



Yet another worthwhile angle might be that of introducing the windows' inclination as a new input parameter: By changing the windows' inclination to the horizon, the radiance flux through south-facing windows can be increased and reach its maximum value. Velux-style windows are an example of how one can increase this energy from the sun, approximating a 90 degree angle λ. Introducing this new parameter allows new considerations and discussions on optimising home-energy income.

Due to international developments, these activities can create an effective and easy way for potential participant schools from different countries to communicate with each other. Among the available platforms, the wiki exchange system is a valuable resource and efficient solution for sharing contents and collaborating among schools. With different access points for teachers and students, these exchange and cooperation platforms are perfect for any school environment and allow students to develop shared activities globally.