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inTruST Learning Scenario

Newton´s laws- Hands On

Picture:



https://youtu.be/otAaw4qiEwM

Research Questions/Tasks

Short Description (max. 500 words)

The Unit 'Newton's Laws – Hands On', introduces a practical and motivating teaching unit that brings the laws of motion to life. Rather than treating Newton's laws as abstract theories, the programme turns them into hands-on experiences that engage learners from the outset. Designed for students aged 7 to 12, the programme caters for different levels of prior knowledge and skill, ensuring accessibility while offering meaningful challenges for more advanced learners.

The unit is structured into two levels of difficulty, each with a strong emphasis on exploration, creativity, and real-world application. In the structured version, younger learners discover the fundamental principles of inertia, force, and reaction by building simple balloon-powered vehicles. These playful experiments encourage curiosity and foster an intuitive understanding of the laws of motion. In the guided version, students take it a step further by integrating technology and design. Using CAD software and 3D printing, they create custom parts and apply Newton's laws to construct more sophisticated prototypes. This strengthens their understanding of physics and introduces them to the latest tools and methods used in engineering and product design.

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The three Newtonian laws serve as the guiding thread throughout the unit. Rather than reading about these concepts, students experience, test and reflect upon them in dynamic classroom activities.

The learning experience is further enriched by its interdisciplinary connections. Beyond physics, the unit also covers technology, mathematics and design. It fosters cross-curricular learning by linking mechanical principles to mobility, aerodynamics, hydraulics and everyday problem solving. By blending theory with hands-on creativity, students can understand scientific principles and see their relevance in the world around them.

By building, testing and improving their own vehicles, students develop a sense of ownership and pride in their learning process. They are encouraged to experiment, make mistakes and persevere — mirroring the practices of real scientists and engineers. This approach promotes inquiry-based learning, collaboration, and critical thinking, while also sparking excitement for science and technology.

In summary, 'Newton's Laws – Hands On' offers a flexible way to teach fundamental physics through creativity, exploration and experimentation. It transforms the classroom into a laboratory of discovery where Newton's principles form the basis of curiosity, invention and long-lasting understanding.

Information about the Implementation

Students' age: 7- 12 Students' language:

Number of lessons: 2-4 Duration of one lesson: 50 minutes

For which subject(s) is the activity usable?

Physics ☒ Chemistry ☐ Biology ☐ Science ☒ Maths ☐

Art ☐ Technology & Design ☒ Other:

Level of Inquiry (see information in the Appendix):

0- Confirmatory ☐ 1- Structured ☒ 2- Guided ☒ 3- Open ☐

Select the Science and Engineering Practices that are the focus of the designed unit:
(Detailed information on the practices can be found here (Next Generation Science Standards).)

1		Asking questions and defining problems	☒
2		Developing and using models	☒
3		Planning and carrying out investigations	☒
4		Analysing and interpreting data	☐
5		Using mathematics and computational thinking	☐
6		Constructing explanations and designing solutions	☒
7		Engaging in argument from evidence	☐
8		Obtaining, evaluating and communicating information	☒

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Information about the Units of Learning

Technology and Design:
https://www.ris.bka.gv.at/NormDokument.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10008568&Artikel=&Paragraf=&Anlage=1&Uebergangsrecht= [Zugriff: 16.9.25}

„- Bewegung/Mobilität/Mechanik: Antrieb und Fortbewegung, Bionik, Fahren/Fliegen/Schwimmen, Hydraulik/Pneumatik, Hydro- und Aerodynamik“

Description of the learning objectives?
„Der Unterrichtsgegenstand ermöglicht durch all diese Zugänge vielfältige Querverbindungen zu anderen Unterrichtsgegenständen (zB im Bereich Mathematik-Informatik-Naturwissenschaften-Technik) und den allgemeinen Unterrichtsprinzipien der Schule.“

“All these approaches enable the subject to be linked in many ways to other subjects (e.g. in the fields of mathematics, computer science, natural sciences, and technology) and to the general teaching principles of the school.”

