Activity 2: Investigating internal waves

Materials

- Rectangular tank with a divider
- Stopwatch
- Food colouring or other appropriate dye
- Two containers: one with fresh water and the other with dyed salt water (approximately 75g salt dissolved in 1 l tap water)
- Wave paddle (a wide piece of plastic about 2 cm high, with a width similar to that of the tank)
- Optional: a piece of plastic the same width as the tank but about one-third of its length

Procedure

1. Place the tap water in one compartment of the tank and the coloured salt solution in the other.
2. Remove the divider between the compartments, and watch what happens. Make a note of any waves you see, and describe their movements.
3. Identify the internal wave – this travels back and forth along the interface between the two differently coloured fluids. Measure the speed of this wave by timing how long it takes for the wave to travel the length of the tank. (Make sure you use an average value by timing several traverses.) Find the speed of the wave using the formula:

   Length of tank (m) / time taken (s) = wave speed (m/s)
4. Try producing surface and internal waves using the wave paddle. For surface waves, lower the paddle into the water and raise it again, repeating the cycle at a fast frequency (at least once a second). For internal waves, do this more slowly (about once every 10 seconds).
5. Discuss your results.
6. Optional: if you have time, you can repeat the experiments using the piece of plastic inserted at an angle to the bottom of the tank, to give the effect of a shallow sea bed. Place the plastic in position as shown below.

Discussion

The energy of internal waves is generally lower than that of surface waves. This is because the gravitational restoring force is smaller for internal waves, due to the relatively slight difference in density between water layers (compared to that between water and air for surface waves). This lower energy means that, for a tank (or water basin) of a given size, the natural frequency of the internal waves will also be lower than for surface waves.

In additional to surface waves, stratified fluids support internal waves; in two-layer fluids, these waves ride on top of the interface between the two fluids. Their periods are significantly longer than those of surface waves and their amplitudes can be significantly higher. When we perturb the two-layer system, many waves are initially excited, but only those that fit (resonate) with the geometry of the basin remain. Inserting the piece of plastic at one end of the tank, simulating an increasingly shallow seabed, can cause internal waves to break, similar to surface waves breaking on a beach, but occurring below the surface.

Image courtesy of Lee Karp-Boss

An internal wave at the interface between the denser (blue) salt water and less dense (clear) water. A wave paddle is shown on the right of the tank, and a piece of plastic to simulate shallow topography on the left.

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Planktonic organisms are incapable of swimming against a current.

Acknowledgement

This article is based on the resource developed through the organisation COSEE (Center for Ocean Sciences Education Excellence) by oceanographers Lee Karp-Boss, Emmanuel Boss, Herman Weller, James Loftin and Jennifer Albright (Karp-Boss et al., 2009).

Reference

Karp-Boss L, et al. (2009) Teaching physical concepts in oceanography: an inquiry based approach. *Oceanography* **22(3)**: supplement. doi: 10.5670/oceanog.2009.supplement.01

Resources

The tanks can be obtained from sciencekit.com, where a set of six tanks costs 130 USD. You could also try building your own, using a small fish tank and constructing a divider with a good seal.

For more information and activities on ocean layering and mixing, see the article *Mix it up, mix it down: Intriguing implications of ocean layering*, available online at: www.tos.org/oceanography/archive/22-1_franks.pdf

The website of COSEE Ocean Systems offers images of density profiles and thermohaline circulation, videos on ocean convection, a collection of hands-on activities, and links to related concepts. See: http://cosee.umaine.edu/climb

In particular, there are videos demonstrating activity 1: water density and stratification (http://cosee.umaine.edu/files/coseeos/video_tsoi04.htm or use the shorter link: http://tinyurl.com/crjzwoq) and activity 2: internal waves (http://cosee.umaine.edu/files/coseeos/video_tsoi11.htm or use the shorter link: http://tinyurl.com/cf4so47#).

NASA offers a website with information and resources on ocean currents. See: http://oceanmotion.org/index.htm

Additional educational resources in oceanography are available on website of COSEE (Centers for Ocean Sciences Education Excellence). See: www.cosee.net/resources/educators

These two books are accessible introductions to oceanography:

Denny MW (1993) *Air and Water: The Biology and Physics of Life's Media*. Princeton, NJ, USA: Princeton University Press

Denny M (2007) *How the Ocean Works: An Introduction to Oceanography*. Princeton, NJ, USA: Princeton University Press

If you found this article useful, why not browse the other teaching activities in *Science in School*? www.scienceinschool.org/teaching

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Physics

Image courtesy of Isolino; image source: Flickr

HOW CAN TEACHERS RECOGNISE CONTENT THAT HAS THE POTENTIAL TO TRAVEL ACROSS NATIONAL, CULTURAL AND LINGUISTIC BOUNDARIES?

