The Virtual Sandbox
An approach to introduce principles of granular flow physics in the classroom

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the idea
idea of the project – science communication

High-Tec
Institute of Process and Particle Engineering
Technical University of Graz

didactics
University College of teacher education of Styria

curiosity
Aims

- Introducing up-to-date contexts for teaching the basics of physics and develop a general understanding of technology and engineering.
- Bridging the gap between fundamentals and application to understand the importance of learning fundamentals.
- Understanding the importance of performing experiments and simulations during the research process.
- Recognizing how modern applications in industry exploit simulations for process design and optimization.
experiment
modeling
simulation
prediction
learning sequence

reality
• properties of particular matter
  – density
  – stability
• explanation of its behaviour
  – capillarity
  – surface tension

virtuality (augmented reality)
• basics for technology
  – modelling – „Keksperiment“
  – simulation
• interaction with the virtual world

can be adopted to primary level

upper secondary level
experiment
Strategy

Inquiry-based learning
What has the higher density?

Dry or wet sand?
paranut - effect

http://p5.focus.de/img/fotos/crop5802312/7532713323-w1200-h627-o-q75-p5/paranuss-effekt.jpg
Why is the density so important?

https://www.welt.de

http://www.fuzzytech.com
measuring the bulk density (engineering standards)
<table>
<thead>
<tr>
<th></th>
<th>trocken</th>
<th>+ 5 ml</th>
<th></th>
<th>trocken</th>
<th>+ 50 ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>154,7 g</td>
<td>98,6 g</td>
<td>6</td>
<td>147,0 g</td>
<td>182 g</td>
</tr>
<tr>
<td>2</td>
<td>150,7 g</td>
<td>113,8 g</td>
<td>7</td>
<td>157,4 g</td>
<td>208,7 g</td>
</tr>
<tr>
<td>3</td>
<td>153,7 g</td>
<td>92,0 g</td>
<td>8</td>
<td>154,0 g</td>
<td>192,0 g</td>
</tr>
<tr>
<td>4</td>
<td>150,5 g</td>
<td>134,7 g</td>
<td>9</td>
<td>154,7 g</td>
<td>114,9 g</td>
</tr>
<tr>
<td>5</td>
<td>149,5 g</td>
<td>121,1 g</td>
<td>10</td>
<td>158,3 g</td>
<td>99,6 g</td>
</tr>
</tbody>
</table>
Masse in g

Dry and wet sand

Volume = const.
standard method

Stativ, Trichter, und 150 ml Messbecher
Wasser-Sand Mischung
Spatel zum Abstreichen
bulk density vs. water content
stability
Reynold’s dilatancy
Reynold’s dilatancy
experiment

modeling
ping pong ball pyramide
capillarity
Keksperimente

geometry

Monte-Carlo-iteration
Keksperiment: „Keksmodell“

\[ \phi = \frac{3 \cdot 60^\circ \cdot D^2 \pi}{360^\circ \cdot \frac{4}{4}} = \frac{\pi}{2\sqrt{3}} \]

\[ \phi \approx 0.907 \]
Keksperiment: „Keksmodell“

Calculation of the space between the „particles“

\[ \phi = \frac{D^2 \pi}{4} \frac{1}{D^2} = \frac{\pi}{4} \]
\[ \phi \approx 0.785 \]
Golden rule of Keksperiments: Never use chocolate cookies!
experiment
modeling
simulation
Is computer-based research necessary?

**goal:** better products, more efficient production

experiments • mostly expensive
• allow only restricted insight
• sometime do not succeed
• safety

simulations • allow deeper insight, especially when using opaque materials
• allow extreme variations of parameters

(TU Graz)
Experiment  
Modeling  
Simulation  
Prediction
Is computer-based research necessary?

Simulations allow predictions and analysis of industrial processes → planning reliability.
finally, „The Virtual Sandbox“?


how do the learners recognize the lectures?
age ≈ 9
age > 16
This lecture was interesting
I learned something new today

I want to learn more about sand.
I want more lectures like this
Some results for primary classes

The workshop with sand was interesting.

I liked the experiments with sand.

N = 79 (43 female, 36 male)
age 9 to 10

I can explain, how to build a stable sandcastle.

I can explain, why wet sand is sticky.
Linda,

Ich fand den Sandkuchen cool, und es war komisch, dass er eine dreiviertel vollle Flasche ausnahm. Auch die kleine Waffe war sehr praktisch. Das Wasser oder Tischtennisbälle zusammenhalten wollte sich nicht. Das Team war sehr sehr nett. Mir hat die Zielscheibe aufgefallen, wo man eingezieht hat, wie es einem gefallen hat.

Niemals Dank!
Thanks to Stefan Radl, Jakob Redlinger-Pohn, Hans Eck, Nora Wiesauer, Andrea Karner, Benjamin Bahar, Lukas Wachtler, Martin Neumayer

More questions than answers?!