Materials and other resources

Structured: 3D Printer(teachers), Wood 3mm Plywood, Balloon, Wheels- Axes- Mounting-Hardware, Variable Material

Guided: 3D Printer(students), CAD-Software (Tinkercad), Wood 3mm Plywood, Balloon, Wheels- Axes- Mounting-Hardware, Variable Material

Previous knowledge of the students

Prior knowledge of working with 3D printers, CAD software, woodworking, and knowledge of safety regulations and working in a workshop, commensurate with the level of difficulty.

Quick facts: Newton’s Laws

1. Principle of Inertia: A body remains in its state of motion until an external force acts upon it. The lower the friction in the axle bearings, or between the tyres and the ground, the less the vehicle is slowed down.

2. Principle of Action: For a constant force, the following applies: the greater the mass of a body, the smaller the acceleration it experiences. The smaller the mass, the smaller the acceleration. The heavier the vehicle, the smaller the acceleration.

3. Principle of Interaction: For every force, there is always an equal and opposite reaction force. The escaping air causes the vehicle to move in the opposite direction.

Description of the lesson plan (simplified version for teachers)

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Structured: Students receive pre-made 3D printed components (balloon adapters) and must use them to develop and build a vehicle that can travel as far as possible. In doing so, components must be modified and used both critically and creatively. The choice of materials and options is up to the teacher and the students.

Guided: Students must consider the conditions (physical, structural, material, etc.) for the balloon adapter and wheels in order to develop them. Once the adapter and wheel has been developed, the vehicle is constructed. This is followed by testing and evaluation phases as well as adaptations.

Levels 1 + 2

1. Getting started: Introduction to Newton's laws using everyday examples; brief demonstration of a reaction-driven vehicle

2. Task: Building a working (balloon-powered) vehicle or a reaction-driven machine.

3. Planning phase: Sketching ideas, selecting materials
   For Level 1: 3D-printed components provided
   For Level 2: CAD modelling of the balloon adapter or other components

4. Construction phase: Bringing the sketches to life; use of various materials and methods possible

5. Testing phase: Testing the vehicles; measuring distance, speed and stability

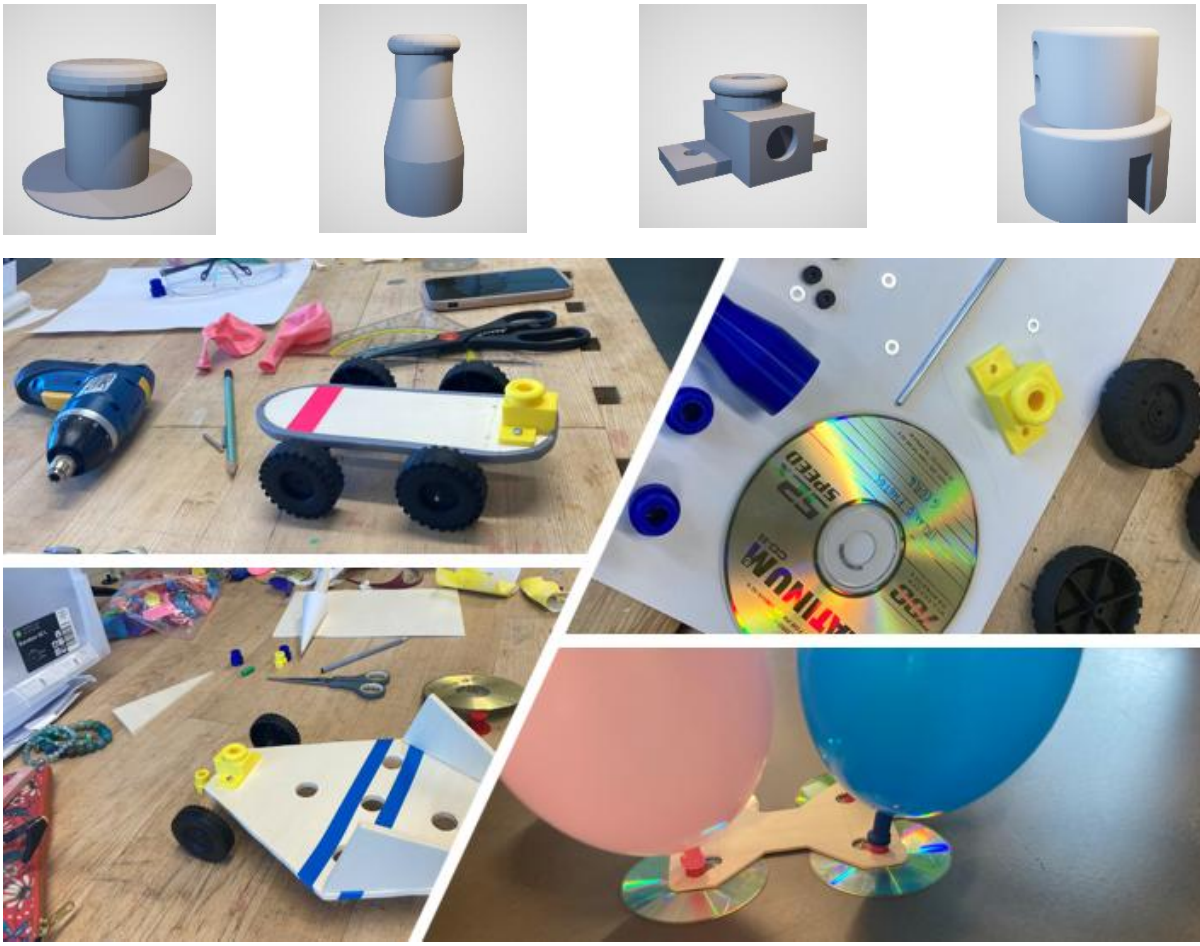
6. Analysis & optimisation: Reflection on the results; derivation of physical relationships; adaptation of the design; Changes to variables: increase/decrease weight, optimise airflow, change the hole size of the adapter, reduce friction, increase the mass of the outflowing material (water instead of air in the balloon)