European Schoolnet, a network of 30 European Ministries of Education based in Brussels, has been active in the field of Open Educational Resources (OER) for over a decade. It has particularly focused on promoting the exchange of quality OERs at the pan-European level via the Learning Resource Exchange for schools (LRE): **http://lreforschools.eun.org**

- The LRE, as a pan-European exchange, enables educators and learners to find over 240,000 resources from more than 50 content providers.
- The LRE relies on a rigorously tested set of criteria developed by the eQNet project to help assess which resources have the potential to 'travel well' across national, cultural and linguistic boundaries.
- Teachers and content producers can now use the criteria in their own work to create and discover OERs with real potential for re-use across Europe.

TRAVEL WELL CRITERIA WITH EXAMPLES

1. TRANS-NATIONAL TOPICS (must be present)

The resource addresses curriculum topics that could be considered trans-national. It can also be a resource well suited for use in multi-disciplinary or cross-curricular contexts.

Example: Encyclopedia of Life

Source: Encyclopedia of Life

2. KNOWLEDGE OF A SPECIFIC LANGUAGE IS NOT NEEDED (must be present)

The resource can be used without having to translate accompanying texts and/or the resource may be available in at least 3 European languages.

Example: Caves at Lascaux

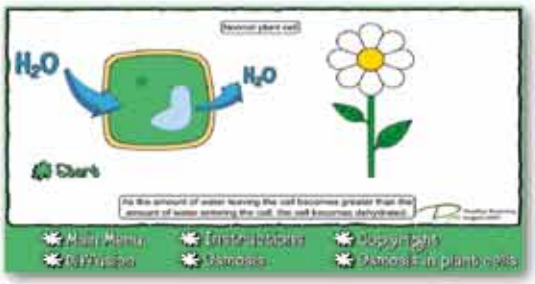
Source: French Ministry of Culture and Communication

3. STORED AS A FILE TYPE THAT IS USABLE WITH GENERALLY AVAILABLE SOFTWARE

The resource can be used in any environment (online and off-line) and runs on multiple platforms (also hand-held, IWB).

Example: Diffusion and Osmosis

Source: Bio-DiTRL



4. METHODOLOGICAL SUPPORT FOR TEACHERS IS NOT NEEDED

Subject teachers can easily recognize how this resource meets their curriculum requirements or how this resource could be used in a teaching scenario without further instructions.

Example: Human Anatomy
Source: ThatQuiz.org

5. INTUITIVE AND EASY TO USE

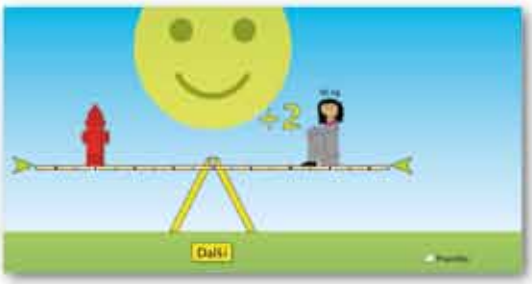
The resource is intuitive to use in the sense that it has a user-friendly interface and is easy to navigate for both teachers and students without having to read or translate complex operating instructions.

Example: Map Maker
Source: TeacherLED

6. INTERACTIVITY WITH OR WITHOUT FEEDBACK IN A DIGITAL ENVIRONMENT

This kind of resource invites or requires a significant degree of user input or engagement, other than just reading something on a page in an online or offline environment.

Example: Balancing Act
Source: PhET



7. CLEAR LICENSE STATUS (must be present)

The user can easily find information about the license/rights (sometimes called Terms of Use, Copyright or Permissions) for this resource, clearly outlining what educators can do with this animation and what they may not do because it will infringe copyright.

Example: CellsAlive! Permission Page
Source: CellsAlive!

SEE A SHOWCASE OF TRAVEL WELL RESOURCES:
http://lreforschools.eun.org/web/guest/travelwell-all

European Schoolnet

Learning Resource Exchange for schools http://lreforschools.eun.org

For more information:
European Schoolnet: **www.europeanschoolnet.org** Email: **lre-contact@eun.org**

Lifelong Learning
The Quality Network for a European Learning Resource Exchange (eQNet) and the work presented in this print ad is supported by the European Commission's Lifelong Learning Programme.