7. Documentation: analogue or digital portfolio, photographs, working drawings; detailed depending on the level, Keep a research log of the variables that have been changed, changing only one variable at a time

8. Presentation & record-keeping: Presentation of the vehicles; discussion of functional versus design aspects

Pictures, Worksheets and Files

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https://www.thingiverse.com/thing:7221149

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Appendix

Level of Inquiry

Refer to the table below for information about the level of inquiry according to Orosz et al. (2023). Select the relevant level of inquiry for your unit in your template above. Please note that, as discussed during LTT2, you can adjust the responsibilities assigned to students and teachers at Levels 1 and 2 if you wish.

Level of Inquiry	Problem/ Question	Procedures	Interpretation of Results	Purpose & Requirements
Level 0 – Confirmatory Inquiry	Teacher	Teacher	Teacher	Students reproduce the results
Level 1 – Structured Inquiry	Teacher	Teacher	Students	Practising simple inquiry skills (e.g., observation, measurement, data interpretation, discussion of results, documentation) or introducing students to IBL
Level 2 – Guided Inquiry	Teacher	Students	Students	Opportunity for cooperative learning, room for creativity, development of skills and abilities (above + formulation of hypotheses, designing the experiment)
Level 3 – Open Inquiry	Students	Students	Students	Greatest level of freedom; demands advanced inquiry skills, reasoning ability and creativity, and high level of responsibility

Science and Engineering Practices

As a framework for designing the learning units, this project used the science and engineering practices according to the Next Generation Science Standards (NGSS). Detailed descriptions of each practice can be found in the Appendix F of the NGSS: *https://www.nextgenscience.org/sites/default/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf*

Literature

NGSS Lead States. (2013). *Next Generation Science Standards: For states, by states. Appendix F: Science and engineering practices in the NGSS.* National Academies Press. https://www.nextgenscience.org/

Orosz, G., Németh, V., Kovács, L., Somogyi, Z., & Korom, E. (2023). Guided inquiry-based learning in secondary-school chemistry classes: A case study. *Chemistry Education Research and Practice*, *24*(1), 50–70. https://doi.org/10.1039/D2RP00110A

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